ADDITIONS AND RENOVATIONS TO PRINCETON MIDDLE SCHOOL

PRINCETON PUBLIC SCHOOLS
PRINCETON - MERCER COUNTY - NEW JERSEY

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FVHD PROJECT #5516B

Consulting Engineers:
Edwards Engineering Group, an L2A Company, Consulting Civil Engineers
Harrison - Hamnett, PC, Consulting Structural Engineers
French & Parrello Associates, P.A., Consulting MEP Engineers

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S P E C I F I C A T I O N S

for

ADDITIONS AND RENOVATIONS TO PRINCETON MIDDLE SCHOOL

located at 217 Walnut Lane, Princeton, NJ 08540

for the

PRINCETON PUBLIC SCHOOLS

Princeton, Mercer County, New Jersey

FVHD PROJECT NO. 5516B

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SECTION 13390 – WET PIPE FIRE SUPPRESSION SPRINKLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Pipes, fittings, and specialties.
2. Fire-protection valves.
3. Sprinklers.
4. Pressure gages.

1.3 DEFINITIONS

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

1.4 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.

1.5 PERFORMANCE REQUIREMENTS

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

B. Delegated Design: Design sprinkler system(s), including comprehensive Engineering analysis by a qualified professional Engineer, using performance requirements and design criteria indicated.

a. Contractor shall arrange and pay all fees associated with a fire hydrant flow test to be used in the design of the fire sprinkler system. Provide copy of test to Architect.

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

1. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water-service piping, valves, and backflow preventers.
2. Sprinkler Occupancy Hazard Classifications:

    a. Building Service Areas: Ordinary Hazard, Group 1.
    b. Electrical Equipment Rooms: Ordinary Hazard, Group 1.
    c. General Storage Areas: Ordinary Hazard, Group 1.
    d. Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
    e. Office and Public Areas: Light Hazard.
    f. Science Classrooms : Light Hazard

3. Minimum Density for Automatic-Sprinkler Piping Design:

4. Maximum Protection Area per Sprinkler: Per UL listing.

5. Total Combined Hose-Stream Demand Requirement: According to NFPA 13 unless otherwise indicated:

    a. Light-Hazard Occupancies: 100 gpm for 30 minutes.
    b. Ordinary-Hazard Occupancies: 250 gpm for 60 to 90 minutes.

D. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and SCE/SEI 7.

1.6 SUBMITTALS

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

B. Shop Drawings: For wet-pipe sprinkler systems. Include plans, elevations, sections, details, and attachments to other Work.

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

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 professional Engineer responsible for their preparation.

D. Coordination Drawings: Sprinkler systems, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Domestic water piping.
2. HVAC hydronic piping.

3. Items penetrating finished ceiling include the following:

    a. Lighting fixtures.
    b. Air outlets and inlets.

E. Qualification Data: For qualified Installer and professional Engineer.

F. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.

G. Welding certificates.

H. Fire-hydrant flow test report.

I. 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."

J. Field quality-control reports.

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

1.7 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional Engineering services needed to assume Engineering responsibility. Base calculations on results of fire-hydrant flow test.

    a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional Engineer.

B. 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.

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

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

2. NFPA 24, "Installation of Private Fire Service Mains and Their Appurtenances."

1.8 COORDINATION

A. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including 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. Standard Weight, Galvanized- and Black-Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.

B. Schedule 10, Black-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, Schedule 10 in NPS 5 and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10, plain end.

C. Galvanized- and Black Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, standard-weight, seamless steel pipe with threaded ends.

D. Galvanized- and Uncoated, Steel Couplings: ASTM A 865, threaded.

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

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

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

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

I. Steel Welding Fittings: ASTM A 234/A 234M and ASME B16.9.

J. 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.
d. Or approved equal.

2. Pressure Rating: 175 psig minimum.
3. Galvanized- and Uncoated, 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.

2.3 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free.

1. Class 125, Cast-Iron Flanges and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.
2. Class 250, Cast-Iron Flanges and Class 300, Steel Raised-Face Flanges: Ring-type gaskets.

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

C. 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.

2.4 LISTED FIRE-PROTECTION VALVES

A. General Requirements:

1. Valves shall be UL listed or FM approved.

2. Minimum Pressure Rating for Standard-Pressure Piping: 175 psig.

B. Ball Valves:

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

    a. Anvil International, Inc.
    b. Victaulic Company.
    c. Or approved equal.

2. Standard: UL 1091 except with ball instead of disc.
3. Valves NPS 1-1/2 and Smaller: Bronze body with threaded ends.
4. Valves NPS 2 and NPS 2-1/2: Bronze body with threaded ends or ductile-iron body with grooved ends.
5. Valves NPS 3: Ductile-iron body with grooved ends.

C. Bronze Butterfly Valves:

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

    a. Fivalco Inc.
    b. Global Safety Products, Inc.
    c. Milwaukee Valve Company.
    d. Or approved equal.

2. Standard: UL 1091.
3. Pressure Rating: 175 psig.
4. Body Material: Bronze.
5. End Connections: Threaded.

D. Iron Butterfly Valves:

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

    a. Anvil International, Inc.
    b. Kennedy Valve; a division of McWane, Inc.
    c. Milwaukee Valve Company.
    d. NIBCO INC.
    e. Pratt, Henry Company.
    f. Shurjoint Piping Products.
    g. Or approved equal.

2. Standard: UL 1091.

3. Pressure Rating: 175 psig.
4. Body Material: Cast or ductile iron.
5. Style: Lug or wafer.
6. End Connections: Grooved.

E. Check Valves:

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

    a. Anvil International, Inc.
    b. Clow Valve Company; a division of McWane, Inc.
    c. Crane Co.; Crane Valve Group; Crane Valves.
    d. Crane Co.; Crane Valve Group; Jenkins Valves.
    e. Crane Co.; Crane Valve Group; Stockham Division.
    f. Kennedy Valve; a division of McWane, Inc.
    g. Metraflex, Inc.
    h. Milwaukee Valve Company.
    i. Mueller Co.; Water Products Division.
    j. NIBCO INC.
    k. Potter Roemer.
    l. Reliable Automatic Sprinkler Co., Inc.
    m. Tyco Fire & Building Products LP.
    n. United Brass Works, Inc.
    o. Venus Fire Protection Ltd.
    p. Victaulic Company.
    q. Viking Corporation.
    r. Watts Water Technologies, Inc.
    s. Or approved equal.

2. Standard: UL 312.
3. Pressure Rating: 250 psig minimum.
4. Type: Swing check.
5. Body Material: Cast iron.
6. End Connections: Flanged or grooved.

F. Iron OS&Y Gate Valves:

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

    a. American Cast Iron Pipe Company; Waterous Company Subsidiary.
    b. American Valve, Inc.
    c. Clow Valve Company; a division of McWane, Inc.
    d. Crane Co.; Crane Valve Group; Crane Valves.

e. Crane Co.; Crane Valve Group; Jenkins Valves.
f. Crane Co.; Crane Valve Group; Stockham Division.
g. Hammond Valve.
h. Milwaukee Valve Company.
i. Mueller Co.; Water Products Division.
j. NIBCO INC.
k. Shurjoint Piping Products.
l. Tyco Fire & Building Products LP.
m. United Brass Works, Inc.
n. Watts Water Technologies, Inc.
o. Or approved equal.

2. Standard: UL 262.
3. Pressure Rating: 250 psig minimum.
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, Inc.
b. Fivalco Inc.
c. Global Safety Products, Inc.
d. Kennedy Valve; a division of McWane, Inc.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Shurjoint Piping Products.
h. Tyco Fire & Building Products LP.
i. Victaulic Company.
j. Or approved equal.

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

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

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

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

6. Valve Operation: Integral electrical, 115-V ac, prewired, two-circuit, supervisory switch indicating device.

2.5 TRIM AND DRAIN VALVES

A. General Requirements:

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

B. Angle Valves:

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

a. Fire Protection Products, Inc.
b. United Brass Works, Inc.
c. Or approved equal.

C. Ball Valves:

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

a. Affiliated Distributors.
b. Anvil International, Inc.
c. Barnett.
d. Conbraco Industries, Inc.; Apollo Valves.
e. Fire-End & Croker Corporation.
f. Fire Protection Products, Inc.
g. Flowserve.
h. FNW.
i. Jomar International, Ltd.
j. Kennedy Valve; a division of McWane, Inc.
k. Kitz Corporation.
l. Legend Valve.
m. Metso Automation USA Inc.
n. Milwaukee Valve Company.
o. NIBCO INC.
p. Potter Roemer.
q. Red-White Valve Corporation.
r. Southern Manufacturing Group.
s. Stewart, M. A. and Sons Ltd.
t. Tyco Fire & Building Products LP.

u. Victaulic Company.
v. Watts Water Technologies, Inc.
w. Or approved equal.

D. Globe Valves:

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

a. Fire Protection Products, Inc.
b. United Brass Works, Inc.
c. Or approved equal.

E. Plug Valves:

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

a. Southern Manufacturing Group.
b. Or approved equal.

2.6 SPECIALTY VALVES

A. General Requirements:

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

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

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

2.7 SPRINKLER SPECIALTY PIPE FITTINGS

A. Branch Outlet Fittings:

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

a. Anvil International, Inc.
b. National Fittings, Inc.
c. Shurjoint Piping Products.

d. Tyco Fire & Building Products LP.
e. Victaulic Company.
f. Or approved equal.

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

B. Flow Detection and Test Assemblies:

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

a. AGF Manufacturing Inc.
b. Reliable Automatic Sprinkler Co., Inc.
c. Tyco Fire & Building Products LP.
d. Victaulic Company.
e. Or approved equal.

2. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
3. Pressure Rating: 175 psig 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.

C. Branch Line Testers:

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

a. Elkhart Brass Mfg. Company, Inc.
b. Fire-End & Croker Corporation.
c. Potter Roemer.
d. Or approved equal.

2. Standard: UL 199.
3. Pressure Rating: 175 psig.
4. Body Material: Brass.
5. Size: Same as connected piping.

6. Inlet: Threaded.
7. Drain Outlet: Threaded and capped.
8. Branch Outlet: Threaded, for sprinkler.

D. Sprinkler Inspector's Test Fittings:

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

    a. AGF Manufacturing Inc.
    b. Triple R Specialty.
    c. Tyco Fire & Building Products LP.
    d. Victaulic Company.
    e. Viking Corporation.
    f. Or approved equal.

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

E. Adjustable Drop Nipples:

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

    a. CECA, LLC.
    b. Corcoran Piping System Co.
    c. Merit Manufacturing; a division of Anvil International, Inc.
    d. Or approved equal.

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

F. Flexible, Sprinkler Hose Fittings:

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

    a. Fivalco Inc.

b. FlexHead Industries, Inc.
c. Gateway Tubing, Inc.
d. Or approved equal.

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

2.8 SPRINKLERS

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

1. AFAC Inc.
2. Globe Fire Sprinkler Corporation.
3. Reliable Automatic Sprinkler Co., Inc.
4. Tyco Fire & Building Products LP.
5. Venus Fire Protection Ltd.
6. Victaulic Company.
7. Viking Corporation.
8. Or approved equal.

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

C. Automatic Sprinklers with Heat-Responsive Element:

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

D. Sprinkler Finishes:

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

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

1. Ceiling Mounting: Chrome-plated steel, two piece, with 1-inch vertical adjustment.
2. Sidewall Mounting: Chrome-plated steel, one piece, flat.

F. Sprinkler Guards:

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

a. Reliable Automatic Sprinkler Co., Inc.
b. Tyco Fire & Building Products LP.
c. Victaulic Company.
d. Viking Corporation.
e. Or approved equal.

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

2.9 PRESSURE GAGES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, the following:

1. AMETEK; U.S. Gauge Division.
2. Ashcroft, Inc.
3. Brecco Corporation.
4. WIKA Instrument Corporation.
5. Or approved equal.

B. Standard: UL 393.

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

D. Pressure Gage Range: 0 to 250 psig 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 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 before deviating from approved working plans.

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

C. Install seismic restraints on piping. Comply with requirements for seismic-restraint device materials and installation in NFPA 13.

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

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

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

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

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

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

J. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft metal seated globe valve, arranged for draining pipe between gage and

valve. Install gages to permit removal, and install where they will not be subject to freezing.

K. Fill sprinkler system piping with water.

L. Install electric heating cables and pipe insulation on sprinkler piping in areas subject to freezing.

M. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 15 Section "Sleeves and Sleeve Seals for Fire-Suppression Piping."

N. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 15 Section "Sleeves and Sleeve Seals for Fire-Suppression Piping."

O. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 15 Section "Escutcheons for Fire-Suppression Piping."

3.3 JOINT CONSTRUCTION

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

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

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

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

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

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

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

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

H. 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.

3.4 VALVE AND SPECIALTIES INSTALLATION

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

B. Specialty Valves:

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

3.5 SPRINKLER INSTALLATION

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

B. 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.

3.6 IDENTIFICATION

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

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 16 Section "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
4. Energize circuits to electrical equipment and devices.
5. 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.

3.8 CLEANING

A. Clean dirt and debris from sprinklers.

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

3.9 DEMONSTRATION

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

3.10 PIPING SCHEDULE

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

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

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

C. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2 to NPS 4 shall be one of the following:

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

D. Standard-pressure, wet-pipe sprinkler system, NPS 5 and larger, shall be one of the following:

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

4. Standard-weight, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
5. Standard-weight, 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.

3.11 SPRINKLER SCHEDULE

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

1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Suspended Ceilings: concealed sprinklers.
3. Wall Mounting: Sidewall sprinklers.
4. Spaces Subject to Freezing: Upright, pendent, dry sprinklers; and sidewall, dry sprinklers as indicated.
5. Special Applications: quick-response sprinklers where indicated at all locations.

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

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

END OF SECTION 13930

SECTION 15057 - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 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 requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

C. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

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

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

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

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

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F.

J. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

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

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

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

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

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

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

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

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

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 15057

SECTION 15061 - 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

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

1.3 DEFINITIONS

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

1.4 PERFORMANCE REQUIREMENTS

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

B. Structural Performance: Hangers and supports for 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.
3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

1.5 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. Pipe stands.
4. Equipment supports.

C. 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. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Copper Pipe Hangers:

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

2.2 TRAPEZE PIPE HANGERS

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

2.3 THERMAL-HANGER SHIELD INSERTS

A. Manufacturers: Subject to compliance with requirements, provide products by 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.
10. Or approved equal.

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: 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.

2.4 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, 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.

2.5 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. High-Type, Single-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: 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.

C. 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.

D. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.6 PIPE POSITIONING SYSTEMS

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

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

D. 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.

E. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 07720 "Roof Accessories" for curbs.

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 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.

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

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

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

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

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

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

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

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

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

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.

20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

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

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

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

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

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

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.

10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

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

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

N. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.

7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

    a. Horizontal (MSS Type 54): Mounted horizontally.
    b. Vertical (MSS Type 55): Mounted vertically.
    c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

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

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

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

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

END OF SECTION 15061

SECTION 15072 - VIBRATION AND SEISMIC CONTROLS FOR FIRE-SUPPRESSION 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Isolation pads.
2. Isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Restraining braces.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading: Refer to Structural Drawings for site Class, Seismic use Group and Building Design Category.

1.5 SUBMITTALS

A. Product Data: For the following:

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 seismic-restraint component used.

a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
b. Annotate to indicate application of each product submitted and compliance with requirements.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details 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. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators, seismic restraints, and for designing vibration isolation bases.

2. Seismic-Restraint Details:

a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
c. Preapproval and Evaluation Documentation: an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

C. Welding certificates.

D. Qualification Data: For professional Engineer.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC and NFPA 13 unless requirements in this Section are more stringent.

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

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional Engineer.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

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

1. Ace Mountings Co., Inc.
2. Amber/Booth Company, Inc.
3. California Dynamics Corporation.
4. Isolation Technology, Inc.
5. Kinetics Noise Control.
6. Mason Industries.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.
9. Vibration Mountings & Controls, Inc.
10. Or approved equal.

B. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

1. Resilient Material: Oil- and water-resistant neoprene.

C. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

D. Restrained Mounts: All-directional mountings with seismic restraint.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

2.2 NEOPRENE

A. Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO

2.3 SEISMIC-RESTRAINT DEVICES

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

1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
3. Cooper B-Line, Inc.; a division of Cooper Industries.
4. Hilti, Inc.
5. Kinetics Noise Control.
6. Loos & Co.; Cableware Division.
7. Mason Industries.
8. TOLCO Incorporated; a brand of NIBCO INC.
9. Unistrut; Tyco International, Ltd.
10. Or approved equal.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

D. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or Reinforcing steel angle clamped to hanger rod.

E. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

F. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.

G. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

H. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

I. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.4 FACTORY FINISHES

A. Finish: Manufacturer's standard prime-coat finish ready for field painting.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Piping Restraints:

1. Comply with requirements in MSS SP-127 and NFPA 13.
2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
3. Brace a change of direction longer than 12 feet.

B. Install cables so they do not bend across edges of adjacent equipment or building structure.

C. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

D. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

E. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

F. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural Engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom

of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.

5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment.

END OF SECTION 15072

SECTION 15076 IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

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

1.3 SUBMITTALS

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

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

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

D. Valve numbering scheme.

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

1.4 COORDINATION

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

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

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

PART 2 - PRODUCTS

2.1 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: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

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

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), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16-inch-thick, and having predrilled holes for attachment hardware.

B. Letter Color: White.

C. Background Color: Red.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 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 partially cover 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.

2.4 VALVE TAGS

A. 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 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.

2.5 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. Piping Color-Coding: Painting of piping is specified in Division 9.

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

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

C. Pipe Label Color Schedule:

1. Domestic Water Piping:

   a. Background Color: Green.
   b. Letter Color: White.

2. Sanitary Waste Piping:

   a. Background Color: Green.
   b. Letter Color: White.

3. Storm Drainage Piping:

   a. Background Color: Green.
   b. Letter Color: White.

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 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.

2. Valve-Tag Color:

   a. Cold Water: Green.
   b. Hot Water: Green.

3. Letter Color:

   a. Cold Water: White.
   b. Hot Water: White.

3.5 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 15076

SECTION 15078 - IDENTIFICATION FOR FIRE-SUPPRESSION 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 1 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.

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

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

D. Valve Schedules: Valve numbering scheme.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

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

a. Brady Corporation.
b. Brimar Industries, Inc.
c. Carlton Industries, LP.
d. Champion America.
e. Craftmark.
f. emedco.
g. Kolbi Pipe Marker Co.
h. LEM Products Inc.
i. Marking Services Inc.
j. Seton Identification Products.
k. Or approved equal.

2. Material and Thickness: Brass, 0.032-inch-thick, with predrilled holes for attachment hardware.
3. Letter Color: White.
4. Background Color: Black.
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: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), 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 WARNING SIGNS AND LABELS

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

1. Brady Corporation.
2. Brimar Industries, Inc.

3. Carlton Industries, LP.
4. Champion America.
5. Craftmark.
6. emedco.
7. LEM Products Inc.
8. Marking Services Inc.
9. National Marker Company.
10. Seton Identification Products.
11. Stranco, Inc.
12. Or approved equal.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8-inch-thick, with predrilled holes for attachment hardware.

C. Letter Color: Red.

D. Background Color: Black.

E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

G. 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.

H. Fasteners: Stainless-steel rivets or self-tapping screws.

I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

J. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

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

1. ActionCraft Products, Inc.; a division of Industrial Test Equipment Co., Inc.
2. Brady Corporation.
3. Brimar Industries, Inc.
4. Carlton Industries, LP.

5. Champion America.
6. Craftmark.
7. emedco.
8. Kolbi Pipe Marker Co.
9. LEM Products Inc.
10. Marking Services Inc.
11. Seton Identification Products.
12. Or approved equal.

B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service and showing flow direction according to ASME A13.1.

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, 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 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.

F. Pipe-Label Colors:

1. Background Color: Safety Red.
2. Letter Color: White.

2.4 VALVE TAGS

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

1. ActionCraft Products, Inc.
2. Brady Corporation.
3. Brimar Industries, Inc.
4. Carlton Industries, LP.
5. Champion America.
6. Craftmark.
7. emedco.
8. Kolbi Pipe Marker Co.

9. LEM Products Inc.
10. Marking Services Inc.
11. Seton Identification Products.
12. Or approved equal.

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, Stainless steel, 0.025-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire-link or beaded chain; or S-hook.

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.

2.5 WARNING TAGS

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

1. Brady Corporation.
2. Brimar Industries, Inc.
3. Carlton Industries, LP.
4. Champion America.
5. Craftmark.
6. emedco.
7. Kolbi Pipe Marker Co.
8. LEM Products Inc.
9. Marking Services Inc.
10. Seton Identification Products.
11. Or approved equal.

B. Description: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: Approximately 4 by 7 inches.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Safety Yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 GENERAL INSTALLATION REQUIREMENTS

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

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

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

3.3 EQUIPMENT LABEL INSTALLATION

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

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

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

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

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

3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in fire-suppression piping systems. List tagged valves in a valve-tag schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and with captions similar to those indicated in "Valve-Tag Size and Shape" Subparagraph below:

1. Valve-Tag Size and Shape:

a. Wet-Pipe Sprinkler System: 2 inches, round.

3.6 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 15078

SECTION 15085 - PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes insulating the following plumbing piping services:

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

1.3 SUBMITTALS

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

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other Work.

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

C. 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.

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

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

1.5 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 15061 "Hangers and Supports for Plumbing Piping and Equipment."

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

C. Coordinate installation and testing of heat tracing.

1.7 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. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

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

    a. Aeroflex USA, Inc.; Aerocel.
    b. Armacell LLC; AP Armaflex.
    c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.
    d. Or approved equal.

G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Manufacturers: Subject to compliance with requirements, provide products by 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.
    f. Or approved equal.

H. Mineral-Fiber, Preformed Pipe Insulation:

1. Manufacturers: Subject to compliance with requirements, provide products by 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.
    f. Or approved equal.

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

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

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

    a. Ramco Insulation, Inc.; Super-Stik.
    b. Or approved equal.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

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

    a. Ramco Insulation, Inc.; Thermokote V.
    b. Or approved equal.

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

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

    a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.
    b. Or approved equal.

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 and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Manufacturers: Subject to compliance with requirements, provide products by 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.
    e. Or approved equal.

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).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

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

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

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
    b. Eagle Bridges - 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.

e. Or approved equal.

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. Manufacturers: Subject to compliance with requirements, provide products by 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; 85-20.
d. Mon-Eco Industries, Inc.; 22-25.
e. Or approved equal.

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. Manufacturers: Subject to compliance with requirements, provide products by 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.
e. Or approved equal.

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

    a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
    b. Vimasco Corporation; 749.
    c. Or approved equal.

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 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. Manufacturers: Subject to compliance with requirements, provide products by 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.
    d. Or approved equal.

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

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

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
    b. Or approved equal.

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:-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

2.8 FIELD-APPLIED JACKETS

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

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

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

    a. Johns Manville; Zeston.
    b. P.I.C. Plastics, Inc.; FG Series.
    c. Proto Corporation; LoSmoke.
    d. Speedline Corporation; SmokeSafe.
    e. Or approved equal.

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

a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

2.9 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 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.
e. Or approved equal.

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

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

a. ABI, Ideal Tape Division; 370 White PVC tape.
b. Compac Corporation; 130.
c. Venture Tape; 1506 CW NS.
d. Or approved equal.

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

    a. ITW Insulation Systems; Gerrard Strapping and Seals.
    b. RPR Products, Inc.; Insul-Mate Strapping and Seals.
    c. Or approved equal.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304; 0.015-inch-thick, 1/2-inch-wide with wing seal or closed 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 or closed seal.

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

C. Wire: 0.080-inch nickel-copper alloy.

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

    a. C & F Wire.
    b. Or approved equal.

2.11 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:

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

    a. Engineered Brass Company.
    b. Insul-Tect Products Co.; a subsidiary of MVG Molded Products.
    c. McGuire Manufacturing.
    d. Plumberex.
    e. Truebro; a brand of IPS Corporation.
    f. Zurn Industries, LLC; Tubular Brass Plumbing Products Operation.
    g. Or approved equal.

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

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

C. 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 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 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.

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

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

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

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

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

1. Comply with requirements in Section 07841 "Through Penetration Firestop Systems" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07841 " Through Penetration Firestop Systems."

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.

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

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

B. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.9 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.

3.10 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 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water:

1. NPS 1 and Smaller: Insulation shall be the following:

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

2. NPS 1-1/4 and Larger: 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 1-1/4 and Smaller: Insulation shall be the following:

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

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

a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 ½” inch thick.

C. Stormwater and Overflow:

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.

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.

3.12 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Domestic Water Piping:

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

a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.

B. Domestic Hot and Recirculated Hot Water:

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

a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches.

C. Stormwater and Overflow:

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.

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, Concealed:

1. None.

D. Piping, Exposed:

1. PVC, Color-Coded by System: 20 mils thick.

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. Piping, Concealed:

1. PVC, Color-Coded by System: 20 mils thick.

END OF SECTION 15085

SECTION 15091 - SLEEVES AND SLEEVE SEALS FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.

1.3 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

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

2.2 STACK-SLEEVE FITTINGS

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

1. Smith, Jay R. Mfg. Co.
2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.
3. Or approved equal.

B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

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

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).
4. Pipeline Seal and Insulator, Inc.
5. Proco Products, Inc.
6. Or approved equal.

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

1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel.
3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

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

1. Presealed Systems.
2. Or approved equal.

B. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

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

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

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

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

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

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

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. 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.
3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.

3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Division 7 Section "Joint Sealants."

E. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 7 Section "Through-Penetration Firestop Systems."

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Division 7 Section "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using grout, seal the space around outside of stack-sleeve fittings.

B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 7 Section "Through-Penetration Firestop Systems."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

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

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

3.4 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.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

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

1. Exterior Concrete Walls above Grade:

   a. Piping Smaller Than NPS 6: Galvanized-steel wall sleeves.
   b. Piping NPS 6 and Larger: Galvanized-steel wall sleeves.

2. Concrete Slabs above Grade:

   a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
   b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves.

3. Interior Partitions:

   a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
   b. Piping NPS 6 and Larger: Galvanized-steel-sheet sleeves.

END OF SECTION 15091

SECTION 15092 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.

1.3 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

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

2.2 STACK-SLEEVE FITTINGS

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

1. Smith, Jay R. Mfg. Co.
2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.
3. Or engineer approved equal

B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

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

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).
4. Pipeline Seal and Insulator, Inc.
5. Proco Products, Inc.
6. Or engineer approved equal

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

1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Stainless steel.
3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

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

1. Presealed Systems.
2. Or engineer approved equal

B. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

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

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

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

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

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

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

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. 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.

3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.

2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 7 "Joint Sealants."

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 7 "Through-Penetration Firestop Systems."

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 7 "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using grout, seal the space around outside of stack-sleeve fittings.

B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 7 "Through-Penetration Firestop Systems."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

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

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

3.4 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.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

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

1. Exterior Concrete Walls above Grade:

    a. Piping Smaller Than NPS 6: Cast-iron wall sleeves or Galvanized-steel wall sleeves.
    b. Piping NPS 6 and Larger: Cast-iron wall sleeves, Galvanized-steel wall sleeves or Galvanized-steel-pipe sleeves.

2. Exterior Concrete Walls below Grade:

    a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system, Galvanized-steel wall sleeves with sleeve-seal system, Galvanized-steel-pipe sleeves with sleeve-seal system.

        1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

    b. Piping NPS 6 and Larger: Cast-iron wall sleeves with sleeve-seal system, Galvanized-steel wall sleeves with sleeve-seal system or Galvanized-steel-pipe sleeves with sleeve-seal system.

        1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:

    a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system, Galvanized-steel wall sleeves with sleeve-seal system or Galvanized-steel-pipe sleeves with sleeve-seal system.

        1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 and Larger: Cast-iron wall sleeves with sleeve-seal system, Galvanized-steel wall sleeves with sleeve-seal system or Galvanized-steel-pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs above Grade:

a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves Stack-sleeve fittings or Sleeve-seal fittings.
b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves or Stack-sleeve fittings.

5. Interior Partitions:

a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
b. Piping NPS 6 and Larger: Galvanized-steel-sheet sleeves.

END OF SECTION 15092

SECTION 15096 - ESCUTCHEONS FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Escutcheons.
   2. Floor plates.

1.3 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

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

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

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

D. Split-Casting Brass Type: With polished, chrome-plated and rough-brass finish and with concealed hinge and setscrew.

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

2.2 FLOOR PLATES

A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

B. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

1. Escutcheons for New Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
b. Chrome-Plated Piping: One-piece, cast-brass type with polished, chrome-plated finish.
c. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated or rough-brass finish.
g. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
h. Bare Piping in Equipment Rooms: One-piece, cast-brass or split-casting brass type with polished, chrome-plated or rough-brass finish.
i. Bare Piping in Equipment Rooms: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.

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

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

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

3.2 FIELD QUALITY CONTROL

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

END OF SECTION 15096

SECTION 15097 - ESCUTCHEONS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.3 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

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

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

C. Split-Casting Brass Type: With polished, chrome-plated finish and with concealed hinge and setscrew.

2.2 FLOOR PLATES

A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

B. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

1. Escutcheons for New Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
b. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
c. Insulated Piping: One-piece, cast brass type or split-plate, stamped-steel type with concealed hinge.
d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
g. Bare Piping in Equipment Rooms: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.

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

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

1. New Piping: One-piece, floor-plate type.
2. Existing Piping: Split-casting, floor-plate type.

3.2 FIELD QUALITY CONTROL

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

END OF SECTION 15097

SECTION 15111 - GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Brass ball valves.
2. Bronze ball valves.
3. Iron ball valves.
4. Bronze swing check valves.
5. Iron swing check valves.
6. Bronze gate valves.
7. Iron gate valves.
8. Lubricated plug valves.

B. Related Sections:

1. Section 15076 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.
2. Section 15140 "Domestic Water Piping" for valves applicable only to this piping.
3. Section 15155 "Sanitary Waste Piping Specialties" for valves applicable only to this piping.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

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

D. OS&Y: Outside screw and yoke.

1.4 SUBMITTALS

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

1.5 QUALITY ASSURANCE

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

B. ASME Compliance:

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

C. NSF Compliance: NSF 61 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 angle, gate, and globe valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.
5. Block check valves in either closed or open position.

B. Use the following precautions during storage:

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

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

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

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

D. Valve Actuator Types:

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

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

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

F. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. Grooved: With grooves according to AWWA C606.
3. Solder Joint: With sockets according to ASME B16.18.
4. Threaded: With threads according to ASME B1.20.1.

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

2.2 BRASS BALL VALVES

A. Two-Piece, Full-Port, Brass Ball Valves with Brass Trim:

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. Hammond Valve.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Red-White Valve Corporation.
g. Or approved equal.

2. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 600 psig.

c. Body Design: Two piece.
d. Body Material: Forged brass.
e. Ends: Threaded.
f. Seats: PTFE or TFE.
g. Stem: Brass.
h. Ball: Chrome-plated brass.
i. Port: Full.

2.3 BRONZE BALL VALVES

A. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:

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

a. Conbraco Industries, Inc.; Apollo Valves.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Hammond Valve.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Red-White Valve Corporation.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
h. Or approved equal.

2. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 600 psig.
c. Body Design: Two piece.
d. Body Material: Bronze.
e. Ends: Threaded.
f. Seats: PTFE or TFE.
g. Stem: Bronze.
h. Ball: Chrome-plated brass.
i. Port: Full.

2.4 IRON BALL VALVES

A. Class 125, Iron Ball Valves:

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

a. American Valve, Inc.

b. Conbraco Industries, Inc.; Apollo Valves.
c. Kitz Corporation.
d. Sure Flow Equipment Inc.
e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
f. Or approved equal.

2. 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.

2.5 BRONZE SWING CHECK VALVES

A. Class 125, Bronze Swing Check Valves with Bronze 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. Hammond Valve.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Red-White Valve Corporation.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
h. Or approved equal.

2. Description:

a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 200 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded.
f. Disc: Bronze.

2.6 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. Hammond Valve.
    d. Milwaukee Valve Company.
    e. NIBCO INC.
    f. Red-White Valve Corporation.
    g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
    h. Or approved equal.

2. Description:

    a. Standard: MSS SP-71, Type I.
    b. CWP Rating: 200 psig.
    c. Body Design: Clear or full waterway.
    d. Body Material: ASTM A 126, gray iron with bolted bonnet.
    e. Ends: Flanged.
    f. Trim: Bronze.
    g. Gasket: Asbestos free.

2.7 BRONZE GATE VALVES

A. Class 125, NRS Bronze Gate Valves:

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. Hammond Valve.
    d. Milwaukee Valve Company.
    e. NIBCO INC.
    f. Powell Valves.
    g. Red-White Valve Corporation.
    h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
    i. Or approved equal.

2. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 200 psig.
c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
d. Ends: Threaded or solder joint.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron.

2.8 IRON GATE VALVES

A. Class 125, NRS, Iron Gate Valves:

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. Hammond Valve.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Powell Valves.
g. Red-White Valve Corporation.
h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
i. Or approved equal.

2. Description:

a. Standard: MSS SP-70, Type I.
b. CWP Rating: 200 psig.
c. Body Material: ASTM A 126, gray iron with bolted bonnet.
d. Ends: Flanged.
e. Trim: Bronze.
f. Disc: Solid wedge.
g. Packing and Gasket: Asbestos free.

2.9 LUBRICATED PLUG VALVES

A. Class 125, Regular-Gland, Lubricated Plug Valves with Threaded Ends:

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. Nordstrom Valves, Inc.

b. Or approved equal.

2. Description:

a. Standard: MSS SP-78, Type II.
b. CWP Rating: 200 psig.
c. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
d. Pattern: Regular or short.
e. Plug: Cast iron or bronze with sealant groove.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

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

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

3.2 VALVE INSTALLATION

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

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

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

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

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

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

3.3 ADJUSTING

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

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

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

1. Shutoff Service: Ball, or gate valves.
2. Pump-Discharge Check Valves:

    a. NPS 2 and Smaller: Bronze swing check valves with bronze or nonmetallic disc.

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

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

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

3.5 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
2. Ball Valves: Two piece, full port, brass or bronze with brass bronze trim.
3. Bronze Swing Check Valves: Class 125, disc.
4. Bronze Gate Valves: Class 125.

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

1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Iron Ball Valves: Class 150.
3. Iron Swing Check Valves: Class 125, metal seats.
4. Iron Gate Valves: Class 125, NRS.

END OF SECTION 15111

SECTION 15113 - GENERAL-DUTY VALVES FOR WATER-BASED FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Two-piece ball valves with indicators.
2. Bronze butterfly valves with indicators.
3. Iron butterfly valves with indicators.
4. Check valves.
5. Bronze OS&Y gate valves.
6. Iron OS&Y gate valves.
7. NRS gate valves.
8. Trim and drain valves.

1.3 DEFINITIONS

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

B. NRS: Nonrising stem.

C. OS&Y: Outside screw and yoke.

D. SBR: Styrene-butadiene rubber.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

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, and weld ends.
3. Set valves open to minimize exposure of functional surfaces.

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 operating handles or stems as lifting or rigging points.

D. Protect flanges and specialties from moisture and dirt.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

1. Main Level: HAMV - Fire Main Equipment.

a. Level 1: HCBZ - Indicator Posts, Gate Valve.
b. Level 1: HLOT - Valves.

1) Level 3: HLUG - Ball Valves, System Control.
2) Level 3: HLXS - Butterfly Valves.
3) Level 3: HMER - Check Valves.
4) Level 3: HMRZ - Gate Valves.

2. Main Level: VDGT - Sprinkler System & Water Spray System Devices.

a. Level 1: VQGU - Valves, Trim and Drain.

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

1. Automated Sprinkler Systems:

a. Indicator posts.
b. Valves.

1) Gate valves.

2) Check valves.

a) Single check valves.

3) Miscellaneous valves.

C. Source Limitations for Valves: Obtain valves for each valve type from single manufacturer.

D. ASME Compliance:

1. ASME B16.1 for flanges on iron valves.
2. ASME B1.20.1 for threads for threaded-end valves.
3. ASME B31.9 for building services piping valves.

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

F. NFPA Compliance: Comply with NFPA 24 for valves.

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

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

I. Valve Actuator Types:

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

2.2 TWO-PIECE BALL VALVES WITH INDICATORS

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

1. NIBCO INC.
2. Victaulic Company.
3. Or approved equal.

B. Description:

1. UL 1091, except with ball instead of disc and FM Global standard for indicating valves (butterfly or ball type), Class Number 1112.
2. Minimum Pressure Rating: 250 psig.
3. Body Design: Two piece.

4. Body Material: Forged brass or bronze.
5. Port Size: Full or standard.
6. Seats: PTFE.
7. Stem: Bronze or stainless steel.
8. Ball: Chrome-plated brass.
9. Actuator: Worm gear or traveling nut.
10. Supervisory Switch: Internal or external.
11. End Connections for Valves NPS 1 through NPS 2: Threaded ends.
12. End Connections for Valves NPS 2-1/2: Grooved ends.

2.3 BRONZE BUTTERFLY VALVES WITH INDICATORS

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. Fivalco Inc.
2. Globe Fire Sprinkler Corporation.
3. Milwaukee Valve Company.
4. Or approved equal.

B. Description:

1. Standard: UL 1091 and FM Global standard for indicating valves, (butterfly or ball type), Class Number 1112.
2. Minimum: Pressure rating: 250 psig.
3. Body Material: Bronze.
4. Seat Material: EPDM.
5. Stem Material: Bronze or stainless steel.
6. Disc: Bronze with EPDM coating.
7. Actuator: Worm gear or traveling nut.
8. Supervisory Switch: Internal or external.
9. Ends Connections for Valves NPS 1 through NPS 2: Threaded ends.
10. Ends Connections for Valves NPS 2-1/2: Grooved ends.

2.4 IRON BUTTERFLY VALVES WITH INDICATORS

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

1. Anvil International, Inc.
2. Fivalco Inc.
3. Globe Fire Sprinkler Corporation.
4. Kennedy Valve; a division of McWane, Inc.

5. NIBCO INC.
6. Tyco Fire & Building Products LP.
7. Victaulic Company.
8. Or approved equal.

B. Description:

1. Standard: UL 1091 and FM Global standard for indicating valves, (butterfly or ball type), Class Number 112.
2. Minimum Pressure Rating: 250 psig.
3. Body Material: Cast or ductile iron with nylon, EPDM, epoxy, or polyamide coating.
4. Seat Material: EPDM.
5. Stem: Stainless steel.
6. Disc: Ductile iron, and EPDM or SBR coated.
7. Actuator: Worm gear or traveling nut.
8. Supervisory Switch: Internal or external.
9. Body Design: Lug or wafer or Grooved-end connections.

2.5 CHECK VALVES

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

1. Anvil International, Inc.
2. Fivalco Inc.
3. Globe Fire Sprinkler Corporation.
4. Kennedy Valve; a division of McWane, Inc.
5. Mueller Co.; Water Products Division.
6. NIBCO INC.
7. Reliable Automatic Sprinkler Co., Inc.
8. Shurjoint Piping Products.
9. Tyco Fire & Building Products LP.
10. Venus Fire Protection Ltd.
11. Victaulic Company.
12. Viking Corporation.
13. Watts Water Technologies, Inc.
14. Or approved equal.

B. Description:

1. Standard: UL 312 and FM Global standard for swing check valves, Class Number 1210.
2. Minimum Pressure Rating: 250 psig.

3. Type: Single swing check.
4. Body Material: Cast iron, ductile iron, or bronze.
5. Clapper: Bronze, ductile iron, or stainless steel with elastomeric seal.
6. Clapper Seat: Brass, bronze, or stainless steel.
7. Hinge Shaft: Bronze or stainless steel.
8. Hinge Spring: Stainless steel.
9. End Connections: Flanged, grooved, or threaded.

2.6 BRONZE OS&Y GATE VALVES

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. Milwaukee Valve Company.
2. NIBCO INC.
3. United Brass Works, Inc.
4. Or approved equal.

B. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 250 psig.
3. Body and Bonnet Material: Bronze or brass.
4. Wedge: One-piece bronze or brass.
5. Wedge Seat: Bronze.
6. Stem: Bronze or brass.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.
9. End Connections: Threaded.

2.7 IRON OS&Y GATE VALVES

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 Cast Iron Pipe Company; Waterous Company subsidiary.
2. Clow Valve Company; a division of McWane, Inc.
3. Hammond Valve.
4. Kennedy Valve; a division of McWane, Inc.
5. Mueller Co.; Water Products Division.
6. NIBCO INC.

7. Victaulic Company.
8. Watts Water Technologies, Inc.
9. Or approved equal.

B. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 250 psig.
3. Body and Bonnet Material: Cast or ductile iron.
4. Wedge: Cast or ductile iron, or bronze with elastomeric coating.
5. Wedge Seat: Cast or ductile iron, or bronze with elastomeric coating.
6. Stem: Brass or bronze.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.
9. End Connections: Flanged Grooved or Threaded.

2.8 NRS GATE VALVES

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 Cast Iron Pipe Company; Waterous Company subsidiary.
2. Clow Valve Company; a division of McWane, Inc.
3. Kennedy Valve; a division of McWane, Inc.
4. Mueller Co.; Water Products Division.
5. NIBCO INC.
6. Victaulic Company.
7. Or approved equal.

B. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 250 psig.
3. Body and Bonnet Material: Cast or ductile iron.
4. Wedge: Cast or ductile iron with elastomeric coating.
5. Wedge Seat: Cast or ductile iron, or bronze with elastomeric coating.
6. Stem: Brass or bronze.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.
9. End Connections: Flanged Grooved or Threaded.

2.9 TRIM AND DRAIN VALVES

A. Ball Valves:

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

    a. Conbraco Industries, Inc.; Apollo Valves.
    b. Fire-End & Croker Corporation.
    c. Fire Protection Products, Inc.
    d. Flowserve.
    e. Jomar International, LTD.
    f. Kitz Corporation.
    g. Legend Valve.
    h. Milwaukee Valve Company.
    i. NIBCO INC.
    j. Potter Roemer.
    k. Red-White Valve Corporation.
    l. Tyco Fire & Building Products LP.
    m. Victaulic Company.
    n. Watts Water Technologies, Inc.
    o. Or approved equal.

2. Description:

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

B. Angle Valves:

1. Manufacturers: 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. Fire Protection Products, Inc.
    b. NIBCO INC.
    c. United Brass Works, Inc.

d. Or approved equal.

2. Description:

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

C. Globe Valves:

1. Manufacturers: 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. NIBCO INC.
b. United Brass Works, Inc.
c. Or approved equal.

2. Description:

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

PART 3 - EXECUTION

3.1 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 GENERAL REQUIREMENTS FOR VALVE INSTALLATION

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

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

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

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

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

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

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

G. Install valve tags. Comply with requirements in Section 15 "Identification for Fire-Suppression Piping and Equipment" for valve tags and schedules and signs on surfaces concealing valves; and the NFPA standard applying to the piping system in which valves are installed. Install permanent identification signs indicating the portion of system controlled by each valve.

H. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections.

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

END OF SECTION 15113

SECTION 15123 - EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Expansion-compensator packless expansion joints.
2. Flexible-hose packless expansion joints.
3. Pipe loops and swing connections.
4. Alignment guides and anchors.

1.3 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.

B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

1.4 SUBMITTALS

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

B. Delegated-Design Submittal: For each anchor and alignment guide 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. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
3. Alignment Guide Details: Detail field assembly and attachment to building structure.

4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

C. Welding certificates.

D. Product Certificates: For each type of expansion joint, from manufacturer.

E. Maintenance Data: For expansion joints to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 PACKLESS EXPANSION JOINTS

A. Metal, Expansion-Compensator Packless Expansion Joints:

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

a. Metraflex.
b. Or approved equal.

2. Minimum Pressure Rating: 150 psig unless otherwise indicated.
3. Configuration for Copper Tubing: Two-ply, phosphor-bronze bellows with copper pipe ends.

a. End Connections for Copper Tubing NPS 2 and Smaller: Solder joint or threaded.
b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4: Threaded.

4. Configuration for Steel Piping: Two-ply, stainless-steel bellows; steel-pipe end connections; and carbon-steel shroud.

a. End Connections for Steel Pipe NPS 2 and Smaller: Threaded.
b. End Connections for Steel Pipe NPS 2-1/2 to NPS 4: Flanged or Weld

B. Flexible-Hose Packless Expansion Joints:

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

    a. Metraflex Company (The).
    b. Or approved equal.

2. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
3. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
4. Expansion Joints for Copper Tubing NPS 2 and Smaller: Copper-alloy fittings with solder-joint end connections.

    a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.

5. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4: Copper-alloy fittings with threaded end connections.

    a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F and 225 psig at 450 deg F ratings.

2.2 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:

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

    a. Metraflex Company (The).
    b. Or approved equal.

2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding spider for bolting to pipe.

B. Anchor Materials:

1. Steel Shapes and Plates: ASTM A 36/A 36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
3. Washers: ASTM F 844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.

a. Stud: Threaded, zinc-coated carbon steel.
b. Expansion Plug: Zinc-coated steel.
c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 EXPANSION-JOINT INSTALLATION

A. Install expansion joints of sizes matching sizes of piping in which they are installed.

B. Install packed-type expansion joints with packing suitable for fluid service.

3.2 PIPE LOOP AND SWING CONNECTION INSTALLATION

A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

B. Connect risers and branch connections to mains with at least four pipe fittings including tee in main.

C. Connect risers and branch connections to terminal units with at least four pipe fittings including tee in riser.

D. Connect mains and branch connections to terminal units with at least four pipe fittings including tee in main.

3.3 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install one guide on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.

C. Attach guides to pipe and secure guides to building structure.

D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

E. Anchor Attachments:

1. Anchor Attachment to Black-Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Anchor Attachment to Galvanized-Steel Pipe: Attach with pipe hangers. Use MSS SP-69, Type 42, riser clamp welded to anchor.
3. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24, U-bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.

1. Anchor Attachment to Steel Structural Members: Attach by welding.
2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 15123

SECTION 15140 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 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. Exterior underground domestic water pipe and fittings from gymnasium addition to existing underground piping.
3. Encasement for piping.

B. Related Requirements:

1. Section 15 “Facility Water Distribution Piping” for water piping outside the building.

1.3 SUBMITTALS

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

B. System purging and disinfecting activities report.

C. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

B. Potable-water piping and components shall comply with NSF 61.

2.2 COPPER TUBE AND FITTINGS

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

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

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

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

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

F. Copper Unions:

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

G. Copper Pressure-Seal-Joint Fittings:

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

    a. Elkhart Products Corporation.
    b. NIBCO Inc.
    c. Viega.
    d. Or approved equal.

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

2.3 PIPING JOINING MATERIALS

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

B. Flux: ASTM B 813, water flushable.

2.4 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.

C. Sleeve-Type Transition Coupling: AWWA C219.

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

a. Cascade Waterworks Manufacturing.
b. Dresser, Inc.; Piping Specialties Products.
c. Ford Meter Box Company, Inc. (The).
d. JCM Industries.
e. Romac Industries, Inc.
f. Smith-Blair, Inc.; a Sensus company.
g. Viking Johnson.
h. Or approved equal.

2.5 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

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

a. Capitol Manufacturing Company; member of the Phoenix Forge Group.
b. Central Plastics Company.
c. Hart Industries International, Inc.
d. Jomar International.
e. Matco-Norca.
f. McDonald, A. Y. Mfg. Co.
g. Watts; a division of Watts Water Technologies, Inc.
h. Wilkins; a Zurn company.
i. Or approved equal.

2. Standard: ASSE 1079.
3. Pressure Rating: 125 psig minimum at 180 deg F.
4. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Nipples:

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

    a. Elster Perfection Corporation.
    b. Grinnell Mechanical Products; Tyco Fire Products LP.
    c. Matco-Norca.
    d. Precision Plumbing Products, Inc.
    e. Victaulic Company.
    f. Or approved equal.

2. Standard: IAPMO PS 66.
3. Electroplated steel nipple complying with ASTM F 1545.
4. Pressure Rating and Temperature: 300 psig at 225 deg F.
5. End Connections: Male threaded or grooved.
6. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Section 2 "Earthwork" 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 shutoff valve immediately upstream of each dielectric fitting.

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

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

F. 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.

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

H. Install piping to permit valve servicing.

I. 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.

J. Install piping free of sags and bends.

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

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

M. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 15092 "Sleeves and Sleeve Seals for Plumbing Piping."

N. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 15092 "Sleeves and Sleeve Seals for Plumbing Piping."

O. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 15097 "Escutcheons for Plumbing Piping."

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. 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."

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

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

3.4 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:

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

3.5 DIELECTRIC FITTING INSTALLATION

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

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.

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

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hanger, support products, and installation in Section 15061 "Hangers and Supports for Plumbing Piping and Equipment."

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

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

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

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

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

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

1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
4. NPS 2-1/2: 108 inches with 1/2-inch rod.
5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
6. NPS 6: 10 feet with 5/8-inch rod.
7. NPS 8: 10 feet with 3/4-inch rod.

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

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

3.8 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 15076 "Identification for Plumbing Piping and Equipment."

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Piping Inspections:

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

b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:

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

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

2. Piping Tests:

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

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

C. Prepare test and inspection reports.

3.10 ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, hydrants, and hose bibbs.

2. Open shutoff valves to fully open position.
3. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.

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

3.11 CLEANING

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

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

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

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

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

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

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

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. Under-building-slab, domestic water, building-service piping, NPS 2and smaller, shall be the following:

1. Soft copper tube, ASTM B 88, Type L; wrought-copper, solder-joint fittings; and brazed joints.

D. Aboveground domestic water piping, NPS 2 and smaller, shall be one of the following:

1. Hard copper tube, ASTM B 88, Type L; cast- or wrought-copper, solder-joint fittings; and soldered joints.
2. Hard copper tube, ASTM B 88, Type L; copper pressure-seal-joint fittings; and pressure-sealed joints.

E. Aboveground domestic water piping, NPS 2-1/2 to NPS 4, shall be one of the following:

1. Hard copper tube, ASTM B 88, Type L; cast- or wrought-copper, solder-joint fittings; and soldered joints.
2. Hard copper tube, ASTM B 88, Type L; copper pressure-seal-joint fittings; and pressure-sealed joints.

F. Exterior underground domestic water piping NPS 2 ½" and smaller shall be the following:

1. Soft copper tube: ASTM, Type K, wrought-copper, brazed Joint fittings.

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

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

END OF SECTION 15140

SECTION 15145 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Vacuum breakers.
2. Backflow preventers.
3. Hose bibbs.
4. Wall hydrants.
5. Drain valves.
6. Water-hammer arresters.
7. Trap-seal primer valves.
8. Flexible connectors.

1.3 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.

C. Field quality-control reports.

D. 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.

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. Ames Fire & Waterworks; a division of Watts Water Technologies, Inc.
    b. Cash Acme; a division of Reliance Worldwide Corporation.
    c. Conbraco Industries, Inc.
    d. FEBCO; a division of Watts Water Technologies, Inc.
    e. Rain Bird Corporation.
    f. Toro Company (The); Irrigation Div.
    g. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
    h. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
    i. Or approved equal.

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. Arrowhead Brass Products.
    b. Cash Acme; a division of Reliance Worldwide Corporation.
    c. Conbraco Industries, Inc.
    d. Legend Valve.
    e. MIFAB, Inc.
    f. Prier Products, Inc.
    g. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
    h. Woodford Manufacturing Company; a division of WCM Industries, Inc.
    i. Zurn Industries, LLC; Plumbing Products Group; Light Commercial Products.

j. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
k. Or approved equal.

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

2.4 BACKFLOW PREVENTERS

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

a. Ames Fire & Waterworks; a division of Watts Water Technologies, Inc.
b. Conbraco Industries, Inc.
c. FEBCO; a division of Watts Water Technologies, Inc.
d. Flomatic Corporation.
e. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
f. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
g. Or approved equal.

2. Standard: ASSE 1013.
3. Operation: Continuous-pressure applications.
4. Accessories:

a. Ball type with threaded ends on inlet and outlet.
b. 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 HOSE BIBBS

A. Hose Bibbs:

1. Standard: ASME A112.18.1 for sediment faucets.
2. Body Material: Bronze.
3. Seat: Bronze, replaceable.
4. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
6. Pressure Rating: 125 psig.

7. Vacuum Breaker: Integral nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
9. Finish for Service Areas: Chrome or nickel plated.
10. Finish for Finished Rooms: Chrome or nickel plated.
11. Operation for Equipment Rooms: Wheel handle or operating key.
12. Operation for Service Areas: Operating key.
13. Operation for Finished Rooms: Operating key.
14. Include operating key with each operating-key hose bibb.
15. Include wall flange with each chrome- or nickel-plated hose bibb.

2.6 WALL HYDRANTS

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

    a. Josam Company.
    b. MIFAB, Inc.
    c. Prier Products, Inc.
    d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
    e. Tyler Pipe; Wade Div.
    f. Watts Drainage Products.
    g. Woodford Manufacturing Company; a division of WCM Industries, Inc.
    h. Zurn Industries, LLC; Plumbing Products Group; Light Commercial Products.
    i. Zurn Industries, LLC; Plumbing Products Group; Specification Drainage Products.
    j. Or approved equal.

2. Standard: ASME A112.21.3M for concealed or exposed-outlet, self-draining wall hydrants.
3. Pressure Rating: 125 psig.
4. Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
6. Inlet: NPS 3/4 or NPS 1.
7. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Box: Deep, flush mounted with cover.
9. Box and Cover Finish: Polished nickel bronze or Chrome plated.
10. Outlet: Exposed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
11. Nozzle and Wall-Plate Finish: Polished nickel bronze.
12. Operating Keys(s): Two with each wall hydrant.

2.7 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.

2.8 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters:

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

    a. AMTROL, Inc.
    b. Josam Company.
    c. MIFAB, Inc.
    d. Precision Plumbing Products, Inc.
    e. Sioux Chief Manufacturing Company, Inc.
    f. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
    g. Tyler Pipe; Wade Div.
    h. Watts Drainage Products.
    i. Zurn Industries, LLC; Plumbing Products Group; Specification Drainage Products.
    j. Or approved equal.

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.

2.9 TRAP-SEAL PRIMER DEVICE

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

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

a. MIFAB, Inc.
b. Precision Plumbing Products, Inc.
c. Sioux Chief Manufacturing Company, Inc.
d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
e. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
f. Or approved equal.

2. Standard: ASSE 1018.
3. Pressure Rating: 125 psig minimum.
4. Body: Bronze.
5. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.
6. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.
7. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

2.10 FLEXIBLE CONNECTORS

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

1. Flex-Hose Co., Inc.
2. Flexicraft Industries.
3. Flex Pression, Ltd.
4. Flex-Weld Incorporated.
5. Hyspan Precision Products, Inc.
6. Mercer Gasket & Shim, Inc.
7. Metraflex, Inc.
8. Proco Products, Inc.
9. TOZEN Corporation.
10. Unaflex.Universal Metal Hose; a Hyspan company.
11. Or approved equal.

B. Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.

1. Working-Pressure Rating: Minimum 200 psig.
2. End Connections NPS 2 and Smaller: Threaded copper pipe or plain-end copper tube.
3. End Connections NPS 2-1/2 and Larger: Flanged copper alloy.

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

C. 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.

3.2 CONNECTIONS

A. Comply with requirements for ground equipment in Section 16 "Grounding and Bonding for Electrical Systems."

B. Fire-retardant-treated-wood blocking is specified in Section 16 "Low-Voltage Electrical Power Conductors and Cables" for electrical connections.

END OF SECTION 15145

SECTION 15150 - SANITARY WASTE 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Pipe, tube, and fittings.
2. Specialty pipe fittings.

1.3 PERFORMANCE REQUIREMENTS

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

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

1.4 SUBMITTALS

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

B. Field quality-control reports.

1.5 QUALITY ASSURANCE

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

1.6 PROJECT CONDITIONS

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

1. Notify Construction Manager no fewer than two days in advance of proposed interruption of sanitary waste service.
2. Do not proceed with interruption of sanitary waste service without Construction Manager'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(es).

B. Gaskets: ASTM C 564, rubber.

C. Caulking Materials: ASTM B29, 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. Heavy-Duty, Hubless-Piping Couplings:

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

    a. ANACO-Husky.
    b. Clamp-All Corp.
    c. Dallas Specialty & Mfg. Co.
    d. MIFAB, Inc.
    e. Mission Rubber Company; a division of MCP Industries, Inc.
    f. Stant.
    g. Tyler Pipe.
    h. Or approved equal.

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 COPPER TUBE AND FITTINGS

A. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.

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

C. Hard Copper Tube: ASTM B 88, Type L and Type M, water tube, drawn temper.

D. Copper Pressure Fittings:

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

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

2.5 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 the following:

1) Dallas Specialty & Mfg. Co.
2) Fernco Inc.
3) Mission Rubber Company; a division of MCP Industries, Inc.
4) Plastic Oddities; a division of Diverse Corporate Technologies, Inc.
5) Or approved equal.

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 Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

4. Shielded, Nonpressure Transition Couplings:

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

1) Cascade Waterworks Mfg. Co.
2) Mission Rubber Company; a division of MCP Industries, Inc.
3) Or approved equal.

b. Standard: ASTM C 1460.

c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

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) Capitol Manufacturing Company.
2) Central Plastics Company.
3) Hart Industries International, Inc.
4) Jomar International Ltd.
5) Matco-Norca, Inc.
6) McDonald, A. Y. Mfg. Co.
7) Watts Regulator Co.; a division of Watts Water Technologies, Inc.
8) Wilkins; a Zurn company.
9) Or approved equal.

b. Description:

1) Standard: ASSE 1079.
2) Pressure Rating: 125 psig minimum at 180 deg F.
3) End Connections: Solder-joint copper alloy and threaded ferrous.

3. Dielectric Flanges:

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

1) Capitol Manufacturing Company.
2) Central Plastics Company.
3) Matco-Norca, Inc.
4) Watts Regulator Co.; a division of Watts Water Technologies, Inc.
5) Wilkins; a Zurn company.
6) Or approved equal.

b. Description:

1) Standard: ASSE 1079.
2) Factory-fabricated, bolted, companion-flange assembly.
3) Pressure Rating: 125 psig minimum at 180 deg F
4) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

4. Dielectric-Flange Insulating Kits:

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

1) Advance Products & Systems, Inc.
2) Calpico, Inc.
3) Central Plastics Company.
4) Pipeline Seal and Insulator, Inc.
5) Or approved equal.

b. Description:

1) Nonconducting materials for field assembly of companion flanges.
2) Pressure Rating: 150 psig.
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 the following:

1) Elster Perfection.
2) Grinnell Mechanical Products.
3) Matco-Norca, Inc.

4) Precision Plumbing Products, Inc.
5) Victaulic Company.
6) Or approved equal.

b. Description:

1) Standard: IAPMO PS 66
2) Electroplated steel nipple.
3) Pressure Rating: 300 psig at 225 deg F.
4) End Connections: Male threaded or grooved.
5) Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Section 2 "Earthwork."

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

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

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

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

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

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

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

O. Plumbing Specialties:

1. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping. Comply with requirements for cleanouts specified in Section 15155 "Sanitary Waste Piping Specialties."
2. Install drains in sanitary drainage gravity-flow piping. Comply with requirements for drains specified in Section 15155 "Sanitary Waste Piping Specialties."

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

Q. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 15092 "Sleeves and Sleeve Seals for Plumbing Piping."

R. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 15092 "Sleeves and Sleeve Seals for Plumbing Piping."

S. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 15097 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

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

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

C. 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.

D. 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.

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: Shielded, nonpressure transition couplings.

B. Dielectric Fittings:

1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.
3. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.
4. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hanger and support devices and installation specified in Section 15061 "Hangers and Supports for Plumbing Piping and Equipment."

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

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

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

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

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

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

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

1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
2. NPS 3: 60 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.

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

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

1. NPS 1-1/4: 72 inches with 3/8-inch rod.
2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
3. NPS 2-1/2: 108 inches with 1/2-inch rod.

4. NPS 3 and NPS 5: 10 feet with 1/2-inch rod.

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

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

J. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2: 48 inches with 3/8-inchrod.
2. NPS 3: 48 inches with 1/2-inchrod.
3. NPS 4 and NPS 5: 48 inches with 5/8-inchrod.

K. Install supports for vertical PVC piping every 48 inches

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

3.6 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. Comply with requirements for cleanouts and drains specified in Section 15155 "Sanitary Waste Piping Specialties."

3.7 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping. Comply with requirements for identification specified in Section 15076 "Identification for Plumbing Piping and Equipment."

3.8 FIELD QUALITY CONTROL

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

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

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

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

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

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

3.9 CLEANING AND PROTECTION

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

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

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

3.10 PIPING SCHEDULE

A. Aboveground, soil and waste piping NPS 4 and smaller shall be any of the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
3. Copper DWV tube, copper drainage fittings, and soldered joints.
4. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

B. Aboveground, soil and waste piping NPS 5 and larger shall be any of the following:

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

C. Aboveground, vent piping NPS 4 and smaller shall be any of the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
3. Copper DWV tube, copper drainage fittings, and soldered joints.
    a. Option for Vent Piping, NPS 2-1/2 and NPS 3-1/2: Hard copper tube, Type M; copper pressure fittings; and soldered joints.
4. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

D. Underground, soil, waste, and vent piping NPS 4 and smaller shall be the following:

1. Service class, cast-iron soil piping; gaskets; and gasketed joints.
2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

E. Underground, soil and waste piping NPS 5 and larger shall be the following:

1. Service class, cast-iron soil piping; gaskets; and gasketed joints.
2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

END OF SECTION 15150

SECTION 15155 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Cleanouts.
2. Floor drains.
3. Roof flashing assemblies.
4. Through-penetration firestop assemblies.
5. Miscellaneous sanitary drainage piping specialties.
6. Flashing materials.

B. Related Requirements:

1. Section 15165 “Storm Drainage Piping Specialties” for storm drainage piping inside the building, drainage piping specialties and drains.

1.3 SUBMITTALS

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

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

1.4 QUALITY ASSURANCE

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

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.

1.5 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3

B. Coordinate size and location of roof penetrations.

PART 2 - PRODUCTS

2.1 CLEANOUTS

A. Exposed Metal Cleanouts (CO):

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

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

1) Josam Company.
2) MIFAB, Inc.
3) Smith, Jay R. Mfg. Co.
4) Tyler Pipe.
5) Watts Drainage Products.
6) Zurn Plumbing Products Group.
7) Or approved equal.

2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
3. Size: Same as connected drainage piping
4. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk or raised-head, brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Closure: Stainless-steel plug with seal.

B. Metal Floor Cleanouts (CODP):

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

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

1) Josam Company.
2) Oatey.
3) Sioux Chief Manufacturing Co., Inc.

4) Smith, Jay R. Mfg. Co.
5) Tyler Pipe.
6) Watts Drainage Products.
7) Zurn Plumbing Products Group.
8) Or approved equal.

2. Standard: ASME A112.36.2M for threaded, adjustable housing cleanout.
3. Size: Same as connected branch.
4. Type: Threaded, adjustable housing.
5. Body or Ferrule: Cast iron.
6. Clamping Device: Required.
7. Outlet Connection: Inside calk.
8. Closure: Brass plug with tapered threads.
9. Adjustable Housing Material: Cast iron with threads.
10. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
11. Frame and Cover Shape: Square.
12. Top Loading Classification: Medium Duty.
13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
14. Standard: ASME A112.3.1.
15. Size: Same as connected branch.
16. Housing: Stainless steel.
17. Closure: Stainless steel with seal.
18. Riser: Stainless-steel drainage pipe fitting to cleanout.

C. Cast-Iron Wall Cleanouts (COWP):

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

a. Josam Company; Josam Div.
b. MIFAB, Inc.
c. Smith, Jay R. Mfg. Co.
d. Tyler Pipe; Wade Div.
e. Watts Drainage Products.
f. Zurn Plumbing Products Group; Specification Drainage Operation.
g. Or approved equal.

2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk or raised-head, 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.

2.2 FLOOR DRAINS

A. Cast-Iron Floor Drains (FD):
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Josam Company; Josam Div.
      b. MIFAB, Inc.
      c. Zurn Plumbing Products Group; Specification Drainage Operation.
      d. Or approved equal.

   2. Standard: ASME A112.6.3.
   3. Pattern: Floor drain.
   4. Body Material: Gray iron.
   5. Seepage Flange: Required.
   6. Anchor Flange: Required.
   7. Clamping Device: Required.
   8. Outlet: Bottom.
   9. Backwater Valve: Not required.
   10. Coating on Interior and Exposed Exterior Surfaces: Not required.
   11. Sediment Bucket: Not required.
   12. Top or Strainer Material: Refer to schedule on Drawings.
   13. Top of Body and Strainer Finish: Refer to schedule on Drawings.
   14. Top Shape: Refer to schedule on Drawings.
   15. Dimensions of Top or Strainer: Refer to schedule on Drawings.
   16. Top Loading Classification: Medium Duty.
   17. Funnel: Not required.
   18. Inlet Fitting: Not required.
   19. Trap Material: Cast iron.
   20. Trap Pattern: Deep-seal P-trap.

2.3 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies:

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

      a. Acorn Engineering Company; Elmdor/Stoneman Div.
      b. Thaler Metal Industries Ltd.
      c. Or approved equal.

2. Description: Manufactured assembly made of 4.0-lb/sq. ft., 0.0625-inch-thick, lead flashing collar and skirt extending at least 6 inches from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.

    a. Extended Vent Cap: With field-installed, vandal-proof vent cap.

2.4 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:

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

    a. ProSet Systems Inc.
    b. Or approved equal.

2. Standard: UL 1479 assembly of sleeve and stack fitting with firestopping plug.
3. Size: Same as connected soil, waste, or vent stack.
4. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
5. Stack Fitting: ASTM A 48/A 48M, gray-iron, hubless-pattern, wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.
6. Special Coating: Corrosion resistant on interior of fittings.

2.5 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Deep-Seal Traps:

1. Description: Cast-iron.
2. Size: Same as connected waste piping.

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

B. Sleeve Flashing Device:

1. Description: Manufactured, cast-iron fitting, with clamping device, that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 2 inches above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
2. Size: As required for close fit to riser or stack piping.

C. 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.

D. Vent Caps:

1. Description: Cast-iron body with threaded or hub inlet and vandal-proof design. Include vented hood and setscrews to secure to vent pipe.
2. Size: Same as connected stack vent or vent stack.

E. Frost-Resistant Vent Terminals:

1. Description: Manufactured or shop-fabricated assembly constructed of copper, lead-coated copper, or galvanized steel.
2. Design: To provide 1-inch enclosed air space between outside of pipe and inside of flashing collar extension, with counterflashing.

2.6 FLASHING MATERIALS

A. Lead Sheet: ASTM B 749, Type L51121, copper bearing, with the following minimum weights and thicknesses, unless otherwise indicated:

1. General Use: 4.0-lb/sq. ft., 0.0625-inch thickness.
2. Vent Pipe Flashing: 3.0-lb/sq. ft., 0.0469-inch thickness.
3. Burning: 6-lb/sq. ft., 0.0938-inch thickness.

B. Copper Sheet: ASTM B 152/B 152M, of the following minimum weights and thicknesses, unless otherwise indicated:

1. General Applications: 12 oz./sq. ft.
2. Vent Pipe Flashing: 8 oz./sq. ft.

C. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch minimum thickness, unless otherwise indicated. Include G90 hot-dip galvanized, mill-phosphatized finish for painting if indicated.

D. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil minimum thickness.

E. Fasteners: Metal compatible with material and substrate being fastened.

F. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.

G. Solder: ASTM B 32, lead-free alloy.

H. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

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

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

D. 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.

E. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.

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

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

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

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

J. Install vent caps on each vent pipe passing through roof.

K. Install frost-resistant vent terminals on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.

L. Install frost-proof vent caps on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.

3.2 CONNECTIONS

A. Comply with requirements in Section 15150 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Ground equipment according to Section 16 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 16 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FLASHING INSTALLATION

A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:

1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.
2. Copper Sheets: Solder joints of copper sheets.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

E. Install flashing for piping passing through roofs with counter flashing or commercially made flashing fittings, according to Section 07600 "Sheet Metal Flashing and Trim."

F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

G. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.4 LABELING AND IDENTIFYING

A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 15076 "Identification for Plumbing Piping and Equipment."

3.5 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.

3.6 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 15155

SECTION 15160 - FACILITY STORM DRAINAGE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Pipe, tube, and fittings.
2. Specialty pipe fittings.

1.3 PERFORMANCE REQUIREMENTS

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

1. Storm Drainage Piping: 10-foot head of water.

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 QUALITY ASSURANCE

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

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

1.6 PROJECT CONDITIONS

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

1. Notify Architect / Owner's Representative no fewer than two days in advance of proposed interruption of storm-drainage service.
2. Do not proceed with interruption of storm-drainage service without Construction Manager'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 classes.

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. Heavy-Duty, Hubless-Piping Couplings:

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. ANACO-Husky.
b. Clamp-All Corp.
c. Dallas Specialty & Mfg. Co.
d. MIFAB, Inc.
e. Mission Rubber Company; a division of MCP Industries, Inc.

f. Stant.
g. Tyler Pipe.
h. Or approved equal.

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 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. Shielded, Nonpressure Transition Couplings:

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

1) Cascade Waterworks Mfg. Co.
2) Mission Rubber Company; a division of MCP Industries, Inc.
3) Or approved equal.

b. Standard: ASTM C 1460.
c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

4. Pressure Transition Couplings:

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

1) Cascade Waterworks Mfg. Co.
2) Dresser, Inc.
3) EBAA Iron, Inc.
4) Ford Meter Box Company, Inc. (The)
5) JCM Industries, Inc.
6) Romac Industries, Inc.

7) Smith-Blair, Inc.; a Sensus company.
8) Viking Johnson; c/o Mueller Co.
9) Or approved equal.

b. Standard: AWWA C219.
c. Description: Metal, sleeve-type couplings same size as, with pressure rating at least equal to and ends compatible with, pipes to be joined.
d. Center-Sleeve Material: Carbon steel.
e. Gasket Material: Natural or synthetic rubber.
f. Metal Component Finish: Corrosion-resistant coating or material.

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 the following:

1) Capitol Manufacturing Company.
2) Central Plastics Company.
3) Hart Industries International, Inc.
4) Jomar International Ltd.
5) Matco-Norca, Inc.
6) McDonald, A. Y. Mfg. Co.
7) Watts Regulator Co.; a division of Watts Water Technologies, Inc.
8) Wilkins; a Zurn company.
9) Or approved equal.

b. Description:

1) Standard: ASSE 1079.
2) Pressure Rating: 150 psig at 180 deg F.
3) End Connections: Solder-joint copper alloy and threaded ferrous.

3. Dielectric Flanges:

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

1) Capitol Manufacturing Company.
2) Central Plastics Company.
3) Matco-Norca, Inc.
4) Watts Regulator Co.; a division of Watts Water Technologies, Inc.

5) Wilkins; a Zurn company.
6) Or approved equal.

b. Description:

1) Standard: ASSE 1079.
2) Factory-fabricated, bolted, companion-flange assembly.
3) Pressure Rating: 150 psig.
4) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

4. Dielectric-Flange Insulating Kits:

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

1) Advance Products & Systems, Inc.
2) Calpico, Inc.
3) Central Plastics Company.
4) Pipeline Seal and Insulator, Inc.
5) Or approved equal.

b. Description:

1) Nonconducting materials for field assembly of companion flanges.
2) Pressure Rating: 150 psig.
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 the following:

1) Elster Perfection.
2) Grinnell Mechanical Products.
3) Matco-Norca, Inc.
4) Precision Plumbing Products, Inc.
5) Victaulic Company.
6) Or approved equal.

b. Description:

1) Electroplated steel nipple complying with ASTM F 1545.
2) Pressure Rating: 300 psig at 225 deg F.

3) End Connections: Male threaded or grooved.
4) Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in "Earthwork."

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 from layout are approved on coordination Drawings.

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

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

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

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

J. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

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

L. Install storm drainage piping at the following minimum slopes unless otherwise indicated:

1. Building Storm Drain: 1 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
2. Horizontal Storm-Drainage Piping: 2 percent downward in direction of flow.

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

N. Plumbing Specialties:

1. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers in storm drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping. Comply with requirements for cleanouts specified in Section 15165 "Storm Drainage Piping Specialties."
2. Install drains in storm drainage gravity-flow piping. Comply with requirements for drains specified in Section 15165 "Storm Drainage Piping Specialties."

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

P. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 15092 "Sleeves and Sleeve Seals for Plumbing Piping."

Q. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 15092 "Sleeves and Sleeve Seals for Plumbing Piping."

R. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 15097 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

A. Hub-and-Spigot, Cast-Iron Soil Piping Gasketed Joints: Join according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

B. Hubless, Cast-Iron Soil Piping Coupled Joints: Join according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

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: Shielded, nonpressure transition couplings.

B. Dielectric Fittings:

1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.
3. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flange kits.
4. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hanger and support devices and installation specified in Section 15061 "Hangers and Supports for Plumbing Piping and Equipment."

1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
3. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
4. Vertical Piping: MSS Type 8 or Type 42, clamps.
5. Individual, Straight, Horizontal Piping Runs:

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

6. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.

7. Base of Vertical Piping: MSS Type 52, spring hangers.

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

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

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

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

1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
2. NPS 3: 60 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
4. NPS 6 and NPS 8: 60 inches with 3/4-inch rod.
5. NPS 10 and NPS 12: 60 inches with 7/8-inch rod.
6. Spacing for 10-foot pipe lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.

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

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

3.6 CONNECTIONS

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

B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.

C. Connect storm drainage piping to roof drains and storm drainage specialties.

1. Install test tees (wall cleanouts) in conductors near floor, and floor cleanouts with cover flush with floor.
2. Comply with requirements for cleanouts and drains specified in Section 15165 "Storm Drainage Piping Specialties."

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

E. Make connections according to the following unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.

2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.7 IDENTIFICATION

A. Identify exposed storm drainage piping. Comply with requirements for identification specified in Section 15076 "Identification for Plumbing Piping and Equipment."

3.8 FIELD QUALITY CONTROL

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

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

B. 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 storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose Work that was covered or concealed before it was tested.
3. Test Procedure: Test storm drainage piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts until completion of inspection, water level must not drop. Inspect joints for leaks.
4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
5. Prepare reports for tests and required corrective action.

3.9 CLEANING

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

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

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

3.10 PIPING SCHEDULE

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

B. Aboveground storm drainage piping NPS 6 and smaller shall be the following:

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

C. Aboveground, storm drainage piping NPS 8 and larger shall be the following:

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

D. Underground storm drainage piping NPS 6 and smaller shall be the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

E. Underground, storm drainage piping NPS 8 and larger shall be the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

END OF SECTION 15160

SECTION 15165 - STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Roof drains.
2. Miscellaneous storm drainage piping specialties.
3. Cleanouts.
4. Flashing materials.

1.3 ACTION SUBMITTALS

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

1.4 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 METAL ROOF DRAINS

A. Cast-Iron, General-Purpose Roof Drains RD:
1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. Josam Company.
b. MIFAB, Inc.
c. Watts Water Technologies, Inc.
d. Zurn Plumbing Products Group; Specification Drainage Operation.
e. Or approved equal.

2. Standard: ASME A112.6.4, for general-purpose roof drains.
3. Body Material: Cast iron.
4. Dimension of Body: Nominal 11-inch diameter.
5. Combination Flashing Ring and Gravel Stop: Required.
6. Flow-Control Weirs: Not Required.
7. Outlet: Bottom.
8. Extension Collars: Required.
9. Underdeck Clamp: Required.
10. Expansion Joint: Not required.
11. Sump Receiver Plate: Required.
12. Dome Material: Cast iron.
13. Wire Mesh: Not required.
14. Vandal-Proof Dome: Not required.

2.2 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

A. Downspout Boots:

1. Description: Manufactured, ASTM A 48/A 48M, gray-iron casting, with strap or ears for attaching to building; NPS 4 outlet; and shop-applied bituminous coating.
2. Size: Inlet size to match downspout and NPS 4 outlet.

2.3 CLEANOUTS

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

    a. Josam Company.
    b. Watts Water Technologies, Inc.
    c. Zurn Plumbing Products Group; Specification Drainage Operation.
    d. Or approved equal.

2. Standard: ASME A112.36.2M, for adjustable housing cleanouts.
3. Size: Same as connected branch.
4. Type: Adjustable housing.
5. Body or Ferrule Material: Cast iron.
6. Clamping Device: Required.
7. Outlet Connection: Inside calk.
8. Closure: Brass plug with tapered threads.
9. Adjustable Housing Material: Cast iron with threads.
10. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.

11. Frame and Cover Shape: Square.
12. Top-Loading Classification: Medium Duty.
13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.

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

a. Josam Company.
b. MIFAB, Inc.
c. Watts Water Technologies, Inc.
d. Zurn Plumbing Products Group; Specification Drainage Operation.
e. Or approved equal.

2. Standard: ASME A112.36.2M, for cleanouts. Include wall access.
3. Size: Same as connected drainage piping.
4. Body Material: Hub-and-spigot, cast-iron soil-pipe T-branch or Hubless, cast-iron soil-pipe test tee as required to match connected piping.
5. Closure: Countersunk, 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 FLASHING MATERIALS

A. Copper Sheet: ASTM B 152/B 152M, 12 oz./sq. ft.

B. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch minimum thickness unless otherwise indicated. Include G90 hot-dip galvanized, mill-phosphatized finish for painting if indicated.

C. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil minimum thickness.

D. Fasteners: Metal compatible with material and substrate being fastened.

E. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.

F. Solder: ASTM B 32, lead-free alloy.

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

B. Install downspout boots at grade with top 5 feet above grade. Secure to building wall.

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

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

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

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

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

G. Install test tees in vertical conductors and near floor.

H. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.

I. Install sleeve flashing device with each conductor passing through floors with waterproof membrane.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 15160 "Facility Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

3.3 FLASHING INSTALLATION

A. Fabricate flashing from single piece of metal unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:

1. Lead Sheets: Burn joints of 6.0-lb/sq. ft. lead sheets, 0.0938-inch thickness or thicker. Solder joints of 4.0-lb/sq. ft. lead sheets, 0.0625-inch thickness or thinner.
2. Copper Sheets: Solder joints of copper sheets.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

1. Pipe Flashing: Sleeve type, matching the pipe size, with a minimum length of 10 inches and with skirt or flange extending at least 8 inches around pipe.
2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

E. Fabricate and install flashing and pans, sumps, and other drainage shapes.

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 15165

SECTION 15223 - CHEMICAL-WASTE SYSTEMS FOR

LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Single-wall piping.
2. Piping specialties.
3. Neutralization tanks.

1.2 PERFORMANCE REQUIREMENTS

A. Single-Wall Piping Pressure Rating: 10 feet head of water.

1.3 ACTION SUBMITTALS

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

B. Shop Drawings: For neutralization system and leak-detection system. Include plans, elevations, sections, details, and attachments to other Work.

1. Detail neutralization-system assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from sewerage system piping. Indicate interface and spatial relationship between piping and proximate structures.

B. Field quality-control test reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For chemical-waste specialties and neutralization tanks, neutralization systems, and leak-detection systems to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Neutralization-Tank Limestone: Equal to 200 percent of amount required for each tank sump initial charge. Furnish limestone in 50-lb bags.
2. Neutralization-System Limestone and Chemicals: For each neutralization system.

    a. Limestone: Equal to 500 percent of amount required for tank sump initial charge. Furnish limestone in 50-lb bags.
    b. Chemicals: Equal to 500 percent of neutralizing chemicals required for filling tanks.

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. NFPA Compliance: Comply with NFPA 70, "National Electrical Code."

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store piping and specialties with sealing plugs in ends or with end protection.

B. Do not store plastic pipe or fittings in direct sunlight.

C. Protect pipe, fittings, and seals from dirt and damage.

1.9 COORDINATION

A. 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 Section 03300 "Cast-in-Place Concrete."

PART 2 - PRODUCTS

2.1 SINGLE-WALL PIPE AND FITTINGS (ALL PIPING SHALL BE PLENUM RATED)

A. PVDF Polyvinylidene Fluoride drainage pipe and fittings conforming to ASTM F 1673. The pipe and fittings shall be joined using socket fusion system conforming to ASTM 2657. The fittings shall meet or exceed Schedule 40 dimensions. The PVDF material shall conform to ASTM D3222. Pipe shall be marked with UL Classified to indicate compliance with UL723 (ASTM E84).

1. Exception: Pipe and fittings made from PP resin without fire-retardant additive may be used for underground installation.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Orion.
    b. Or approved equal.

2.2 JOINING MATERIALS

A. Couplings: Assemblies with combination of clamps, gaskets, sleeves, and threaded or flanged parts; compatible with piping and system liquid; and made by piping manufacturer for joining system piping.

B. Adapters and Transition Fittings: Assemblies with combination of clamps, couplings, adapters, gaskets, and threaded or flanged parts; compatible with piping and system liquid; and made for joining different piping materials.

C. Flanges: Assemblies of companion flanges and gaskets complying with ASME B16.21 and compatible with system liquid, and bolts and nuts.

2.3 PIPING SPECIALTIES

A. Corrosion-Resistant Traps:

1. Type: P-trap or drum trap.
2. Size: NPS 1-1/2 or NPS 2, as required to match connected piping.
3. PP: ASTM D 4101, with mechanical-joint pipe connections.

B. PP Floor Drains (as designated on Drawings):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Orion Fittings, Inc.; a division of Watts Water Technologies, Inc

b. Or approved equal.

2. Outlet: Bottom, to match connecting pipe, with NPS 2, NPS 3, NPS 4, or NPS 6 as indicated.

2.4 NEUTRALIZATION TANKS

A. Plastic Neutralization Tanks:

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

   a. Town & Country Plastics, Inc.
   b. Or approved equal.

2. Description: Corrosion-resistant plastic materials; with removable, gastight cover; interior, sidewall, dip-tube inlet; outlet; vent; and threaded or flanged, sidewall pipe connections.

   a. Material: HDPE or ASTM D 4101, PP.
   b. Tank Capacity: As designated on Drawing.
   c. Dip Tube: On outlet pipe instead of inlet pipe.
   d. Extension: HDPE, PE, or PP.
   e. Limestone: Chips or lumps, with more than 90 percent calcium carbonate content and 1- to 3-inch diameter.

PART 3 - EXECUTION

A. Anchor neutralization tanks and neutralization system tanks to concrete bases.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 19-inch centers around full perimeter of base.
2. For installed 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 imbedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
6. Comply with requirements in Section 03300 "Cast-in-Place Concrete" for cast-in-place concrete materials and placement.

3.1 PIPING INSTALLATION

A. Chemical-Waste Piping Inside the Building:

1. Install piping next to equipment, accessories, and specialties to allow service and maintenance.
2. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used unless otherwise indicated.
3. Flanges may be used on aboveground piping unless otherwise indicated.
4. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
5. 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.
6. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
7. Install piping at indicated slopes.
8. Install piping free of sags and bends.
9. Install fittings for changes in direction and branch connections.
10. Verify final equipment locations for roughing-in.
11. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 15092 "Sleeves and Sleeve Seals for Plumbing Piping."
12. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 15092 "Sleeves and Sleeve Seals for Plumbing Piping."
13. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 15097 "Escutcheons for Plumbing Piping."

3.2 JOINT CONSTRUCTION

A. Chemical-Waste Piping Inside the Building:

1. Plastic-Piping Electrofusion Joints: Make polyolefin drainage-piping joints according to ASTM F 1290.
2. Dissimilar-Material Piping Joints: Make joints using adapters compatible with both system materials.

3.3 HANGER AND SUPPORT INSTALLATION

A. Pipe sizes in this article refer to aboveground, single-wall piping.

B. Comply with requirements in Section 15061 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices. Install the following:

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

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

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

C. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for installation of supports.

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

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

F. Rod diameter may be reduced 1 size for double-rod hangers, to minimum of 3/8 inch.

G. Install vinyl-coated hangers for PP piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 2: 33 inches with 3/8-inch rod.
2. NPS 2-1/2 and NPS 3: 42 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
4. NPS 6: 48 inches with 3/4-inch rod.

H. Install supports for vertical PP piping every 72 inches.

3.4 NEUTRALIZATION TANK INSTALLATION

A. Install interior neutralization tanks on smooth and level floor surface. Include full initial charge of limestone.

3.5 CONNECTIONS

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

B. Make connections to piping so finished Work complies as nearly as practical with requirements specified for Work.

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

D. Protect existing piping to prevent concrete or debris from entering while making connections. Remove debris or other extraneous material that may accumulate.

3.6 LABELING AND IDENTIFICATION

A. Comply with requirements in Section 15076 "Identification for Plumbing Piping and Equipment" for labeling of equipment and piping.

B. Provide Special Warning/Maintenance Signs:
   1. Provide signs stenciled in black letters, 1” high on acrylic plastic backgrounds. The
      a. Sign #1:
         1) Approximate size: 16” high by 32” long
         2) Title: “IMPORTANT”
         3) Body Text: “BASIN MUST BE INSPECTED FREQUENTLY AND NEUTRALIZING AGENT REPLACED WHEN NECESSARY. FAILURE TO DO SO MAY RESULT IN SERIOUS DAMAGE TO PIPING SYSTEMS.”
         4) Bottom area of sign: “FURTHER INFORMATION CONTACT:” (List Supplier of Neutralization system, including address & telephone number.)
      b. Sign #2:
         1) Approximate size: 10” high by 20” long.
         2) Title: WARNING”
         3) Body Text: “ALWAYS WEAR EYE PROTECTION GEAR, RUBBER GLOVES AND CARBON FILTER FACE MASK WHEN RECHARGING THE TANK WITH LIMESTONE CHIPS.
         4) Bottom area of sign: “FURTHER INFORMATION CONTACT:” (List Supplier of Neutralization system, including address & telephone number.)

3.7 FIELD QUALITY CONTROL

A. Replace leaking sewerage piping using new materials, and repeat testing until leakage is within allowances specified.

B. Contractor shall install all equipment and components in accordance with manufacturer’s recommendations, local codes and safety requirements.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

D. 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. Manufacturer's Field Service: Engage a factory-authorized service representative to calibrate pH panel and sensor.

E. Tests and Inspections:

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect assembled leak-detection systems and their installation, including piping and electrical 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.

F. Chemical-waste piping will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

3.8 Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain neutralization systems and leak-detection systems.

3.9 CLEANING

A. Use procedures prescribed by authorities having jurisdiction or, if not prescribed, use procedures described below:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Clean piping by flushing with potable water.

3.10 PIPING SCHEDULE

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

B. Single-Wall, Chemical-Waste Sewerage Piping: Use the following piping materials for each size range:

1. NPS 1-1/2 to NPS 4: PP drainage pipe and fittings and electrofusion joints.

C. Aboveground Chemical-Waste Piping: Use the following piping materials for each size range:

1. NPS 1-1/2 to NPS 6: PP drainage piping and electrofusion or mechanical joints.

D. Under Slab-on-Grade, Indoor, Chemical-Waste Piping: Use the following piping materials for each size range:

1. NPS 1-1/2 to NPS 6: PP drainage piping and electrofusion joints.

END OF SECTION 15223

SECTION 15415 - PRESSURE WATER COOLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes pressure water coolers and related components.

1.3 SUBMITTALS

A. Product Data: For each type of pressure water cooler.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Maintenance Data: For pressure water coolers to include in 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. Filter Cartridges: Equal to 10 percent of quantity installed for each type and size indicated, but no fewer than 6 of each.

PART 2 - PRODUCTS

2.1 PRESSURE WATER COOLERS

A. Pressure Water Coolers: Wall mounted, with bottle filler, wheelchair accessible.
1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   a. Halsey Taylor.
   b. Haws Corporation.

c. Or approved equal.

2. Cabinet: Single level with bottle filling station, vinyl-covered steel with stainless-steel top.
3. Bubbler: One, with adjustable stream regulator.
4. Control: Push bar.
5. Bottle filling station.
6. Drain: Grid with NPS 1-1/4 tailpiece.
7. Supply: NPS 3/8 with shutoff valve.
8. Waste Fitting: ASME A112.18.2/CSA B125.2, NPS 1-1/4 brass P-trap.
9. 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.

    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.

10. Capacities and Characteristics:

    a. Cooled Water: Basis of design as scheduled on Drawing.
    b. Ambient-Air Temperature: 90 deg F.
    c. Inlet-Water Temperature: 80 deg F.
    d. Cooled-Water Temperature: 50 deg F.
    e. Electrical Characteristics:
        1) Volts: 120-V ac.
        2) Phase: Single.
        3) Hertz: 60.

11. Support: ASME A112.6.1M, Type I water-cooler carrier.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

3.2 INSTALLATION

A. Install fixtures level and plumb according to roughing-in Drawings. For fixtures indicated for children, install at height required by authorities having jurisdiction.

B. Set freestanding pressure water coolers on floor.

C. Install off-the-floor carrier supports, affixed to building substrate, for wall-mounted fixtures.

D. Install mounting frames, affixed to building construction, and attach recessed, pressure water coolers to mounting frames.

E. Install water-supply piping with shutoff valve on supply to each fixture to be connected to domestic-water distribution piping. Use ball, gate, or globe valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Section 15111 "General-Duty Valves for Plumbing Piping."

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

G. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 15097 "Escutcheons for Plumbing Piping."

H. Seal joints between fixtures and walls using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 07900 "Joint Sealants."

3.3 CONNECTIONS

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

B. Comply with water piping requirements specified in Section 15140 "Domestic Water Piping."

C. Install ball, gate, or globe shutoff valve on water supply to each fixture. Comply with valve requirements specified in Section 15111 "General-Duty Valves for Plumbing Piping."

D. Comply with soil and waste piping requirements specified in Section 15150 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

A. Adjust fixture flow regulators for proper flow and stream height.

B. Adjust pressure water-cooler temperature settings.

3.5 CLEANING

A. After installing fixture, 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.

C. Provide protective covering for installed fixtures.

D. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 15415

SECTION 15416 - COMMERCIAL WATER CLOSETS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Water closets.
2. Flushometer valves.
3. Toilet seats.

1.3 SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for water closets.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

C. Operation and Maintenance Data: For flushometer valves to include in operation and maintenance manuals.

1.4 MAINTENANCE MATERIAL SUBMITTALS

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

1. Flushometer-Valve Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than six of each type.

PART 2 - PRODUCTS

2.1 FLOOR-MOUNTED, BOTTOM-OUTLET WATER CLOSETS

A. Water Closets: Floor mounted, bottom outlet, top spud.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

      a. Kohler.
      b. Crane Plumbing, L.L.C.
      c. Or approved equal.

   1. Bowl:

      a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
      b. Material: Vitreous china.
      c. Type: Siphon jet.
      d. Style: Flushometer valve.
      e. Height: Standard and Handicapped, complying with ICC/ANSI A117.1.
      f. Rim Contour: Elongated.
      g. Water Consumption: 1.1 gal. to 1.6 gal. per flush.
      h. Spud Size and Location: NPS 1-1/2; top.
      i. Color: Selected by Architect

   2. Bowl-to-Drain Connecting Fitting: ASTM A 1045 or ASME A112.4.3.
   3. Flushometer Valve: Battery Powered, solenoid-actuator, piston flushometer.
   4. Toilet Seat: See Toilet Seat section.

2.2 FLUSHOMETER VALVES

A. Battery-Powered, Solenoid-Actuator, Diaphragm Flushometer Valves:
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

      a. Coyne & Delany Co.
      b. Kohler Co.
      c. TOTO USA, INC.
      d. Zurn Industries, LLC; Commercial Brass and Fixtures.
      e. Or approved equal.

2.3 TOILET SEATS

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

      a. Church Seats.
      b. Or approved equal.

   2. Standard: IAPMO/ANSI Z124.5.
   3. Material: Plastic.
   4. Type: Commercial (Heavy duty).
   5. Shape: Elongated rim, open front.
   6. Hinge: Self-sustaining, check.
   7. Hinge Material: Noncorroding metal.
   8. Seat Cover: Not required.
   9. Color: selected by Architect.

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 water-closet installation.

B. Examine walls and floors for suitable conditions where water closets will be installed.

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

3.2 INSTALLATION

A. Water-Closet Installation:

   1. Install level and plumb according to roughing-in Drawings.
   2. Install floor-mounted water closets on bowl-to-drain connecting fitting attachments to piping or building substrate.
   3. Install accessible, wall-mounted water closets at mounting height for handicapped/elderly, according to ICC/ANSI A117.1.

B. Support Installation:

   1. Use carrier supports with waste-fitting assembly and seal.
   2. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals; and affix to building substrate.

3. Install floor mounted, back outlet water closets attached to building floor substitute, onto waste fitting seals: and attach to support.

C. Flushometer-Valve Installation:

1. Install flushometer-valve, water-supply fitting on each supply to each water closet.
2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
3. Install actuators in locations that are easy for people with disabilities to reach.

D. Install toilet seats on water closets.

E. Wall Flange and Escutcheon Installation:

1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork.
2. Install deep-pattern escutcheons if required to conceal protruding fittings.
3. Comply with escutcheon requirements specified in Section 15097 "Escutcheons for Plumbing Piping."

F. Joint Sealing:

1. Seal joints between water closets and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
2. Match sealant color to water-closet color.
3. Comply with sealant requirements specified in Section 07900 "Joint Sealants."

3.3 CONNECTIONS

A. Connect water closets with water supplies and soil, waste, and vent piping. Use size fittings required to match water closets.

B. Comply with water piping requirements specified in Section 15140 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 15150 "Sanitary Waste and Vent Piping."

D. Where installing piping adjacent to water closets, allow space for service and maintenance.

3.4 ADJUSTING

A. Operate and adjust water closets and controls. Replace damaged and malfunctioning water closets, fittings, and controls.

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

C. Install fresh batteries in flushometers.

3.5 CLEANING AND PROTECTION

A. Clean water closets and fittings with manufacturers' recommended cleaning methods and materials.

B. Install protective covering for installed water closets and fittings.

C. Do not allow use of water closets for temporary facilities unless approved in writing by Owner.

END OF SECTION 15416

SECTION 15417 - COMMERCIAL URINALS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Urinals.
2. Flushometer valves.

1.3 SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for urinals.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Operation and Maintenance Data: For flushometer valves to include in operation and maintenance manuals.

1.4 MAINTENANCE MATERIAL SUBMITTALS

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

1. Flushometer-Valve Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than six of each type.

PART 2 - PRODUCTS

2.1 WALL-HUNG URINALS

A. Urinals: Wall hung, back outlet, washout, accessible.

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

    a. Kohler.
    b. Crane Plumbing, L.L.C.
    c. Or approved equal.

2. Fixture:

    a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
    b. Material: Vitreous china.
    c. Type: Washout with extended shields.
    d. Strainer or Trapway: (No strainer) with integral trap.
    e. Water Consumption: Basis of design, refer to schedule on Drawings.
    f. Spud Size and Location: NPS 3/4, top.
    g. Outlet Size and Location: NPS 2, back.
    h. Color: Selected by Architect.

3. Flushometer Valve: See “Urinal Flushometer Valves” Article.
4. Waste Fitting:

    a. Standard: ASME A112.18.2/CSA B125.2 for coupling.
    b. Size: NPS 2.

5. Support: ASME A112.6.1M, Type I, urinal carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture. Include rectangular, steel uprights.

2.2 URINAL FLUSHOMETER VALVES

A. Battery-Powered, Solenoid-Actuator, Diaphragm Flushometer Valves:
    1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

        a. Coyne & Delany Co.
        b. Kohler Co.
        c. TOTO USA, INC.
        d. Zurn Industries, LLC; Commercial Brass and Fixtures.
        e. Or approved equal.

    2. Standard: ASSE 1037.
    3. Minimum Pressure Rating: 125 psig (860 kPa).
    4. Features: Include integral check stop and backflow-prevention device.
    5. Material: Brass body with corrosion-resistant components.
    6. Consumption: Basis of design, refer to schedule on Drawings.

7. Minimum Inlet: NPS 3/4 (DN 20).
8. Minimum Outlet: NPS 3/4 (DN 20).

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 urinal installation.

B. Examine walls and floors for suitable conditions where urinals will be installed.

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

3.2 INSTALLATION

A. Urinal Installation:

1. Install urinals level and plumb according to roughing-in Drawings.
2. Install wall-hung, back-outlet urinals onto waste fitting seals and attached to supports.
3. Install accessible, wall-mounted urinals at mounting height for the handicapped/elderly, according to ICC/ANSI A117.1.

B. Support Installation:

1. Install supports, affixed to building substrate, for wall-hung urinals.
2. Use off-floor carriers with waste fitting and seal for back-outlet urinals.
3. Use carriers without waste fitting for urinals with tubular waste piping.
4. Use chair-type carrier supports with rectangular steel uprights for accessible urinals.

C. Flushometer-Valve Installation:

1. Install flushometer-valve water-supply fitting on each supply to each urinal.
2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.

D. Wall Flange and Escutcheon Installation:

1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations.
2. Install deep-pattern escutcheons if required to conceal protruding fittings.
3. Comply with escutcheon requirements specified in Section 15097 "Escutcheons for Plumbing Piping."

E. Joint Sealing:

1. Seal joints between urinals and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
2. Match sealant color to urinal color.
3. Comply with sealant requirements specified in Section 07900 "Joint Sealants."

3.3 CONNECTIONS

A. Connect urinals with water supplies and soil, waste, and vent piping. Use size fittings required to match urinals.

B. Comply with water piping requirements specified in Section 15140 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 15150 "Sanitary Waste and Vent Piping."

D. Where installing piping adjacent to urinals, allow space for service and maintenance.

3.4 ADJUSTING

A. Operate and adjust urinals and controls. Replace damaged and malfunctioning urinals, fittings, and controls.

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

3.5 CLEANING AND PROTECTION

A. Clean urinals and fittings with manufacturers' recommended cleaning methods and materials.

B. Install protective covering for installed urinals and fittings.

C. Do not allow use of urinals for temporary facilities unless approved in writing by Owner.

END OF SECTION 15417

SECTION 15421 - COMMERCIAL LAVATORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Lavatories.
2. Faucets.

1.3 SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for lavatories.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories.

C. Operation and Maintenance Data: For lavatories and faucets 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. 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.

PART 2 - PRODUCTS

2.1 VITREOUS CHINA, WALL-MOUNTED LAVATORIES

A. Lavatory: Vitreous china, wall mounted, with back.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

      a. Kohler.
      b. Crane Plumbing, L.L.C.
      c. Or approved equal.

   2. Fixture:

      a. Standard: ASME A112.19.2/CSA B45.1.
      b. Type: For wall hanging. Rectangular 21 x 18 inches, bowl size 16 x 10 inches.
      c. Nominal Size:
      d. Faucet-Hole Punching: Single hole.
      e. Faucet-Hole Location: Top.
      f. Color: Selected by Architect.
      g. Mounting Material: Chair carrier.

   3. Faucet: Solid-Brass, Automatically Operated Battery Powered Faucets.
   4. Support: ASME A112.6.1M, Type II, concealed-arm lavatory carrier with escutcheons. Include rectangular, steel uprights.

2.2 VITREOUS CHINA, COUNTER MOUNTED LAVATORIES

A. Lavatory: Oval, Self rimming, vitreous china, counter mounted.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

      a. Kohler.
      b. Crane Plumbing, L.L.C.
      c. Or approved equal.

   2. Fixture:

      a. Standard: ASME A112.19.2/CSA B45.1.
      b. Type: Self rimming for above counter mounting.
      c. Nominal Size: Oval, 19 x 16 inches.
      d. Faucet-Hole Punching: One hole.
      e. Mounting Material: Sealant.

3. Faucet: See "Solid-Brass, Automatically Operated Battery Powered Faucets".

2.3 SOLID-BRASS, AUTOMATICALLY OPERATED LAVATORY FAUCETS

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

B. Lavatory Faucets: Automatic-type, battery-powered, electronic-sensor-operated, mixing, solid-brass valve.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

      a. Coyne & Delany Co.
      b. Kohler Co.
      c. TOTO USA, INC.
      d. Zurn Industries, LLC; Commercial Brass and Fixtures.
      e. Or approved equal.

   2. Standards: ASME A112.18.1/CSA B125.1 and UL 1951.
   3. 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.
   4. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
   5. Body Type: Single hole.
   6. Body Material: Commercial, solid brass.
   7. Finish: Polished chrome plate.
   8. Maximum Flow Rate: 0.5 gpm.
   9. Mounting Type: Deck.
   10. Spout: Rigid type.
   11. Spout Outlet: Laminar flow Spray.
   12. Drain: Not part of faucet.

2.4 SUPPLY FITTINGS

A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for supply-fitting materials that will be in contact with potable water.

B. Standard: ASME A112.18.1/CSA B125.1.

C. Supply Piping: Chrome-plated-brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated-brass or stainless-steel wall flange.

D. Supply Stops: Chrome-plated-brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.

E. Operation: Loose key.

F. Risers:

1. NPS 3/8 (DN 10).
2. Chrome-plated, rigid-copper-pipe and brass straight or offset tailpieces.

2.5 WASTE FITTINGS

A. Standard: ASME A112.18.2/CSA B125.2.

B. Drain: Grid type with NPS 1-1/4 offset and straight tailpiece.

C. Trap:

1. Size: Basis of Design, refer to Schedule on Drawings. Or approved equal.
2. Material: Chrome-plated, two-piece, cast-brass trap and ground-joint swivel elbow with 0.032-inch-thick; and chrome-plated, brass or steel wall flange.

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 lavatory installation.

B. Examine counters and walls for suitable conditions where lavatories will be installed.

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

3.2 INSTALLATION

A. Install lavatories level and plumb according to roughing-in Drawings.

B. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 15097 "Escutcheons for Plumbing Piping."

C. Seal joints between lavatories, counters, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 07900 "Joint Sealants."

3.3 CONNECTIONS

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

B. Comply with water piping requirements specified in Section 15140 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 15150 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

A. Operate and adjust lavatories and controls. Replace damaged and malfunctioning lavatories, fittings, and controls.

B. Adjust water pressure at faucets to produce proper flow.

3.5 CLEANING AND PROTECTION

A. After completing installation of lavatories, inspect and repair damaged finishes.

B. Clean lavatories, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed lavatories and fittings.

D. Do not allow use of lavatories for temporary facilities unless approved in writing by Owner.

END OF SECTION 15421

SECTION 15422 – COMMERCIAL SINKS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Service basins.
2. Sink faucets.
3. Supply fittings.
4. Waste fittings.

1.3 SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for sinks.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories.

C. Maintenance Data: For sinks to include in 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. 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.

PART 2 - PRODUCTS

2.1 SERVICE SINKS

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

      a. Acorn Engineering Company.
      b. Florestone Products Co., Inc.
      c. Stern-Williams Co., Inc.
      d. Or approved equal.

   2. Fixture:

      a. Standard: IAPMO/PS99.
      b. Material: Terrazzo.
      c. Nominal Size: Refer to specified product. On Drawings
      d. Tiling Flange: Refer to architectural plans.
      e. Rim Guard: On open sides, refer to architectural Drawings.
      f. Color: Selected by Architect.
      g. Drain: Refer to Specified product on Drawings.

   3. Mounting: On floor and flush to wall.
   4. Faucet: Refer to specified product.

2.2 UTILITY SINKS

A. Utility Sinks: Stainless steel, counter mounted.

   1. Refer to Architectural Sections.

   2. Faucet(s): See "Sink Faucets" Article.

      a. Number Required: One.
      b. Mounting: On ledge.

   3. Supply Fittings:

      a. Standard: ASME A112.18.1/CSA B125.1.
      b. Supplies: Chrome-plated brass compression stop with inlet connection matching water-supply piping type and size.

         1) Operation: Loose key.
         2) Risers: NPS 1/2, chrome-plated, soft-copper flexible tube.

4. Waste Fittings:

    a. Standard: ASME A112.18.2/CSA B125.2.
    b. Trap(s):

        1) Size: Basis of design, refer schedule on Drawings.
        2) Material: Chrome-plated, two-piece, cast-brass trap and ground-joint swivel elbow with 0.032-inch-thick brass tube to wall; and chrome-plated brass or steel wall flange.

5. Mounting: On counter with sealant.

2.3 SINK FAUCETS

A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for faucet-spout materials that will be in contact with potable water.

B. Sink Faucets: Refer to Architectural Sections.

2.4 SUPPLY FITTINGS

A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for supply-fitting materials that will be in contact with potable water.

B. Standard: ASME A112.18.1/CSA B125.1.

C. Supply Piping: Chrome-plated brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated brass or stainless-steel wall flange.

D. Supply Stops: Chrome-plated brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.

E. Operation: Loose key.

F. Risers:

1. NPS 1/2
2. Chrome-plated, soft-copper flexible tube.

2.5 WASTE FITTINGS

A. Standard: ASME A112.18.2/CSA B125.2.

B. Drain: Grid type with NPS 1-1/2 offset and straight tailpiece.

C. Trap:

1. Size: Refer to specified product.
2. Material: Chrome-plated, two-piece, cast-brass trap and ground-joint swivel elbow with 0.032-inch-thick brass tube to wall; and chrome-plated brass or steel wall flange.

2.6 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

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

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

3.2 INSTALLATION

A. Install sinks level and plumb according to roughing-in Drawings.

B. Install supports, affixed to building substrate, for wall-hung sinks.

C. Install accessible wall-mounted sinks at handicapped/elderly mounting height according to ICC/ANSI A117.1.

D. Set floor-mounted sinks in leveling bed of cement grout.

E. Install water-supply piping with stop on each supply to each sink faucet.

1. Exception: Use ball, gate, or globe valves if supply stops are not specified with sink. Comply with valve requirements specified in Section 15111 "General-Duty Valves for Plumbing Piping."
2. Install stops in locations where they can be easily reached for operation.

F. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 15097 "Escutcheons for Plumbing Piping."

G. Seal joints between sinks and counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 07900 "Joint Sealants."

H. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks. Comply with requirements in Section 15085 "Plumbing Piping Insulation."

3.3 CONNECTIONS

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

B. Comply with water piping requirements specified in Section 15140 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 15150 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

A. Operate and adjust sinks and controls. Replace damaged and malfunctioning sinks, fittings, and controls.

B. Adjust water pressure at faucets to produce proper flow.

3.5 CLEANING AND PROTECTION

A. After completing installation of sinks, inspect and repair damaged finishes.

B. Clean sinks, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed sinks and fittings.

D. Do not allow use of sinks for temporary facilities unless approved in writing by Owner.

END OF SECTION 15422

SECTION 15441 - DOMESTIC WATER PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. In-line, sealless centrifugal pumps.

1.3 DEFINITIONS

A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

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

1.5 QUALITY ASSURANCE

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

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

1.6 DELIVERY, STORAGE, AND HANDLING

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

B. Protect bearings and couplings against damage.

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

1.7 COORDINATION

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

PART 2 - PRODUCTS

2.1 IN-LINE, SEALLESS CENTRIFUGAL PUMPS

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

1. Armstrong Pumps Inc.
2. Grundfos Pumps Corp.
3. TACO Incorporated.
4. Or approved equal.

B. Description: Factory-assembled and -tested, in-line, close-coupled, canned-motor, sealless, overhung-impeller centrifugal pumps.

C. Pump Construction:

1. Pump and Motor Assembly: Hermetically sealed, replaceable-cartridge type with motor and impeller on common shaft and designed for installation with pump and motor shaft horizontal.
2. Casing: Bronze, with threaded or companion-flange connections.
3. Impeller: Plastic.
4. Motor: Single speed, unless otherwise indicated.

D. Capacities and Characteristics:

1. Capacity: as indicated on the Drawings.

2.2 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements for Plumbing Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 16 Sections.

2.3 CONTROLS

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

1. Type: Water-immersion temperature sensor, for installation in piping.
2. Range: 50 to 125 deg F.
3. Enclosure: NEMA 250, Type 4X.
4. Operation of Pump: On or off.
5. Transformer: Provide if required.
6. Power Requirement: 120 V, ac.
7. Settings: Start pump at 105 deg F and stop pump at 120 deg F.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 PUMP INSTALLATION

A. Comply with HI 1.4.

B. Install in-line, sealless centrifugal pumps with shaft horizontal unless otherwise indicated.

C. Install continuous-thread hanger rods and spring hangers of size required to support pump weight.

1. Comply with requirements for hangers and supports specified in Division 15 Section "Hangers and Supports for Plumbing Piping and Equipment."

D. Install thermostats in hot-water return piping.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in Division 15 Section "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

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

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

1. Install flexible connectors adjacent to pumps in suction and discharge piping of the following pumps:

    a. Horizontally mounted, in-line, separately coupled centrifugal pumps.

2. Install shutoff valve and strainer on suction side of each pump, and check, shutoff, and throttling valves on discharge side of each pump. Install valves same size as connected piping. Comply with requirements for valves specified in Division 15 Section "General-Duty Valves for Plumbing Piping" and comply with requirements for strainers specified in Division 15 Section "Domestic Water Piping Specialties."
3. Install pressure gage and snubber at suction of each pump and pressure gage and snubber at discharge of each pump. Install at integral pressure-gage tappings where provided or install pressure-gage connectors in suction and discharge piping around pumps

D. Comply with Division 16 Sections for electrical connections, and wiring methods.

E. Connect thermostats, to pumps that they control.

3.4 IDENTIFICATION

A. Comply with requirements for identification specified in Division 15 Section "Identification for Plumbing Piping and Equipment" for identification of pumps.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check piping connections for tightness.

3. Clean strainers on suction piping.
4. Set thermostats, for automatic starting and stopping operation of pumps.
5. Perform the following startup checks for each pump before starting:

    a. Verify bearing lubrication.
    b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
    c. Verify that pump is rotating in the correct direction.

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

3.6 ADJUSTING

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

B. Adjust initial temperature set points.

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

END OF SECTION 15441

SECTION 15486 - 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 1 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 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. Shop Drawings:

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

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

D. Source quality-control reports.

E. Field quality-control reports.

F. Warranty: Sample of special warranty.

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

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, 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, "Drinking Water System Components - Health Effects."

1.5 COORDINATION

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

1.6 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: Two year(s).

PART 2 - PRODUCTS

2.1 COMMERCIAL, GAS-FIRED, STORAGE, DOMESTIC-WATER HEATERS

A. Commercial, Gas-Fired, High Efficiency Storage, Domestic-Water Heaters:
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

      a. Lochinvar.
      b. Bock Water Heaters, Inc.
      c. Bradford White.
      d. PVI Industries, LLC.
      e. Or approved equal.

   2. Standard: ANSI Z21.10.3/CSA 4.3.
   3. Storage-Tank Construction: ASME-code steel with 150-psig working-pressure rating.

      a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.

         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.

      b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
      c. Lining: Glass complying with NSF 61 Annex G barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.

   4. Factory-Installed Storage-Tank Appurtenances:

      a. Anode Rod: Replaceable magnesium.
      b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
      c. Drain Valve: Corrosion-resistant metal 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: UL 795 for power-burner, gas-fired, domestic-water heaters and natural-gas fuel.
      g. Automatic Ignition: ANSI Z21.20/CSA C22.2 No. 199, electric, automatic, gas-ignition system.

h. Temperature Control: Adjustable thermostat.
i. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
j. 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.

5. Special Requirements: NSF 5 construction.
6. Power-Vent System: Exhaust fan, interlocked with burner.

7. Factory-Installed Storage-Tank Appurtenances:

a. Anode Rod: Permanent.
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.

8. Capacity and Characteristics:

a. See Drawings.

2.2 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Compression Tanks:
1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
a. Flexcon Industries.
b. Honeywell International Inc.
c. Smith, A. O. Water Products Co.; a division of A. O. Smith Corporation.
d. Or approved equal.

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

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

4. Capacity and Characteristics:

    a. See Drawings.

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 with ASME B1.20.1 pipe threads or with ASME B1.20.7 garden-hose threads.

C. Heat-Trap Fittings: ASHRAE 90.2.

D. Comply with requirements for ball-, butterfly-, or gate-type shutoff valves specified in Section 15111 "General Duty Valves for Plumbing Piping,".

1. Comply with requirements for balancing valves specified in Section 15145 "Domestic Water Piping Specialties."

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 1/2-psig pressure rating as required to match gas supply.

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

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

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

2.3 SOURCE QUALITY CONTROL

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

B. Hydrostatically test commercial 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.

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.

1. Maintain manufacturer's recommended clearances.
2. Arrange units so controls and devices that require servicing are accessible.
3. 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.

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 15111 "General Duty Valves for Plumbing Piping".

C. Install gas-fired, domestic-water heaters according to the International Fuel Gas Code.

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. Comply with requirements for gas shutoff valves, gas pressure regulators, and automatic gas valves specified in Section 15195 "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 15145 "Domestic Water Piping Specialties."

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

G. Fill domestic-water heaters with water.

H. Charge domestic-water compression tanks with air.

3.2 CONNECTIONS

A. Comply with requirements for domestic-water piping specified in Section 15140 "Domestic Water Piping."

B. Comply with requirements for gas piping specified in Section 15195 "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 15076 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

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

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

C. Prepare test and inspection reports.

3.5 DEMONSTRATION

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

END OF SECTION 15486

SECTION 15487 - ELECTRIC, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Commercial, electric, storage, domestic-water heaters.
   2. Domestic-water heater accessories.

1.2 PERFORMANCE REQUIREMENTS

1.3 ACTION SUBMITTALS

A. Product Data: For each type and size of domestic-water heater indicated.

B. Shop Drawings:

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

1.4 INFORMATIONAL SUBMITTALS

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

B. Source quality-control reports.

C. Field quality-control reports.

D. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

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. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

C. ASME Compliance: 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, "Drinking Water System Components - Health Effects."

1.7 WARRANTY

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

1. Warranty Periods: From date of Substantial Completion.

a. Commercial, Electric, Storage, Domestic-Water Heaters:

1) Storage Tank: Five years.
2) Controls and Other Components: Two years.

b. Compression Tanks: Five years.

PART 2 - PRODUCTS

2.1 COMMERCIAL, ELECTRIC, DOMESTIC-WATER HEATERS

A. Commercial, Electric, Storage, Domestic-Water Heaters:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   a. Bradford White Corporation.
   b. Lochinvar Corporation.
   c. Or approved equal.

2. Standard: UL 1453.
3. Storage-Tank Construction: ASME-code, steel vertical arrangement.

a. Tappings: Factory fabricated of materials compatible with tank and piping connections. Attach tappings to tank before testing.

1) NPS 2and Smaller: Threaded ends according to ASME B1.20.1.

b. Pressure Rating: 160 psig
c. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.

4. Factory-Installed Storage-Tank Appurtenances:

a. Anode Rod: Replaceable magnesium.
b. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
c. Insulation: Comply with ASHRAE/IESNA 90.1.
d. Jacket: Steel with enameled finish.
e. Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.
f. Temperature Control: Adjustable thermostat.
g. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
h. 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 domestic-water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

5. Special Requirements: NSF 5 construction.

B. Capacity and Characteristics:

1. Capacity: See schedule on Drawings.
2. Recovery: See schedule on Drawings.
3. Power Demand: See schedule on Drawings.
4. Heating Elements:

a. Number of Elements: Three.
5. Kilowatts Each Element: See schedule on Drawings.

6. Electrical Characteristics:

a. As scheduled on the Drawings.

2.2 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Compression Tanks:
1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
a. Smith, A. O. Water Products Co.; a division of A. O. Smith Corporation.

b. State Industries.
c. Or approved equal.

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

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

4. Capacity and Characteristics:

a. See schedule on Drawings.

B. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1 or ASHRAE 90.2.

C. Heat-Trap Fittings: ASHRAE 90.2.

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

E. Pressure Relief Valves: ASME rated and stamped. Include pressure setting less than domestic-water heater working-pressure rating.

F. Shock Absorbers: ASSE 1010 or PDI-WH 201, Size A water hammer arrester.

2.3 SOURCE QUALITY CONTROL

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

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

C. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER HEATER INSTALLATION

A. Commercial, Electric, Domestic-Water Heater Mounting: Install commercial, electric, domestic-water heaters on concrete base. Install on galvanized steel support stand in CTE.

1. Maintain manufacturer's recommended clearances.
2. Arrange units so controls and devices that require servicing are accessible.
3. 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.
4. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
5. Place and secure anchorage devices. Use setting Drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
6. Install anchor bolts to elevations required for proper attachment to supported equipment.
7. Anchor domestic-water heaters to substrate.

B. Install electric, 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 15111.

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

D. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for electric, domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 15145 "Domestic Water Piping Specialties."

E. Install thermometers on outlet piping of electric, domestic-water heaters.

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

G. Fill electric, domestic-water heaters with water.

H. Charge domestic-water compression tanks with air.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 15140 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

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

3.3 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 15076 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

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

B. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION

PART 5 – HEATING, VENTILATING & AIR CONDITIONING (HVAC)

SECTION 15058 - 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 1 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 requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

C. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

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

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

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

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

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F.

J. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

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

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

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

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

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

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

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

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

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 15058

SECTION 15059 - VARIABLE FREQUENCY DRIVES FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 DESCRIPTION

A. This Specification is to cover a complete Variable Frequency Drive (VFD aka: VSD, AFD, ASD, Inverter, AC Drive, et al) consisting of a pulse width modulated (PWM) inverter designed for use with a standard NEMA Design B induction motor.

B. The drive manufacturer shall supply the drive and all necessary options as herein specified. The manufacturer shall have been engaged in the production of this type of equipment for a minimum of twenty years. VFDs that are manufactured by a third party and "brand labeled" shall not be acceptable. Drive manufacturers who do not build their own power boards and assemblies, or do not have full control of the power board manufacturing and quality control, shall be considered as a "brand labeled" drive. All VFDs installed on this project shall be from the same manufacturer.

1.03 QUALITY ASSURANCE

A. Referenced Standards and Guidelines:

1. Institute of Electrical and Electronic Engineers (IEEE)
    a. IEEE 519-1992, Guide for Harmonic Content and Control.
2. Underwriters Laboratories (as appropriate)
    a. UL508
    b. UL508A
    c. UL508C
3. National Electrical Manufacturer's Association (NEMA)
    a. ICS 7.0, AC Adjustable Speed Drives
4. International Electrotechnical Commission (IEC)
    a. EN/IEC 61800-3
5. National Electric Code (NEC)
    a. NEC 430.120, Adjustable-Speed Drive Systems
6. International Building Code (IBC)
    a. IBC Seismic – referencing ASC 7-05 and ICC AC-156

B. Qualifications:

1. VFDs and options shall be UL508 listed as a complete assembly. The base VFD shall be UL labeled 100 kA RMS Symmetrical, 600V max. C
2. CE Mark – The base VFD shall conform to the European Union Electromagnetic Compatibility directive, a requirement for CE marking. The VFD shall meet product standard EN 61800-3 for the First Environment restricted level (Category C2). Base drives that only meet the Second Environment (Category C3, C4) shall be supplied with filters to bring the drive in compliance with the First Environment levels.
3. The entire VFD assembly, including the bypass (if specified), shall be seismically certified and labeled as such in accordance with the International Building Code (IBC):
    a. VFD manufacturer shall provide Seismic Certification and Installation requirements at time of submittal.
    b. Seismic importance factor of 1.5 rating is required, and shall be based upon actual shake test data as defined by ICC AC-156.
    c. Seismic ratings based upon calculations alone are not acceptable. Certification of Seismic rating must be based on testing done in all three axis of motion.
    d. Special seismic certification of equipment and components shall be provided by OSHPD preapproval.
4. Factory authorized start up and Owner training should be provided locally upon request.

1.04 SUBMITTALS

A. Submittals shall include the following information:
1. Outline dimensions, conduit entry locations and weight.
2. Customer connection and power wiring diagrams.
3. Complete technical product description include a complete list of options provided. Any portions of this Specification not met must be clearly indicated or the supplier and Contractor shall be liable to provide all additional components required to meet this Specification.

1.05 BUILDING INFORMATION MODELING (BIM)

A. BIM objects shall contain IFC parameters and associated data applicable to building system requirements. These elements shall support the analytic process including size, clearance, location, mounting heights, and system information where applicable.

B. VFD BIM models shall contain as a minimum the following attributes:
1. Input voltage
2. Current rating
3. Model number
4. Manufacturer
5. Enclosure type

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. ABB Low Voltage HVAC Drives model ACH550.
2. Or approved equal.

2.02 VARIABLE FREQUENCY DRIVES

A. The VFD package as specified herein and defined on the VFD schedule shall be enclosed in a UL Type enclosure (enclosures with only NEMA ratings are not acceptable), completely assembled and tested by the manufacturer in an ISO9001 facility.

B. The VFD shall provide full rated output from a line of ±10% of nominal voltage. The VFD shall continue to operate without faulting from a line of +30% to -35% of nominal voltage.

1. VFDs shall be capable of continuous full load operation under the following environmental operating conditions:
   a. -15 to 40° C (5 to 104° F) ambient temperature. Operation to 50° C shall be allowed with a 10% reduction from VFD full load current.
   b. Altitude 0 to 3300 feet above sea level. Operation to 6600 shall be allowed with a 10% reduction from VFD full load current.
   c. Humidity less than 95%, non-condensing.

C. All VFDs shall have the following standard features:

1. All circuit boards shall be coated to protect against corrosion.
2. All VFDs shall have the same customer interface, including digital display, and keypad, regardless of horsepower rating. The keypad shall be removable, capable of remote mounting and allow for uploading and downloading of parameter settings as an aid for start-up of multiple VFDs.
3. The keypad shall include Hand-Off-Auto selections and manual speed control. The drive shall incorporate “bumpless transfer” of speed reference when switching between “Hand” and “Auto” modes. There shall be fault reset and “Help” buttons on the keypad. The Help button shall include “on-line” assistance for programming and troubleshooting.
4. There shall be a built-in time clock in the VFD keypad. The clock shall have a battery backup with 10 years minimum life span. The clock shall be used to date and time stamp faults and record operating parameters at the time of fault. VFD programming shall be held in non-volatile memory and is not dependent on battery power
5. The VFD’s shall utilize pre-programmed application macros specifically designed to facilitate start-up. The Application Macros shall provide one command to reprogram all parameters and customer interfaces for a particular application to reduce

programming time. The VFD shall have two user macros to allow the end-user to create and save custom settings.

6. The VFD shall have cooling fans that are designed for easy replacement. The fans shall be designed for replacement without requiring removing the VFD from the wall or removal of circuit boards. The VFD cooling fans shall operate only when required, based on the temperature of and run command to the drive. VFD protection shall be based on thermal sensing and not cooling fan operation.
7. The VFD shall be capable of starting into a coasting load (forward or reverse) up to full speed and accelerate or decelerate to set point without tripping or component damage (flying start).
8. The VFD shall have the ability to automatically restart after an over-current, over-voltage, under-voltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between attempts shall be programmable.
9. The overload rating of the drive shall be 110% of its normal duty current rating for 1 minute every 10 minutes, 130% overload for 2 seconds every minute. The minimum FLA rating shall meet or exceed the values in the NEC/UL table 430.250 for 4-pole motors.
10. Product harmonic compliance shall be restricted to that identified by IEC/EN 61000-3-12.
11. VFDs through 200 HP shall have internal swinging (non-linear) chokes providing impedance equivalent to 5% to reduce the harmonics to the power line. Swinging choke shall be required resulting in superior partial load harmonic reduction. Linear chokes are not acceptable. 5% impedance may be from dual (positive and negative DC bus) chokes, or 5% swinging AC line chokes. VFD's with only one DC choke shall add an AC line choke.
12. The input current rating of the VFD shall not be greater than the output current rating. VFD's with higher input current ratings require the upstream wiring, protection devices, and source transformers to be oversized per NEC 430.122. Input and output current ratings must be shown on the VFD nameplate.
13. The VFD shall include a coordinated AC transient surge protection system consisting of 4 MOVs (phase to phase and phase to ground), a capacitor clamp, 1600 PIV Diode Bridge and internal chokes. The MOV's shall have a minimum 125 joule rating per phase across the diode bridge. VFDs that do not include coordinated AC transient surge protection shall include an external TVSS (Transient Voltage Surge Suppressor).
14. The VFD shall provide a programmable loss-of-load (broken belt / broken coupling) Form-C relay output. The drive shall be programmable to signal the loss-of-load condition via a keypad warning, Form-C relay output, and / or over the serial communications bus. The loss-of-load condition sensing algorithm shall include a programmable time delay that will allow for motor acceleration from zero speed without signaling a false loss-of-load condition.

15. The VFD shall include multiple “two zone” PID algorithms that allow the VFD to maintain PID control from two separate feedback signals (4-20mA, 0-10V, and / or serial communications). The two-zone control PID algorithm will control motor speed based on a minimum, maximum, or average of the two feedback signals. All of the VFD PID controllers shall include the ability for “two zone” control.

16. If the input reference is lost, the VFD shall give the user the option of either (1) stopping and displaying a fault, (2) running at a programmable preset speed, (3) hold the VFD speed based on the last good reference received, or (4) cause a warning to be issued, as selected by the user. The drive shall be programmable to signal this condition via a keypad warning, Form-C relay output and / or over the serial communication bus.

17. The VFD shall have programmable “Sleep” and “Wake up” functions to allow the drive to be started and stopped from the level of a process feedback signal.

D. All VFDs to have the following adjustments:

1. Three (3) programmable critical frequency lockout ranges to prevent the VFD from operating the load continuously at an unstable speed. The lockout range must be fully adjustable, from 0 to full speed.

2. Two (2) PID Set point controllers shall be standard in the drive, allowing pressure or flow signals to be connected to the VFD, using the microprocessor in the VFD for the closed-loop control. The VFD shall have 250 ma of 24 VDC auxiliary power and be capable of loop powering a transmitter supplied by others. The PID set point shall be adjustable from the VFD keypad, analog inputs, or over the communications bus. There shall be two independent parameter sets for the PID controller and the capability to switch between the parameter sets via a digital input, serial communications or from the keypad. The independent parameter sets are typically used for night setback, switching between summer and winter set points, etc.

3. There shall be an independent, second PID loop that can utilize the second analog input and modulate one of the analog outputs to maintain the set point of an independent process (i.e. valves, dampers, etc.). All set points, process variables, etc. to be accessible from the serial communication network.

4. Two (2) programmable analog inputs shall accept current or voltage signals.

5. Two (2) programmable analog outputs (0-20ma or 4-20 ma). The outputs may be programmed to output proportional to Frequency, Motor Speed, Output Voltage, Output Current, Motor Torque, Motor Power (kW), DC Bus voltage, Active Reference, Active Feedback, and other data.

6. Six (6) programmable digital inputs for maximum flexibility in interfacing with external devices. All digital inputs shall be programmable to initiate upon an application or removal of 24VDC.

7. Three (3) programmable, digital Form-C relay outputs. The relay outputs shall include programmable on and off delay times and adjustable hysteresis. The relays shall be rated for maximum switching current 8 amps at 24 VDC and 0.4 A at 250

VAC; Maximum voltage 300 VDC and 250 VAC; continuous current rating of 2 amps RMS. Outputs shall be true Form-C type contacts; open collector outputs are not acceptable. Drives that have only two (2) relay outputs must provide an option card that provides additional relay outputs.

8. Run permissive circuit - There shall be a run permissive circuit for damper or valve control. Regardless of the source of a run command (keypad, input contact closure, time-clock control, or serial communications), the VFD shall provide a dry contact closure that will signal the damper to open (VFD motor does not operate). When the damper is fully open, a normally open dry contact (end-switch) shall close. The closed end-switch is wired to a VFD digital input and allows VFD motor operation. Two separate safety interlock inputs shall be provided. When either safety is opened, the motor shall be commanded to coast to stop and the damper shall be commanded to close. The keypad shall display "start enable 1 (or 2) missing". The safety input status shall also be transmitted over the serial communications bus.
9. The VFD control shall include a programmable time delay for VFD start and a keypad indication that this time delay is active. A Form C relay output provides a contact closure to signal the VAV boxes open. This will allow VAV boxes to be driven open before the motor operates. The time delay shall be field programmable from 0 – 120 seconds. Start delay shall be active regardless of the start command source (keypad command, input contact closure, time-clock control, or serial communications), and when switching from drive to bypass.
10. Seven (7) programmable preset speeds.
11. Two independently adjustable accel and decel ramps with 1 – 1800 seconds adjustable time ramps.
12. The VFD shall include a motor flux optimization circuit that will automatically reduce applied motor voltage to the motor to optimize energy consumption and reduce audible motor noise. The VFD shall have selectable software for optimization of motor noise, energy consumption, and motor speed control.
13. The VFD shall include a carrier frequency control circuit that reduces the carrier frequency based on actual VFD temperature that allows higher carrier frequency settings without derating the VFD.
14. The VFD shall include password protection against parameter changes.

E. The Keypad shall include a backlit LCD display. The display shall be in complete English words for programming and fault diagnostics (alpha-numeric codes are not acceptable). All VFD faults shall be displayed in English words. The keypad shall include a minimum of 14 assistants including:

1. Start-up assistant
2. Parameter assistants
    a. PID assistant
    b. Reference assistant

c. I/O assistant

d. Serial communications assistant

e. Option module assistant

f. Panel display assistant

g. Low noise set-up assistant

3. Maintenance assistant

4. Troubleshooting assistant

5. Drive optimizer assistants

F. All applicable operating values shall be capable of being displayed in engineering (user) units. A minimum of three operating values from the list below shall be capable of being displayed at all times. The display shall be in complete English words (alpha-numeric codes are not acceptable):

1. Output Frequency

2. Motor Speed (RPM, %, or Engineering units)

3. Motor Current

4. Motor Torque

5. Motor Power (kW)

6. DC Bus Voltage

7. Output Voltage

G. The VFD shall include a fireman's override input. Upon receipt of a contact closure from the fire / smoke control station, the VFD shall operate in one of two modes: 1) Operate at a programmed predetermined fixed speed ranging from -500Hz (reverse) to 500Hz (forward). 2) Operate in a specific fireman's override PID algorithm that automatically adjusts motor speed based on override set point and feedback. The mode shall override all other inputs (analog/digital, serial communication, and all keypad commands), except customer defined safety run interlocks, and force the motor to run in one of the two modes above. "Override Mode" shall be displayed on the keypad. Upon removal of the override signal, the VFD shall resume normal operation, without the need to cycle the normal digital input run command.

H. Serial Communications

1. The VFD shall have an EIA-485 port as standard. The standard protocols shall be Modbus, Johnson Controls N2, Siemens Building Technologies FLN, and BACnet. Optional protocols for LonWorks, Profibus, EtherNet, BACnet IP, and DeviceNet shall be available. Each individual drive shall have the protocol in the base VFD. The use of third party gateways and multiplexers is not acceptable. All protocols shall be "certified" by the governing authority (i.e. BTL Listing for BACnet). Use of non-certified protocols is not allowed.

2. The BACnet connection shall be an EIA-485, MS/TP interface operating at 9.6, 19.2, 38.4, or 76.8 Kbps. The connection shall be tested by the BACnet Testing Labs (BTL) and be BTL Listed. The BACnet interface shall conform to the BACnet standard device type of an Applications Specific Controller (B-ASC). The interface shall support all BIBBs defined by the BACnet standard profile for a B-ASC including, but not limited to:

    a. Data Sharing – Read Property – B.

    b. Data Sharing – Write Property – B.

    c. Device Management – Dynamic Device Binding (Who-Is; I-Am).

    d. Device Management – Dynamic Object Binding (Who-Has; I-Have).

    e. Device Management – Communication Control – B.

3. Serial communication capabilities shall include, but not be limited to; run-stop controls, speed set adjustment, and lock and unlock the keypad. The drive shall have the capability of allowing the BAS to monitor feedback such as process variable feedback, output speed / frequency, current (in amps), % torque, power (kW), kilowatt hours (resettable), operating hours (resettable), and drive temperature. The BAS shall also be capable of monitoring the VFD relay output status, digital input status, and all analog input and analog output values. All diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote VFD fault reset shall be possible.

4. Serial communication in bypass (if bypass is specified) shall include, but not be limited to; bypass run-stop control, the ability to force the unit to bypass, and the ability to lock and unlock the keypad. The bypass shall have the capability of allowing the BAS to monitor feedback such as, current (in amps), kilowatt hours (resettable), operating hours (resettable), and bypass logic board temperature. The BAS shall also be capable of monitoring the bypass relay output status, and all digital input status. All bypass diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote bypass fault reset shall be possible.

5. The VFD / bypass shall allow the BAS to control the drive and bypass digital and analog outputs via the serial interface. This control shall be independent of any VFD function. The analog outputs may be used for modulating chilled water valves or cooling tower bypass valves. The drive and bypass' digital (Form-C relay) outputs may be used to actuate a damper, open a valve or control any other device that requires a maintained contact for operation. In addition, all of the drive and bypass' digital inputs shall be capable of being monitored by the BAS system. This allows for remote monitoring of which (of up to 4) safeties are open.

6. The VFD shall include an independent PID loop for customer use. The independent PID loop may be used for cooling tower bypass value control, chilled water value / hot water valve control, etc. Both the VFD PID control loop and the independent PID control loop shall continue functioning even if the serial communications connection is lost. As default, the VFD shall keep the last good set point command and last good

DO & AO commands in memory in the event the serial communications connection is lost and continue controlling the process.

I. EMI / RFI filters. All VFD's shall include EMI/RFI filters. The onboard filters shall allow the VFD assembly to be CE Marked and the VFD shall meet product standard EN 61800-3 for the First Environment restricted level (Category C2) with up to 100 feet of motor cable. Second environment (Category C3, C4) is not acceptable, no Exceptions. Certified test reports shall be provided with the submittals confirming compliance to EN 61800-3, First Environment (C2).

J. DRIVE OPTIONS – Options shall be furnished and mounted by the drive manufacturer as defined on the VFD schedule. All optional features shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label.

1. Circuit Breaker - Door interlocked padlockable circuit breaker that will disconnect all input power from the drive and all internally mounted options. Circuit breaker option shall be available with or without systems requiring bypass.

2. Disconnect Switch with Fuses - Door interlocked, padlockable disconnect switch that will disconnect all input power from the drive and all internally mounted options. Drive input fusing is included.

3. Fieldbus adapters – The following optional fieldbus adapters shall be available as plug-in modules.

   a. LonWorks

   b. DeviceNet

   c. Ethernet IP

      1) ControlNet over Ethernet & ModBus TCP

   d. BACnet IP

   e. Profibus

K. BYPASS OPTION – Bypasses shall be furnished and mounted by the drive manufacturer as defined on the VFD schedule. All VFD with bypass configurations shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label.

1. A complete factory wired and tested bypass system consisting of a door interlocked, padlockable circuit breaker, output contactor, bypass contactor, and fast acting VFD input fuses. UL Listed motor overload protection shall be provided in both drive and bypass modes.

2. The bypass enclosure door and VFD enclosure must be mechanically interlocked such that the disconnecting device must be in the "Off" position before either enclosure may be accessed.

3. The VFD and bypass package shall have a UL listed short circuit current rating (SCCR) of 100,000 Amps and this rating shall be indicated on the UL data label.

4. The drive and bypass package shall be seismic certified and labeled to the IBC:

a. Seismic importance factor of 1.5 rating is required, and shall be based upon actual shake table test data as defined by ICC AC-156.

b. Special seismic certification of equipment and components shall be provided by OSHPD preapproval.

5. Drive Isolation Fuses - To ensure maximum availability of bypass operation, fast acting fuses, exclusive to the VFD, shall be provided to allow the VFD to disconnect from the line prior to clearing upstream branch circuit protection. This maintains bypass operation capability in the event of a VFD failure. Bypass designs which have no such fuses, or that incorporate fuses common to both the VFD and the bypass, will not be accepted. Third contactor "isolation contactors" are not an acceptable alternative to fuses, as contactors could weld closed and are not an NEC recognized disconnecting device.

6. The bypass shall maintain positive contactor control through the voltage tolerance window of nominal voltage +30%, -35%. This feature is designed to avoid contactor coil failure during brown out / low line conditions and allow for input single phase operation when in the VFD mode. Designs that will not allow input single phase operation in the VFD mode are not acceptable.

7. Motor protection from single phase power conditions - the bypass system must be able to detect a single-phase input power condition while running in bypass, disengage the motor in a controlled fashion, and give a single-phase input power indication. Bypass systems not incorporating single phase protection in bypass mode are not acceptable.

8. The bypass system shall be designed for stand-alone operation and shall be completely functional in both Hand and Automatic modes even if the VFD has been removed from the system for repair / replacement. Serial communications shall remain functional even with the VFD removed. Bypass systems that do not maintain full functionality with the drive removed are not acceptable.

9. Serial communications – the bypass shall be capable of being monitored and / or controlled via serial communications. On-board communications protocols shall include ModBus RTU; Johnson Controls N2; Siemens Building Technologies FLN (P1); and BACnet MS/TP.

    a. Serial communication capabilities shall include, but not be limited to: bypass run-stop control, the ability to force the unit to bypass, and the ability to lock and unlock the keypad. The bypass shall have the capability of allowing the BAS to monitor feedback such as, current (Amps), kilowatt hours (resettable), operating hours (resettable), and bypass logic board temperature. The BAS shall also be capable of monitoring the bypass relay output status, and all digital input status. All bypass diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote bypass fault reset shall be possible. The following additional status indications and settings shall be transmitted over the serial communications bus and / or via a Form-C relay output – keypad "Hand" or "Auto" selected, bypass selected, and broken belt indication. The BAS system

shall also be able to monitor if the motor is running in the VFD mode or bypass mode over serial communications. A minimum of 50 field serial communications points shall be capable of being monitored in the bypass mode.

b. The bypass serial communications shall allow control of the drive/bypass (system) digital outputs via the serial interface. This control shall be independent of any bypass function or operating state. The system digital (relay) outputs may be used to actuate a damper, open a valve or control any other device that requires a maintained contact for operation. All system analog and digital I/O shall be capable of being monitored by the BAS system.

10. There shall be an adjustable motor current sensing circuit for the bypass and VFD modes to provide proof of flow (broken belt) indication. The condition shall be indicated on the keypad display, transmitted over the BAS and / or via a Form-C relay output contact closure. The broken belt indication shall be programmable to be a system (drive and bypass) indication. The broken belt condition sensing algorithm shall be programmable to cause a warning or system shutdown.

11. The digital inputs for the system shall accept 24VDC. The bypass shall incorporate an internally sourced power supply and not require an external control power source. The bypass power board shall supply 250 mA of 24 VDC for use by others to power external devices.

12. There shall be a coordinated run permissive circuit for damper or valve control. Regardless of the source of a run command (keypad command, time-clock control, digital input, or serial communications) the bypass shall provide a dry contact closure that will signal the damper to open before the motor can run. When the damper is fully open, a normally open dry contact (end-switch) shall close. The closed end-switch is wired to a bypass system input and allows motor operation. Up to four separate safety interlock inputs shall be provided. When any safety is opened, the motor shall be commanded to coast to stop, and the damper shall be commanded to close. This feature will also operate in Fireman's override / smoke control mode.

13. The bypass control shall monitor the status of the VFD and bypass contactors and indicate when there is a welded contactor contact or open contactor coil. This failed contactor condition shall be indicated on the bypass LCD display, programmed to activate a Form-C relay output, and / or over the serial communications protocol.

14. The bypass control shall include a programmable time delay bypass start including keypad indication of the time delay. A Form C relay output commands the VAV boxes open. This will allow VAV boxes to be driven open before the motor operates at full speed in the bypass mode. The time delay shall be field programmable from 0 – 120 seconds.

15. There shall be a keypad adjustment to select manual or automatic transfer to bypass. The user shall be able to select via keypad programming which drive faults will result in an automatic transfer to bypass mode and which faults require a manual transfer to bypass. The user may select whether the system shall automatically transfer from drive to bypass mode on the following drive fault conditions:

a. Over current

b. Over voltage

c. Under voltage

d. Loss of analog input

16. The following operators shall be provided:

    a. Bypass Hand-Off-Auto

    b. Drive mode selector

    c. Bypass mode selector

    d. Bypass fault reset

17. The bypass shall include the ability to select the operating mode of the system (VFD/Bypass) from either the bypass keypad or digital input.

18. The bypass shall include a two-line, 20-character LCD display. The display shall allow the user to access and view:

    a. Energy savings – in US dollars

    b. Bypass motor amps

    c. Bypass input voltage– average and individual phase voltage

    d. Bypass power (kW)

    e. Bypass faults and fault logs

    f. Bypass warnings

    g. Bypass operating time (resettable)

    h. Bypass energy (kilowatt hours – resettable)

    i. I/O status

    j. Parameter settings / programming

    k. Printed circuit board temperature

19. The following indicating lights (LED type) or keypad display indications shall be provided. A test mode or push to test feature shall be provided.

    a. Power-on (Ready)

    b. Run enable

    c. Drive mode selected

    d. Bypass mode selected

    e. Drive running

    f. Bypass running

    g. Drive fault

h. Bypass fault

i. Bypass H-O-A mode

j. Automatic transfer to bypass selected

k. Safety open

l. Damper opening

m. Damper end-switch made

20. The Bypass controller shall have six programmable digital inputs, and five programmable Form-C relay outputs. This I/O allows for a total System (VFD and Bypass) I/O count of 24 points as standard. The bypass I/O shall be available to the BAS system even with the VFD removed.

21. The on-board Form-C relay outputs in the bypass shall programmable for any of the following indications.

    a. System started

    b. System running

    c. Bypass override enabled

    d. Drive fault

    e. Bypass fault

    f. Bypass H-O-A position

    g. Motor proof-of-flow (broken belt)

    h. Overload

    i. Bypass selected

    j. Bypass run

    k. System started (damper opening)

    l. Bypass alarm

    m. Over temperature

22. The bypass shall provide a separate terminal strip for connection of freeze, fire, smoke contacts, and external start command. All external safety interlocks shall remain fully functional whether the system is in VFD or Bypass mode. The remote start/stop contact shall operate in VFD and bypass modes. The terminal strip shall allow for independent connection of up to four (4) unique safety inputs.

23. The bypass shall include a supervisory control mode. In this bypass mode, the bypass shall monitor the value of the VFD's analog input (feedback). This feedback value is used to control the bypass contactor on and off state. The supervisory mode shall allow the user to maintain hysteresis control over applications such as cooling towers and booster pumps.

24. The user shall be able to select the text to be displayed on the keypad when an external safety opens. Example text display indications include “FireStat”, “FreezeStat”, “Over pressure” and “Low suction”. The user shall also be able to determine which of the four (4) safety contacts is open over the serial communications connection.

25. Smoke Control Override Mode (Override 1) – The bypass shall include a dedicated digital input that will transfer the motor from VFD mode to Bypass mode upon receipt of a dry contact closure from the Fire / Smoke Control System. The Smoke Control Override Mode action is not programmable and will always function as described in the bypass User’s Manual documentation. In this mode, the system will ignore low priority safeties and acknowledge high priority safeties. All keypad control, serial communications control, and normal customer start / stop control inputs will be disregarded. This Smoke Control Mode shall be designed to meet the intent of UL864/UUKL.

26. Fireman’s Override Mode (Override 2) – the bypass shall include a second, programmable override input which will allow the user to configure the unit to acknowledge some digital inputs, all digital inputs, ignore digital inputs or any combination of the above. This programmability allows the user to program the bypass unit to react in whatever manner the local Authority Having Jurisdiction (AHJ) requires. The Override 2 action may be programmed for “Run-to-Destruction”. The user may also force the unit into Override 2 via the serial communications link.

27. Class 10, 20, or 30 (programmable) electronic motor overload protection shall be included.

28. Drive Service Switch – Drive service switches shall be furnished and mounted by the drive manufacturer as defined on the VFD schedule. VFD/Bypass configurations that utilize contactors as a means to remove VFD input power for the purpose of VFD servicing are not acceptable. NEC Code does not recognize a contactor as a means of disconnect in a motor control circuit.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Installation shall be the responsibility of the Mechanical Subcontractor. The Subcontractor shall install the drive in accordance with the recommendations of the VFD manufacturer as outlined in the VFD installation manual.

B. Power wiring shall be completed by the Electrical Subcontractor, to NEC code 430.122 wiring requirements based on the VFD input current. The Subcontractor shall complete all wiring in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.

3.02 START-UP

A. Factory start-up shall be provided for each drive by a factory authorized service center. A start-up form shall be filled out for each drive with a copy provided to the Owner, and a copy kept on file at the manufacturer.

3.03 PRODUCT SUPPORT

A. Factory trained application engineering and service personnel that are thoroughly familiar with the VFD products offered shall be locally available at both the specifying and installation locations. A toll free 24/365 technical support line connected to factory support personnel located in the US shall be available. Technical support offered only through the local sales office is not acceptable.

B. Training shall include installation, programming and operation of the VFD, bypass and serial communication. Factory authorized start up and Owner training to be provided locally upon request.

3.04 WARRANTY

A. PROPOSED: The VFD Product Warranty shall be 36 months from the date of factory shipment. The warranty shall include all parts, labor, travel time and expenses. A toll free 24/365 technical support line shall be available.

END OF SECTION 15059

SECTION 15062 - 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

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

B. Related Sections:

1. Division 5 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for vibration isolation devices.
3. Division 15 Section(s) "Metal Ducts" for duct hangers and supports.

1.3 DEFINITIONS

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

1.4 PERFORMANCE REQUIREMENTS

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

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

2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.5 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. Pipe stands.
4. Equipment supports.

C. 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. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

B. Copper Pipe Hangers:

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

2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

2.2 TRAPEZE PIPE HANGERS

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

2.3 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.
10. Or approved equal.

B. Insulation-Insert Material for Hot Piping: ASTM C 552, Type II cellular glass with 100-psigor ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength.

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 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. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
3. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: One or more; plastic.
3. Vertical Members: Two or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.6 EQUIPMENT SUPPORTS

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

2.7 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.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Division 7 Section "Roof Accessories" for curbs.

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 2-1/2and 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. 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 8and Larger: Include 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. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 9 painting Sections. Section "High-Performance Coatings."

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

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

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

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

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. 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.
17. 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.
18. 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.

19. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.

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

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

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

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

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

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.

12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

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

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

N. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected

equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

a. Horizontal (MSS Type 54): Mounted horizontally.
b. Vertical (MSS Type 55): Mounted vertically.
c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

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

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

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

END OF SECTION 15062

SECTION 15071 - VIBRATION ISOLATION, SEISMIC, WIND LOAD RESTRAINTS FOR HVAC COMPONENTS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specifications Sections apply to this Section

B. This section specifies required vibration control and seismic restraints for all equipment, where applicable, with the wind load requirements for all equipment in outdoor locations. When projects are located in a geographically active seismic, wind or flood location, Section 1.4, General Design and Performance Requirements, will elaborate on those requirements and include specifics pertaining to a facility's "continued operation." Para. 1.2, Section D is a partial list of components covered herein.

1.2 SUMMARY

A. This section includes the following:

1. All equipment, piping and ductwork as noted on the Drawing's schedule or in the Specification shall be seismically braced if the building is so classified as listed herein. Vibration control shall apply as described in all cases herein.
2. All outdoor equipment, including roof-mounted components, shall comply with section 1609, Wind Load, IBC-2021. There shall be no decrease of the effects of wind load on a component due to other structures or components acting as blocks or screens.
3. All below, at grade or above grade locations located in a flood hazard area as defined and located herein.
4. Seismic bracing, wind load and isolation materials shall be the certified products of the same manufacturing group and shall be certified by that group.
5. It is the intent of the seismic and wind load portion of this Specification to keep all mechanical, building system components in place during a seismic or high wind event and additionally operational where the occupancy category of the building so requires as listed herein.
6. All such systems must be installed in strict accordance with seismic/wind codes, component manufacturer's and building construction standards.
7. This Specification is considered to be minimum requirements for seismic, wind, flood and vibration control considerations.
8. Any variation, which results in non-compliance with the Specification Requirements, shall be corrected by the Contractor in an approved manner.

B. The Work in this section includes, but is not limited to, the following:

1. Vibration isolation for piping, ductwork and equipment, all referred to as components.
2. Component isolation bases.
3. Seismic restraints for isolated components.
4. Seismic restraints for non-isolated components.
5. Wind restraints for isolated components.
6. Wind restraints for non-isolated components.
7. Certification of seismic, wind or flood restraint designs.
8. Installation supervision.
9. Design of attachment of housekeeping pads.
10. All components requiring IBC compliance and certification.
11. All inspection and test procedures for components requiring IBC compliance.

C. All mechanical equipment, pipe and ductwork, within, on or outdoors of the building and entry of services to the building, up to but not including, the utility connection, is part of this Specification.

D. Components referred to below are typical. (Components not listed are still included in this Specification.) All systems that are part of the building in any way are referred to as components, including:

- AC Units
- Energy Recovery
- Cabinet Unit Heaters
- Condensing Units
- Curbs
- Ductwork
- Equipment Supports
- Fans (all types)
- Fan Coil Units
- Pipe
- Pumps (all types)
- Risers
- Rooftop Units
- Supports
- Unit Heaters
- VAV Boxes
- Vibration Isolators
- Water Heaters

1.3 DEFINITIONS (building and components, all codes)

A. ESSENTIAL FACILITIES, (Occupancy Category IV, IBC-2021)

1. Buildings and other structures that are intended to remain operational in the event of extreme environmental loading from flood, wind, snow or earthquakes.

B. LIFE SAFETY AND HIGH HAZARD

1. All systems involved with fire protection, including sprinkler piping, jockey pumps, fire pumps, control panels, service water supply piping, water tanks, fire

dampers, smoke exhaust systems and fire alarm panels. (Life Safety)

2. All mechanical, electrical, plumbing or fire protection systems that support the operation of, or are connected to, emergency power equipment, including all lighting, generators, transfer switches and transformers. (Life Safety)
3. All medical and life support systems. (Life Safety)
4. Hospital heating systems and air conditioning systems for maintaining normal ambient temperature. (Life Safety)
5. Automated supply, exhaust, fresh air and relief air systems on emergency control sequence, including air handlers, duct, dampers, etc., or manually-operated systems used for smoke evacuation, purge or fresh air relief by the fire department. (Life Safety)
6. All gases or fluids that must be contained in a closed system which are flammable or combustible. Any gas that poses a health hazard if released into the environment and vented Fuel Cells. (High Hazard)
7. Heating systems in any facility in Seismic Use Group III, IBC-2021 or Occupancy Category IV, IBC-2021 where the ambient temperature can fall below 32 degrees Fahrenheit. (Life Safety)

C. GENERAL

Anchor: A device, such as an expansion bolt, for connecting equipment bracing members to the structure of a building.

Approved Agency: An established and recognized agency regularly engaged in conducting tests or furnishing analytical or inspection services, when such agency has been approved.

Attachment: See Positive Attachment below.

Basic Wind Speed: The basic wind speed, in mph, for determination of the wind loads shall be as per Section 1609 (IBC-2021), or local code, if more severe. Local jurisdictions shall determine wind speeds for indicated special wind regions located near gorges or mountainous terrain. Section 6.5.4 of ASCE 7-05 shall be used after determination of basic wind speed by the local jurisdiction. See Section 1609.3 ASCE 7-05 for basic wind speed determination in non-hurricane prone regions.

Bracing: Metal channels, cables or hanger angles that prevent components from breaking away from the structure during an earthquake or high winds. See also Longitudinal Bracing and Transverse Bracing. Together, they resist environmental loads from any direction.

Certificate of Compliance: A certificate stating that materials and products meet specified standards or that Work was done in compliance with approved construction documents, provided by an approved agency. (Certificate to be supplied by equipment component manufacturer.)

Component: A non-structural part or element of an architectural, electrical, mechanical, plumbing or fire protection system within or without of a building system.

Component Importance Factor: Factor applied to a component that defines the criticality of that component. This factor can be 1.0 or 1.5.

Component, flexible: Component, including its attachments, having a fundamental period greater than 0.06 seconds.

Component, rigid: Component, including its attachments, having a fundamental period less than or equal to 0.06 seconds.

Consequential Damage: The functional and physical interrelationship of components, their supports and their effect on each other shall be considered so that the failure of an essential or non-essential architectural, mechanical or electrical component shall not cause the failure of an essential architectural, mechanical or electrical component.

Equipment: Systems associated with ducts, pipes and conduits also called components.

Gas pipes: For the purposes of this Specification Guide, gas pipe is any pipe that carries fuel, gas, fuel oil, medical gas, or compressed air.

Hazardous Contents: A material that is highly toxic or potentially explosive or corrosive and in sufficient quantity to pose a significant life-safety threat to the general public if an uncontrolled release were to occur.

Hurricane Prone Regions: Areas prone to hurricanes include the U.S. Atlantic Ocean, Gulf Coasts, Hawaii, Puerto Rico, Guam, Virgin Islands, and American Samoa where the wind speed is greater than 90 mph.

Importance Factor, I: A factor that accounts for the degree of hazard to human life and damage to property.

Inspection Certificate: An identification applied on a product by an approved agency containing the name of the manufacturer, the function and performance characteristics, and the name and identification of an approved agency that indicates that the product or material has been inspected and evaluated by an approved agency *(see Section 1703.5 and "Label" and "Manufacturer's Designation" and "Mark")*.

Label: An identification applied on a product by the manufacturer that contains the name of the manufacturer, the function and performance characteristics, and the name and identification of an approved agency that indicates that the representative

sample of the product or material has been tested and evaluated by an approved agency *(see Section 1703.5 and "Inspection Certificate," "Manufacturer's Designation" and "Mark")*.

Lateral forces: A force acting on a component in the horizontal plane. This force can be in any direction.

Longitudinal bracing: Bracing that prevents a component from moving in the direction of its run.

Longitudinal force: An applied force that happens to be in the same direction as the duct or pipe run.

Mark: An identification applied on a product by the manufacturer indicating the name of the manufacturer and the function of a product or material *(see also "Inspection Certificate," "Label" and "Manufacturer's Designation").*

Manufacturer's Designation: An identification applied on a product by the manufacturer indicating that a product or material complies with a specified standard or set of rules *(see also "Inspection Certificate," "Label" and "Mark".)*

Occupancy Category: A classification used to determine structural load requirements including those imposed by wind, flood, snow and seismic based on occupancy of the structure.

Positive Attachment: A mechanical device, designed to resist seismic forces, which connects a non-structural element, such as a duct, to a structural element, such as a beam. Bolts and welding are examples of positive attachments. Surface glue and friction anchorage do not constitute positive attachment. Examples of positive attachment are epoxy cast in anchors and drill in wedge shaped anchor bolts to concrete and welded or bolted connections directly to the building structure. Double-sided beam clamps, C type are not acceptable as either brace point attachments to the structure or for the support of the component at the bracing location.

Seismic: Related to an earthquake. Seismic loads on a structure are caused by wave movements in the earth during an earthquake.

Seismic Design Category: A classification assigned to a structure based on its Seismic Use Group or Occupancy Category and the severity of the design earthquake ground motion at the site.

Seismic Forces: The assumed forces prescribed herein, related to the response of the structure to earthquake motions, to be used in the design of the structure and its components.

Seismic Use Group, Occupancy Category, IBC-2021: A classification assigned to a building based on its use as defined in *Section 1604.516.2.*

Site Class: A classification assigned to a site based on the types of soils present and their engineering properties as defined in Table 1613.5.2 (IBC-2021).

Special Inspection: Inspection as herein required of the materials, installation, fabrication, erection or placement of components and connections requiring special documents and referenced standards *(see Section 1704, IBC*-2021*).*

Special Inspection, Continuous: The full-time observation of Work requiring special inspection by an approved special inspector who is present in the area where the Work is being performed.

Special Inspection, Periodic: The part-time or intermittent observation of Work requiring special inspection by an approved special inspector who is present in the area where the Work has been or is being performed and at the completion of the Work.

Story Drift Ratio: The story drift (Lateral displacement) divided by the story height.

Transverse bracing: Bracing that prevents a component from moving from side to side.

Wind-Borne Debris Region: Portions of hurricane-prone regions that are within 1 mile of the coastal mean high water line where the basic wind speed is 110 mph or greater, or portions of hurricane-prone regions where the basic wind speed is 120 mph or greater; or Hawaii.

1.4 GENERAL DESIGN AND PERFORMANCE REQUIREMENTS

A. General Design Requirements.

1. SEISMIC CONSIDERATIONS: This project has seismic design requirements as follows:

    a. Occupancy Category I, II & III (Seismic Design Category C through F)
    Life Safety Components (Ip = 1.5)
    High Hazard Components (All Gas Fired Components; Indoor and Outdoor) (Ip = 1.5)
    Components affected by Consequential Damage (Ip = 1.0)

2. WIND CONSIDERATIONS: This project has wind design requirements as follows:

    a. Wind load in hurricane, tornado and or wind-borne debris regions (90 plus

mph) having a building height less than 60 feet. (Rooftop structures; Section 6.5.15.1 of ASCE 7-05 design requirements apply)

B. General Design Performance Requirements

1. Seismic and Wind Load Certification and Analysis:

a. Attachment calculations by the Seismic Restraint Manufacturer's licensed Engineer substantiating the mounting system, seismic or wind restraints, fasteners or ICC Certified Concrete Anchors shall be submitted for approval along with the Shop Drawings. Seismic loads shall have their calculations based on seismic loads as established in Specification *Section 1.4, Paragraph B, article 7, Design Seismic Loads*. Wind loads shall have their calculations based on *Section 1.4, Paragraph B, article 8, Design Wind Loads*. A registered Professional Engineer having a PE from the same state as the project, or state of restraint manufacturer shall stamp all analysis, or as required by local building codes.

b. Unless otherwise specified, all equipment, piping and ductwork shall be restrained to resist seismic forces. Restraints shall maintain equipment, piping or ductwork in a captive position. Restraint devices shall be designed and selected to meet seismic requirements as defined in the latest issue of:

1. International Building Code, IBC and ASCE applicable state and local codes.

2. Importance Factor, Ip = 1.5 Components:

a. In addition to all of the above provisions, for components having an Ip greater than 1.0, all trades shall comply with Sections 16 and 17 of the International Building Code using, when available, vendors that comply with the provisions stated herein and submitting the special inspections listed within these Specifications. Where compliance is not possible, each Contractor shall submit a vendor report (form CVC-1 at end of this Specification) clearly indicating that none of the specified, listed or other vendors known to the Contractor meets the compliance, testing and certification portions of the IBC Specification's Sections 16 and 17. Special inspections of the component installation shall still be conducted (Section 1.4, Paragraph B, Article 4) even if no vendors meet the following requirements. All non-isolated and isolated equipment (components) shall be secured to the structure in accordance with that code.

3. All component manufacturers shall submit for approval the following as required below:

a. For all life safety system components noted in this Specification: the

Approved Agency's Certificate of Compliance for the specific equipment on this project when the Seismic Design Category is C through F. Analytical or Shaker Test certification through the component's load path to structure at its center of gravity shall include anchorage, structural and on-line capability. Use of seismic experience data shall be permitted if evidence confirms that the historical based component has the same construction and weight and accompanying center of gravity as submitted unit and basis of experience claim conforms to loads derived in testing with accompanying accelerations based on AC-156. Seismic qualification by seismic experience data based upon nationally recognized procedures acceptable to the authority having jurisdiction shall be deemed to satisfy the design and evaluation requirements provided that the substantiated seismic capacities equal or exceed the seismic demands determined in accordance with Sections 13.3.1 and 13.3.2 of ASCE 7-05.

b. In addition, all components needed for the continued operation of the facility in the above stated categories will have the manufacturer of that component submit the Approved Agency's Certificate of Compliance for their equipment when the Seismic Design Category is C through F. Analytical or Shaker Test certification through the component's load path to structure at its center of gravity shall include on line capability. This requirement also pertains to projects that combine an emergency preparedness center within a structure of another Use Group. Where components do not effect the facility's functional operation but could affect the performance of other components should they dislodge, only anchorage of that component requires compliance. Components needed for continued operation of the building require Analytical or Shaker Test certification through the total component's load path to structure calculated at its center of gravity. Certification shall prove anchorage, structural and on line capability. For use of seismic experience data, see (a) above.

c. All components containing hazardous or flammable materials will have the manufacturer of the component submit the Approved Agency's Certificate of Compliance for their equipment when used on any project having a minimum Seismic Design Category of C through F. Testing shall be conducted by Analytical or Shaker Test through the total component's load path to structure at its center of gravity and shall prove anchorage, structural capability and hazardous material containment. Testing shall prove that no internal component will rupture to insure against loss of hazardous or flammable (explosive) material that could support combustion, ignite or contaminate.

d. All components requiring anchorage compliance only, not listed in the above categories, shall have the manufacturer of each component submit a PE stamped calculation package stating that their project specific equipment will accept anchorage by calculating its reactions through the component's load path to structure at its center of gravity at the designated anchorage locations. This requirement is for all projects having a Seismic Design Category of C through F.

4. Special and Periodic Inspection: (Occupancy Category IV Projects)

   The following systems shall require Special Inspection and Periodic Special Inspection for seismic installation and anchorage during the course of construction, as defined earlier in this section for all buildings in Seismic Design Categories C through F.

   a. All smoke control systems. Periodic Special Inspection during erection of ductwork and prior to concealment, for leakage testing. Additionally, prior to occupancy for pressure differential testing. (see IBC-2021, Section 1704.14)
   b. All electrical components for standby or emergency power systems require Periodic Special Inspection. *
   c. All electrical equipment in Seismic Design Categories E and F. (Periodic)*
   d. All flammable, combustible and highly toxic piping and their associated mechanical systems. (Periodic)*
   e. All ductwork containing hazardous materials. (Periodic)*
   f. All equipment using combustible or toxic energy sources. (Special $^{-1}$)
   g. All electric motors, transformers, switchgear unit substations and motor control centers. (Special $^{-1}$)
   h. Reciprocating and rotating type machinery. (Special $^{-1}$)
   i. Pipe, 3" and larger. (Special $^{-1}$)
   j. Tanks, heat exchangers and pressure vessels. (Special $^{-1}$)
   k. Isolator units for seismic isolation system. (Periodic)*
   l. Manufacturer's written Quality Control Program for projects in Seismic Design Categories E or F.

5. Contractor Responsibilities and Approvals: (Occupancy Category IV Projects)

   a. Each Contractor responsible for the installation of the components asterisked above (*) shall be responsible for submitting a written Contractor's Statement of Responsibility (IBC Section 1706.1) (as outlined below) to the design team for their approval.
   b. In addition all -1 items above require Special Inspection in accordance with IBC Section 1707.8 (Form CQAP and SQA-1) at the end of this Specification.
   c. Contractor Shall:

1. Identify the components that are part of the Quality Assurance Plan. (Asterisked above)*
2. Identify all Special Inspection and Testing for components installed as part of this Contract.
3. List control procedures within the Contractor's organization for all special inspection and testing, including methods, frequency of reporting and their distribution of those reports.
4. List all personnel, including their qualifications, exercising control over the seismic aspects of the project.

6. Seismic Use Group I & II, IBC-2021 & Occupancy Category II & III Structures, IBC-2021, Ip 1.0, Seismic Design Category C:

    a. Projects in these categories require seismic bracing for all life safety and high hazard components, Paragraph 1.3B sub-paragraphs 1, 2, 5 and 6. In addition, any un-braced component that could adversely affect the performance of a component that must remain functional, Ip 1.5, or could cause the failure or release of hazardous materials (gas or liquid fuel), must be braced or anchored to avoid such failure. This includes any component that could fall or move laterally. (Consequential Damage, ASCE 7-05, Section 16.2.3.)

7. Design Seismic Loads:

    a. Projects in the United States have a minimum design load of 0.4g for statically mounted components and 0.5g for resiliently mounted components. Actual loads for both internal and external isolation and/or anchorage of components shall be as above or as calculated for the specific project location but in no event shall it be less than the above.
    b. Exclusions for seismic restraint of piping and duct shall be according to applicable codes and as stated herein. The minimum horizontal restraint capability shall be 0.4g horizontal and 0.27g vertical (in addition to the gravity load). Life safety equipment defined above shall be designed to withstand a horizontal load of 0.9g and a vertical load of 0.6g.
    c. Analysis for anchorage must indicate calculated dead loads, static seismic loads and capacity of materials utilized for connections to equipment and structure. Analysis must detail anchoring methods, bolt diameter, embedment depth and/or welded length. All seismic restraint devices shall be designed to accept, without failure, the forces detailed in this section, acting through the equipment center of gravity.
    d. Vertical load shall be calculated at 1/3 the horizontal load as a minimum, or, as prescribed by the code as 0.2 times Sds.
    e. Internally isolated equipment in lieu of specified isolation and restraint systems must meet all of the requirements of this section, all articles.
    f. A Seismic Design Errors and Omissions Insurance Certificate MUST accompany the seismic restraint equipment manufacturer's calculation.

Product liability insurance certificates are not acceptable.

g. Whether the equipment is internally or externally isolated and restrained, the entire unit assembly must be seismically attached to the structure. Curb or roof rail mounted equipment must not only have seismic or wind attachment of the equipment to the roof but also to the curb or rails. The attachment and certification thereof shall be by this section. Sheet metal screw attachment is acceptable provided that the following five conditions are met and verified.

    1. Calculations support sufficient quantity and size of sheet metal screws to handle all loads including shear.
    2. Shear and tension allowables are obtained from an accredited third party source, such as ICC or NDS, not from the screw manufacturer.
    3. Space or gap between the inside overhang of the rooftop unit and the curb at each of the screw locations is closed with structural material, tapered to contour to both the curb and the components' inside edge structure.
    4. Attachment points of the roof-mounted unit to curb and the curb to structure demonstrates structural load path.
    5. The method of attachment does not violate the NRCA rating of the curb by violating the roof member's waterproofing.

h. Failure is defined as the discontinuance of any attachment point or load path between component and structure. Permanent deformation of the component is acceptable as long as the component continues to operate without failure and, if permanent, it is within acceptable manufacturing or structural tolerances.

8. Design Wind Loads:

    a. All outdoor mounted components shall be positively fastened to their supporting structure as discussed below. Fastening to metal deck is unacceptable.

        1. If component is curb mounted, article 7, Design Seismic Loads, paragraph g shall be followed for all roof-mounted components in excess of 9 sq. ft. in cross-sectional area. Curbs shall be as described in Base Type B-3 if isolated, Base type B-4 if non-isolated.
        2. If component is support mounted, article 7, Design Seismic Loads, paragraph g shall be followed for all roof-mounted components requiring waterproofed rail supports. Equipment supports shall be Base Type B-5 if isolated, Base type B-6 if non-isolated.

3. If equipment is dunnage mounted, positive attachment shall occur through welding or bolting of equipment to dunnage steel.

b. Loads and calculations shall be based on IBC-2021, figure 1609 and related sections in ASCE 7-05.
c. Where buildings are less than or equal to 60 feet in height to the top of the roof slab (not parapet walls), *the force on* roof-mounted components shall be based on Section 6.5.15.1, ASCE 7-05.
d. Equivalent basic wind speed shall be based on IBC-2021, Table 1609.3.1.
e. In no event shall adjacent buildings, structures or screens be considered to diminish the calculated wind load or its effect on an outdoor component.

1.5 SUBMITTALS

A. Refer to Part 1, General.

B. Product Data: The manufacturer of vibration isolation, seismic and wind restraints shall provide submittals for products as follows:

1. Descriptive Data:

a. Catalog cuts or data sheets on vibration isolators and specific restraints detailing compliance with the Specification.
b. Detailed schedules of flexible and rigidly mounted equipment, showing vibration isolators and restraints by referencing numbered descriptive Drawings.

2. Shop Drawings:

a. Submit fabrication details for equipment bases including dimensions, structural member sizes and support point locations.
b. Provide all details of suspension and support for ceiling hung equipment.
c. Where walls, floors, slabs or Supplementary Steel Work are used for restraint locations, details of acceptable attachment methods for ducts and pipe must be included and approved before the condition is accepted for installation. Restraint manufacturer's submittals must include spacing and maximum seismic/wind loads at the restraint points.
d. Provide specific details of restraints and anchors, include number, size and locations for each piece of equipment. Restraint and anchor allowables shall be by structural testing, shake testing, analysis or third party certification.
e. Calculations shall be submitted as required in Section 1.4, General Design and Performance Requirements.

1.6 QUALITY ASSURANCE

A. Manufacturer of vibration isolation, seismic and wind load control equipment or manufacturer's approved representative shall have the following responsibilities:

1. Determine vibration isolation and restraint sizes and locations.
2. Provide vibration isolation and restraints as scheduled or specified.
3. Provide calculations and materials, if required, for restraint of non-isolated equipment.
4. Provide installation instructions in writing, Drawings and trained field supervision, where necessary, to insure proper installation and performance.
5. Certify correctness of installation upon completion, in writing.
6. All provisions of Section 1.4, General Design and Performance Requirements.

B. All manufacturers of vibration control, seismic, wind or flood restraining systems must provide a Seismic Design Error and Omissions Insurance Certificate for their firm or their design consultant to certify their ability to provide engineering and design as required by this section. This document shall be provided at the time of first submittal from the seismic restraint provider.

C. All manufacturers of any type of equipment including OEM are responsible for Section 1.4.

D. Equipment manufacturer's substitution of internally or externally isolated and/or restrained equipment supplied by the equipment vendor, in lieu of the isolation and restraints specified in this section, is acceptable provided all conditions of this section are met. The equipment manufacturer shall provide a letter of guarantee from their engineering department, PE stamped and certified per the section on the Seismic Restraint Design (See Section 1.4B, article 3), stating that the seismic restraints are in full compliance with these Specifications. Where used on an Essential or High Hazard Facility, manufacturer's certification proving on line capability shall be required in addition to all requirements stated in Section 1.4B. Letters from field offices or representatives are unacceptable.

E. All costs for converting to the specified vibration isolation and/or restraints shall be borne by the component vendor in the event of non-compliance with the preceding. Substitution of internal isolation is unacceptable for:

1. Indoor or outdoor mounted equipment over or adjacent to:

a. Office locations
b. Classroom locations

1.7 RELATED WORK

A. Housekeeping pad structural design, including its attachment to building

structure, shall be by the Structural Engineer of record or as shown on the Contract Drawings. Attachment of all components and restraints to the pad and size of the pad shall be designed and certified according to this section by the seismic/isolation supplier. Material and labor required for attachment and construction shall be by the Concrete Section Subcontractor, or by the Contractor where specified. Housekeeping pads shall be sized to accommodate a minimum 6" of clearance all around the equipment; or 12 times the outermost anchor bolt diameter, whichever is greater. Where exterior isolators are used, this distance shall be as measured from the outermost holes in the isolator base plate to the edge of the housekeeping pad.

B. The project's Structural Engineer shall design all roof and interior steel to support and make connections to all components, including roof-mounted equipment specified in other sections. Design shall comply with IBC requirements including load path to structure.
C. Roof steel supporting roof-mounted equipment shall be designed for all seismic and wind forces including, but not limited to, tension, compression and moment loads.
D. Chimneys, stacks and water heater breeching passing through floors are to be attached at each floor level with a riser guide.
E. Where ceilings are not braced, lay-in lighting fixtures, weighing more than 20 lbs, shall have at least 2 independent corner diagonal wire ties to structure.
F. Lay-in ceilings in compliance with seismic code requirements may use earthquake clips or other approved means of positive attachment to brace fixtures such as panel lights and diffusers less than 40 lbs to T-bar structures. Local codes dictate fixture support requirements.

1.8 CODE AND STANDARDS REQUIREMENTS

A. Typical Applicable Codes and Standards

    A. All City, State and Local Codes (Code)

        a. SMACNA Guidelines for Seismic Restraint of Mechanical Systems, Second Edition (Standard reference, to be used for design purposes only, not code)
        b. International Conference of Building Officials (ICBO) (Standard)
        c. International Building Code (Code)
        d. ASHRAE (Standard reference, to be used for design purposes only, not code).
        e. VISCMA (Vibration Isolation and Seismic Controls Manufacturers Association) (Standard reference, to be used for design purposes only, not code).

B. In cases where requirements vary, the guideline for the most stringent shall be utilized.

C. Use IBC-2021 as reference code standard unless otherwise designated.

SECTION 2 – PRODUCTS

2.1 MANUFACTURERS

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

1. Mason Industries.
2. Kinetics Noise Control.
3. Or approved equal.

B. Available Manufacturers:

1. All vibration isolators and seismic restraints described in this Section shall be the product of a single manufacturer.
2. The basis of this Specification is The VMC Group, including Vibration Mountings & Controls, Amber/Booth or Korfund Dynamics.
3. Or Approved Equal.

2.2 VIBRATION ISOLATION TYPES

A. Type A: Spring Isolator – Free Standing
A*

1. Spring isolators shall be free standing and laterally stable without any housing and complete with a molded elastomeric cup or ¼" elastomeric acoustical friction pad between the bottom of isolator and the support.
2. All mountings shall have leveling bolts that must be rigidly bolted to the equipment.
3. Spring diameters shall be no less than 0.8" of the compressed height of the spring at rated load.
4. Springs shall have a minimum additional travel to solid equal to 50% of the operating deflection.

B. Type B: Seismically and Wind Restrained Spring Isolator
MS, MSS, AEQM, ASCM, AMSR

1. Restrained spring mountings shall have a Type A spring isolator within a rigid housing that includes vertical limit stops to prevent spring extension if weight is removed. The housing shall serve as blocking during erection. A maximum clearance of ¼" shall be maintained around restraining bolts and internal elastomeric deceleration bushings. Limit stops shall be out of contact during normal operation. If housings are to be bolted or welded in position there must be an internal isolation pad or elastomeric cup. Housing shall be designed to

resist all seismic forces.

C. Type C: Combination Spring/Elastomer Hanger Isolator (30° Type)
HRSA

1. Hangers shall consist of rigid steel frames containing minimum 1 ¼″ thick elastomeric elements at the top and a steel spring with general characteristics as in Type A. The elastomeric element shall have resilient bushings projecting through the steel box.
2. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc from side to side before contacting the rod bushing and short-circuiting the spring.
3. Submittals shall include a hanger Drawing showing the 30° capability.
4. Hanger locations requiring pre-compression for holding piping at fixed elevation shall be type pre-compressed or pre-positioning for all manufacturers.

D. Type D: Elastomer Double Deflection Hanger Isolator
HR

1. Molded (minimum 1 ¼″ thick) elastomeric element with projecting bushing lining the rod clearance hole. Static deflection at rated load shall be a minimum of 0.35.″
2. Steel retainer box encasing elastomeric mounting capable of supporting equipment up to two times the rated capacity of the element.

E. Type E: Combination Spring/Elastomer Hanger Isolator
HRS

1. Spring and elastomeric elements in a steel retainer box with the features as described for Type C and D isolators.
2. Hanger locations requiring pre-compression for holding piping at fixed elevation shall be type pre-compressed or pre-positioning for all manufacturers.
3. 30° angularity feature is not required.

F. Type F: Seismically Restrained Elastomer Floor Isolator
RSM, MB, RUD

1. Bridge-bearing elastomeric mountings shall have a minimum static deflection of 0.2″ and all-directional seismic capability. The mount shall consist of a ductile iron or aluminum casting containing molded elastomeric elements. The elements shall prevent the central threaded sleeve and attachment bolt from contacting the casting during normal operation. The shock-absorbing elastomeric materials shall be compounded to bridge-bearing or Durulene™ Specifications.

G. Type G: Pad Type Elastomer Isolator (Standard)

Maxiflex

1. One layer of ¾″ thick elastomeric pad consisting of 2″ square modules for size required.
2. Load distribution plates shall be used as required.
3. Bolting required for seismic compliance. Elastomeric and duck washers and bushings shall be provided to prevent short-circuiting.

H. Type H: Pad Type Elastomer Isolator (High Density)
Fabri-Flex, NDB, NRC

1. Laminated canvas duck and neoprene, maximum loading 1000 psi, minimum ½″ thick.
2. Load distribution plate shall be used as required.
3. Bolting required for seismic compliance. Elastomeric and duck washers and bushings shall be provided to prevent short-circuiting.

I. Type I: Thrust Restraints
RSHTR, TRK

1. A spring element similar to Type A isolator shall be combined with steel angles, backup plates, threaded rod, washers and nuts to produce a pair of devices capable of limiting movement of air handling equipment to ¼″ due to thrust forces. Contractor shall supply hardware.
2. Thrust restraints shall be installed on all cabinet fan heads, axial or centrifugal fans whose thrust exceeds 10% of unit weight.

J. Type J: Pipe Anchors
MDPA, AG

1. All-directional acoustical pipe anchor, consisting of two sizes of steel tubing or piping separated by a minimum ½″ thick 60 durometer elastomer.
2. Vertical restraint shall be provided by similar material arranged to prevent vertical travel in either direction.
3. Applied loads on the isolation material shall not exceed 500 psi and the design shall be balanced for equal resistance in any direction.

K. Type K: Pipe Guides
PG/AG/SWP/SWX

1. Pipe guides shall consist of a telescopic arrangement of two sizes of steel tubing or piping separated by a minimum ½″ thickness of 60 durometer elastomer.

2. The height of the guides shall be preset with a shear pin to allow vertical motion due to pipe expansion or contraction. Shear pin shall be removable and replaceable to allow for selection of pipe movement.

3. Guides shall be capable of ± 1 5/8″ motion, or to meet location requirements.

L. Type L: Isolated Pipe Hanger System
CIH, CIR, TIH, PIH

1. Pre-compressed spring and elastomer isolation hanger combined with pipe support into one assembly. Replaces standard clevis, single or double rod roller, or double rod fixed support.
2. Spring element (same as Type A) with steel lower spring retainer and an upper elastomer retainer cup with an integral bushing to insulate support rod from the isolation hanger.
3. The elastomeric element under the lower steel spring retainer shall have an integral bushing to insulate the support rod from the steel spring retainer.
4. Hangers shall be designed and constructed to support loads over three times the rated load without failure.
5. Systems shall be pre-compressed to allow for rod insertion and standard leveling.

2.3 SEISMIC RESTRAINT TYPES

A. Type I: Spring Isolator, Restrained
MS, MSS, AEQM, ASCM, AMRS

1. Refer to vibration isolation Type B.

B. Type II: Seismically Restrained Elastomer Floor Isolator
MB, RUD

1. Refer to vibration isolation Type F.

C. Type III: All-Directional Seismic Snubber
SR, ER

1. All-directional seismic snubbers shall consist of interlocking steel members restrained by an elastomeric bushing. Bushing shall be replaceable and a minimum of ¼″ thick. Applied loading shall not exceed 1000 psi. A minimum air gap of 1/8″ shall be incorporated in the snubber design in all directions before contact is made between the rigid and resilient surfaces. Snubber end caps shall be removable to allow inspection of internal clearances. Elastomeric bushings shall be rotated to insure no short circuits exist before systems are activated.

D. Type IV: Floor or Roof Anchorage
Cast-In Plates

1. Rigid attachment to structure utilizing wedge type anchor bolts, anchored plates, machine screw, bolting or welding. Power shots are unacceptable.

E. Type V: Seismic Cable Restraints
SB, LRC

1. Seismic Cable Restraints shall consist of galvanized steel aircraft cables sized to resist seismic loads with a minimum safety factor of two and arranged to provide all-directional restraint. Cable end connections shall be steel assemblies that swivel to final installation angle and utilize two clamping bolts to provide proper cable engagement. Cables must not be allowed to bend across sharp edges.

F. Type VI: Rigid Arm Brace
SAB

1. Seismic solid braces shall consist of steel angles or channels to resist seismic loads with a minimum safety factor of two and arranged to provide all-directional restraint. Seismic solid brace end connectors shall be steel assemblies that swivel to the final installation angle and utilize two anchor bolts to provide proper attachment spaced to ICBO standards for attachment to concrete.

G. Type VII: Internal Clevis Cross Brace
ICB

1. Internal clevis cross braces at seismic locations shall be pre-cut pipe or other approved device sized for internal dimensions.

H. Type VIII: Seismic Waterproof Foundation Wall Sleeve
SWFWS

1. Seismic waterproof foundation wall sleeves shall consist of two elastomeric sleeves that shall be mounted both inside and out of the vertical foundation wall. The conical design shall have a suitably waterproof means of fastening to both concrete and to its concentric utility pipe. Allowable vertical drift shall be ± 2″ from the installed neutral point along the vertical “y” axis. All fittings shall be stainless steel or galvanized.

2.4 EQUIPMENT BASES

A. General

1. All curbs and roof rails are to be bolted or welded to the building steel or anchored to the concrete deck (minimum thickness shall be 4″) for resisting wind and seismic forces in accordance with the project location. (Fastening to metal deck is unacceptable.)

B. Base Types

1. Type B-1: Integral Structural Steel Base
   WFB, SFB, WSB

   a. Rectangular bases are preferred for all equipment.
   b. Centrifugal refrigeration machines and pump bases may be T or L shaped where space is a problem. Pump bases for split case and end suction pumps shall include supports for suction and discharge elbows.
   c. All perimeter members shall be structural steel beams with a minimum depth equal to 1/12 of the longest dimension between isolators.
   d. Base depth need not exceed 12″ provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer.
   e. Height saving brackets shall be employed in all mounting locations to provide a minimum base clearance of 2.″

2. Type B-2: Concrete Inertia Base
   MPF, WPF, CPF

   a. Vibration isolation manufacturer shall furnish rectangular welded or bolted modular steel concrete pouring forms for floating and inertia foundations.
   b. Bases for split case and end suction pumps shall be large enough to provide for suction and discharge elbows.
   c. Bases shall be a minimum of 1/12 of the longest dimension between isolators but not less than 6.″
   d. The base depth need not exceed 12″ unless specifically recommended by the base manufacturer for mass or rigidity.
   e. Forms shall include a minimum concrete reinforcing consisting of 3/8″ bars welded in place a maximum of 16″ on centers running both ways in a layer 1 to 1½″ above the bottom.
   f. Forms shall be furnished with steel templates to hold the component anchor bolts sleeves and anchors while concrete is being poured.
   g. Height saving brackets shall be employed in all mounting locations to maintain a 2″ minimum operational clearance below the base.

3. Type B-3: Seismic Isolation Curb
   P6200, P6300

   Option: Sound Package 1 & 2 VMC/AB-RPFMA/SRPFMA

   a. Curb-mounted rooftop equipment shown on isolation schedule shall be mounted on structural seismic spring isolation curbs. The upper frame must provide continuous support for the equipment and must be captive

so as to resiliently resist wind and seismic forces. The lower frame must accept point support for both seismic attachment and leveling. The upper frame must be designed with positive fastening provisions (welding or bolting), to anchor the rooftop unit to the curb, which will not violate the National Roofing Contractors Association (NRCA) ratings of the membrane waterproofing. Sheet metal screws are only acceptable if all provisions in Section 1.4, Article B, paragraph 7, Design Seismic Loads, are met. Contact points between the rooftop unit, the curb and the building's structure shall show load path through those locations only.

b. All-directional elastomeric snubber bushings shall be minimum of ¼" thick. Steel springs shall be laterally stable and rest on ¼" thick elastomeric acoustical pads or cups.
c. Hardware must be plated and the springs shall be powder-coated or cadmium-plated.
d. The curb's waterproofing shall be designed to meet all NRCA requirements.
e. All spring locations shall have full spring view access ports with removable waterproof covers and all isolators shall be adjustable, removable and interchangeable.
f. Isolated curbs shall be supplied with a continuous air seal between the upper floating member and the stationary wood nailer.

Option #1 Where sound barrier package is required, curb shall have full size lay in attenuation panels having a minimum STC rating of 60 when combined with the roof deck's rating. Attenuation system shall add a full sound attenuation structural floor to the curb capable of spanning the curb's width and designed for live loads of 20 psf. Panels shall not weigh more than 6 psf. The 4" nominal galvanized panel shall be joined to allow for airtight construction and additionally shall have a support system where the panels are used below an outside condenser section. Panels shall be waterproof for both outdoor and indoor application. The space below the curb panels and the roof deck shall have 4" of insulation Contractor furnished and installed.

Curb wall construction shall utilize the roofer's standard insulation where curbs use the TAS open thermal acoustical screening system. Solid wall curbs shall use 2" of the factory duct liner installed by the curb manufacturer. The entire curb shall have a continuous neoprene elastomeric air seal. Type RPFMA shall use an open return system with the roof return opening set as far as possible from the unit's return opening.

Option # 2 When curb type SRPFMA (Supply Return Plenum Construction) is required, in addition to Option # 1 the walls of the supply section will use 2" sound attenuating panels as well as a continuous inner elastomeric air seal and isolated plenum divider. Both supply and return ducts shall seal directly to curb base floor attenuation panels.

4. Type B-4: Seismic Non-Isolated Curbs
   P6000

   Option: Sound Package VMC-RPFMA/SRPFMA System

   a. Seismic curbs shall have all provisions as Type B-3 curbs with the exception of spring isolation.
   b. System shall be designed for positive anchorage or welding of equipment to supports and welding of supports to the building steel, capable of carrying the design seismic loads.

5. Type B-5: Isolated Equipment Supports
   R7200/R7300

   a. Continuous structural equipment support rails that combine equipment support and isolation mounting into one unitized roof flashed assembly with all features as described for Type B-3.
   b. System shall be designed for positive anchorage or welding of equipment to supports and welding of supports to the building steel, capable of carrying the design seismic loads.

6. Type B-6: Non-Isolated Equipment Supports
   R7000

   a. This shall have the same provisions as Type B-5 without the spring isolation.

7. Type B-7: Computer Room Unit Base
   SFS

   a. Computer Room air conditioning units shall be welded or bolted to welded structural steel stands having a minimum 0.5 "G" certified lateral acceleration capabilities, but no less than the design seismic loads.
   b. Elastomeric isolated stands shall have 1" of adjustment to accommodate floor irregularities and 0.25" of nominal static deflection.
   c. Spring isolated stands shall have 1" of adjustment to accommodate floor irregularities and 2" of nominal static deflection.
   d. Bolting or welding is required to meet seismic criteria.
   e. Stands to have positive fastening provisions for bolting of computer room unit to seismic floor stand and fastening of seismic isolated floor stand to structure, capable of carrying the design seismic loads.

8. Type B-8 AHU / AC unit Structural Base Frames

   a. Where roof mounted Air Conditioning or Air Handling Units are placed

on steel platforms and are incapable of being point loaded or supported, structural frames shall be furnished which will either match the centerline dimensions of the unit's base frame rail or its curb dimensions. The structural frame shall have provisions to be welded or bolted to the unit's base frame and shall be supported on type "B" wind /seismic restrained isolation system.

b. Isolator deflection shall be either 1.5" or 2.5" depending on the tonnage of the roof mounted component as shown in Isolation Table "A". Structural Base Frame shall be type RTSBF as manufactured by The VMC Group.

9. Type B-9: Structural Adapter Curbs

a. Structural Adapter Curbs will be designed to match the replacement unit's curb dimensions to the existing unit's curb dimensions, matching both supply and return air delivery systems of both components or creating a plenum to accommodate airflow of both components.
b. The new adapter curb will be structurally designed to rest on the existing curb only and carry the new unit's load directly to building steel or concrete thru stanchions that are welded or bolted to both within the confines of the existing curb. Additionally, the new roof mounted unit will be welded or bolted to the structural adapter and shall demonstrate load path of all loads from all components into the building structure.
c. Where the installed unit component's height to the unit's electrical disconnect box is in excess of 78", a service platform or other suitable staging shall be utilized.
d. Structural Adapter Curbs shall be Type PSAC-6000 as manufactured by The VMC Group.

10. Type B-10 Structural Isolated Adapter Curbs:

a. Where isolation is required to be incorporated into the adapter curb, isolation and restraining system shall be similar to the requirements highlighted under Base Type B-3. Isolator deflection shall be either 2" or 3" deflection as required by Isolation Table "A". Structural Isolated Adapter Curbs shall be Type PSAC-6200 or PSAC-6300 as manufactured by The VMC Group.

b. Or Approved Equal.

2.5 FLEXIBLE CONNECTORS

A. Type FC-2: Flexible Stainless Steel Hose
SS-FP, SS-FW, SS-PM, SS-WE

1. Flexible stainless steel hose shall have stainless steel braid and carbon steel

fittings. Sizes 3" and larger shall be flanged. Smaller sizes shall have male nipples.

B. Type BC-2 connector shall be braided bronze for Freon connections.

1. Minimum lengths shall be as tabulated:

Flanged		Male Nipples	
3 x 14	10 x 26	½ x 9	1 ½ x 13
4 x 15	12 x 28	¾ x 10	2 x 14
5 x 19	14 x 30	1 x 11	2 ½ x 18
6 x 20	16 x 32	1 ¼ x 12	
8 x 22			

2. Hoses shall be installed on the equipment side of the shut-off valves horizontally and parallel to the equipment shafts wherever possible.

SECTION 3- EXECUTION

3.1 EXAMINATION

A. All areas that will receive components requiring vibration control, seismic or wind load bracing shall be thoroughly examined for deficiencies that will affect their installation or performance. Such deficiencies shall be corrected prior to the installation of any such system.

B. Examine all "rough ins" including anchors and reinforcing prior to placement.

3.2 APPLICATIONS

A. All vibration isolators and seismic, wind restraint systems must be installed in strict accordance with the manufacturer's written instructions and all certified submittal data.

B. Installation of vibration isolators and seismic, wind restraints must not cause any change of position of equipment, piping or ductwork resulting in stresses or misalignment.

C. No rigid connections between equipment and the building structure shall be made that degrades the noise and vibration control system specified herein.

D. The Contractor shall not install any isolated components in a manner that makes rigid connections with the building unless isolation is not specified. "Building" includes, but is not limited to, slabs, beams, columns, studs and walls.

E. Coordinate Work with other trades to avoid rigid contact with the building.

F. Overstressing of the building structure must not occur due to overhead support of equipment. Contractor must submit loads to the Structural Engineer of record for approval. General bracing may occur from flanges of structural beams, upper truss cords in bar joist construction and cast in place inserts or wedge type drill-in concrete anchors.

G. Seismic cable restraints shall be installed slightly slack to avoid short circuiting the isolated suspended equipment or piping.

H. Seismic cable assemblies are installed taut on non-isolated systems. Seismic rigid braces may be used in place of cables on rigidly attached systems.

I. At locations where seismic cable restraints or seismic single arm braces are located, the support rods must be braced when necessary to accept compressive loads. See Table "E."

J. At all locations where seismic cable braces and seismic cable restraints are attached to the pipe clevis, the clevis bolt must be reinforced with pipe clevis cross bolt braces or double inside nuts if required by seismic acceleration levels.

K. Vibration isolation manufacturer shall furnish integral structural steel bases as required. Independent steel rails are not permitted.

L. Air handling equipment and centrifugal fans shall be protected against excessive displacement which results from high air thrust in relation to the equipment weight. Horizontal thrust restraints shall be those described in the Specification when horizontal motion exceeds 3/8."

M. Special and Periodic Inspections for items listed in Section 1.4, Article B shall be conducted and submitted on a timely basis.

3.3 EQUIPMENT INSTALLATION

A. Equipment shall be isolated and/or restrained as per Tables A-E at the end of this section.

B. Place floor mounted equipment on 4" actual height concrete housekeeping pads properly sized and doweled or expansion shielded to the structural deck to meet acceleration criteria (see Section 1.4). Anchor isolators and/or bases to housekeeping pads. Concrete Work is specified under that section of the Bid Documents.

C. Additional Requirements:

1. The minimum operating clearance under all isolated components bases shall be 2."
2. All bases shall be placed in position and supported temporarily by blocks or shims, as appropriate, prior to the installation of the equipment, isolators and restraints.
3. All components shall be installed on blocks to the operating height of the isolators. After the entire installation is complete and under full load including water, the isolators shall be adjusted so that the load is transferred from the blocks to the isolators. Remove all debris from beneath the equipment and verify that there are no short circuits of the isolation. The equipment shall be free to move in all directions, within the limits of the restraints.
4. Ceilings containing diffusers or lighting fixtures must meet seismic requirements by using earthquake clips of other approved means of positive attachment to secure diffuser and fixtures to T-bar structure.
5. All floor or wall-mounted equipment and tanks shall be restrained with Type V restraints.

3.4 PIPING AND DUCTWORK ISOLATION

A. Vibration Isolation of Piping:

1. HVAC Water Piping: All spring type isolation hangers shall be pre-compressed or pre-positioned if isolators are installed prior to fluid charge. If installed afterwards, field pre-compressed isolators can be used. All HVAC piping in the machine room shall be isolated as well as pressurized runs in other locations of the building 6" and larger. Type E hangers shall isolate horizontal pressurized runs in all other locations of the building. Floor supported piping shall rest on Type B isolators. Heat exchangers and expansion tanks are considered part of the piping run. The first 3 isolators from the isolated equipment shall have at least the same static deflection as specified for the mountings under the connected equipment. If piping is connected to equipment located in basements and hangs from ceilings under occupied spaces, the first 3 hangers shall have 0.75" nominal deflection or greater for pipe sizes up to and including 3," 1 3/8" nominal deflection or greater for pipe sizes greater than 3." Where column spacing exceeds 35', isolation hanger deflection shall be 2½" for pipes exceeding 3" diameter. Type L hangers may be substituted for the above where isolation hangers are required.
2. Plumbing Water Lines: Plumbing water lines in the machine room shall only be isolated if connected to isolated equipment. (See Table B.) Isolator type shall be as listed in Article 1, above.
3. Riser Location: All risers shall be supported on Type J or K anchors or guide restraints positively attached to both the riser and structure. Spiders welded to the pipe can substitute for Type K guides using J Type anchors.
4. Gas lines shall not be isolated.
5. Fire protection lines shall not be isolated.

B. Seismic Restraint of Piping:

1. All high hazard and life safety pipe regardless of size such as fire protection mains, gas piping, and piping with an Ip=1.5 shall be seismically restrained or braced. Type V seismic cable restraints or resilient single arm braces shall be used if piping is isolated. Type V seismic cable restraints or Type VI single arm braces may be used on non-isolated piping. There are no exclusions for size or distance in this category.
2. Seismically restrain piping, with an Ip = 1.0, located in boiler rooms, mechanical equipment rooms and refrigeration equipment rooms that is 1¼" I.D. and larger. Type V seismic cable restraints or resilient single arm braces shall be used if piping is isolated. Type V seismic cable restraints or Type VI single arm braces may be used on non-isolated piping.
3. Seismically restrain all other piping 2½" diameter and larger. Type V seismic cable restraints or resilient single arm braces shall be used if piping is isolated. Type VI seismic cable restraints or single arm braces may be used on non-isolated piping.
4. See Table D for maximum seismic bracing distances.
5. Multiple runs of pipe on the same support shall have distance determined by calculation.
6. Rod braces shall be used for all rod lengths as listed in Table E.
7. Clevis hangers shall have braces placed inside of hanger at seismic brace locations.
8. Where thermal expansion is a consideration, guides and anchors may be used as transverse and longitudinal restraints provided they have a capacity equal to or greater than the restraint loads in addition to the loads induced by expansion or contraction.
9. For all gas piping, transverse restraints must be at 20' maximum and longitudinal restraints at 40' maximum spacing.
10. Transverse restraint for one pipe section may also act as longitudinal restraint for a pipe section of the same or smaller size connected perpendicular to it if the restraint is installed within 24" of the centerline of the smaller pipe or combined stresses are within allowable limits at longer distances.
11. Hold down clamps must be used to attach pipe to all trapeze members before applying restraints. Use Type V or VI restraint, if trapeze is smaller than 48" long.
12. Branch lines may not be used to restrain main lines or cross-mains.
13. All fire protection branch lines shall be end tied.
14. Where pipe passes through a fire-rated, seismic gypsum wall, the wall can act as a lateral/transverse brace for pipe sizes up to and including 6," provided fire stopping material is tight to the pipe.
15. Where pipe passes through a seismic block or concrete wall, the wall can act as a lateral/transverse brace.
16. Where horizontal pipe crosses a building's drift expansion joint, allowance shall be part of the design to accommodate differential motion.
17. Vertical pipe rises between floors shall have their differential movement part of the seismic design for building drift.

18. For horizontal passage of all underground utilities through building's foundation wall, all pipes shall pass freely through an oversized opening and waterproofed accordingly to accommodate maximum allowable building drift. (Seismic Restraint Type VIII).

C. Vibration Isolation of Ductwork:

1. All discharge runs for a distance of 50' from the connected equipment shall be isolated from the building structure by means of Type A or Type E isolators. Actual spring deflection shall be a minimum of 0.75".
2. All duct runs having air velocity of 1500 feet per minute (fpm) or more shall be isolated from the building structure by Type E combination spring elastomer hangers or Type A floor spring supports. Spring deflection shall be a minimum of 0.75".

D. Seismic Restraint of Ductwork:

1. Restrain rectangular ductwork with cross sectional area of 6 square feet or larger. Type V seismic cable restraints or Type VI single arm braces shall be used on this duct. Duct that serves a life safety function or carries toxic materials in an "Essential or High Hazard Facility" must be braced with no exceptions regardless of size or distance requirements.
2. Restrain round ducts with diameters of 28" or larger. Type V seismic cable restraints or Type VI single arm braces.
3. Restrain flat oval ducts the same as rectangular ducts of the same nominal size.
4. See Table D for maximum seismic bracing distances.
5. Duct must be reinforced at the restraint locations. Reinforcement shall consist of an additional angle on top of the ductwork that is attached to the support hanger rods. Ductwork is to be attached to both upper angle and lower trapeze. Additional reinforcing is not required if duct sections are mechanically fastened together with frame bolts and positively fastened to the duct support suspension system.
6. A group of ducts may be combined in a larger frame so that the combined weights and dimensions of the ducts are less than or equal to the maximum weight and dimensions of the duct for which bracing details are selected.
7. Walls, including gypsum board non-bearing partitions, which have ducts running through them, may replace a typical transverse brace. Provide channel framing around ducts and solid blocking between the duct and frame.
8. If ducts are supported by angles, channels or struts, ducts shall be fastened to it at seismic brace locations in lieu of duct reinforcement.

EXEMPTIONS

A. <u>EQUIPMENT:</u>

1. Curb-mounted mushroom, exhaust and vent fans with curb area less than nine

square feet are excluded.

2. Floor or curb-mounted equipment weighing less than 400 lbs and not resiliently mounted, where the Importance Factor, Ip = 1.0 and there is no possibility of consequential damage.

3. Equipment weighing less than 20 lbs and distribution systems weighing less than 5 lbs/lineal foot, with an Ip = 1.0 and where flexible connections exist between the component and associated ductwork, piping or conduit.

4. Chain supported lighting fixtures as described in Section 13.6.1 (ASCE 7-05).

B. DUCT (Applies to Ip = 1.0 only)

1. Rectangular, square, and oval air handling ducts less than six square feet in cross sectional area.
2. Round air handling duct less than 28 inches in diameter.
3. Duct runs supported at locations by two rods less than 12 inches in length from the structural support to the structural connection to the ductwork.

C. PIPING

1. All high deformability pipe 3″ or less in diameter suspended by individual hanger rods where Ip = 1.0.
2. High deformability pipe or conduit in Seismic Design Category C, 2″ or less in diameter suspended by individual hanger rods where Ip = 1.5.
3. High deformability pipe in Seismic Design Category D, E or F, 1″ or less in diameter suspended by individual hanger rods where Ip = 1.5.
4. All clevis supported pipe runs installed less than 12″ from the top of the pipe to the underside of the support point and trapeze supported pipe suspended by hanger rods having a distance less than 12″ in length from the underside of the pipe support to the support point of the structure.
5. Piping systems, including their supports, designed and constructed in accordance with ASME B31.
6. Piping systems, including their supports, designed and constructed in accordance with NFPA, provided they meet the force and displacement requirements of Section 13.3.1 and 13.3.2 (ASCE 7-05).

EXEMPTIONS DO NOT APPLY FOR:

A. LIFE SAFETY or HIGH HAZARD COMPONENTS

1. Including gas, fire protection, medical gas, fuel oil and compressed air needed for the continued operation of the facility or whose failure could impair the facility's continued operation, Occupancy Category IV, IBC-2021 as listed in Section 1.3 B regardless of governing code for HVAC, Plumbing, Electrical piping or equipment. *(A partial list is illustrated.)* High Hazard is additionally classified as

any system handling flammable, combustible or toxic material. Typical systems not excluded are additionally listed below.

B. ELECTRICAL

1. Includes critical, standby or emergency power components including conduit (1" nominal diameter and larger) cable tray or bus duct, lighting, panels, communication lines involving 911, etc.

C. PIPING

1. Natural gas, or any piping containing hazardous, flammable, combustible, toxic or corrosive materials. Fire protection standpipe, risers and mains. Fire Sprinkler Branch Lines must be end tied.

D. DUCT

1. Fresh air make up duct connected to emergency system, breeching or as used by the fire department on manual override.

E. EQUIPMENT

1. Previously excluded non-life safety duct mounted systems such as fans, variable air volume boxes, heat exchangers and humidifiers having a weight greater than 75 lbs require independent seismic bracing.

3.5 FIELD QUALITY CONTROL, INSPECTION

A. All Independent Special and Periodic Inspections must be performed and submitted on components as outlined in Section 1.4 B, Article 4. (See also Contractor Responsibility, Section 1.4B, Article 5.) Note: Special Inspection services are to be supplied by the Owner.

B. Upon completion of installation of all vibration isolation devices, the manufacturer's chosen representative shall inspect the completed project and certify in writing to the Contractor that all systems are installed properly, or list any that require correction. The Contractor shall submit a report to the Architect, including the representative's report, certifying correctness of the installation or detailing Corrective Work to be done.

4.1 SELECTION GUIDE FOR VIBRATION ISOLATION AND SEISMIC RESTRAINT

TABLE "A" HVAC EQUIPMENT										
	ON GRADE, BASEMENT OR SLAB ON GRADE						ABOVE GRADE			
EQUIPMENT (See Notes)	Size/Type	Mtg	Isol	Nom Defl*	Base	Restr	Isol	Nom Defl*	Base	Restr
Outdoor Condensing Units/Condensers		Roof	---	---	---	IV	B	2.50 Minimum	B-5	IV
Axial Fans (Inline Type)		Floor	B	0.75	---	IV	B	See Guide	---	IV
		Ceiling	---	---	---	---	E	See Guide	---	V
Centrifugal Fans Arr. 1 & 3	Class 1	Floor	B	0.75	B-1	IV	B	See Guide	B-1	IV
	Class 2 & 3	Floor	B	0.75	B-2	IV	B	See Guide	B-2	IV
Centrif. Fans (Vent Sets) Arr. 9 & 10	Class 1	Floor	B	0.75	---	IV	B	See Guide	See Note 4	IV
	Class 2 & 3	Ceiling	---	---	---	---	E	See Guide	B-2	V
Condensate Pumps		Floor	F	0.20	If req.	IV	F	0.20	If req.	IV
Curb Mtd. Equip. (Non-Isol.)		Roof	---	---	---	IV	---	---	B-6	---
Fan Coil Units		Floor	F	0.20	---	IV	B	0.75	---	IV
		Ceiling	---	---	---	---	E	0.75	---	V
Rooftop AHU/AC *(curb mounted)*	< 10 Ton	Roof	---	---	---	IV	B	1.50	B-3 See Notes 5,6	---
	> 10 Ton	Roof	---	---	---	IV	B	2.50	B-3 See Notes 5,6	---
Rooftop AHU/AC *(dunnage mounted)*	< 10 Ton	Roof	---	---	---	IV	B	1.50	B-8	---
	> 10 Ton	Roof	---	---	---	IV	B	2.50	B-8	---

**See Minimum Deflection Guide for Equipment with Low RPM*

Minimum Deflection Guide for Equipment with Low RPM

Lowest RPM of Rotating Equipment	Minimum Actual Deflection
Less Than 400	3.5"
401 thru 600	2.5"
601 thru 900	1.5"
Greater than 900	0.75"

General Notes for All Tables:

1. Abbreviations:
   (1) Mtg = Mounting
   (2) ol = Vibration Isolator Type per Section 2.2, Vibration Isolation Types
   (3) Defl = Minimum Deflection of Vibration Isolator
   (4) Base = Base Type per Section 2.4, Equipment Bases
   (5) Restr = Seismic Restraint Type per Section 2.3 Seismic Restraint Types
2. All deflections indicated are in inches.
3. For equipment with variable speed driven components having driven operating speed below 600 rpm, select isolation deflection from minimum deflection guide.
4. For roof applications, use base Type B-5.
5. Specification Option #1 called out on equipment schedule in curb Type B-3 shall use sound barrier RPFMA when there is no concrete under rooftop units and this option is selected. Curbs can be used for return plenums. (See Option #1 under curb type B-3.)
6. Specification Option #2, called out on equipment schedule in curb Type B-3 shall be used where curbs require supply and return sound attenuation package type SPFMA shall be used. (See Option #2 under curb type B-3.)
7. Units may not be capable of point support. Refer to separate air handling unit Specification section. If that section does not provide base and external isolation is required, provide Type B-1 base by this section for entire unit.
8. Static deflection shall be determined based on the deflection guide for Table "A."
9. Deflections indicated are minimums at actual load and shall be selected for manufacturer's nominal 5," 4," 3," 2" and 1" deflection spring series; RPM is defined as the lowest operating speed of the equipment.
10. Single stroke compressors may require inertia bases with thicknesses greater than 14" maximum as described for base B-2. Inertia base mass shall be sufficient to maintain double amplitude for 1/8."
11. Floor mounted fans, substitute base Type B-2 for class 2 or 3 or any fan having static pressure over 5."
12. Indoor utility sets with wheel diameters less than 24" need not have deflections greater than .75."
13. Curb-mounted fans with curb area less than 9 square feet are excluded.
14. For equipment with multiple motors, Horsepower classification applies to largest single motor.

4.2 SPACING CHART FOR SUSPENDED COMPONENTS

Table "D" Seismic Bracing (Maximum Allowable Spacing Shown- Actual Spacing to Be Determined by Calculation)			
Equipment	On Center Transverse	On Center Longitudinal	Change Of Direction
Duct			
All Sizes	30 Feet	60 Feet	4 Feet
Pipe Threaded, Welded, Soldered Or Grooved; Conduit and Conduit Racks			
To 16"	40 Feet	80 Feet	4 Feet
18" – 28"	30 Feet	60 Feet	4 Feet
30" – 40"	20 Feet	60 Feet	4 Feet
42" & Larger	10 Feet	30 Feet	4 Feet

4.3 VERTICAL HANGER ROD BRACING SCHEDULE

Table "E" Hanger Rod Bracing Schedule (Stiffener to be maximum 6" from end of rod)					
Rod Dia.	Clamp Size	Maximum Un-braced Rod Length	Steel Angle Size	Clamp Spacing	Min # of Clamps per Stiffener
3/8"	SRBC-1-1/4	19"	1 x 1 x ¼"	16"	2
1/2"	SRBC-1-1/4	25"	1 x 1 x ¼"	20"	2
5/8"	SRBC-1-1/4	31"	1 x 1 x ¼"	24"	2
3/4"	SRBC-1-1/2	37"	1 ½ x 1 ½ x ¼"	28"	2
7/8"	SRBC-1-1/2	43"	1 ½ x 1 ½ x ¼"	33"	2
1"	SRBC-1-1/2	50"	1 ½ x 1 ½ x ¼"	40"	2
1 1/8"	SRBC-1-1/2	62"	1 ½ x 1 ½ x ¼"	50"	2

FORM CQAP
FOR USE GROUP III PROJECTS, IBC-2021,
OCCUPANCY CATEGORY IV PROJECTS, IBC-2021

Section 15071
Vibration Isolation and Seismic Restraints

Contractor Name: _____

Date: _____

Project: _____

Specification Section: _____

Contractor IBC Quality Assurance Seismic Program.

This form is to be filled out as the identifying document for the Contractor's Quality Assurance Program (see Contractor Responsibility section 1.4B article 4) before the first submission in any vendor group by the installing Contractor. All items listed herein shall be part of that program.

1. Acknowledge special requirements contained in the quality assurance plan
2. Acknowledge that control will be exercised to obtain conformance with the construction documents
3. Procedures for exercising control within the Contractor's organization including frequency and distributions of inspections and testing reports
4. Identification and qualification of the persons exercising control of this program within their organization

Contractor to submit this program acknowledging receipt and program implementation. Each of the 4 listed programs are to be submitted including all applicable details as listed above.

_____
Signature

_____
Print Name

FORM CVC-1
FOR USE GROUP III PROJECTS, IBC-2021 &
OCCUPANCY IV PROJECTS, IBC-2021.

Section 15071
Vibration Isolation and Seismic Restraints

Contractor Name: _____

Date: _____

Project: _____

Specification Section: _____

Notes to the installing Contractor

The purpose of this form is for you, the Contractor to fill in all vendors that are IBC compliant as part of your initial submission for any group of equipment, i.e., fans, ac units, pumps, etc. It is acceptable to submit vendors that will be compliant as long as a factory letter is issued stating full compliance will occur at time of shipment. Only IBC compliant vendors can participate on this project. In the event that no vendor in any group is IBC compliant, this information must be submitted to the project's MEP for approval.

Manufacturer	IBC Compliant	
	Yes	No

_____
Signature

_____
Print Name

FORM SQA-1
FOR USE GROUP III PROJECTS, IBC-2021,
OCCUPANCY CATEGORY IV PROJECTS, IBC-2021.

Section 15071
Vibration Isolation and Seismic Restraints
Seismic Quality Assurance Plan for The Installation of Life Safety
And High Hazard Systems (Inspections)

Contractor Name: _____

Date: _____

Project: _____

Specification Section: _____

The following are required for the Seismic Quality Assurance Installation Plan for Life Safety and High Hazard systems to be prepared and submitted by each installing Contractor (see Contractor's Responsibilities paragraph 1.4B, article 5). This plan must reflect all of the provisions and reports outlined in the paragraph below. As part of this Contractor's final requisition, this form must accompany, along with all satisfactorily completed tests and reports, the final payment's request including all applicable certification reports.

- Special field inspection and testing is required by IBC Sections 1704, 1707 and 1708 during the installation of Life Safety and High Hazard System components including equipment, piping and all electrical connections. Components must be inspected by a Building Official or approved independent special inspector periodically during the course of installation. Contractor shall submit such inspection reports as part of his project wrap up for each group of equipment, components so requiring this program. All components, which are Life Safety, designate or Handle Hazardous substances fall into this category. Typical Life Safety and High Hazard components as well as non-life safety components listed in that section are outlined in 1.3 B of the SGMEC® Specifications.

_____
Signature

_____
Print Name

END OF SECTION 15071

SECTION 15077 - 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 1 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 SUBMITTALS

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

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

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

D. Valve numbering scheme.

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

1.4 COORDINATION

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

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

C. Install identifying devices before installing acoustic 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, 1/8 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: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

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

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), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Red.

C. Background Color: Black.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 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 partially cover 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.

2.4 VALVE TAGS

A. 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, Stainless steel, 0.025-inch minimum 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.

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. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels with painted, color-coded bands or rectangles, complying with ASME A13.1, on each piping system.

1. Identification Paint: Use for contrasting background.
2. Stencil Paint: Use for pipe marking.

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

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

C. Pipe Label Color Schedule:

1. Heating Water Piping (HWS & HWR):

a. Background Color: White.
b. Letter Color: Red.

2. Refrigerant Piping:

a. Background Color: Blue.
b. Letter Color: White.

3. Cold Water Make-Up Piping (CW):

a. Background Color: White.
b. Letter Color: Green.

4. Boiler Feed Piping (BF):

a. Background Color: Black.
b. Letter Color: White.

5. Pumped Low-Pressure Steam Condensate Piping (PC):

a. Background Color: Black.
b. Letter Color: White.

6. Low-Pressure Steam Piping (LPS):

a. Background Color: Black.
b. Letter Color: White.

7. Low-Pressure Steam Condensate Piping (LPC):

a. Background Color: Black.
b. Letter Color: Blue.

8. Gas Piping

    a. Background Color: White.
    b. Letter Color: Yellow.

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:

1. Valve-Tag Size and Shape:

    a. Refrigerant: 1-1/2 inches, Diamond.
    b. Hot Water: 1-1/2 inches, square.
    c. Gas: 1-1/2 inches square.

2. Valve-Tag Color:

    a. Refrigerant: Green.
    b. Hot/Chilled Water: Natural.
    c. Gas: Yellow.

3. Letter Color:

    a. Refrigerant: Black.
    b. Hot/Chilled Water: Black.
    c. Gas: White.

3.5 WARNING-TAG INSTALLATION

A. Write the required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 15077

SECTION 15081 - DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, supply and outdoor air.
2. Indoor, return air.
3. Outdoor, exposed supply and return.

B. Related Sections:

1. Division 15 Section "HVAC Piping Insulation."
2. Division 15 Section "Metal Ducts" for duct liners.

1.3 SUBMITTALS

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

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other Work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
3. Detail application of field-applied jackets.
4. Detail application at linkages of control devices.

C. Qualification Data: For qualified Installer.

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

E. 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 Division 15 Section "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. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one of 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.
    f. Or approved equal.

G. 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 FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

    a. CertainTeed Corp.; Commercial Board.
    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.
g. Or approved equal.

H. Mineral-Fiber, Pipe and Tank Insulation: 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.

1. Products: Subject to compliance with requirements, provide one of 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.
f. Or approved equal.

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, provide one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
b. Eagle Bridges - 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.
e. Or approved equal.

2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of

Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

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, provide one of 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.
d. Mon-Eco Industries, Inc.; 22-25.
e. Or approved equal.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

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, provide one of the following:

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
b. Vimasco Corporation; 749.
c. Or approved equal.

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, provide one of 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.
    e. Or approved equal.

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, provide one of 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.
    d. Or approved equal.

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, provide one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
b. Eagle Bridges - 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.
f. Or approved equal.

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.

2.4 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. 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, provide one of 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.
d. Or approved equal.

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, provide one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
b. Eagle Bridges - 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.
e. Or approved equal.

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, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Use sealants that comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

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

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.

b. Or approved equal.

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, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Use sealants that comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

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.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.7 FIELD-APPLIED JACKETS

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

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

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

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

    a. Johns Manville; Zeston.
    b. P.I.C. Plastics, Inc.; FG Series.
    c. Proto Corporation; LoSmoke.
    d. Speedline Corporation; SmokeSafe.
    e. Or approved equal.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: Color as selected by Architect.

D. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with white 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. Polyguard Products, Inc.; Alumaguard 60.
    b. Venture Clad 1577 CW.
    c. Or approved equal.

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, provide one of 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.
    e. Or approved equal.

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, provide one of 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.
    e. Or approved equal.

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, provide one of the following:

a. ABI, Ideal Tape Division; 370 White PVC tape.
b. Compac Corporation; 130.
c. Venture Tape; 1506 CW NS.
d. Or approved equal.

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.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

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

a. ABI, Ideal Tape Division; 488 AWF.
b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
c. Compac Corporation; 120.
d. Venture Tape; 3520 CW.
e. Or approved equal.

2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces' force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.9 SECUREMENTS

A. Bands:

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

a. ITW Insulation Systems; Gerrard Strapping and Seals.
b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.
c. Or approved equal.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304; 0.015-inch-thick, 3/4 inch wide with wing seal or closed seal.
3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated.

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

        1) AGM Industries, Inc.; CWP-1.
        2) GEMCO; CD.
        3) Midwest Fasteners, Inc.; CD.
        4) Nelson Stud Welding; TPA, TPC, and TPS.
        5) Or approved equal.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-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, provide one of 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.
        5) Or approved equal.

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, provide one of the following:

        1) AGM Industries, Inc.; Tactoo Perforated Base Insul-Hangers.
        2) GEMCO; Perforated Base.
        3) Midwest Fasteners, Inc.; Spindle.
        4) Or approved equal.

    b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030-inch-thick by 2 inches square.
    c. Spindle: Stainless 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. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, 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, provide one of the following:

1) AGM Industries, Inc.; RC-150.
2) GEMCO; R-150.
3) Midwest Fasteners, Inc.; WA-150.
4) Nelson Stud Welding; Speed Clips.
5) Or approved equal.

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.

D. Wire: 0.062-inch soft-annealed, stainless steel.

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

a. C & F Wire.

b. Or approved equal.

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 316.

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 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 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.

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 Division 07 Section "Penetration Firestopping "firestopping and fire-resistive joint sealers.

E. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

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 100 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 100 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 glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

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

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

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

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

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.7 FINISHES

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

3.8 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Inspect ductwork, 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 one location for each duct system defined in the "Duct Insulation Schedule, General" Article.

B. 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:

1. Indoor, supply and outdoor air.
2. Indoor, return and exhaust.
3. Outdoor, supply and return.

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

A. Supply-air duct insulation shall be one of the following:
1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density, minimum R-6.
2. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density, minimum R-6.

B. Return-air duct insulation shall be one of the following:

1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density, minimum R-6.
2. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density, minimum R-6.

C. Outdoor-air duct insulation shall be one of the following:

1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density, minimum R-6.

2. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density, minimum R-6.

D. Exhaust-air duct insulation shall be one of the following:

1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density, minimum R-6.
2. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density, minimum R-6.

3.11 ABOVEGROUND, OUTDOOR (OR ATTIC DUCT) AND PLENUM INSULATION SCHEDULE

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

B. Supply-air duct insulation shall be the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density, minimum R-8.

C. Return-air duct insulation shall be the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density, minimum R-8.

D. Outdoor-air duct insulation shall be the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density, minimum R-8.

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. Ducts and Plenums, Concealed:

1. None.

D. Ducts and Plenums, Exposed:

1. PVC, Color- As selected by Architect: 20 mils thick.

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. Ducts and Plenums, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:
   1. VentureClad 1577CW (All Finishes). Contractor shall install as per strict manufacturer's installation instructions, recommendations, and requirements.

D. Ducts and Plenums, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:
   1. VentureClad 1577CW (All Finishes). Contractor shall install as per strict manufacturer's installation instructions, recommendations, and requirements.

END OF SECTION 15081

SECTION 15082 - HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes insulating the following HVAC equipment that is not factory insulated:

1. Heating, hot-water pumps.
2. Expansion/compression tanks.
3. Air separators.
4. Piping system filtration unit housings.

B. Related Sections:

1. Section 15 "Duct Insulation."
2. Section 15 "HVAC Piping Insulation."

1.3 ACTION SUBMITTALS

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

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other Work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail removable insulation at equipment connections.
4. Detail application of field-applied jackets.
5. Detail application at linkages of control devices.
6. Detail field application for each equipment type.
7. Detail paintable surfaces - Critical for exposed areas – Architect to select colors.

C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:

1. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
2. Sheet Form Insulation Materials: 12 inches square.
3. Sheet Jacket Materials: 12 inches square.
4. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

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

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

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

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

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

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 15 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with equipment Installer for equipment insulation application.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

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

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

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Breeching Insulation Schedule" and "Equipment Insulation Schedule" articles for where insulating materials shall be applied.

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

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

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

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

F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

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

a. Aeroflex USA, Inc.

b. Armacell LLC.
c. K-Flex USA.
d. Or approved equal.

G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type II with factory-applied vinyl jacket or Type III with factory-applied FSK or FSP jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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.
d. Or approved equal.

H. High-Temperature, Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type V, without factory-applied jacket.

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.
d. Or approved equal.

I. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. Provide insulation with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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.
d. Or approved equal.

J. High-Temperature, Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type III, without factory-applied jacket.

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.
    d. Or approved equal.

K. 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. Manson Insulation Inc.
    d. Owens Corning.
    e. Or approved equal.

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

L. Mineral-Fiber, Pipe and Tank Insulation: 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.

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.
    d. Or approved equal.

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

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

a. Ramco Insulation, Inc.
b. Or approved equal.

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. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.

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

a. Foster Brand; H. B. Fuller Construction Products.
b. Or approved equal.

C. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

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

a. Childers Brand; H. B. Fuller Construction Products.
b. Falle Bridges.
c. Foster Brand; H. B. Fuller Construction Products.
d. Or approved equal.

D. 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. Aeroflex USA.
b. Armaflex.
c. Foster Brand; H. B. Fuller Construction Products.
d. U-Flex.
e. Or approved equal.

E. ASJ Adhesive, and FSK and PVDC 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.
d. Or approved equal.

F. PVC Jacket Adhesive: Compatible with PVC jacket.

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

a. Childers Brand.
b. Eagle Bridges.
c. Foster Brand.
d. Or approved equal.

2.4 MASTICS

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

B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor 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. Foster Brand; H. B. Fuller Construction Products.
c. Knauf Insulation.
d. Or approved equal.

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

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.
    c. Knauf Insulation.
    d. Or approved equal.

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

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.
    c. Knauf Insulation.
    d. Or approved equal.

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

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.
    c. Knauf Insulation.
    d. Or approved equal.

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

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.
    c. Vimasco Corporation.
    d. Or approved equal.

2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment insulation.
3. Service Temperature Range: 0 to plus 180 deg F.
4. Color: White.

2.6 SEALANTS

A. 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. Foster Brand; H. B. Fuller Construction Products.
    c. Vimsco Corp.
    d. Or approved equal.

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.

B. FSK and Metal Jacket Flashing Sealants:

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

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

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

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.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. PVDC Jacket for Indoor Applications: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

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

        1) ITW Insulation Systems; Illinois Tool Works, Inc.
        2) Or approved equal.

6. PVDC Jacket for Outdoor Applications: 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

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

1) ITW Insulation Systems; Illinois Tool Works, Inc.
2) Or approved equal.

7. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

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

1) ITW Insulation Systems; Illinois Tool Works, Inc.
2) Or approved equal.

8. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. in. for covering equipment.

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

a. Childers Brand; H. B. Fuller Construction Products.
b. Or approved equal.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for equipment.

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

a. Foster Brand; H. B. Fuller Construction Products.
b. Vimasco Corporation.
c. Or approved equal.

2.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..

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

    a. Alpha Associates, Inc.
    b. Or approved equal.

2.10 FIELD-APPLIED JACKETS

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

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

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

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

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

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: Paintable - Color as selected by Architect.
4. Factory-fabricated tank heads and tank side panels.

D. Metal Jacket:

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

    a. ITW Insulation Systems; Illinois Tool Works, Inc.
    b. RPR Products, Inc.
    c. Or approved equal.

2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

    a. Option 1: Sheet and roll stock ready for shop or field sizing.

b. Option 2: Factory cut and rolled to size.
c. Finish and thickness are indicated in field-applied jacket schedules.
d. Moisture Barrier for Indoor Applications: 1-mil- thick, heat-bonded polyethylene and kraft paper.
e. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper or 2.5-mil- thick polysurlyn.
f. Factory-Fabricated Fitting Covers:

1) Same material, finish, and thickness as jacket.
2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
3) Tee covers.
4) Flange and union covers.
5) End caps.
6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

3. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.

a. Option1: Sheet and roll stock ready for shop or field sizing.
b. Option 2: Factory cut and rolled to size.
c. Material, finish, and thickness are indicated in field-applied jacket schedules.
d. Moisture Barrier for Indoor Applications: 1-mil- thick, heat-bonded polyethylene and kraft paper.
e. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper or 2.5-mil- thick polysurlyn.
f. Factory-Fabricated Fitting Covers:

1) Same material, finish, and thickness as jacket.
2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
3) Tee covers.
4) Flange and union covers.
5) End caps.
6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

E. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground

outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with white or stucco-embossed aluminum-foil facing.

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

    a. Polyguard Products, Inc.
    b. Or approved equal.

F. PVDC Jacket for Indoor Applications: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

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

    a. ITW Insulation Systems; Illinois Tool Works, Inc.
    b. Or approved equal.

G. PVDC Jacket for Outdoor Applications: 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

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

    a. ITW Insulation Systems; Illinois Tool Works, Inc.
    b. Or approved equal.

H. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

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

    a. ITW Insulation Systems; Illinois Tool Works, Inc.
    b. Or approved equal.

2.11 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 the following:

    a. Venture Tape.
    b. Or approved equal.

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

    a. Venture Tape.
    b. Or approved equal.

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

    a. Venture Tape.
    b. Or approved equal.

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.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

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

    a. Venture Tape.
    b. Or approved equal.

2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

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

    a. ITW Insulation Systems; Illinois Tool Works, Inc.
    b. Or approved equal.

2. Width: 3 inches.
3. Film Thickness: 4 mils.
4. Adhesive Thickness: 1.5 mils.
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 lbf/inch in width.

F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

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

    a. ITW Insulation Systems; Illinois Tool Works, Inc.
    b. Or approved equal.

2. Width: 3 inches.
3. Film Thickness: 6 mils.
4. Adhesive Thickness: 1.5 mils.
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 lbf/inch in width.

2.12 SECUREMENTS

A. Bands:

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

    a. ITW Insulation Systems; Illinois Tool Works, Inc.
    b. RPR Products, Inc.
    c. Or approved equal.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 3/4 inch wide with wing seal or closed seal.
3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal or closed 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, 0.135-inch- diameter shank, length to suit depth of insulation indicated.

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

        1) AGM Industries, Inc.
        2) Gemco.
        3) Midwest Fasteners, Inc.
        4) Nelson Stud Welding.
        5) Or approved equal.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

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

1) AGM Industries, Inc.
2) CL WARD & Family Inc.
3) Gemco.
4) Midwest Fasteners, Inc.
5) Nelson Stud Welding.
6) Or approved equal.

3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.

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

1) AGM Industries, Inc.
2) Gemco.
3) Midwest Fasteners, Inc.
4) Or approved equal.

b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
c. Spindle: Copper- or zinc-coated, low-carbon steel or Aluminum or Stainless 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.

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

1) Gemco.
2) Midwest Fasteners, Inc.
3) Or approved equal.

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. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.

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

1) AGM Industries, Inc.
2) Gemco.
3) Midwest Fasteners, Inc.
4) Or approved equal.

b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
c. Spindle: Copper- or zinc-coated, low-carbon steel or Aluminum or Stainless steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
d. Adhesive-backed base with a peel-off protective cover.

6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel or aluminum 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) AGM Industries, Inc.
2) Gemco.
3) Midwest Fasteners, Inc.
4) Nelson Stud Welding.
5) Or approved equal.

b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

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

        1) Gemco.
        2) Midwest Fasteners, Inc.
        3) Or approved equal.

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

D. Wire: 0.062-inch soft-annealed, stainless steel.

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

    a. C & F Wire.
    b. Or approved equal.

2.13 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

C. 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 or Type 316.

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 and equipment to be insulated have been tested and are free of defects.

2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

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

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

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

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

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

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment 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.
4. Cover inserts with jacket material matching adjacent insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

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

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

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

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

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

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

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

3.4 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.

C. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch- diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
2. Fabricate boxes from aluminum or stainless steel, at least 0.060 inch thick.
3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.5 FIELD-APPLIED JACKET INSTALLATION

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

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.

3. Completely encapsulate insulation with coating, leaving no exposed insulation.

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

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

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

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

E. Where PVDC jackets are indicated, install as follows:

1. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. 33-1/2-inch-circumference limit allows for 2-inch- overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
2. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.6 FINISHES

A. Equipment Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 09900 "Exterior Painting" and Section 09900 "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. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

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

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

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections: Inspect field-insulated equipment, 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 one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.

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

3.8 EQUIPMENT INSULATION SCHEDULE

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

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

C. Insulation shall comply with ASHRAE 90.1-2013.

D. Heating-hot-water pump insulation shall be one of the following:
1. Mineral-Fiber Board: 2 inches thick and 6-lb/cu. ft. nominal density.

E. Heating-hot-water expansion/compression tank insulation shall be one of the following:
1. Mineral-Fiber Board: 1 inch thick and 6-lb/cu. ft. nominal density.
2. Mineral-Fiber Pipe and Tank: 1 inch thick.

F. Heating-hot-water air-separator insulation shall be one of the following:
1. Mineral-Fiber Board: 2 inches thick and 6-lb/cu. ft. nominal density.

2. Mineral-Fiber Pipe and Tank: 2 inches thick.

G. Piping system filter-housing insulation shall be one of the following:
1. Mineral-Fiber Board: 2 inches thick and 6-lb/cu. ft. nominal density.
2. Mineral-Fiber Pipe and Tank: 2 inches thick.

3.9 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. Equipment, Concealed:

1. None.
2. PVC, Color-Coded by System: 20 mils thick.
3. Painted Aluminum, Smooth or Corrugated or Stucco Embossed: 0.020 inch thick.

D. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:

1. None.
2. PVC, Color-Coded by System: 20 mils thick.
3. Painted Aluminum, Smooth or Corrugated or Stucco Embossed: 0.020 inch thick.

E. Equipment, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:

1. None.
2. Painted Aluminum, Smooth or Stucco Embossed with 1-1/4-Inch- Deep Corrugations or 2-1/2-Inch- Deep Corrugations or 4-by-1-Inch Box Ribs: 0.032 inch thick.

3.10 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. Equipment, Concealed:

1. None.

2. PVC, Color-Coded by System: 30 mils thick.
3. Painted Aluminum, Smooth or Corrugated or Stucco Embossed: 0.032 inch thick.

D. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:

1. Painted Aluminum, Smooth or Corrugated or Stucco Embossed with Z-Shaped Locking Seam: 0.032 inch thick.

E. Equipment, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:

1. Painted Aluminum, Smooth or Stucco Embossed with 1-1/4-Inch- Deep Corrugations or 2-1/2-Inch- Deep Corrugations or 4-by-1-Inch Box Ribs: 0.040 inch thick.

END OF SECTION 15082

SECTION 15088 - 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes insulating the following HVAC piping systems:

1. Refrigerant suction and hot-gas piping, indoors and outdoors.
2. Condensate Drain Piping.
3. Hydronic Piping

1.3 SUBMITTALS

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

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other Work.

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

C. Qualification Data: For qualified Installer.

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

E. 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.

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 Division 15 Section "Hangers and Supports for HVAC Piping and Equipment."

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

1.7 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. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

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

    a. Aeroflex
    b. Armacell
    c. K-flex
    d. Or approved equal.

F. Mineral-Fiber, Preformed Pipe Insulation:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include 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.
f. Or approved equal.

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

2.2 INSULATING CEMENTS

A. Mineral-Fiber 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. Or approved equal.

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. 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 the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
b. Eagle Bridges - 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.
e. Or approved equal.

2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

C. ASJ Adhesive, and FSK and PVDC 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 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.
    d. Mon-Eco Industries, Inc.; 22-25.
    e. Or approved equal.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

D. Flexible Elastomeric and Polyolefin Adhesive: 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 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
    e. Or approved equal.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

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 the following:

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
b. Vimasco Corporation; 749.
c. Or approved equal.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 permat 43-mildry 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 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.
d. Or approved equal.

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. Joint Sealants:

1. Joint Sealants for Cellular-Glass, Phenolic, and Polyisocyanurate Products: Subject to compliance with requirements, available products that may be incorporated into the Work include the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
    b. Eagle Bridges - Marathon Industries; 405.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
    d. Mon-Eco Industries, Inc.; 44-05.
    e. Pittsburgh Corning Corporation; Pittseal 444.
    f. Or approved equal.

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.

    b. Or approved equal.
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, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Use sealants that comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

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.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. PVDC Jacket for Indoor Applications: 4-mil-white PVDC biaxially oriented barrier film with a permeance at 0.02 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

    a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include the following:

        1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

        2) Or approved equal.

6. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.8 FIELD-APPLIED JACKETS

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

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

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

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include the following:

    a. Johns Manville; Zeston.
    b. P.I.C. Plastics, Inc.; FG Series.
    c. Proto Corporation; LoSmoke.
    d. Speedline Corporation; SmokeSafe.
    e. Or approved equal.

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

a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

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; 0.015-inch-thick, 1/2 inch3/4-inch-wide with wing seal.

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

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140

and 300 deg F Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

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

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

3.3 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.

3.4 PENETRATIONS

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

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

3.5 GENERAL PIPE INSULATION INSTALLATION

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

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

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket

flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. 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.

3.6 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

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

B. Insulation Installation on Pipe Flanges:

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

C. Insulation Installation on Pipe Fittings and Elbows:

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

D. Insulation Installation on Valves and Pipe Specialties:

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

3.7 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.

3.8 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.

3.9 INDOOR PIPING INSULATION SCHEDULE

A. Pipe insulation shall meet or exceed ASHRAE 90.1-2013 minimum piping insulation thicknesses.

B. Heating-Hot-Water Supply and Return, 200 Deg F and Below:

1. NPS 1-1/4" and Smaller Pipe Size: Insulation shall be the following:

a. Mineral-Fiber, Preformed Pipe, Type I: 1.5 inch thick.

2. NPS 1-1/2" and Larger Pipe Size: Insulation shall be the following:

a. Mineral-Fiber, Preformed Pipe, Type I: 2.0 inch thick.

C. Refrigerant Suction, Hot-Gas Piping, Liquid, and Condensate Drain:

1. Less than 1" Pipe Size: Insulation shall be the following:

a. Flexible Elastomeric: 3/4" inch thick.

2. 1" and Larger Pipe Size: Insulation shall be the following:

a. Flexible Elastomeric: 1 inch thick.

3.10 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Refrigerant Suction, Hot-Gas Piping, Liquid and Condensate Drain:

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

a. Flexible Elastomeric: 1" inch thick.

2. Provide manufacturer's outdoor finish for weather and UV protection (water-based latex enamel - minimum 2 coats).

3.11 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, Concealed:

1. None.

D. Piping, Exposed:

1. PVC: 20 mils thick.

3.12 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. Piping, Concealed:

1. None.

D. Piping, Exposed:

1. PVC: 30 mils thick

END OF SECTION 15088

SECTION 15110 – 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following general-duty valves:

1. Ball valves.
2. Butterfly valves.
3. Check valves.
4. Gate valves.
5. Globe valves.

B. Related Sections include the following:
1. Section, 15077 “Identification for HVAC Piping & Equipment".
2. Section, 15900 - HVAC Instrumentation & Controls".
3. Piping Sections for specialty valves applicable to those Sections only.

1.3 DEFINITIONS

A. The following are standard abbreviations for valves:

1. CWP: Cold working pressure.
2. EPDM: Ethylene-propylene-diene terpolymer rubber.
3. PTFE: Polytetrafluoroethylene plastic.
4. TFE: Tetrafluoroethylene plastic.

1.4 SUBMITTALS

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

1.5 QUALITY ASSURANCE

A. ASME Compliance: ASME B31.9 for building services piping valves.

B. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.

C. NSF Compliance: NSF 61 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 and globe valves closed to prevent rattling.
4. Set ball valves open to minimize exposure of functional surfaces.
5. Set butterfly valves closed or slightly open.
6. Block check valves in either closed or open position.

B. Use the following precautions during storage:

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

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

2.2 VALVES, GENERAL

A. Refer to Part 3 "Valve Applications" Article for applications of valves.

B. Bronze Valves: NPS 2 and smaller with threaded ends, unless otherwise indicated.

C. Ferrous Valves: NPS 2-1/2 and larger with flanged ends, unless otherwise indicated.

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

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

F. Valve Actuators:

1. Chainwheel: For attachment to valves, of size and mounting height, as indicated in the "Valve Installation" Article in Part 3.
2. Gear Drive: For quarter-turn valves NPS 8 and larger.
3. Handwheel: For valves other than quarter-turn types.
4. Lever Handle: For quarter-turn valves NPS 6 and smaller, except plug valves.

G. Extended Valve Stems: On insulated valves.

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

I. Valve Grooved Ends: AWWA C606.

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

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

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

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

2.3 COPPER-ALLOY BALL VALVES

A. Manufacturers:

1. Copper-Alloy Ball Valves:

a. Hammond Valve.
b. Milwaukee Valve.
c. NIBCO INC.
d. RuB, Inc (Dietrich Associates).
e. Stockham Valves & Fittings.
f. Or approved equal.

B. Copper-Alloy Ball Valves, General: MSS SP-110.

C. Two-Piece, Copper-Alloy Ball Valves: Bronze body with full or regular-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.

2.4 FERROUS-ALLOY BALL VALVES

A. Manufacturers:

1. Hammond Valve.
2. Milwaukee Valve.
3. NIBCO INC.
4. Stockham Valves & Fittings
5. Or approved equal.

B. Ferrous-Alloy Ball Valves, General: MSS SP-72, with flanged ends.

C. Ferrous-Alloy Ball Valves: Class 150 or Class 300, full or regular port.

2.5 HIGH-PERFORMANCE BUTTERFLY VALVES

A. Class 150, Single-Flange, High-Performance Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:

a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
b. Bray Controls; a division of Bray International.
c. Cooper Cameron Valves; a division of Cooper Cameron Corp.
d. Crane Co.; Crane Valve Group; Jenkins Valves.
e. Crane Co.; Crane Valve Group; Stockham Division.
f. DeZurik Water Controls.
g. Hammond Valve.
h. Milwaukee Valve Company.
i. NIBCO INC.
j. Tyco Valves & Controls; a unit of Tyco Flow Control.
k. Or approved equal.

2. Description:

a. Standard: MSS SP-68.
b. CWP Rating: 285 psig at 100 deg. F.

c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: Carbon steel, cast iron, ductile steel, or stainless steel.
e. Seat: Reinforced PTFE or metal.
f. Stem: Stainless steel; offset from plane seat.
g. Disc: Carbon steel.
h. Service: Bidirectional.

2.6 BRONZE CHECK VALVES

A. Manufacturers:

1. Bronze Check Valves:

a. Hammond Valve.
b. Milwaukee Valve.
c. NIBCO INC.
d. Stockham Valves & Fittings.
e. Or approved equal.

B. Bronze Check Valves, General: MSS SP-80.

C. Type 3, Class 125, 150, or 200 as required, Bronze, Swing Check Valves: Bronze body with bronze disc and seat.

D. Type 4, Class 125, 200, or 200 as required, Bronze, Swing Check Valves: Bronze body with nonmetallic disc and bronze seat.

2.7 GRAY-IRON SWING CHECK VALVES

A. Manufacturers:

1. Gray-Iron Swing Check Valves:

a. Hammond Valve.
b. NIBCO INC.
c. Milwaukee Valve.
d. Stockham Valves & Fittings.
e. Or approved equal.

B. Gray-Iron Swing Check Valves, General: MSS SP-71.

C. Type I, Class 125 or 250 as required, gray-iron, swing check valves with metal seats.

D. Type II, Class 125 or 250 as required, gray-iron, swing check valves with composition to metal seats.

2.8 BRONZE GATE VALVES

A. Manufacturers:

1. Bronze Gate Valves:

a. Hammond Valve.
b. NIBCO INC.
c. Milwaukee Valve.
d. Stockham Valves & Fittings.
e. Or approved equal.

B. Bronze Gate Valves, General: MSS SP-80, with ferrous-alloy handwheel.

C. Type 2, Class 150, Bronze Gate Valves: Bronze body with rising stem and bronze solid wedge and union-ring bonnet.

2.9 CAST-IRON GATE VALVES

A. Manufacturers:

1. Cast-Iron Gate Valves:

a. Hammond Valve.
b. NIBCO INC.
c. Milwaukee Valve.
d. Stockham Valves & Fittings.
e. Or approved equal.

B. Cast-Iron Gate Valves, General: MSS SP-70, Type I.

C. Class 125, OS&Y, Bronze-Mounted, Cast-Iron Gate Valves: Cast-iron body with bronze trim, rising stem, and solid-wedge disc.

D. Class 125, OS&Y, All-Iron, Cast-Iron Gate Valves: Cast-iron body with cast-iron trim, rising stem, and solid-wedge disc.

E. Class 250, OS&Y, Bronze-Mounted, Cast-Iron Gate Valves: Cast-iron body with bronze trim, rising stem, and solid-wedge disc.

F. Class 250, OS&Y, All-Iron, Cast-Iron Gate Valves: Cast-iron body with cast-iron trim, rising stem, and solid-wedge disc.

2.10 BRONZE GLOBE VALVES

A. Manufacturers:

1. Bronze Globe Valves:

a. Hammond Valve.
b. NIBCO INC.
c. Milwaukee Valve
d. Stockham Valves & Fittings
e. Or approved equal.

B. Bronze Globe Valves, General: MSS SP-80, with ferrous-alloy handwheel.

C. Type 1, Class 125, 150, or 200 as required, Bronze Globe Valves: Bronze body with bronze disc and union-ring bonnet.

D. Type 2, Class 125, 150, or 200 as required, Bronze Globe Valves: Bronze body with nonmetallic, PTFE or TFE disc and union-ring bonnet.

E. Type 3, Class 125, 150, or 200 as required, Bronze Globe Valves: Bronze body with bronze disc and renewable seat. Include union-ring bonnet.

2.11 CAST-IRON GLOBE VALVES

A. Manufacturers:

1. Cast-Iron Globe Valves:

a. Hammond Valve.
b. NIBCO INC.
c. Milwaukee Valve.
d. Stockham Valves & Fittings.
e. Or approved equal.

B. Cast-Iron Globe Valves, General: MSS SP-85.

C. Type I, Class 125 or 250 as required, Cast-Iron Globe Valves: Gray-iron body with bronze seats.

2.12 CHAINWHEEL ACTUATORS

A. Manufacturers:

1. Babbitt Steam Specialty Co.

2. Roto Hammer Industries, Inc.
3. Or approved equal.

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.

1. Sprocket Rim with Chain Guides: Ductile iron or Cast iron or Aluminum or Bronze, of type and size required for valve. Include zinc coating.
2. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
3. Chain: Hot-dip, galvanized steel of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

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

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

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

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

3.2 VALVE APPLICATIONS

A. Refer to piping Sections for specific valve applications. If valve applications are not indicated, use the following:

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

3. Pump Discharge: Check valves.

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

C. Domestic Water Piping: Use the following types of valves:

1. Ball Valves, NPS 2 and Smaller: Two-piece, 600-psig CWP rating, copper alloy.
2. Ball Valves, NPS 2-1/2 and Larger: Class 150, ferrous alloy.
3. Swing Check Valves, NPS 2 and Smaller: Type 4, Class 125, bronze.
4. Swing Check Valves, NPS 2-1/2 and Larger: Type II, Class 125, gray iron.
5. Gate Valves, NPS 2 and Smaller: Type 2, Class 125, bronze.
6. Gate Valves, NPS 2-1/2 and Larger: Type I, Class 125, OS&Y, bronze-mounted cast iron.
7. Globe Valves, NPS 2 and Smaller: Type 2, Class 125, bronze.
8. Globe Valves, NPS 2-1/2 and Larger: Type I, Class 125, bronze-mounted cast iron.

D. Heating Water Piping: Use the following types of valves:

1. Ball Valves, NPS 2 and Smaller: Two-piece, 600-psig CWP rating, copper alloy.
2. Ball Valves, NPS 2-1/2 and Larger: Class 150, ferrous alloy.
3. Swing Check Valves, NPS 2 and Smaller: Type 4, Class 150, bronze.
4. Butterfly Valves, NPS 3 and Larger. See Part 2 of the Specification for details.
5. Swing Check Valves, NPS 2-1/2 and Larger: Type II, Class 125, gray iron.
6. Gate Valves, NPS 2 and Smaller: Type 2, Class 150, bronze.
7. Gate Valves, NPS 2-1/2 and Larger: Type I, Class 125, OS&Y, bronze-mounted cast iron.
8. Globe Valves, NPS 2 and Smaller: Type 2, Class 150, bronze.
9. Globe Valves, NPS 2-1/2 and Larger: Type I, Class 125, bronze-mounted cast iron.

E. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Solder-joint or threaded ends, except provide valves with threaded ends for heating hot water services.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends.
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.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.3 VALVE INSTALLATION

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

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

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

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

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

F. Install chainwheel operators on valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor elevation.

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

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

3.4 JOINT CONSTRUCTION

A. Refer to Section "Basic Mechanical Materials and Methods" for basic piping joint construction.

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

3.5 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.

END OF SECTION 15110

SECTION 15127 - 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

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

1.3 SUBMITTALS

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

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

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

D. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:

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

a. Trerice, H. O. Co.

b. Or approved equal.

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

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

9. Connector: 3/4 inch, 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.

B. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:

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

    a. Trerice, H. O. Co.
    b. Weiss Instruments, Inc.
    c. Or approved equal.

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

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

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 or CSA.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

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

2.4 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 available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Ernst Flow Industries
    b. Trerice, H. O. Co.
    c. AMETEK, Inc.; U.S. Gauge.
    d. Weiss Instruments, Inc.
    e. Or approved equal.

2. Standard: ASME B40.100.
3. Case: Liquid-filled or Open-front, pressure relief type(s); cast aluminum; 4-1/2-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.

5. Pressure Connection: Brass, with NPS 1/4, 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.

2.5 GAGE ATTACHMENTS

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

B. Valves: Brass ball, 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, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Peterson Equipment Co., Inc.
2. Sisco Manufacturing Company, Inc.
3. Trerice, H. O. Co.
4. Or approved equal.

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, 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 into fluid one-third of pipe diameter and in vertical position in piping tees.

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

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

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

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

G. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

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

I. Install remote-mounted pressure gages on panel.

J. Install valve and snubber in piping for each pressure gage for fluids (except steam).

K. Install test plugs in piping tees.

L. Install flow indicators in piping systems in accessible positions for easy viewing.

M. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.

N. Install flowmeter elements in accessible positions in piping systems.

O. Install wafer-orifice flowmeter elements between pipe flanges.

P. Install differential-pressure-type flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.

Q. Install permanent indicators on walls or brackets in accessible and readable positions.

R. Install connection fittings in accessible locations for attachment to portable indicators.

S. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.

T. 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.
4. Two inlets and two outlets of each hydronic heat exchanger.

U. Install pressure gages in the following locations:

1. Suction and discharge of each secondary pump.

3.2 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each hydronic zone shall be the following:

1. Compact-style, liquid-in-glass type.

B. Thermometers at inlet and outlet of each hydronic boiler shall be the following:

1. Compact-style, liquid-in-glass type.

C. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central systems shall be one of the following:

1. Compact Industrial-style, liquid-in-glass type.

D. Thermometers at inlets and outlets of each hydronic heat exchanger shall be the following:

1. Compact Industrial-style, liquid-in-glass type.

3.3 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Heating, Hot-Water Piping: 0 to 250 deg F.

3.4 PRESSURE-GAGE SCHEDULE

A. Pressure gages at suction and discharge of each pump shall be one of the following:

1. Liquid-filled Open-front, pressure-relief.

3.5 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Heating, Hot-Water Piping: 0 to 100 psi.

END OF SECTION 15127

SECTION 15181 - 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:

1. Hot-water heating piping.
2. Condensate piping.
3. Safety-valve-inlet and -outlet piping.
4. Makeup-water piping

B. Related Sections include the following:

1. Division 15 Section "Hydronic Pumps" for pumps, motors, and accessories for hydronic piping.

1.3 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:
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.

1.4 SUBMITTALS

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

1. Fittings.

2. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
3. Air control devices.
4. Chemical treatment.
5. Hydronic specialties.

B. Shop Drawings: Detail, at 1/4 scale, the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

C. Welding certificates.

D. Qualification Data: For Installer.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For air control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

G. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installers of Pressure-Sealed Joints: Installers shall be certified by the pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

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

C. Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

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.

D. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. 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 01.

1.6 EXTRA MATERIALS

A. Water-Treatment Chemicals: Furnish enough chemicals for initial system startup and for preventive maintenance for one year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L (aboveground.

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K (belowground and within slabs.

C. Wrought-Copper Unions: ASME B16.22.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3 "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3 "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3 "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes' spot faced as indicated in Part 3 "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.3 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. 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 Company.
    b. Central Plastics Company.
    c. Hart Industries International, Inc.
    d. Jomar International Ltd.
    e. Matco-Norca, Inc.
    f. McDonald, A. Y. Mfg. Co.
    g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
    h. Wilkins; a Zurn company.
    i. Or approved equal.

2. Description:
    a. Standard: ASSE 1079.
    b. Factory-fabricated, bolted, companion-flange assembly.
    c. Pressure Rating: 125 psig minimum at 250 deg F.
    d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and 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 Company.
    b. Central Plastics Company.
    c. Matco-Norca, Inc.
    d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
    e. Wilkins; a Zurn company.
    f. Or approved equal.

2. Description:

    a. Standard: ASSE 1079.
    b. Factory-fabricated, bolted, companion-flange assembly.

c. Pressure Rating: 125 psig minimum at 250 deg F
d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

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

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

2. Description:

a. Nonconducting materials for field assembly of companion flanges.
b. Pressure Rating: 150 psig.
c. Gasket: Neoprene or phenolic.
d. Bolt Sleeves: Phenolic or polyethylene.
e. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

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

a. Elster Perfection.
b. Grinnell Mechanical Products.
c. Matco-Norca, Inc.
d. Precision Plumbing Products, Inc.
e. Or approved equal.

2. Description:

a. Standard: IAPMO PS 66
b. Electroplated steel nipple, complying with ASTM F 1545.
c. Pressure Rating: 300 psigat 225 deg F.
d. End Connections: Male threaded or grooved.
e. Lining: Inert and noncorrosive, propylene.

2.4 VALVES

A. Gate, Check, Ball, and Butterfly Valves: Comply with requirements specified in Division 15 Section "General-Duty Valves for HVAC Piping."

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Division 15 Section "Instrumentation and Control for HVAC."

C. Bronze, Calibrated-Orifice, Balancing Valves:

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

    a. Armstrong Pumps, Inc.
    b. Bell & Gossett Domestic Pump; a division of ITT Industries.
    c. Flow Design Inc.
    d. Gerand Engineering Co.
    e. Griswold Controls.
    f. Taco.
    g. Or approved equal.

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, provide products by one of the following:

    a. Armstrong Pumps, Inc.
    b. Bell & Gossett Domestic Pump; a division of ITT Industries.
    c. Flow Design Inc.
    d. Gerand Engineering Co.
    e. Griswold Controls.
    f. Taco.
    g. Tour & Andersson; available through Victaulic Company.
    h. Or approved equal.

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:

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

    a. Amtrol, Inc.
    b. Armstrong Pumps, Inc.
    c. Bell & Gossett Domestic Pump; a division of ITT Industries.
    d. Conbraco Industries, Inc.
    e. Spence Engineering Company, Inc.
    f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
    g. Or approved equal.

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 steel, 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 pressure and capacity factory set and field adjustable.

F. Diaphragm-Operated Safety Valves:

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

    a. Amtrol, Inc.
    b. Armstrong Pumps, Inc.
    c. Bell & Gossett Domestic Pump; a division of ITT Industries.

d. Conbraco Industries, Inc.
e. Spence Engineering Company, Inc.
f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
g. Or approved equal.

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.

G. Automatic Flow-Control Valves:

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

a. Flow Design Inc.
b. Griswold Controls.
c. Or approved equal.

2. Body: Brass or ferrous metal.
3. Piston and Spring Assembly: Stainless steel, tamper proof, self cleaning, and removable.
4. Combination Assemblies: Include bonze or brass-alloy ball valve.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.
8. Minimum CWP Rating: 175 psig.
9. Maximum Operating Temperature: 250 deg F

2.5 AIR CONTROL DEVICES

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

1. Amtrol, Inc.
2. Armstrong Pumps, Inc.

3. Bell & Gossett Domestic Pump; a division of ITT Industries.
4. Taco.
5. Or approved equal.

B. Manual Air Vents:

1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/8.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 225 deg F.

C. Automatic Air Vents:

1. Body: Bronze or cast iron.
2. Internal Parts: Nonferrous.
3. Operator: Noncorrosive metal float.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/4.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 240 deg F.

D. Expansion Tanks:
1. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature, with taps in bottom of tank for tank fitting and taps in end of tank for gage glass. Tanks shall be factory tested with taps fabricated and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Air-Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless-steel ball check, 100-gal. unit only; sized for compression-tank diameter. Provide tank fittings for 125-psig working pressure and 250 deg F maximum operating temperature.
3. Tank Drain Fitting: Brass body, nonferrous internal parts; 125-psig working pressure and 240 deg F maximum operating temperature; constructed to admit air to compression tank, drain water, and close off system.

E. Bladder-Type Expansion Tanks:
1. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Factory test with taps fabricated and supports installed and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.

3. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

F. Tangential-Type Air Separators:
1. Tank: Welded steel; ASME constructed and labeled for 125-psig minimum working pressure and 375 deg F maximum operating temperature.
2. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
3. Tangential Inlet and Outlet Connections: Threaded for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger.
4. Blowdown Connection: Threaded.
5. Size: Match system flow capacity.

G. In-Line Air Separators:
1. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
2. Maximum Working Pressure: Up to 175 psig.
3. Maximum Operating Temperature: Up to 300 deg F.

H. Air Purgers:
1. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
2. Maximum Working Pressure: 150 psig.
3. Maximum Operating Temperature: 250 deg F.

2.6 CHEMICAL TREATMENT

A. Bypass Chemical Feeder: 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.

B. Ethylene and Propylene Glycol: Industrial grade with corrosion inhibitors and environmental-stabilizer additives for mixing with water in systems indicated to contain antifreeze or glycol solutions.

2.7 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 2-1/2and larger.

3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

B. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2and smaller; flanged ends for NPS 2-1/2and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

C. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: 40 mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
4. CWP Rating: 750 psig.

D. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

E. Expansion fittings are specified in Division 15 Section "Expansion Fittings and Loops for HVAC Piping."

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water heating-water piping aboveground, NPS 2 and smaller, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered, brazed.
2. Schedule 40 steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

B. Hot-water heating-water piping, aboveground, NPS 2-1/2 and larger, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
2. Type L, drawn-temper copper tubing, wrought-copper fittings, and pressure-seal joints.
3. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints. Type ERW piping shall not be accepted.

C. Hot-water heating-water piping, installed belowground and within slabs:

1. Type K, annealed-temper copper tubing, wrought-copper fittings, and brazed joints. Use the fewest possible joints.

D. Makeup-water piping installed aboveground shall be the following:
1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
2. Type L, drawn-temper copper tubing, wrought-copper fittings.

E. Condensate-Drain Piping: Type M, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

F. Air-Vent Piping:
1. Inlet: Same as service where installed.
2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

G. 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.

3.2 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains, and at supply connection to each piece of equipment.

B. Install throttling-duty valves at each branch connection to return main.

C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; and 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.

3.3 PIPING INSTALLATIONS

A. 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 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 3/4ball valve, and short NPS 3/4threaded 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 Division 15 Section "General-Duty Valves for HVAC Piping."

P. Install unions in piping, NPS 2and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

Q. Install flanges in piping, NPS 2-1/2and larger, at final connections of equipment and elsewhere as indicated.

R. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4nipple and ball valve in blowdown connection of strainers NPS 2and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

S. Install expansion loops, expansion joints, anchors, and pipe alignment guides as specified in Division 15 Section "Expansion Fittings and Loops for HVAC Piping."

T. Identify piping as specified in Division 15 Section "Identification for HVAC Piping and Equipment."

U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 15 Section "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 Division 15 Section "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 Division 15 Section "Escutcheons for HVAC Piping."

X. Fire caulk/smoke seal all piping penetrations of walls, ceilings, and floors as required by Division 7 Section “Penetration Firestopping.”

3.4 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Division 15 Section "Hangers and Supports for HVAC Piping and Equipment." Comply with the following requirements for maximum spacing of supports.

B. Seismic restraints are specified in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

C. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.

4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

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

1. NPS 3/4: Maximum span, 7 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 7 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
4. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
5. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.
6. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8 inch.
7. NPS 4: Maximum span, 14 feet; minimum rod size, 1/2 inch.
8. NPS 6: Maximum span, 17 feet; minimum rod size, 1/2 inch.
9. NPS 8: Maximum span, 19 feet; minimum rod size, 5/8 inch.

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 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
4. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
5. NPS 2-1/2: Maximum span, 9feet; minimum rod size, 3/8 inch.
6. NPS 3: Maximum span, 10feet; 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. Join pipe and fittings according to the following requirements and Division 15 Sections specifying piping systems.

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

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

D. Copper tubing shall be cut square to permit proper joining with fittings.

E. 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.

F. 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.

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 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.

H. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

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

J. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Insure that sealing elements and grip rings (2-1/2” to 4”) are in place and free from damage. The tubing shall be fully inserted into the fitting and the tubing marked at the shoulder of the fitting. Leave insertion marks on pipe after assembly.

3.6 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. Manual vents at heat-transfer coils and elsewhere as required for air venting.

3.7 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 according to Division 15 Section "Meters and Gages for HVAC Piping."

3.8 CHEMICAL TREATMENT

A. Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics:

1. pH: 9.0 to 10.5.
2. "P" Alkalinity: 100 to 500 ppm.
3. Boron: 100 to 200 ppm.
4. Chemical Oxygen Demand: Maximum 100 ppm. Modify this value if closed system contains glycol.
5. Corrosion Inhibitor:

    a. Sodium Nitrate: 1000 to 1500 ppm.
    b. Molybdate: 200 to 300 ppm.
    c. Chromate: 200 to 300 ppm.
    d. Sodium Nitrate Plus Molybdate: 100 to 200 ppm each.
    e. Chromate Plus Molybdate: 50 to 100 ppm each.

6. Soluble Copper: Maximum 0.20 ppm.
7. Tolyiriazole Copper and Yellow Metal Corrosion Inhibitor: Minimum 10 ppm.
8. Total Suspended Solids: Maximum 10 ppm.

9. Ammonia: Maximum 20 ppm.
10. Free Caustic Alkalinity: Maximum 20 ppm.
11. Microbiological Limits:

    a. Total Aerobic Plate Count: Maximum 1000 organisms/ml.
    b. Total Anaerobic Plate Count: Maximum 100 organisms/ml.
    c. Nitrate Reducers: 100 organisms/ml.

B. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.

C. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

3.9 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate 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 "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.
7. If pressure sealed fittings are used the system shall be tested per fitting manufacturers requirements.

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 15181

SECTION 15183 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 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 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. Hot-gas bypass valves.
4. Filter dryers.
5. Strainers.
6. 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. Shop Drawing Scale: 1/4 inch equals 1 foot.
2. 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.

C. Welding certificates.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.5 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."

D. Install all refrigerant piping in strict accordance with manufacturer recommendation. Contractor shall engage the VRF manufacturer and finalize the piping layout and all fitting requirement of refrigerant piping prior to installation. Contractor shall engage manufacturer representative to inspect the refrigerant piping installation and install all refrigerant piping, fitting and all associated accessories in strict accordance with VRF manufacturer recommendation.

1.6 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.

1.7 COORDINATION

A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 88, Type L or 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. Brazing Filler Metals: AWS A5.8.

F. 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. Diaphragm Packless Valves:

1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
3. Operator: Rising stem and hand wheel.
4. Seat: Nylon.
5. End Connections: Socket, union, or flanged.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

B. Packed-Angle Valves:

1. Body and Bonnet: Forged brass or cast bronze.
2. Packing: Molded stem, back seating, and replaceable under pressure.
3. Operator: Rising stem.
4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 275 deg F.

C. 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.

D. 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.

E. 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, and 24-V ac coil.
6. Working Pressure Rating: 400 psig.
7. Maximum Operating Temperature: 240 deg F.
8. Manual operator.

F. 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.

G. 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. Suction Temperature: 42 deg F.
6. Superheat: Adjustable.
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.
9. Working Pressure Rating: 450 psig.

H. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.

1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
5. Seat: Polytetrafluoroethylene.
6. Equalizer: Internal.
7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24-V ac coil.
8. End Connections: Socket.
9. Set Pressure: as required
10. Throttling Range: Maximum 5 psig.
11. Working Pressure Rating: 500 psig.
12. Maximum Operating Temperature: 240 deg F.

I. 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.

J. 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.

K. 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.

L. 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 alumina.
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. Rated Flow: See Plan Schedules.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 240 deg F.

M. Mufflers:

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or flare.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

N. Receivers: Comply with ARI 495.

1. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
2. Comply with UL 207; listed and labeled by an NRTL.
3. Body: Welded steel with corrosion-resistant coating.
4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
5. End Connections: Socket or threaded.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

O. Liquid Accumulators: Comply with ARI 495.

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 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:

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

1. Atofina Chemicals, Inc.
2. DuPont Company; Fluorochemicals Div.
3. Honeywell, Inc.; Genetron Refrigerants.
4. INEOS Fluor Americas LLC.
5. Or approved equal.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction, Hot-Gas, and Liquid Lines for Conventional Air-Conditioning Applications: Copper, Type ACR or Type L (B), drawn-temper tubing and wrought-copper fittings with brazed joints.

B. Safety-Relief-Valve Discharge Piping: Copper, Type ACR or Type L (B) drawn-temper tubing and wrought-copper fittings with brazed joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install diaphragm packless valves on inlet and outlet side of filter dryers.

E. Install a full-sized, three-valve bypass around filter dryers.

F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

G. 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.

H. 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.

I. 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.

J. 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. Hot-gas bypass valves.
4. Compressor.

K. Install filter dryers in liquid line between compressor and thermostatic expansion valve.

L. Install receivers sized to accommodate pump-down charge.

M. 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 were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

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

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

E. 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 Division 15 Sections " HVAC Instrumentation and Control " and "Sequence of Operations" 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. Install access doors or panels as specified in Division 8 Section "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

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 hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

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. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:

1. Shot blast the interior of piping.
2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.

3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
4. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.

R. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

S. Identify refrigerant piping and valves according to Division 15 Section "Identification for HVAC Piping and Equipment."

T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 15 Section "Sleeves and Sleeve Seals for HVAC Piping."

U. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 15 Section "Sleeves and Sleeve Seals for HVAC Piping."

V. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 15 Section "Escutcheons for HVAC Piping."

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. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

E. 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.

F. Threaded Joints: Thread steel 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. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.

H. Welded Joints: Construct joints according to AWS D10.12/D10.12M.

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

3.5 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Division 15 Section "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 multi-floor 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.
    e. Install all refrigerant piping in strict accordance with manufacturer recommendation. Contractor shall engage the VRF manufacturer and finalize the piping layout and all fitting requirement of refrigerant piping prior to installation. Contractor shall engage manufacturer representative to inspect the refrigerant piping installation and install all refrigerant piping, fitting and all associated accessories in strict accordance with VRF manufacturer recommendation.

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 or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 15183

SECTION 15185 - 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.

B. Related Sections include the following:

1. Division 01 Section “Construction Waste Management”.

1.2 SUMMARY

A. Section Includes:

1. Close-coupled, in-line centrifugal pumps.
2. Automatic condensate pump units.

1.3 DEFINITIONS

A. Buna-N: Nitrile rubber.

B. EPT: Ethylene propylene terpolymer.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of pump. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.

B. Shop Drawings: For each pump.

1. Show pump layout and connections.
2. Include setting Drawings with templates for installing foundation and anchor bolts and other anchorages.
3. Include diagrams for power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

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

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Mechanical Seals: One mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.1 IN-LINE CENTRIFUGAL PUMPS

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

1. Armstrong Pumps Inc.
2. Bell & Gossett.
3. Grundfos Pumps Corporation.
4. TACO Incorporated.
5. Or approved equal.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump with integrated intelligent controls; designed for installation with pump and motor shafts mounted vertically.

C. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, replaceable bronze wear rings, and threaded companion-flange connections.
2. Impeller: To ASTM A743 CF8M, Stainless Steel Type 316, fully enclosed and dynamically balanced to ANSI G6.3 and fitted to shaft with key. Use two-plane balancing when installed impeller diameter is less than 6 times impeller width. Pump Shaft: Stainless steel.
3. 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 shaft between motor and seal.

4. 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.
5. Pump Bearings: Permanently lubricated ball bearings.

D. Motor: Single speed and rigidly mounted to pump casing.

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 Division 15 Section "Common Motor Requirements for HVAC Equipment."

a. Enclosure: Open, dripproof.
b. Enclosure Materials: Cast iron Cast aluminum.
c. Motor Bearings: Permanently lubricated ball bearings.
d. Unusual Service Conditions:

1) Ambient Temperature: 60 F.
2) Altitude: 0 above sea level.
3) High humidity.

e. Efficiency: Premium efficient.
f. Service Factor: 1.2.

E. Capacities and Characteristics: See Plan Schedules.

2.2 AUTOMATIC CONDENSATE PUMP UNITS

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

1. Beckett Corporation.
2. Hartell Pumps Div.; Milton Roy Co.
3. Little Giant Pump Co.
4. Mepco, LLC.
5. Or approved equal.

B. Description: Packaged units with corrosion-resistant pump, plastic tank with cover, and automatic controls. Include factory- or field-installed check valve and a 72-inch-minimum, electrical power cord with plug (Plug is for non-plenum applications only. For plenum applications such as a ceiling space, pump must be hard-wired. See Specification below).

C. For condensate pumps located inside air handling units and plenums (ceiling spaces), the pumps shall be plenum-rated meeting the requirements of UL 2043 and labeled "For Plenum Applications." Pumps shall be designed for hard-wire installation only (no plug cord). Pump model shall be similar to Little Giant VCC-20-P Series. The VCC-20-P is constructed with plastics that have been tested by Underwriter's Laboratories' to UL Standard 2043 "Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air Handling Spaces."

D. Capacities and Characteristics: See Plan Schedules.

2.3 PUMP SPECIALTY FITTINGS

A. Suction Diffuser:

1. Angle pattern.
2. 175-psig pressure rating, cast ductile-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.

B. Triple-Duty Valve:

1. Angle or straight pattern.
2. 175-psig pressure rating, cast ductile-iron body, pump-discharge fitting.
3. Drain plug and bronze-fitted shutoff, balancing, and check valve features.
4. Brass gage ports with integral check valve and orifice for flow measurement.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

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

3.2 PUMP INSTALLATION

A. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

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

C. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

D. Equipment Mounting: Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases specified in Division 03 Section "Cast-in-Place Concrete Miscellaneous Cast-in-Place Concrete."

1. Coordinate sizes and locations of concrete bases with actual equipment provided.
2. Construct bases to withstand, without damage to equipment, seismic force required by code.
3. Construct concrete bases 4 inches high and extend base not less than 6 inches in all directions beyond the maximum dimensions of base-mounted pumps unless otherwise indicated or unless required for seismic-anchor support.
4. Minimum Compressive Strength: 4000 psi at 28 days.

E. Equipment Mounting: Install base-mounted pumps on cast-in-place concrete equipment base(s) using elastomeric pads elastomeric mounts. Comply with requirements for equipment bases specified in Division 03 Section "Cast-in-Place Concrete Miscellaneous Cast-in-Place Concrete." Comply with requirements for vibration isolation devices specified in Division 16 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: 1/4 inch.
2. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.
3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of concrete base.
4. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
5. Place and secure anchorage devices. Use setting Drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
6. Install anchor bolts to elevations required for proper attachment to supported equipment.
7. Install on 4-inch high concrete base designed to withstand, without damage to equipment, seismic force required by code.

F. Equipment Mounting: Install base-mounted pumps using elastomeric pads. Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: 1/4 inch.

G. 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 seismic-restraint devices specified in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
2. Comply with requirements for hangers and supports specified in Division 15 Section "Hangers and Supports for HVAC Piping and Equipment."

3.3 CONNECTIONS

A. Where installing piping adjacent to pump, allow space for service and maintenance.

B. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

C. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

D. Install triple-duty valve on discharge side of pumps.

E. Install Y-type strainer and shutoff valve on suction side of pumps.

F. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

G. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping, or install single gage with multiple-input selector valve.

H. Install check valve and gate or ball valve on each condensate pump unit discharge.

I. Ground equipment according to Division 16 Section "Grounding and Bonding for Electrical Systems."

J. Connect wiring according to Division 16 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping.
4. Perform the following startup checks for each pump before starting:

    a. Verify bearing lubrication.
    b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
    c. Verify that pump is rotating in the correct direction.

5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
6. Start motor.
7. Open discharge valve slowly.

3.5 DEMONSTRATION

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

B. The Contractor shall provide general HVAC system training of 40 hours which shall include operating instruction, and review of wiring and control diagram showing complete layout of each system. Contractor shall engage a factory certified technician and ATC vendor to assist during training.

END OF SECTION 15185

SECTION 15189 - HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes water-treatment systems for the following:

1. Heating, hot-water piping (closed-loop system).
2. Closed circulating water system related to HVAC.
3. Heating and condensate piping.
4. Steam and condensate piping for humidifiers (open systems).

B. Related Sections include the following:

1. Section "Water Softeners" for water treatment in hydronic and steam and condensate piping.

1.3 CHEMICAL FEED SYSTEM DESCRIPTION

A. Closed-Loop System: One bypass feeder on each system with isolating and drain valves downstream from circulating pumps, unless otherwise indicated.

1. Introduce chemical treatment through bypass feeder when required or indicated by test.

B. Open-Loop Systems for Humidifiers: Drip feeders or Polypropylene mesh bags or PVC tubing with hole to feed chemical.

1. Conductivity controller samples sump water when activated by pump and operates solenoid bleed-off valve in line to drain.

1.4 PERFORMANCE REQUIREMENTS

A. Maintain water quality for HVAC systems that controls corrosion and build-up of scale and biological growth for maximum efficiency of installed equipment without posing a hazard to operating personnel or the environment.

B. Base chemical treatment performance requirements on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

1. Closed System: Maintain system essentially free of scale, corrosion, and fouling to sustain the following water characteristics:

a. pH: 8 to 9.

2. Small, Open Systems for Humidifiers, Air Washers, Evaporative Condensers, and Cooling Towers: Maintain system essentially free of scale, total suspended solids, and fouling to sustain the following water characteristics:

a. pH: 8 to 9

1.5 SUBMITTALS

A. Product Data: Include rated capacities; water-pressure drops; shipping, installed, and operating weights; and furnished products listed below:

1. Pumps.
2. Control equipment and devices.
3. Test equipment.
4. Filters.

B. Shop Drawings: Detail equipment assemblies indicating dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Detail power and control wiring and differentiate between manufacturer-installed and field-installed wiring.

C. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

E. Maintenance Data: For pumps, agitators, filters, system controls, and accessories to include in maintenance manuals specified in Division 1.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who is an authorized representative of the chemical treatment manufacturer for both installation and maintenance of chemical treatment equipment required for this Project.

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.

1.7 MAINTENANCE

A. Scope of Service: Provide chemicals and service program for maintaining optimum conditions in the circulating water for inhibiting corrosion, scale, and organic growths in the following:

1. Heating hot-water piping.
2. Steam and condensate system for humidifier applications.
3. Equipment.

B. Services and chemicals shall be provided for a period of one year from date of Substantial Completion, including the following:

1. Initial water analysis and recommendations.
2. Startup assistance.
3. Periodic field service and consultation.
4. Customer report charts and log sheets.
5. Laboratory technical assistance.
6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

1.8 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. Chemicals: Furnish quantity equal to 50% percent of amount initially installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. HVAC Water-Treatment Products:

a. Aqua-Chem, Inc.; Cleaver-Brooks Div.
b. Neptune Chemical Pump Company, Inc.
c. Trane Boland Services; Water Treatment.
d. Or approved equal.

2.2 BYPASS FILTER FEEDER

A. Manufacturer & Model: Neptune FTF-5HP with 5-micron filter and leg set or approved equal.

B. Provide bypass filter feeder(s) with a capacity of 5-gallons for each:

1. Hot water heating system.
2. Closed circulating water system related to HVAC.

C. The feeder shell shall be constructed of 10-gauge steel minimum for 5-gallon and larger units. Tank heads shall be minimum 9-gauge steel for 5-gallon units. The bypass feeder shall be rated at 300 psi and to 200 degrees F.

D. The tank shall have a wide mouth, 3-1/2” opening so that chemical addition can be performed without the need of a funnel. The bypass feeder shall have a continuous threaded closure requiring 2-1/2 turns to close and seal. Closures using partial threads or lugs shall not be considered. Closures rated less than 300 psi shall not be considered equal.

E. The cap shall be constructed of cast iron with an epoxy-coated underside to prevent corrosion and shall use a square ring gasket seal. The ring gasket shall not be glued or restrained from movement. Closures using “o” rings or gaskets, which are glued or restrained from free movement by snap rings, shall not be considered equal.

F. Required Accessories:

1. Legs – The bypass feeder shall be provided with legs to elevate the feeder off the floor. The legs shall have holes to allow mounting by anchor bolts.

2. Filter (provide one of the two filter accessories):

    a. Bag Filter – The bypass feeder shall be provided with a 5-micron filter bag fully supported by a stainless-steel filter basket for simultaneous side stream filtering.
    b. Cartridge Filter – The bypass feeder shall be provided with a 5-micron cartridge filter for simultaneous side stream filtering.

2.3 CHEMICAL FEEDING EQUIPMENT

A. Drip Feeders: Plastic reservoir with capillary tubing probe, weight, charging syringe, and clip.

B. Positive-Displacement Diaphragm Pump (for normal operating pressures): Simplex, self-priming, rated for intended chemical with 25 percent safety factor for design pressure and temperature.

1. Adjustable flow rate.
2. Thermoplastic construction.
3. Fully enclosed, continuous-duty, 120-V, 60-Hz, single-phase motor. Comply with requirements in Section “Motors.”
4. Built-in relief valve.

C. Positive-Displacement Piston Pump (for higher operating pressures): Metal and thermoplastic construction.

1. Fully enclosed, continuous-duty, 120-V, 60-Hz, single-phase motor. Comply with requirements in Section “Motors.”
2. Built-in relief valve.

D. Chemical Solution Tanks: Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with graduated markings.

1. Molded fiberglass cover with recess for mounting pump, agitator, and liquid-level switch.
2. Capacity: 30 gal. or 50 gal.

E. Agitator: Direct drive, 1750 rpm, mounted on tank with angle adjustment.

1. Fully enclosed, continuous-duty, 120-V, 60-Hz, single-phase motor. Comply with requirements in Section “Motors.”
2. Stainless-steel clamp and motor mount, with stainless-steel shaft and propeller.

F. Liquid-Level Switch: Polypropylene housing, integrally mounted PVC air trap, receptacles for connection to metering pump, and low-level alarm.

G. Packaged Conductivity Controller: Solid-state circuitry, 5 percent accuracy, linear dial adjustment, built-in calibration switch, on-off switch and light, control-function light, output to control circuit, and recorder.

H. Cold-Water Meter: Positive-displacement type with sealed, tamperproof magnetic drive; impulse contact register; single-pole, double-throw, dry-contact switch.

1. Rotating-disc (for small units) or Turbine (for larger units) type with bronze or cast-iron body rated for 125 psig.
2. Magnetic-drive or mechanical-impulse contactor matched to signal receiver.
3. At least six-digit totalizers.
4. 120-V ac.

I. Solenoid Valves: Forged-brass body, globe pattern, and general-purpose solenoid enclosure with 120-V, continuous-duty coil.

J. Electronic Timers: 150-second and 5-minute ranges, with infinite adjustment over full range, and mounted in cabinet with hand-off-auto switches and status lights.

K. Chemical Tubing: Schedule 40, PVC with solvent-cement joints; or polypropylene tubing with heat fusion.

L. Plastic Ball Valves: Rigid PVC or CPVC body, integral union ends, and polytetrafluoroethylene seats and seals.

M. Plastic-Body Strainer: Rigid PVC or CPVC with cleanable stainless-steel strainer element.

N. Condenser Water-Treatment Control Panel: Incorporate solid-state integrated circuits and digital LED displays, in NEMA 250, Type 12 enclosure with gasketed and lockable door.

1. Control dissolved solids, based on conductivity, and include the following:

a. Digital readout display.
b. Temperature-compensated sensor probe adaptable to sample stream manifold.
c. High, low, and normal conductance indicator lights.
d. High or low conductance alarm light, trip points field adjustable; with silence switch.
e. Hand-off-auto switch for solenoid bleed-off valve.
f. Bleed-off light to indicate valve operation.
g. Internal adjustable hysteresis or dead band.

2. Control inhibitor feeding, based on makeup volume, and include the following:

a. Solid-state reset counter (accumulator), with selections from 1 to 15.
b. Solid-state timer, adjustable from 15 to 300 seconds.
c. Test switch.
d. Hand-off-auto switch for chemical pump.
e. Illuminated legend to indicate feed when pump is activated.
f. Solid-state lockout timer, adjustable from 15 to 180 minutes, with indicator light. Lockout timer to deactivate the pump and activate alarm circuits.
g. Electromechanical-type, panel-mounted makeup totalizer to measure amount of makeup water.

3. Control biocide with an adjustable time programmer and include the following:

a. 24-hour timer with 14-day skip feature to permit activation any hour of day.
b. Precision, solid-state, bleed-off lockout timer (zero to nine hours) and clock-controlled biocide pump timer (zero to two and one-half hours). Prebleed and bleed lockout.
c. Solid-state alternator to enable the use of two different formulations.
d. 24-hour digital display of time of day.
e. 14-day LED display of day of week.
f. Fast and slow internal clock set controls.
g. Battery backup so clock is not disturbed by power outages.
h. Quartz timekeeping accuracy.
i. Hand-off-auto switches for biocide pumps.
j. Biocide A and Biocide B illuminated legends to indicate pump is running.

2.4 CHEMICAL TREATMENT TEST EQUIPMENT

A. Test Kit: Manufacturer recommended equipment and chemicals, in a carrying case, for testing pH, total dissolved solids, dissolved oxygen, biocount, chloride, and total alkalinity and for calcium hardness field tests.

B. Corrosion Test Coupon Assembly: Constructed of corrosion material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test coupon assembly.

1. **Two**-station rack for closed-loop systems.
2. **Four**-station rack for open condenser water systems.

2.5 CHEMICALS

A. Furnish chemicals recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment.

B. System Cleaner: Liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products.

C. Biocide: Chlorine release agents or microbiocides.

D. Closed-Loop, Water Piping Chemicals: Sequestering agent to reduce deposits and adjust pH, corrosion inhibitors, and conductivity enhancers.

E. Heating Steam and Condensate Piping Chemicals: Sequestering agent to reduce hardness and prevent feedline congestion and to provide alkalinity, oxygen scavenger, carbon-dioxide neutralizer, and filming amines.

F. Open-Loop, Condenser Water Piping Chemicals: Sequestering agent to inhibit scaling, acid to reduce alkalinity and pH, corrosion inhibitor, and biocide.

G. Open-Loop Piping Chemicals Serving Humidifiers, Air Washers, Evaporative Condensers, Small Cooling Towers, and Liquid Coolers: Sequestering agent to inhibit scaling, corrosion inhibitor, and biocide nonoxidizing.

2.6 HOT-WATER FILTRATION UNIT

A. Filtration Unit: Stainless-steel housing and polypropylene filter with polypropylene core.

B. Replaceable Filter Media: Compatible with antifreeze and water-treatment chemicals.

C. Filter Media for Sediment Removal Service: Rated at 98 percent efficiency for 20-micrometer particulate.

D. Pressure Drop through the Filter Cartridge: Not to exceed manufacturer's recommended pressure drop at design-flow rate when clean, and manufacturer's maximum pressure drop when filter is dirty.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine the type and quantities of chemical treatment needed to maintain the water quality as specified in "Performance Requirements" Article.

3.2 INSTALLATION

A. Install treatment equipment level and plumb.

B. Add cleaning chemicals as recommended by manufacturer.

3.3 CONNECTIONS

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

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

C. Confirm applicable electrical requirements in Electrical Sections for connecting electrical equipment.

D. Ground equipment.

1. 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.

3.4 FIELD QUALITY CONTROL

A. Engage a factory-authorized service representative to perform startup service.

1. Inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.
2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC systems' startup procedures.

B. Test chemical feed piping as follows:

1. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
2. 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.
3. 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.
4. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
5. Repair leaks and defects with new materials and retest piping until satisfactory results are obtained.
6. Prepare test reports, including required corrective action.

3.5 ADJUSTING

A. Sample boiler water at one-week intervals after boiler startup for a period of five weeks, and prepare certified test report for each required water performance characteristic. Where applicable, comply with ASTM D 3370 and the following standards:

1. Silica: ASTM D 859.
2. Steam System: ASTM D 1066.
3. Acidity and Alkalinity: ASTM D 1067.
4. Iron: ASTM D 1068.
5. Water Hardness: ASTM D 1126.

B. Occupancy Adjustments: Within 12 months of Substantial Completion, perform two separate water analyses to prove that automatic chemical feed systems are maintaining water quality within performance requirements specified in this Section. Perform analyses at least 60 days apart. Submit written reports of water analysis.

3.6 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.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.

B. Review manufacturer's safety data sheets for handling of chemicals.

C. Review data in maintenance manuals, especially data on recommended parts inventory and supply sources and on availability of parts and service. Refer to Division 1 Section "Contract Closeout" or Division 1 Section "Operation and Maintenance Data."

D. Schedule at least four hours of training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 15189

SECTION 15195 - 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 SUMMARY

A. Section Includes:

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

1.3 DEFINITIONS

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

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

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

1.4 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig minimum unless otherwise indicated.
2. Service Regulators: 65 psig minimum unless otherwise indicated.

B. Natural-Gas System Pressures within Buildings:

1.5 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.
5. Dielectric fittings.

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

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

C. Delegated-Design Submittal: For natural-gas piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified Professional Engineer responsible for their preparation.

1. Detail fabrication and assembly of seismic restraints.
2. Design Calculations: Calculate requirements for selecting seismic restraints.

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

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

F. Qualification Data: For qualified Professional Engineer.

G. Welding certificates.

H. Field quality-control reports.

I. Operation and Maintenance Data: For motorized gas valves pressure regulators and service meters 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.

D. Protect stored PE pipes and valves 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 Construction Manager Owner no fewer than five days in advance of proposed interruption of natural-gas service.
2. Do not proceed with interruption of natural-gas service without Construction Manager's Owner's written permission.

1.9 COORDINATION

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

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

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

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

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

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

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

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

6. Mechanical Couplings:

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

        1) Dresser Piping Specialties; Division of Dresser, Inc.
        2) Smith-Blair, Inc.
        3) Or approved equal.

    b. Stainless-steel flanges and tube with epoxy finish.
    c. Buna-nitrile seals.

d. Stainless-steel bolts, washers, and nuts.
e. Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
f. Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.

2.2 PIPING SPECIALTIES

A. 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.

C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.4 MANUAL GAS SHUTOFF VALVES

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

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

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

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

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

D. One-Piece, Bronze Ball Valve 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.
    f. Or approved equal.

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

E. 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.
f. Or approved equal.

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

F. 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.
c. Or approved equal.

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

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

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

a. Flowserve.

b. Homestead Valve; a division of Olson Technologies, Inc.
c. McDonald, A. Y. Mfg. Co.
d. Milliken Valve Company.
e. Mueller Co.; Gas Products Div.
f. R&M Energy Systems, A Unit of Robbins & Myers, Inc.
g. Or approved equal.

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

2.5 MOTORIZED GAS VALVES

A. Automatic Gas Valves: Comply with ANSI Z21.21.

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

a. ASCO Power Technologies, LP; Division of Emerson.
b. Dungs, Karl, Inc.
c. Eaton Corporation; Controls Div.
d. Eclipse Combustion, Inc.
e. Honeywell International Inc.
f. Johnson Controls.
g. Or approved equal.

3. Body: Brass or aluminum.
4. Seats and Disc: Nitrile rubber.
5. Springs and Valve Trim: Stainless steel.
6. Normally closed.
7. Visual position indicator.
8. Electrical operator for actuation by appliance automatic shutoff device.

B. Electrically Operated Valves: Comply with UL 429.

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

    a. ASCO Power Technologies, LP; Division of Emerson.
    b. Dungs, Karl, Inc.
    c. Eclipse Combustion, Inc.
    d. Goyen Valve Corp.; Tyco Environmental Systems.
    e. Magnatrol Valve Corporation.
    f. Parker Hannifin Corporation; Climate & Industrial Controls Group; Skinner Valve Div.
    g. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
    h. Or approved equal.

3. Pilot operated.
4. Body: Brass or aluminum.
5. Seats and Disc: Nitrile rubber.
6. Springs and Valve Trim: Stainless steel.
7. 120-V ac, 60 Hz, Class B, continuous-duty molded coil, and replaceable.
8. NEMA ICS 6, Type 4, coil enclosure.
9. Normally closed.
10. Visual position indicator.

2.6 PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

B. Line Pressure Regulators: Comply with ANSI Z21.80.

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

    a. Actaris.

b. American Meter Company.
c. Eclipse Combustion, Inc.
d. Fisher Control Valves and Regulators; Division of Emerson Process Management.
e. Invensys.
f. Maxitrol Company.
g. Richards Industries; Jordan Valve Div.
h. Or approved equal.

3. Body and Diaphragm Case: Cast iron or die-cast aluminum.
4. Springs: Zinc-plated steel; interchangeable.
5. Diaphragm Plate: Zinc-plated steel.
6. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
7. Orifice: Aluminum; interchangeable.
8. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
9. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
10. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
11. Overpressure Protection Device: Factory mounted on pressure regulator.
12. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
13. Maximum Inlet Pressure: 4 psig.

2.7 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. 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 Company.
b. Central Plastics Company.
c. Hart Industries International, Inc.
d. Jomar International Ltd.
e. Matco-Norca, Inc.
f. McDonald, A. Y. Mfg. Co.

g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
h. Wilkins; a Zurn company.
i. Or approved equal.

2. Description:

a. Standard: ASSE 1079.
b. Pressure Rating: 125 psig minimum at 200 deg F.
c. End Connections: Solder-joint copper alloy and 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 Company.
b. Central Plastics Company.
c. Matco-Norca, Inc.
d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
e. Wilkins; a Zurn company.
f. Or approved equal.

2. Description:

a. Standard: ASSE 1079.
b. Factory-fabricated, bolted, companion-flange assembly.
c. Pressure Rating: 125 psig minimum at 200 deg F.

2.8 LABELING AND IDENTIFYING

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

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

3.2 PREPARATION

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

B. Inspect natural-gas piping according to NFPA 54 and the International Fuel Gas Code to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with NFPA 54 and the International Fuel Gas Code requirements for prevention of accidental ignition.

3.3 INDOOR PIPING INSTALLATION

A. Comply with NFPA 54 and the International Fuel Gas Code for installation and purging of natural-gas piping.

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

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

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

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

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

G. Locate valves for easy access.

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

I. Install piping free of sags and bends.

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

K. Verify final equipment locations for roughing-in.

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

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

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

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

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

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

1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
2. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
3. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.
4. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.

    a. Exception: Tubing passing through partitions or walls does not require striker barriers.

5. Prohibited Locations:

    a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.

b. Do not install natural-gas piping in solid walls or partitions.

Q. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

R. Connect branch piping from top or side of horizontal piping.

S. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

T. Do not use natural-gas piping as grounding electrode.

U. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

V. Install pressure gage downstream from each line regulator. Pressure gages are specified in Division 15 Section "Meters and Gages for HVAC Piping."

W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 15 Section "Sleeves and Sleeve Seals for HVAC Piping."

X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 15 Section "Sleeves and Sleeve Seals for HVAC Piping."

Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 15 Section "Escutcheons for HVAC Piping."

Z. Install service meters downstream from pressure regulators.

3.4 OUTDOOR PIPING INSTALLATION

A. Comply with NFPA 54 and the International Fuel Gas Code for installation and purging of natural-gas piping.

B. Install underground, natural-gas piping buried at least 36 inches below finished grade.

1. If natural-gas piping is installed less than 36 inches below finished grade, install it in containment conduit.

C. Install underground, PE, natural-gas piping according to ASTM D 2774.

D. Install fittings for changes in direction and branch connections.

E. Install pressure gage downstream from each service regulator. Pressure gages are specified in Division 15 Section "Meters and Gages for HVAC Piping."

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 underground valves with valve boxes.

C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

3.6 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:

1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

F. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

G. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

H. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.7 HANGER AND SUPPORT INSTALLATION

A. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

B. Comply with requirements for pipe hangers and supports specified in Division 15 Section "Hangers and Supports for HVAC Piping and Equipment."

C. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
4. NPS 2-1/2 to NPS 3-1/2: Maximum span, 10 feet; minimum rod size, 1/2 inch.
5. NPS 4 and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.

3.8 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 Division 15 Section "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. Comply with requirements in Division 09 painting Sections for painting interior and exterior natural-gas piping.

B. Paint exposed, exterior metal piping, valves, service regulators, and meter bars, and piping specialties, except components, with factory-applied paint or protective coating.

1. Alkyd System: MPI EXT 5.1D.

    a. Prime Coat: Alkyd anticorrosive metal primer.
    b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
    c. Topcoat: Exterior alkyd enamel semigloss.
    d. Color: Yellow.

C. Paint exposed, interior metal piping, valves, service regulators and meter bars, 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: Quick-drying alkyd metal primer.
    b. Intermediate Coat: Interior latex matching topcoat.
    c. Topcoat: Interior latex: semigloss.
    d. Color: Yellow.

2. Alkyd System: MPI INT 5.1E.

    a. Prime Coat: Quick-drying alkyd metal primer.
    b. Intermediate Coat: Interior alkyd matching topcoat.
    c. Topcoat: Interior alkyd: semigloss.
    d. Color: Yellow.

D. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Test, inspect, and purge natural gas according to NFPA 54 and 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.

3.12 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain earthquake valves.

B. Aboveground natural-gas piping shall be one of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.

3.13 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG

A. Aboveground, branch piping NPS 1 and smaller shall be the following:

1. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping shall be one of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.

C. Underground, below building, piping shall be one of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.

D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

E. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.14 OUTDOOR PIPING SCHEDULE

A. Underground natural-gas piping shall be the following:

1. PE pipe and fittings joined by heat fusion, or mechanical couplings; service-line risers with tracer wire terminated in an accessible location.

B. Aboveground natural-gas piping shall be one of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.

C. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

3.15 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves for pipe sizes NPS 2 and smaller at service meter shall be one of the following:

1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, full-port, bronze ball valves with bronze trim.
3. Bronze plug valve.

B. Valves for pipe sizes NPS 2-1/2 and larger at service meter shall be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.
3. Cast-iron, nonlubricated plug valve.

C. Distribution piping valves for pipe sizes NPS 2 and smaller shall be one of the following:

1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, full-port, bronze ball valves with bronze trim.
3. Bronze plug valve.

D. Distribution piping valves for pipe sizes NPS 2-1/2 and larger shall be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.

2. Bronze plug valve.
3. Cast-iron, lubricated plug valve.

E. Valves in branch piping for single appliance shall be one of the following:

1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, full-port, bronze ball valves with bronze trim.
3. Bronze plug valve.

END OF SECTION 15195

SECTION 15198 - ESCUTCHEONS 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

A. Split-Casting Brass Type: With polished, chrome-plated finish and with concealed hinge and setscrew.

B. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed hinge, and spring-clip fasteners.

2.2 FLOOR PLATES

A. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons for New Piping:

a. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
b. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge or split-plate, stamped-steel type with exposed-rivet hinge.
c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: split-casting brass type with polished, chrome-plated finish.
d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
e. Bare Piping at Ceiling Penetrations in Finished Spaces: cast-brass or split-casting brass type with polished, chrome-plated finish.
f. Bare Piping at Ceiling Penetrations in Finished Spaces: stamped-steel type split-plate, stamped-steel type with concealed hinge.

2. Escutcheons for Existing Piping:

a. Chrome-Plated Piping: Split-casting brass type with polished, chrome-plated finish.
b. Insulated Piping: Split-plate, stamped-steel type with concealed hinge.
c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge.
e. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: One-piece, floor-plate type.
2. Existing Piping: Split-casting, floor-plate type.

3.2 FIELD QUALITY CONTROL

A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 15198

SECTION 15513 - CONDENSING BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract apply to this Section, including General and Supplementary Conditions and Division 01 Specification Sections.

1.2 SUMMARY

A. This Section includes packaged, factory-fabricated and assembled, gas-fired, fire-tube condensing boilers, trim and accessories for 16generating hot water.

1.3 SUBMITTALS

A. Product Data: Include performance data, operating characteristics, furnished specialties and accessories.

1. Prior to flue vent installation, engineered calculations and Drawings must be submitted to Architect/Engineer to thoroughly demonstrate that size and configuration conform to recommended size, length and footprint for each submitted boiler.

B. Efficiency Curves: At a minimum, submit efficiency curves for 100%, 50% and 7% input firing rates at incoming water temperatures ranging from 80°F to 160°F. Test protocols shall conform to AERCO's AE-1 standards.

C. Pressure Drop Curve. Submit pressure drop curve for the following flow ranges per designated capacities below:

1. 0 - 399 MBH: 0-40 GPM
   440 - 500 MBH: 0-40 GPM
   660 - 750 MBH: 0-60 GPM
   880 - 1000 MBH: 0-80 GPM
2. If submitted material is different from that of the design basis, boiler manufacture shall incur all costs associated with reselection of necessary pumps. Possible differences include, but are not limited to, the pump type, pump pad size, electrical characteristics and piping changes.

D. Shop Drawings: For boilers, boiler trim and accessories include:

1. Plans, elevations, sections, details and attachments to other Work
2. Wiring Diagrams for power, signal and control wiring

E. Source Quality Control Test Reports: Reports shall be included in submittals.

F. Field Quality Control Test Reports: Reports shall be included in submittals.

G. Operation and Maintenance Data: Data to be included in boiler emergency, operation and maintenance manuals.

H. Warranty: Standard warranty specified in this Section

I. Other Informational Submittals:

1. ASME Stamp Certification and Report: Submit "H" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices and Accessories: Boilers must be 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. I=B=R Performance Compliance: Condensing boilers must be rated in accordance with applicable federal testing methods and verified by AHRI as capable of achieving the energy efficiency and performance ratings as tested within prescribed tolerances.

C. ASME Compliance: Condensing boilers must be constructed in accordance with ASME Boiler and Pressure Vessel Code, Section IV “Heating Boilers”.

D. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil-Fired Boilers - Minimum Efficiency Requirements."

E. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers."

F. UL Compliance: Boilers must be tested 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.

G. NOx Emission Standards: When installed and operated in accordance with manufacturer’s instructions, the following condensing boiler models shall comply with the NOx emission standards outlined in South Coast Air Quality Management District (SCAQMD), Rule 1146.1; and the Texas Commission on Environmental Quality (TCEQ), Title 30, Chapter 117, and Rule 117.465 or the NOx emissions referenced below:

- AM 399-1000: <20 ppm NOx corrected to 3% oxygen at all firing rates when firing on natural gas

1.5 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.

1.6 WARRANTY

A. Standard Warranty: Boilers shall include 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. The pressure vessel/heat exchanger shall carry a 15-year from shipment, non-prorated, limited warranty against any failure due to condensate corrosion, thermal stress, mechanical defects or workmanship.

   b. The burner shall be conditionally guaranteed against any failure for (5) five years from shipment.

   c. Manufacturer labeled control panels are conditionally warranted against failure for (3) three years from shipment.

   d. All other components, with the exception of the igniter, flame detector and O_2 sensor, are conditionally guaranteed against any failure for (2) two years from shipment.

PART 2 - PRODUCTS

A. This specification is based on the Benchmark Platinum Series boilers as manufactured by AERCO International Inc. Equivalent units and manufacturers must meet all performance criteria, and will be considered upon prior approval.

B. Basis-of-Design Product: Subject to compliance with requirements, provide AERCO International, Benchmark or Benchmark Platinum Series Boiler Models:

3. BMK 750-6000 (750,000-6,000,000 BTU/hr input)
4. Or approved equal.

2.1 CONSTRUCTION

A. Description: Boiler shall be either natural gas, propane or dual fuel (nat. gas/propane; BMK1500-6000 models only) fired, fully condensing, fire tube design. Power burner

shall have full modulation, discharge into a positive or negative pressure vent and the minimum firing rate shall not exceed the following per model:

- BMK750-1000: 50,000 BTU/hr input
- BMK1500: 75,000 BTU/hr input
- BMK2000: 100,000 BTU/hr input
- BMK2500: 167,000 BTU/hr input
- BMK3000: 200,000 BTU/hr input
- BMK5000-6000: 400,000 BTU/hr input

Boilers that have an input greater than what is specified above at minimum fire will not be considered. Boiler efficiency shall increase with decreasing load (output), while maintaining setpoint. Boiler shall be factory-fabricated, factory-assembled and factory-tested, fire-tube 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.

B. Heat Exchanger: The heat exchanger shall be constructed of 439 stainless steel fire tubes and tubesheets, with a one-pass combustion gas flow design. The fire tubes shall be 1/2" or 5/8" OD, with no less than 0.049" wall thickness. The upper and lower stainless steel tubesheet shall be no less than 0.25" thick. The pressure vessel/heat exchanger shall be welded construction. The heat exchanger shall be ASME stamped for a working pressure not less than 150 psig. Access to the tubesheets and heat exchanger shall be available by burner and exhaust manifold removal. Minimum access opening shall be no less than 8-inch diameter.

C. Pressure Vessel: The pressure vessel shall have a maximum water volume per each model as listed below:

- BMK750: 16.25 gallons (61.5 liters)
- BMK1000: 14.25 gallons (54.9 liters)
- BMK1500: 44 gallons (166.6 liters)
- BMK2000: 40 gallons (151.4 liters)
- BMK2500: 58 gallons (219.6 liters)
- BMK3000: 55 gallons (208.2 liters)
- BMK5000/6000: 110 gallons (416.4 liters)

The boiler water pressure drop shall not exceed the following per model size:

- BMK750-1000: 3 psig @ 100 gpm
- BMK1500-2000: 3 psig @ 170 gpm
- BMK2500: 3 psig @ 218 gpm
- BMK3000: 3 psig @ 261 gpm
- BMK5000/6000: 4 psig @ 500 gpm

The boiler water connections shall be 3-inch (BMK750-1000), 4-inch (BMK1500-3000) or 6-inch (BMK5000-6000) flanged 150-pound, ANSI rated. The pressure vessel shall be constructed of ASME SA53 carbon steel, with a 0.25-inch thick wall and 0.50-inch thick upper head. Inspection openings in the pressure vessel shall be in accordance with ASME Section IV pressure vessel code. The boiler shall be designed so that the thermal efficiency increases as the boiler firing rate decreases.

E. Dual Returns: The boiler shall include dual return connections for low and high return temperature zones for added flexibility and thermal efficiency optimization. The boiler shall be able to handle a variety of flow splits and not have a minimum flow rate requirement through the low temperature return as long as the specified minimum flow of the boiler is met through the secondary high temperature return. Boilers without this feature from other manufacturers will be deemed unacceptable.

F. Modulating Air/Fuel Valve and Burner: The boiler burner shall be capable of up to 20-to-1 turndown ratio of the firing rate without loss of combustion efficiency or staging of gas valves. The burner shall not operate above 7.5% oxygen level or 55% excess air. The burner shall produce less than 20 ppm of NOx, under standard calibration, corrected to 3% excess oxygen when firing on natural gas. The burner shall be metal-fiber mesh covering a stainless steel body with spark or proven pilot ignition and flame rectification. All burner material exposed to the combustion zone shall be of stainless steel construction. There shall be no moving parts within the burner itself. A modulating air/fuel valve shall meter the air and fuel input. The modulating motor must be linked to both the gas valve body and air valve body with a single linkage. The linkage shall not require any field adjustment. A variable speed cast aluminum pre-mix blower shall be used to ensure the optimum mixing of air and fuel between the air/fuel valve and the burner.

G. Dual Fuel Capability. If dual fuel is required (nat. gas/propane), the boiler shall include a combustion system with dual fuel capability. The dual fuel unit shall be capable of operating on both Natural Gas and Propane. The boiler efficiency and turndown shall remain unchanged regardless of fuel source. The dual fuel system shall incorporate independent natural gas and propane gas trains and a fuel selector switch. This switching mechanism shall be such that it shall not be possible to flow both fuels simultaneously. The unit shall be calibrated to run on both fuel sources at start-up. No additional re-calibration shall be required when switching between fuel sources for a period of one year from the initial calibration

F. Minimum boiler efficiencies shall be as follows at a 20 degree delta-T:

EWT	100% Fire	50% Fire	7% Fire
160 °F	86.5%	87%	87%
140 °F	87%	87.5%	87.5%
120 °F	88.5%	89%	90%

100 °F	93.2%	94.5%	95.2%
80 °F	95.6%	96.8%	98.2%

G. Exhaust Manifold: The exhaust manifold shall be of corrosion resistant cast aluminum or 316 stainless steel with the following diameter flue connections:

- BMK750-1500: 6 inch
- BMK2000-3000: 8 inch
- BMK5000: 12 inch or 14 inch
- BMK6000: 12 inch (<20 ppm NOx) or 14 inch (<9 ppm NOx)

The exhaust manifold shall have a collecting reservoir and a gravity drain for the elimination of condensation.

H. Blower: The boiler shall include a variable-speed, DC centrifugal fan to operate during the burner firing sequence and pre-purge the combustion chamber.

5. Motors: Blower motors shall comply with requirements specified in Division 15 Section "Common Motor Requirements for HVAC Equipment."

a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require a motor to operate in the service factor range above 1.0.

I. Ignition: Ignition shall be via spark or proven pilot ignition with 100 percent main-valve shutoff and electronic flame supervision.

J. The boiler shall be designed such that the combustion air is drawn from the inside of the boiler enclosure, decoupling it from the combustion air supply and preheating the air to increase efficiency.

K. Enclosure: The plastic and sheet metal enclosure shall be fully removable, allowing for easy access during servicing.

2.2 CONTROLS

A. Refer to Division 15, Section “Instrumentation and Control of HVAC.”

B. The boiler control system shall be segregated into three components: “C-More” Control Panel, Power Panel and Input/Output Connection Box. The entire system shall be Underwriters Laboratories recognized.

C. The control panel shall consist of seven individual circuit boards using state-of-the-art surface-mount technology in a single enclosure. These circuit boards shall include:

6. A display board incorporating LED display to indicate temperature and a vacuum fluorescent display module board for all message enunciation
7. A CPU board housing all control functions
8. An electric low-water cutoff board with test and manual reset functions
9. A power supply board
10. An ignition /stepper board incorporating flame safeguard control
11. A connector board

Each board shall be individually field replaceable.

D. The combustion safeguard/flame monitoring system shall use spark or proven pilot ignition and a rectification-type flame sensor.

E. The control panel hardware shall support RS-485 remote communications.

F. The controls shall annunciate boiler and sensor status and include extensive self-diagnostic capabilities that incorporate a minimum of eight separate status messages and 52 separate fault messages.

G. The control panel shall incorporate three self-governing features designed to enhance operation in external control modes. When operating by an external control signal, the control panel can work to eliminate nuisance faults, such as over-temperature, resulting from improper external signal or loss of external signal. These features include:

12. Setpoint High Limit: Setpoint high limit allows for a selectable maximum boiler outlet temperature and acts as temperature limiting governor. Setpoint limit is based on a PID function that automatically limits firing rate to maintain outlet temperature within a 0 to 10 degree selectable band from the desired maximum boiler outlet temperature.
13. Setpoint Low Limit: Allow for a selectable minimum operating temperature.
14. Failsafe Mode: Failsafe mode allows the boiler to switch its mode to operate from an internal setpoint if its external control signal is lost, rather than shut off. This is a selectable mode, enabling the control can to shut off the unit upon loss of external signal, if so desired.

H. The boiler control system shall incorporate the following additional features for enhanced external system interface:

15. System start temperature feature
16. Pump delay timer
17. Auxiliary start delay timer
18. Auxiliary temperature sensor
19. Analog output feature to enable simple monitoring of temperature setpoint, outlet temperature or fire rate
20. Remote interlock circuit

21. Delayed interlock circuit
22. Fault relay for remote fault alarm

I. Each boiler shall include an electric, single-seated combination safety shutoff valve/regulator with proof of closure switch in its gas train. Each boiler shall incorporate dual over-temperature protection with manual reset, in accordance with ASME Section IV and CSD-1.

J. Each boiler shall be equipped with the patented AERtrim system, an advanced O_2-trim system for condensing boiler applications. The system shall utilize a low cost reliable automotive O_2 sensor that measures and monitors the oxygen content of the exhaust gases. The system shall adjust the blower speed to maintain optimal air-fuel ratios in the event of any site condition changes (air density, gas pressure, BTU content, etc.). The system shall have the following capabilities:

1. Self Diagnostics

    a. System Status and Error Messages
    b. When excessive trimming is occurring
    c. When O_2 sensor has fallen out of calibration

2. Adjustable parameter settings

    a. O_2 target and range to meet site requirements
    b. Schedule daily or weekly self diagnostics

Output of O2 information shall be displayed on the C-More control panel.

The O_2 sensor shall be installed through the unit's burner plate and measure the oxygen content directly within the unit's combustion chamber.

Boilers without an equivalent O_2 trim will be deemed unacceptable. Due to the moisture content of flue gases from condensing boilers, placing the O_2 sensor in the exhaust manifold or stack will be deemed unacceptable.

K. Each boiler shall be OnAER ready with a standard Ethernet port and include a 5 year OnAER subscription at no additional charge. AERCO's OnAER service grants the user online access to real time operation and status of their system plant from any computer, tablet or mobile device along with the following capabilities:

1. Efficiency status and trends
2. Savings calculator
3. Efficiency and performance optimization tips
4. Maintenance alerts and scheduling
5. Warning and error messages
6. Weekly or monthly performance and status reports

7. Manage multiple boiler plants or buildings
8. Customizable dashboard
9. Add email contacts for alerts and reports, including local AERCO trained technicians
10. Manage and store startup, maintenance and service documentation

The boiler manufacturer shall be able to provide a network hub to connect up 8 boilers to an online network.

L. Each boiler shall have integrated Boiler Sequencing Technology (BST), capable of multi-unit sequencing with lead-lag functionality and parallel operation. The system will incorporate the following capabilities:

1. Efficiently sequence 2-to-8 units on the same system to meet load requirement.
2. Integrated control and wiring for seamless installation of optional isolation valve. When valves are utilized, the system shall operate one motorized valve per unit as an element of load sequencing. Valves shall close with decreased load as units turn off, minimum of one must always stay open for recirculation.
3. Automatically rotate lead/lag amongst the units on the chain and monitor run hours per unit and balance load in an effort to equalize unit run hours.
4. Option to manually designate lead and last boiler
5.
6. Designated master control, used to display and adjust key system parameters.
7. Automatic bump-less transfer of master function to next unit on the chain in case of designated master unit failure; master/slave status should be shown on the individual unit displays.

M. For boiler plants greater than 8 units, the Boiler Manufacturer shall supply as part of the boiler package a completely integrated AERCO Control System (ACS) to control all operation and energy input of the multiple boiler heating plant. The ACS shall be comprised of a microprocessor based control utilizing the MODBUS protocol to communicate with the Boilers via the RS-485 port. One ACS controller shall have the ability to operate up to 32 AERCO boilers.

The controller shall have the ability to vary the firing rate and energy input of each individual boiler throughout its full modulating range to maximize the condensing capability and thermal efficiency output of the entire heating plant. The ACS shall control the boiler outlet header temperature within $\pm$2ºF. The controller shall be a PID type controller and uses Ramp Up/Ramp Down control algorithm for accurate temperature control with excellent variable load response. The ACS controller shall provide contact closure for auxiliary equipment such as system pumps and combustion air inlet dampers based upon outdoor air temperature.

The ACS shall have the following anti-cycling features:

- Manual designation of lead boiler and last boiler.

- Lead boiler rotation at user-specified time interval.
- Delay the firing/shutting down of boilers when header temperature within a predefined deadband.

When set on Internal Setpoint Mode, temperature control setpoint on the ACS shall be fully field adjustable from 50ºF to 190ºF in operation. When set on Indoor/Outdoor Reset Mode, the ACS will operate on an adjustable inverse ratio in response to outdoor temperature to control the main header temperature. Reset ratio shall be fully field adjustable from 0.3 to 3.0 in operation. When set on 4ma to 20ma Temperature Control Mode, the ACS will operate the plant to vary header temperature setpoint linearly as an externally applied 4-20 ma signal is supplied.

When set on MODBUS Temperature Control Mode, the ACS will operate the plant to vary header temperature setpoint as an external communication utilizing the MODBUS protocol is supplied via the RS-232 port. The ACS controller shall have a vacuum fluorescent display for monitoring of all sensors and interlocks. Non-volatile memory backup of all control parameters shall be internally provided as standard. The controller will automatically balance the sequence of operating time on each boiler by a first-on first-off mode and provide for setback and remote alarm contacts. Connection between central ACS system and individual boilers shall be twisted pair low voltage wiring, with the boilers 'daisy-chained' for ease of installation.

2.3 ELECTRICAL POWER

A. Controllers, Electrical Devices and Wiring: Electrical devices and connections are specified in Division 26 sections.

B. Single-Point Field Power Connection: Factory-installed and factory-wired switches, motor controllers, transformers and other electrical devices shall provide a single-point field power connection to the boiler.

C. Electrical Characteristics:

Electrical Specifications	Models			
	BMK750-2000	BMK2500-6000	BMK2500-6000	BMK5000-6000
Voltage	120 V	208 V	460 V	575 V
Phase	1	3	3	3
Frequency	60 Hz	60 Hz	60 Hz	60 Hz
Full Load Current	13-16 Amps	10-19 Amps	5-12 Amps	8 Amps

2.4 VENTING

A. The exhaust vent must be UL Listed for use with Category II, III and IV appliances and compatible with operating temperatures up to 230°F, condensing flue gas service. UL-listed vents of Polypropylene and Al 29-4C stainless steel must be used with boilers.

- PVC/CPVC is approved for use with BMK750-1000 models

B. The minimum exhaust vent duct size for each boiler is six-inch (BMK750-1500), 8-inch (BMK2000-3000) or 12-inch (BMK5000-6000) diameter.

C. Combustion-Air Intake: Boilers shall be capable of drawing combustion air from the outdoors via a metal or PVC duct connected between the boiler and the outdoors.

D. The minimum ducted combustion air duct size for each boiler is six-inch (BMK750-1500), 8-inch (BMK2000-3000) or 14-inch (BMK5000-6000) diameter.

E. Common vent and common combustion air must be an available option for boiler installation. Consult manufacturer for common vent and combustion air sizing.

F. Follow guidelines specified in manufacturer's venting guide.

2.5 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 testing.

B. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.

1. If boilers are not factory assembled and fire-tested, the local vendor is responsible for all field assembly and testing.

C. Allow Owner access to source quality-control testing of boilers. Notify Architect fourteen days in advance of testing.

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. Install boilers level on concrete bases. Concrete base is specified in Division 15 Section "Common Work Results for HVAC," and concrete materials and installation requirements are specified in Division 03.

B. Install gas-fired boilers according to NFPA 54.

C. Boiler plant piping shall be field constructed of materials as specified. Each boiler shall have individually isolating shutoff valves by installing Contractor for service and maintenance. Each natural gas boiler shall require a minimum gas pressure of 3" W.C. at the gas flows indicated in the table below (full load rated capacity). For applications with gas supply pressure greater than 13" W.C., each boiler shall be provided with an individual supply gas regulator by installing Contractor for proper gas regulation.

Model	Gas Flow (scfh)
AM 399B	399
AM 500B	500
AM 750B	750
AM 1000B	1000

D. Assemble and install boiler trim.

E. Install electrical devices furnished with boiler but not specified to be factory mounted.

F. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 sections. Drawings indicate general arrangement of piping, fittings and specialties.

B. Install piping adjacent to boiler to permit 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 gas piping to boiler gas-train inlet with unions. Piping shall be at least full size of gas train connection. Provide a reducer if required.

E. Connect hot-water piping to supply and return boiler tappings with shutoff valve and union or flange at each connection and automatic isolation valve.

F. Install piping from safety relief valves to nearest floor drain.

G. Boiler Venting

1. Install flue venting kit and combustion-air intake.
2. Connect venting full size to boiler connections. [Comply with requirements in Division 15 Section "Breechings, Chimneys and Stacks."]

H. Ground equipment according to Division 16 Section "Grounding and Bonding for Electrical Systems."

I. Connect wiring according to Division 16 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 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 components, assemblies and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Perform hydrostatic test. Repair leaks and retest until no leaks exist.
3. 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. Occupancy Adjustments: When requested within 2 months of date of Substantial Completion, provide on-site assistance adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

E. Performance Tests:

The boiler manufacturer is expected to provide partial load thermal efficiency curves. These thermal efficiency curves must include at least three separate curves at various BTU input levels. If these curves are not available, it is the responsibility of the boiler manufacturer to complete the following 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 Architect 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 ERUs and RTUs. Refer to Division 1 Section "Demonstration and Training."

B. The Contractor shall provide general HVAC system training of 40 hours which shall include operating instruction, and review of wiring and control diagram showing complete layout of each system. Contractor shall engage a factory certified technician and ATC vendor to assist during training.

END OF SECTION 15513

SECTION 15550 - 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Listed special gas vents.
2. Listed double-wall vents.
3. Domestic hot water heater vents.

1.3 SUBMITTALS

A. Product Data: For the following:

1. Building-heating or domestic hot water heater appliance chimneys.

B. Shop Drawings: For vents, breechings, chimneys, and stacks. Include plans, elevations, sections, details, and attachments to other Work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, methods of field assembly, components, hangers and seismic restraints, and location and size of each field connection.
2. Contractor shall be required to submit breeching layout Drawings for the Engineer's approval.
3. Computer software calculations for sizing vents, breeching, chimneys, and stacks shall be required as part of the shop Drawing submittal.
4. Metal content for both interior and exterior liners and insulation must be clearly identified.
5. Breeching shall meet the required Type and Category of breeching as required by the boiler (or applicable equipment) manufacturer.
6. Contractor shall utilize two 45° elbows to sweep all turns. To eliminate dead ends and to achieve proper airflow, 90° elbows or tees shall not be acceptable.
7. Breeching components shall include but not be limited to adapter flanges, tees, elbows, clean-outs, drain caps, band joiners, high temperature sealant, roof

flashing, and rain cap (or finishing cone) as required to make a full breeching system.

8. Where prefabricated breeching is specified, unbranded or field fabricated breeching shall not be acceptable.

C. 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.

B. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code--Steel," for hangers and supports and AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents, breechings, and stacks.

C. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

D. International Fuel Gas Code - Installation: Vent systems shall be sized, installed and terminated in accordance with the vent (chimney/flue) and appliance manufacturer's installation instructions and Section 503 (Venting of Equipment).

1.5 COORDINATION

A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section “Roof Accessories.”

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of venting system that fail in materials or workmanship within specified warranty period. Failures include, but are not limited to, structural failures caused by expansion and contraction.

1. Warranty Period: ten years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LISTED SPECIAL GAS VENT (Condensing Appliances)

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, the following:
   1. Heat-Fab, Inc.
   2. Metal-Fab, Inc.
   3. Selkirk, Inc.
   4. Or approved equal.

B. Description: Double-wall metal vents tested according to UL 1738 and rated for 550 deg F continuously, with positive or negative flue pressure complying with NFPA 211 and suitable for condensing-gas temperatures.

C. Construction: Inner shell and outer jacket separated by at least a 1-inch airspace with 1" fiber insulation.

D. Inner Shell: ASTM A 959, Type AL29-4C stainless steel.

E. Outer Jacket: 430 stainless steel.

2.2 LISTED INSULATED POSITIVE PRESSURE VENTS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, the following:
   1. Heat-Fab, Inc.
   2. Metal-Fab, Inc.
   3. Selkirk, Inc.
   4. Or approved equal.

B. Provide factory-built modular connector, manifold and stack system that is tested and listed by the Underwriters' Laboratories, Inc. for use with building heating equipment and appliances which produce exhausted flue gases at a temperature not exceeding 1000 degrees F under continuous operating conditions, and not exceeding 1400 degrees F under intermittent operating conditions (see UL103) when burning gaseous, solid or liquid fuels as described in NFPA-211. Additionally, the vent system shall be U.L. 103 positive pressure tested and listed.

C. The U.L. listed fiber insulated flue gas vent system shall have skin temperatures that have been obtained by Underwriters Laboratories (UL) test procedures. The published surface temperatures shall be the result of the UL-103 1000 degrees' Fahrenheit chimney test.

D. The double wall flue system shall have a 304-stainless steel inner liner and an aluminized or stainless steel outer jacket. The materials and construction of the modular sections and accessories shall be as specified by the terms of the product's U.L. listing.

E. Ceramic fiber insulation between the inner liner and outer jacket shall be a nominal two-inch thick.

F. This stack system shall be designed and installed to be gas tight and thus prevent leakage of combustion products into a building.

G. Inner pipe joints shall be securely connected and sealed with factory supplied overlapping V-bands and appropriate sealant as specified in the manufacturer's installation instructions.

H. The vent system shall be designed to compensate for all flue gas induced thermal expansion.

2.3 DOMESTIC HOT WATER HEATER VENTS

A. The following venting Specification is for an A.O. Smith, Cyclone, model BTH, high efficiency, domestic hot water heater. The Contractor shall follow the manufacturer’s latest recommended installation instructions and as per code.

B. The domestic hot water heater shall be vented using only Schedule 40 CPVC (ASTM F-411) pipe. The fittings, other than the TERMINATIONS shall be equivalent to CPVC fittings, ASTM F-438 for CPVC pipe. If CPVC Pipe and fittings are used, then the proper cement must be used for all joints, including joining the pipe to the Termination Tee; CPVC Materials shall use ASTM F-493 Grade Cement. NOTE: For water heaters in locations with high ambient temperatures (above 100°F) and/or insufficient dilution air, it is recommended that CPVC pipe and fittings (MUST USE SUPPLIED VENT TERMINAL) be used.

2.4 GUYING AND BRACING MATERIALS

A. Cable: Three galvanized, stranded wires of the following thickness:

1. For ID Sizes 4 to 15 Inches: 5/16 inch
2. For ID Sizes 18 to 24 Inches: 3/8 inch.
3. For ID Sizes 27 to 30 Inches: 7/16 inch.
4. For ID Sizes 33 to 36 Inches: 1/2 inch.
5. For ID Sizes 39 to 48 Inches: 9/16 inch.
6. For ID Sizes 51 to 60 Inches: 5/8 inch.

B. Angle Iron: Two galvanized steel, 2 by 2 by 0.25 inch

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of Work.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATION

A. Listed Special Gas, Double-Wall Vents: Condensing gas boilers and appliances.

B. Listed Insulated Positive Pressure, Double-Wall Vents: Non-condensing gas-fired appliances/boilers.

3.3 INSTALLATION OF LISTED VENTS AND CHIMNEYS

A. Locate to comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

B. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

C. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.

D. Slope breechings down in direction of appliance, with condensate drain connection where shown on Drawings.

E. Lap joints in direction of flow.

F. Connect base section to foundation using anchor lugs of size and number recommended by manufacturer.

G. Join sections with acid-resistant joint cement to provide continuous joint and smooth interior finish.

H. Erect stacks plumb to finished tolerance of no more than 1 inch out of plumb from top to bottom.

3.4 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

B. Clean breechings internally, during and after installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth and apply touchup finish to match factory or shop finish.

C. Provide temporary closures at ends of breechings, chimneys, and stacks that are not completed or connected to equipment.

END OF SECTION 15550

SECTION 15636 – NATURAL GAS & CO GAS DETECTION AND ALARM

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 CO (carbon monoxide) and Methane (natural gas) monitors and notification appliances.

1.3 ACTION SUBMITTALS

A. Product Data:

1. For each type of monitor, include sensing range in ppm, temperature and humidity range, alarm outputs, display range, furnished specialties, installation requirements, and electric power requirement.

B. Shop Drawings:

1. Wiring Diagrams: Power, signal, and control wiring.
2. Locations of the specific sensors and alarm panel location

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant monitoring equipment and SCBA 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. One calibration kit including clean air calibration gas bottle for zero calibration and specific refrigerant calibration gas for span calibration, minimum 58-L capacity, pressure regulator, and tubing.

PART 2 - PRODUCTS

2.1 Manufacturers: Subject to compliance with requirements, provide products by the following:

A. Mine Safety Appliances Company.

B. Or approved equal.

2.2 Z GARD CONTROLLER

A. Provide a standalone CO/LELcontroller as shown on the plans. The controller shall be housed in a NEMA 1 Painted steel enclosure. Operating range shall be from –20 degrees F to 122 degrees F. Units that are not capable of these temperature limits shall be provided with a method of auxiliary heat and fans as required to maintain the required ambient conditions.

B. Controller shall accept 110 Vac, direct to the controller, internal step down transformers shall be provided to power up to the field mounted CO and LEL sensors. System shall be UL and or CSA listed to accommodate controller and step down transformer in one panel. If alternate system requires mounting of more than 1 panel the manufacturer shall include all costs required for additional field wiring to accommodate this task.

C. The Controller shall be connected via a 4 wire field bus to remotely mounted Z Gard sensors that are automatically recognized and establishes the sensors range and gas type. The sensors shall be linked by a RS485 network communication system. The controller shall continuously monitor the sensors for excessive levels of the Specified target gases and provide the necessary notification controls in the event that the gas levels rise above the preset limits.

D. The controller shall manage the Z Gard S sensor inputs on the RS485 Serial communications network. The controller shall provide minimum of 8 relays that can be used to start fans and open OA Louvers. Upon sensing the concentration of target gas at levels equivalent to the warning or alarm set point the relay contact(s) shall energize signaling the event.

E. The controller shall have a programmable Off time delay function that is adjustable from 0 – 600 seconds. The warning and alarm relay shall deactivate from 0-600 seconds after the warning or alarm occurrence has abated.

F. The controller shall have the capability of providing a full scale, 2 wire 4 to 20 ma sourcing analog output that is representative of the highest concentration level of any

zone of sensors on the network. This output shall be able to communicate with the BAS system.

G. The Controller shall have a local Readout display indicating the active Sensor Point number, the corresponding gas concentration level and gas type, Warning and Alarm indication, Zone number, number of Sensors, Voting and Diagnostic status of the system. The display will scan through all active channels in 5 second intervals. The readout display will visible from a minimum of 5 feet and will be present always, and will not require being turned on or off.

H. The Controller shall have a LCD Readout for the purpose of displaying the Diagnostic Status of the system and associated Sensors. The User Interface Keypad of 16 items to access the menu driven operating parameters located inside the front door of the enclosure. All setup parameters shall be accessed using the keypad.

I. The controller shall include 4 Common LEDs to indicate Sensor Okay, Warning, Alarm and Sensor Fail status.

J. This Controller shall include a local mounted Audible Alarm rated @ 90 dB with push-button reset switch. The pushbutton reset switch shall silence and reset the Audible Alarm when alarm points are exceeded. The Common LED visual alarms will remain on as long as any Warning or Alarm levels are exceeded. This push-button will reset latched alarms if normal gas conditions exist. A horn relay shall be included to facilitate control of a remote alarm reset pushbutton.

K. Warning and Alarm Set Point Levels - The controller shall provide 4 relays for control of the wall mounted exhaust fans and outdoor intake louvers. Provide manual 3 hour override timers for each relay. Timers shall be labelled to the system served.

L. The controller shall provide a normally energized Sensor Fail Relay. If a loss of communication occurs between the Controller and remote Sensor Transmitter the Sensor Fail Relay will be activated and the Sensor Okay LED located on the Controller door will turn off.

M. All Warning, Alarm and Sensor Fail Relays shall be shall be Form C, single pole, double throw. Contacts shall be rated for 10 Amps 1/8 HP @ 125VAC, 5 amps resistive at 250VAC or 30VDC.

N. The contacts shall be capable of being selected normally open or normally closed.

O. The control panel must be a MSA Z Gard CX controller or Engineer approved equal by General Monitors or Mil Ram.

P. Optional remote relay panel shall be available for remote fans operation

Q. BACnet interface shall be included for communications to the BMS system

2.3 Z-GARD CO AND LEL SENSORS

A. Provide as shown on the plans Carbon monoxide and LEL sensors. Sensors have been located for radius coverage and points of egress. Locations as shown on the plans shall not be modified by the manufacturer.

B. Sensors housing shall be NEMA 4 enclosure with plastic cover. Sensors shall utilize electro chemical technology. Accuracy of the sensors shall not be less than ±2% of Full Scale with no requirement of periodic addition of reagents. Solid State Sensors shall not be acceptable

C. When used with the Z Gard C Controller: The RS 485 Network communication wiring from the Sensor to the Z Gard C Controller shall be a shielded 4-wire cable of sufficient gage to meet distance requirements of the Z Gard RS 485 Network Communication. The Sensor Transmitter terminal strips shall be removable for ease of wiring and accept up to 10 GA AWG wire.

D. The Sensor electronics shall consist of dual PCB that is microprocessor-based computer-aided and factory-calibrated for the target gas compounds with compensation for ambient humidity and temperature and linearized signal output. The PCB includes all the components required to power, operate the sensor, make calibration adjustments and set the network address jumpers when used in the Z Gard Communication network. The single PCB shall be mounted to the enclosure using industry standard hardware.

E. CO sensors shall be located at 5’ AFF

F. LEL sensors shall be located 12“ below the roof Line

2.4 MONITOR ALARM SEQUENCE

A. The MSA Control panel will constantly Poll the CO and LEL sensors located in the Boiler Room Upon increase in CO levels above 25 PPM or LEL levels above 10% LEL the alarm shall sound.

B. If the CO increase above 35 PPM or the LEL increase above 35% LEL the 2nd alarm contact shall close and the boilers shall be checked to ensure they are working properly.

2.5 NOTIFICATION APPLIANCES

A. Horns: Comply with UL 464; electric-vibrating-polarized type, listed by a qualified testing agency with provision for housing the operating mechanism behind a grille.

Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet (3 m) from the horn.

B. Visible Alarm Devices: Comply with UL 1971; three color xenon strobe lights, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The words "REFRIGERANT DETECTION" printed in minimum 1/2-inch- high letters on the lens. Rated light output is 75 candela.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Audible Alarm-Indicating Devices: Install at each entry door to, mechanical equipment room, and position not less than 6 inches (150 mm) below the ceiling. Install horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.

B. Visible Alarm-Indicating Devices: Install adjacent to each alarm horn at each entry door to mechanical equipment room. Install in accordance with manufacturers recommendations.

3.2 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. Report results in writing.

B. Perform tests and inspections and prepare test reports.

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. Inspect field-assembled components, equipment installation, and electrical connections for compliance with requirements.
2. Test and adjust controls and safeties.
3. 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. Repair or replace malfunctioning units and retest as specified above.

3.3 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain refrigerant detection devices.

END OF SECTION 15636

SECTION 15732 - PACKAGED, OUTDOOR, ROOFTOP UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes packaged, outdoor, central-station air-handling units (rooftop units) with the following components and accessories:

1. Direct-expansion cooling.
2. Hot-gas reheat.
3. Hot water heating coil.
4. Economizer outdoor- and return-air damper section.
5. Integral, space temperature controls.
6. Roof curbs.

1.3 DEFINITIONS

A. DDC: Direct-digital controls.

B. ECM: Electrically commutated motor.

C. Outdoor-Air Refrigerant Coil: Refrigerant coil in the outdoor-air stream to reject heat during cooling operations and to absorb heat during heating operations. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.

D. Outdoor-Air Refrigerant-Coil Fan: The outdoor-air refrigerant-coil fan in RTUs. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.

E. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, outdoor, central-station air-handling units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

F. Supply-Air Fan: The fan providing supply air to conditioned space. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

G. Supply-Air Refrigerant Coil: Refrigerant coil in the supply-air stream to absorb heat (provide cooling) during cooling operations and to reject heat (provide heating) during heating operations. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

H. VVT: Variable-air volume and temperature.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design RTU supports to comply with wind and seismic performance requirements, including comprehensive engineering analysis by a qualified Professional Engineer, using performance requirements and design criteria indicated.

B. Wind-Restraint Performance:

1. Basic Wind Speed: Refer to architectural/structural Drawings for wind and seismic requirements.
2. Building Classification Category: Refer to architectural/structural Drawings for classification category.

C. Seismic Performance: RTUs shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

D. Sound Ratings shall be equal or better than basis of design. Any sound rating deviation shall be approved by Owner.

1.5 SUBMITTALS

A. Product Data: Include manufacturer's technical data for each RTU, including rated capacities, sound criteria which shall not exceed the values specified in basis of design equipment, dimensions, required clearances, characteristics, furnished specialties, and accessories.

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.
2. Sound ratings: Provide sound data measurements/ratings measured at same distance as basis of design specified equipment.

C. Delegated-Design Submittal: For RTU supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified Professional Engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.

D. Manufacturer Wind Loading Qualification Certification: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Basis for Certification: Indicate whether the withstand certification is based on actual test of assembled components or on calculations.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Coordination Drawings: Plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural members to which RTUs will be attached.
2. Roof openings
3. Roof curbs and flashing.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For RTUs to include in emergency, operation, and maintenance manuals.

H. Warranty: Special warranty specified in this Section.

1.6 QUALITY ASSURANCE

A. ARI Compliance:

1. Comply with ARI 210/240 and ARI 340/360 for testing and rating energy efficiencies for RTUs.
2. Comply with ARI 270 for testing and rating sound performance for RTUs.

B. ASHRAE Compliance:

1. Comply with ASHRAE 15 for refrigeration system safety.
2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
3. Comply with applicable requirements in ASHRAE 62.1-2013, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA 90.1-2013 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2013, Section 6 - "Heating, Ventilating, and Air-Conditioning."

D. NFPA Compliance: Comply with NFPA 90A and NFPA 90B.

E. UL Compliance: Comply with UL 1995.

F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of RTUs thatfail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
2. Warranty Period for Gas Furnace Heat Exchangers: Manufacturer's standard, but not less than 15 years from date of Substantial Completion.
3. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than three years from date of Substantial Completion.
4. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

1.8 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. Fan Belts: One set for each belt-driven fan.

2. Filters: One set of filters for each unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings (Daikin) or a comparable product by one of the following:

1. Trane.
2. Daikin.
3. Carrier.
4. Or approved equal.

2.2 SUMMARY

A. The Contractor shall furnish and install package rooftop unit(s) as shown and scheduled on the Bid Documents. The unit(s) shall be installed in accordance with this Specification and perform at the specified conditions as scheduled.

2.3 GENERAL UNIT DESCRIPTION

A. Unit(s) furnished and installed shall be packaged rooftop (s) as scheduled on Bid Documents and these Specifications. Cooling capacity ratings shall be based on AHRI Standard. Unit(s) shall consist of insulated weather-tight casing with compressor(s), air-cooled condenser coil, condenser fans, evaporator coil, return-air filters, supply motors and unit controls.

B. Unit(s) shall be 100% fully charged with R-410A

C. Unit(s) shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.

D. Units shall be convertible airflow design as manufactured.

E. Wiring internal to the unit shall be colored and numbered for identification.

2.4 UNIT CASING

A. Panel construction shall be double-wall construction for all panels. All floor panels shall have a solid galvanized steel inner liner on the air stream side of the unit to

protect insulation during service and maintenance. Insulation shall be a minimum of 1" thick with an R-value of 13.0, and shall be 2-part injected foam. Panel design shall include no exposed insulation edges. Unit cabinet shall be designed to operate at total static pressures up to 5.0 inches w.g.

B. Exterior surfaces shall be constructed of pre-painted galvanized steel for aesthetics and long term durability. Paint finish to include a base primer with a high quality, polyester resin topcoat of a neutral beige color. Finished panel surfaces to withstand a minimum 1000-hour salt spray test in accordance with ASTM B117 standard for salt spray resistance.

C. Cabinet construction shall allow for all service/ maintenance from one side of the unit.

D. Cabinet top cover shall be one piece construction or where seams exits, it shall be double-hemmed and gasket-sealed.

E. Access Panels: Water- and air-tight panels with handles shall provide access to filters, heating section, return air fan section, supply air fan section, evaporator coil section, and unit control section.

F. Units base pan shall have a raised 1 1/8 inch high lip around the supply and return openings for water integrity.

G. Insulation: Provide 1/2 inch thick fiberglass insulation with foil face on all exterior panels in contact with the return and conditioned air stream. All edges must be captured so that there is no insulation exposed in the air stream.

H. Provide 115-volt convenience outlet, factory-installed and POWER, per NEC requirements.

I. Provide openings either on side of unit or through the base for power, control, condensate, and gas connections.

J. The base of the unit shall have 3 sides for forklift provisions. The base of the units shall have rigging/lifting holes for crane maneuvering.

2.5 AIR FILTERS

A. Unit shall be provided with a draw-through filter section. The filter rack shall be designed to accept a 2” prefilter and a 4” final filter. The unit design shall have a hinged access door for the filter section. The manufacturer shall ship the rooftop unit with 2” construction filters. The Contractor shall furnish and install, at building occupancy, the final set of filters per the Bid Documents.

2.6 SUPPLY FAN

A. Supply fan shall be a single width, single inlet (SWSI) airfoil centrifugal fan. The fan wheel shall be Class II construction with aluminum fan blades that are continuously welded to the hub plate and end rim. The supply fan shall be a direct drive fan mounted to the motor shaft.

B. Fan assembly shall be a slide out assembly for servicing and maintenance

C. All fan assemblies shall be statically and dynamically balanced at the factory, including a final trim balance, prior to shipment.

D. The fan motor shall be a totally enclosed EC motor that is speed controlled by the rooftop unit controller. The motor shall include thermal overload protection and protect the motor in the case of excessive motor temperatures. The motor shall have phase failure protection and prevent the motor from operation in the event of a loss of phase. Motors shall be premium efficiency.

E. The supply fan shall be capable of airflow modulation from 30% to 100% of the scheduled designed airflow. The fan shall not operate in a state of surge at any point within the modulation range.

2.7 ECONOMIZER SECTION

A. Unit shall be provided with an outdoor air economizer section. The economizer section shall include outdoor, return, and exhaust air dampers. The economizer operation shall be fully integral to the mechanical cooling and allow up to 100% of mechanical cooling if needed to maintain the cooling discharge air temperature. The outdoor air hood shall be factory installed and constructed from galvanized steel finished with the same durable paint finish as the main unit. The hood shall include moisture eliminator filters to drain water away from the entering air stream. The outside and return air dampers shall be sized to handle 100% of the supply air volume. The dampers shall be parallel blade design. Damper blades shall be gasketed with side seals to provide an air leakage rate of 4 cfm / square foot of damper area at 1” differential pressure per ASHRAE 90.1 Energy Standard. A barometric exhaust damper shall be provided to exhaust air out of the back of the unit. A bird screen shall be provided to prevent infiltration of rain and foreign materials. Exhaust damper blades shall be lined with vinyl gasketing on contact edges. Control of the dampers shall be by a factory installed direct coupled actuator. Damper actuator shall be of the modulating, spring return type. A comparative enthalpy control shall be provided to sense and compare enthalpy in both the outdoor and return air streams to determine if outdoor air is suitable for “free” cooling. If outdoor air is suitable for “free” cooling, the outdoor air dampers shall modulate in response to the unit’s temperature control system

2.8 EVAPORATOR COIL

A. Provide configured aluminum fin surface mechanically bonded to copper tubing coil.

B. Provide an independent expansion device for each refrigeration circuit. Factory pressure tested at 450 psig and leak tested at 200 psig.

C. Provide factory installed thermal expansion valve (TXV) for each refrigerant circuit. Factory pressure tested at 450 psig and leak tested at 200 psig.

D. The drain pan shall be stainless steel and positively sloped. The slope of the drain pan shall be in two directions and comply with ASHRAE Standard 62.1. The drain pan shall have a minimum slope of 1/8" per foot to provide positive draining. The drain pan shall extend beyond the leaving side of the coil. The drain pan shall have a threaded drain connection extending through the unit base.

2.9 GAS HEATING SECTION

A. Gas heating section includes a tubular heat exchanger in low, medium and high heat capacities and shall be made of corrosion-resistant aluminized steel tubes and burners.

B. Burner system shall have an induced draft combustion blower.

C. Heater uses a direct spark ignition (DSI) system and a flame sensor.

D. Units are designed for use with natural gas or propane (field-installed propane conversion kit).

E. Manufacturer shall offer stainless steel heat exchangers with 409 stainless steel tubes and 439 stainless steel burners. Stainless steel heat exchanger shall have a 15 year warranty.

2.10 WATER COIL WITH FREEZE BLOCK

A. Provide a factory mounted water coil with Freeze Block Technology. Coil shall be provided with an expansion header that is tied into each and every return bend. On this expansion header shall be a dual sensing, pressure and temperature, relief valve to protect the coil during freezing conditions. The pressure relief set point to be 300 psi to remain well within the limits of the material ratings. Valve shall be situated above a drain pan. This technology shall be wind tunnel, climate room tested and field tested with a 100% success rate over a minimum of 3 years.

B. All coils to be thoroughly cleaned and vapor degreased with Perchlorethylene or equivalent.

C. Provide a 30 month guarantee against any freeze related damages to the coil. Guarantee shall cover repair of existing or supply of a replacement coil.

2.11 CONDENSER SECTION

A. Provide internally finned seamless copper tube mechanically bonded. Factory pressure test to 450 psig.

B. Provide vertical discharge, direct drive fans with aluminum blades. Fans shall be statically balanced. Motors shall be permanently lubricated, with integral thermal overload protection in a weather tight casing.

2.12 REFRIGERATION SYSTEM

A. Compressor(s): Provide scroll compressor with direct drive operating at 3600 rpm. Integral centrifugal oil pump. Provide suction gas cooled motor with winding temperature limits and compressor overloads.

B. Units shall have cooling capabilities down to 0 degree F as standard. For field-installed low ambient accessory, the manufacturer shall provide a factory-authorized service technician that will assure proper installation and operation.

C. Provide each unit with refrigerant circuit(s) factory-supplied completely piped with liquid line filter-drier, suction and liquid line pressure ports.

D. For heat pump units, provide reversing valve, discharge muffler, flow control check valve, and electronic adaptive demand defrost control on all units.

2.13 REFRIGERANT DETECTION SYSTEM (RDS)

A. Systems with refrigerant classified as A2L shall include RDS.

B. RDS shall engage mitigation measures at 12% of LFL.

C. Mitigation will continue for 5 minutes once the alarm is cleared.

D. Detection of refrigerant leak(s) in the airstream shall:
   1. De-energize compressors, UV Lights, heaters, and fan motors, excluding Indoor Fan Motor(s).
   2. Run indoor fan motor(s) at minimum Hz.
   3. For building comfort, to avoid freezing or overheating the space, the damper command will not change, and the unit will still provide full dilution of any leaked refrigerant.

a. Except for units with 2 position dampers and no return duct. In which case the damper shall be commanded open.

4. 24VAC status terminal will energize on OAUTS.

E. Detection of refrigerant leak(s) in a non-airstream compartment shall:
1. De-energize all loads including: compressors, motors and heaters.
2. Energize the mechanical ventilation fans internal to the unit.

F. E-stop shall be given priority control of the unit over that of the RDS.

2.14 LEAK DETECTION SENSORS

A. Unit shall be furnished with a leak detection system from the factory when a circuit refrigerant charge exceeds 3.91 lbs. The leak detection system shall consist of one or more refrigerant detection sensors. When the system detects a leak, the unit controller shall initiate mitigation actions.

2.15 OUTDOOR AIR SECTION

A. Provide a fully integrated comparative enthalpy 100% modulating outside air economizer with unit return and barometric relief air dampers, minimum position setting, preset linkage, wiring harness with plug. Unit operation is through primary temperature controls that automatically modulate dampers to maintain space temperature conditions.

B. Provide economizer with power exhausts.

C. Provide adjustable minimum position control located in the economizer section of the unit.

D. Provide spring return motor for outside air damper closure during unit shutdown or power interruption.

2.16 POWER EXHAUST

A. Manufacturer shall offer power exhaust of return air. When power exhaust is provided factory, the MCA and MOP shown on the unit rating plate shall include the electrical characteristic of the power exhaust unit.

2.17 VARIABLE AIR VOLUME CONTROL

A. The unit controller shall proportionally control the Electronically Commutated Motors (ECM) on the supply and exhaust fans. The supply fan shall be controlled to maintain

an adjustable duct pressure setpoint. A duct static pressure sensor shall be factory mounted in the control panel. The field shall furnish and install the pneumatic tubing for the duct static pressure sensor and the building pressure sensor. The field shall furnish and install the outdoor air pressure sensor.

B. The unit controller shall proportional control the ECM motors on the supply fan based on space temperature. The unit controller shall increase/decrease the speed of the supply fan in order to maintain the space temperature within its setpoint and deadband. The unit controller shall provide discharge air temperature control with the compressor modulation.

2.18 CONTROLS

A. Control equipment and sequence of operation are specified in Division 15900 Section "Instrumentation and Control for HVAC."

B. Using Bacnet interface, connect to the existing automatic temperature control to interface with the rooftop units and/or energy recovery units.

C. Provide a complete integrated microprocessor based Direct Digital Control (DDC) system to control all unit functions including temperature control, scheduling, monitoring, unit safety protection, including compressor minimum run and minimum off times, and diagnostics. This system shall consist of all required temperature sensors, pressure sensors, controller and keypad/display operator interface. All MCBs and sensors shall be factory mounted, wired and tested.

D. The stand-alone DDC controllers shall not be dependent on communications with any on-site or remote PC or master control panel for proper unit operation. The microprocessor shall maintain existing set points and operate standalone if the unit loses either direct connect or network communications. The microprocessor memory shall be protected from voltage fluctuations as well as any extended power failures. All factory and user set schedules and control points shall be maintained in nonvolatile memory. No settings shall be lost, even during extended power shutdowns.

E. The DDC control system shall permit starting and stopping of the unit locally or remotely. The control system shall be capable of providing a remote alarm indication. The unit control system shall provide for outside air damper actuation, emergency shutdown, remote heat enable/disable, remote cool enable/disable, heat indication, cool indication, and fan operation.

F. All digital inputs and outputs shall be protected against damage from transients or incorrect voltages. All field wiring shall be terminated at a separate, clearly marked terminal strip

G. The DDC controller shall have a built-in time schedule. The schedule shall be programmable from the unit keypad interface. The schedule shall be maintained in nonvolatile memory to ensure that it is not lost during a power failure. There shall be one start/stop per day and a separate holiday schedule. The controller shall accept up to sixteen holidays each with up to a 5-day duration. Each unit shall also have the ability to accept a time schedule via BAS network communications.

H. The keypad interface shall allow convenient navigation and access to all control functions. The unit keypad/display character format shall be 4 lines x 20 characters. All control settings shall be password protected against unauthorized changes. For ease of service, the display format shall be English language readout. Coded formats with look-up tables will not be accepted. The user interaction with the display shall provide the following information as a minimum:

1. Return air temperature.
2. Discharge air temperature.
3. Outdoor air temperature.
4. Space air temperature.
5. Outdoor enthalpy, high/low.
6. Compressor suction temperature and pressure
7. Compressor head pressure and temperature
8. Expansion valve position
9. Condenser fan speed
10. Inverter compressor speed
11. Dirty filter indication.
12. Airflow verification.
13. Cooling status.
14. Control temperature (Changeover).
15. VAV box output status.
16. Cooling status/capacity.
17. Unit status.
18. All time schedules.
19. Active alarms with time and date.
20. Previous alarms with time and date.
21. Optimal start
22. Supply fan and exhaust fan speed.
23. System operating hours.

    a. Fan
    b. Exhaust fan
    c. Cooling
    d. Individual compressor
    e. Heating
    f. Economizer

g. Tenant override

I. The user interaction with the keypad shall provide the following:

1. Controls mode

    a. Off manual
    b. Auto
    c. Heat/Cool
    d. Cool only
    e. Heat only
    f. Fan only

2. Occupancy mode

    a. Auto
    b. Occupied
    c. Unoccupied
    d. Tenant override

3. Unit operation changeover control

    a. Return air temperature
    b. Space temperature
    c. Network signal

4. Cooling and heating change-over temperature with deadband
5. Cooling discharge air temperature (DAT)
6. Supply reset options

    a. Return air temperature
    b. Outdoor air temperature
    c. Space temperature
    d. Airflow (VAV)
    e. Network signal
    f. External (0-10 vdc)
    g. External (0-20 mA)

7. Temperature alarm limits

    a. High supply air temperature
    b. Low supply air temperature
    c. High return air temperature

8. Lockout control for compressors.
9. Compressor interstage timers
10. Night setback and setup space temperature.

11. Building static pressure.
12. Economizer changeover

    a. Enthalpy
    b. Drybulb temperature

13. Currently time and date
14. Tenant override time
15. Occupied/unoccupied time schedule
16. One event schedule
17. Holiday dates and duration
18. Adjustable set points
19. Service mode

    a. Timers normal (all time delays normal)
    b. Timers fast (all time delays 20 sec)

J. If the unit is to be programmed with a night setback or setup function, an optional space sensor shall be provided. Space sensors shall be available to support field selectable features. Sensor options shall include:

1. Zone sensor with tenant override switch
2. Zone sensor with tenant override switch plus heating and cooling set point adjustment. (Space Comfort Control systems only)

K. To increase the efficiency of the cooling system the DDC controller shall include a discharge air temperature reset program for part load operating conditions. The discharge air temperature shall be controlled between a minimum and a maximum discharge air temperature (DAT) based on one of the following inputs:

1. Airflow
2. Outside air temperature
3. Space temperature
4. Return air temperature
5. External signal of 1-5 vdc
6. External signal of 0-20 mA
7. Network signal

2.19 ELECTRICAL POWER CONNECTION

A. Provide for single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

2.20 ELECTRICAL

A. Unit wiring shall comply with NEC requirements and with all applicable UL standards. All electrical components shall be UL recognized where applicable. All wiring and electrical components provided with the unit shall be number and color-coded and labeled according to the electrical diagram provided for easy identification. The unit shall be provided with a factory wired weatherproof control panel. Unit shall have a single point power terminal block for main power connection. A terminal board shall be provided for low voltage control wiring. Branch short circuit protection, 115-volt control circuit transformer and fuse, system switches, and a high temperature sensor shall also be provided with the unit. Each compressor and condenser fan motor shall be furnished with contactors and inherent thermal overload protection. Supply fan motors shall have contactors and external overload protection. Knockouts shall be provided in the bottom of the main control panels for field wiring entrance.

B. A single non-fused disconnect switch shall be provided for disconnecting electrical power at the unit. Disconnect switches shall be mounted internally to the control panel and operated by an externally mounted handle.

2.21 ACCESSORIES (See Plan Schedule Notes)

2.22 ROOF CURBS

A. Roof curbs with vibration isolators and wind or seismic restraints are specified in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

B. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.

1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

    a. Materials: ASTM C 1071, Type I or II.

2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.

    a. Liner Adhesive: Comply with ASTM C 916, Type I.
    b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
    c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.

d. Liner Adhesive: Comply with ASTM C 916, Type I.

C. Curb Height: As required

D. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match RTU, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for wind-load requirements.

2.23 CAPACITIES AND CHARACTERISTICS (See Plan Schedule)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.

B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.

C. Examine roofs for suitable conditions where RTUs will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Division 7 Section "Roof Accessories." Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.

B. Unit Support: Install unit level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.

C. Install wind and seismic restraints according to manufacturer's written instructions. Wind and seismically restrained vibration isolation roof-curb rails are specified in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

D. Provide high water level sensor in unit condensate pan and wire cooling control circuit in series through N.C. contact.

3.3 CONNECTIONS

A. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or splash block at unit.

B. Install piping adjacent to RTUs to allow service and maintenance.

1. Gas Piping: Comply with applicable requirements in Division 15 Section "Facility Natural-Gas Piping." Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.

C. Duct installation requirements are specified in other Division 15 Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:

1. Install ducts to termination at top of roof curb.
2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
3. Connect supply ducts to RTUs with flexible duct connectors specified in Division 15 Section "Air Duct Accessories."
4. Install return-air duct continuously through roof structure.

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. Report results in writing.

B. Perform tests and inspections and prepare test reports.

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. Report results in writing.

C. Tests and Inspections:

1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.

3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace malfunctioning units and retest as specified above.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions and do the following:

1. Inspect for visible damage to unit casing.
2. Inspect for visible damage to furnace combustion chamber.
3. Inspect for visible damage to compressor, coils, and fans.
4. Inspect internal insulation.
5. Verify that labels are clearly visible.
6. Verify that clearances have been provided for servicing.
7. Verify that controls are connected and operable.
8. Verify that filters are installed.
9. Clean condenser coil and inspect for construction debris.
10. Clean furnace flue and inspect for construction debris.
11. Connect and purge gas line.
12. Remove packing from vibration isolators.
13. Inspect operation of barometric relief dampers.
14. Verify lubrication on fan and motor bearings.
15. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
16. Adjust fan belts to proper alignment and tension.
17. Start unit according to manufacturer's written instructions.

    a. Start refrigeration system.
    b. Do not operate below recommended low-ambient temperature.
    c. Complete startup sheets and attach copy with Contractor's startup report.

18. Inspect and record performance of interlocks and protective devices; verify sequences.
19. Operate unit for an initial period as recommended or required by manufacturer.
20. Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency.

    a. Measure gas pressure on manifold.

b. Inspect operation of power vents.
c. Measure combustion-air temperature at inlet to combustion chamber.
d. Measure flue-gas temperature at furnace discharge.
e. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
f. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

21. Calibrate thermostats.
22. Adjust and inspect high-temperature limits.
23. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
24. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F above return-air temperature:

    a. Coil leaving-air, dry- and wet-bulb temperatures.
    b. Coil entering-air, dry- and wet-bulb temperatures.
    c. Outdoor-air, dry-bulb temperature.
    d. Outdoor-air-coil, discharge-air, dry-bulb temperature.

25. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
26. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.

    a. Supply-air volume.
    b. Return-air volume.
    c. Relief-air volume.
    d. Outdoor-air intake volume.

27. Simulate maximum cooling demand and inspect the following:

    a. Compressor refrigerant suction and hot-gas pressures.
    b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.
28. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:

    a. High-temperature limit on gas-fired heat exchanger.
    b. Low-temperature safety operation.
    c. Filter high-pressure differential alarm.
    d. Economizer to minimum outdoor-air changeover.
    e. Relief-air fan operation.
    f. Smoke and firestat alarms.

29. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

3.6 CLEANING AND 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 site during other-than-normal occupancy hours for this purpose.

B. After completing system installation and testing, adjusting, and balancing RTU 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 ERUs and RTUs. Refer to Division 1 Section "Demonstration and Training."

B. The Contractor shall provide general HVAC system training of 40 hours which shall include operating instruction, and review of wiring and control diagram showing complete layout of each system. Contractor shall engage a factory certified technician and ATC vendor to assist during training.

END OF SECTION 15732

SECTION 15733 - PACKAGED, OUTDOOR ENERGY RECOVERY UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes packaged, outdoor, central-station air-handling units (rooftop units) with the following components and accessories:

1. Direct-expansion cooling.
2. Hot-gas reheat.
3. Gas furnace.
4. Economizer outdoor- and return-air damper section.
5. Integral, space temperature controls.
6. Roof curbs.

1.3 DEFINITIONS

A. DDC: Direct-digital controls.

B. ECM: Electrically commutated motor.

C. Outdoor-Air Refrigerant Coil: Refrigerant coil in the outdoor-air stream to reject heat during cooling operations and to absorb heat during heating operations. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.

D. Outdoor-Air Refrigerant-Coil Fan: The outdoor-air refrigerant-coil fan in RTUs. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.

E. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, outdoor, central-station air-handling units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

F. Supply-Air Fan: The fan providing supply air to conditioned space. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

G. Supply-Air Refrigerant Coil: Refrigerant coil in the supply-air stream to absorb heat (provide cooling) during cooling operations and to reject heat (provide heating) during heating operations. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

H. VVT: Variable-air volume and temperature.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design RTU supports to comply with wind and seismic performance requirements, including comprehensive engineering analysis by a qualified Professional Engineer, using performance requirements and design criteria indicated.

B. Wind-Restraint Performance:

1. Basic Wind Speed: Refer to architectural/structural Drawings for wind and seismic requirements.
2. Building Classification Category: Refer to architectural/structural Drawings for classification category.

C. Seismic Performance: RTUs shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

D. Sound Ratings shall be equal or better than basis of design. Any sound rating deviation shall be approved by Owner.

1.5 SUBMITTALS

A. Product Data: Include manufacturer's technical data for each RTU, including rated capacities, sound criteria which shall not exceed the values specified in basis of design equipment, dimensions, required clearances, characteristics, furnished specialties, and accessories.

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.
2. Sound ratings: Provide sound data measurements/ratings measured at same distance as basis of design specified equipment.

C. Delegated-Design Submittal: For RTU supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified Professional Engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.

D. Manufacturer Wind Loading Qualification Certification: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Basis for Certification: Indicate whether the withstand certification is based on actual test of assembled components or on calculations.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Coordination Drawings: Plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural members to which RTUs will be attached.
2. Roof openings
3. Roof curbs and flashing.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For RTUs to include in emergency, operation, and maintenance manuals.

H. Warranty: Special warranty specified in this Section.

1.6 QUALITY ASSURANCE

A. ARI Compliance:

1. Comply with ARI 210/240 and ARI 340/360 for testing and rating energy efficiencies for RTUs.
2. Comply with ARI 270 for testing and rating sound performance for RTUs.

B. ASHRAE Compliance:

1. Comply with ASHRAE 15 for refrigeration system safety.
2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
3. Comply with applicable requirements in ASHRAE 62.1-2013, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA 90.1-2013 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2013, Section 6 - "Heating, Ventilating, and Air-Conditioning."

D. NFPA Compliance: Comply with NFPA 90A and NFPA 90B.

E. UL Compliance: Comply with UL 1995.

F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of RTUs thatfail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
2. Warranty Period for Gas Furnace Heat Exchangers: Manufacturer's standard, but not less than 15 years from date of Substantial Completion.
3. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than three years from date of Substantial Completion.
4. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

1.8 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. Fan Belts: One set for each belt-driven fan.

2. Filters: One set of filters for each unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings (Daikin) or a comparable product by one of the following:
   1. Trane.
   2. Daikin.
   3. Carrier.
   4. Or approved equal.

2.2 UNIT DISCHARGE AIR FLOW

A. Vertical discharge thru unit base

B. Horizontal discharge through side of unit.

2.3 COILS

A. Supply-Air Refrigerant Coil:

   1. Aluminum-plate fin and seamless copper tube in steel casing with equalizing-type vertical distributor.
   2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
   3. Coil Split: Interlaced.
   4. Condensate Drain Pan: Stainless steel formed with pitch and drain connections complying with ASHRAE 62.1.
   5. Overflow sensor for system shutdown.

B. Outdoor-Air Refrigerant Coil:

   1. Aluminum-copper tube in steel casing with equalizing-type vertical distributor.
   2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.

C. Hot-Gas Reheat Refrigerant Coil:

   1. Aluminum-copper tube in steel casing with equalizing-type vertical distributor.

2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.

2.4 ELECTRICAL POWER CONNECTION

A. Provide for single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

2.5 GENERAL DESCRIPTION

A. Furnish as shown on plans. Unit performance and electrical characteristics shall be per the job schedule.

B. Configuration: Fabricate as detailed on prints and Drawings:

1. Return plenum / economizer section
2. Filter section
3. Cooling coil section
4. Supply fan section
5. Gas heating section.
6. Condensing unit section
7. Energy recovery wheel

C. The complete unit shall be cETLus listed.

D. Each unit shall be specifically designed for outdoor rooftop application and include a weatherproof cabinet. Each unit shall be completely factory assembled and shipped in one piece. Packaged units shall be shipped fully charged with R-454B Refrigerant and oil.

E. The unit shall undergo a complete factory run test prior to shipment. The factory test shall include a refrigeration circuit run test, a unit control system operations checkout, a unit refrigerant leak test and a final unit inspection.

F. All units shall have decals and tags to indicate caution areas and aid unit service. Unit nameplates shall be fixed to the main control panel door. Electrical wiring diagrams shall be attached to the control panels. Installation, operating and maintenance bulletins and start-up forms shall be supplied with each unit.

G. Performance: All scheduled EER, IEER, capacities and face areas are minimum accepted values. All scheduled amps, kW, and HP are maximum accepted values that allow scheduled capacity to be met.

H. Unit(s) shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.

2.6 CABINET, CASING, AND FRAME

A. Cabinet panels: 2” double-wall foamed panel construction throughout the indoor section of unit to provide nonporous, cleanable interior surfaces. All interior seams exposed to airflow shall be sealed.

B. Insulation: 2” polyisocyanurate foam metal encapsulated with no exposed edges. Initial R value of 6.6 per inch of thickness.

C. Cabinet base shall be double wall construction designed to prevent trapping or ponding of water within the unit base. Cabinet base pan shall be insulated with 2” thick polyisocyanurate foam. Foam insulation shall be fully enclosed with galvanized steel insulation cover. Insulation shall not be applied to underside of unit base.

D. Cabinet Base Rails: Side and end base rails shall include openings for forklift and tie-down access. To protect unit base from fork damage side rails shall include removable heavy gauge fork pockets.

E. Shipping anchors attach to and/or through unit base rails. Straps over unit shall not be used to secure unit for shipping.

F. Cabinet material interior and base rails: shall be G-90 zinc-coated galvanized steel. Material gauge shall be a minimum of 14-gauge for base rails, 16-gauge for structural members and 20-gauge for access doors and cabinet panels.

G. Exterior Corrosion Protection: Exterior cabinet panels shall be a base coat of G-90 galvanized steel with both exterior and interior surfaces cleaned, phosphatized and finished with a weather-resistant baked enamel finish. Unit’s surface shall be in compliance with ASTM B45 salt spray testing at a minimum of 672 hour duration.

H. Cabinet construction shall provide hinged panels providing easy access for all parts requiring routine service.

I. Cabinet top cover shall be one piece construction or where seams exist, it shall be double-hemmed and gasket-sealed.

J. Hinged Access Panels: Water- and air-tight hinged access panels shall provide access to all areas requiring routine service including air filters, heating section, electrical and control cabinet sections, optional ERV and power exhaust fan section, supply air fan section, evaporator and reheat coil sections. Insulated doors shall be constructed to allow the hinges to be reversed in the field.

1. Hold-open devices shall be factory installed on all hinged access doors. Chains shall not be used as hold-open devices.
2. Latches with locking hasp or tool operated closure devices shall be factory installed on all hinged access panels.

K. Drain Pan material shall be Type 430 Stainless steel drain and constructed to sloped in two directions to ensure positive drainage with corners exposed to standing water and drain fittings welded liquid tight to prevent leaks. Pan shall have a minimum depth of 2". Base of drain pan shall be insulated with 1" thick foam insulation.

L. Provide openings either on side of unit or thru the base for power, control and gas connections.

M. Cabinet shall include optional interior liner constructed of Type 304 stainless steel with sealed seams.

N. Air inlet hood shall be factory installed and shall not require field assembly. Hood shall include 2" thick removable aluminum mesh mist eliminators sized for a velocity not to exceed 500 FPM at maximum unit rated airflow. Service access shall be hinged and held in place with thumb latches that shall not require tools for service access.

O. Unit shall be equipped with a 6" filter rack upstream of the evaporator. Frame shall be field-adjustable to match any filter combination specified in the following section.

2.7 AIR FILTER

A. Unit inlet hood shall include 2" thick aluminum mesh removable mist eliminators with hinged access cover. Inlet velocity shall not exceed 500 FPM.

B. Evaporator Inlet shall include a full complement of pleated media air filters. Filters shall be:
1. 2" deep MERV 13

2.8 DAMPERS

A. Unit shall include a motor operated outdoor air damper constructed of galvanized steel.

B. Damper blades shall be air foil design with rubber edge seals designed not to exceed a 4 CFM/SQ FT leakage rate exceeding ASHRAE 90.1 damper leakage requirements.

C. Damper actuator shall be factory mounted and wired sealed spring return and either two-position or fully modulating.

D. Dampers air velocity shall not exceed 2000 fpm.

E. Return Air damper shall be of same material, construction and leakage rate as outdoor air damper. Return air damper actuator shall be factory mounted and wired sealed spring fully modulating and operate based on outdoor air damper feedback signal to properly regulate RA airflow.

2.9 ECONOMIZER SECTION

A. Unit shall be provided with an outdoor air economizer section. The economizer section shall include outdoor, return, and exhaust air dampers. The economizer operation shall be fully integral to the mechanical cooling and allow up to 100% of mechanical cooling if needed to maintain the cooling discharge air temperature. The outdoor air hood shall be factory installed and constructed from galvanized steel finished with the same durable paint finish as the main unit. The hood shall include moisture eliminator filters to drain water away from the entering air stream. The outside and return air dampers shall be sized to handle 100% of the supply air volume. The dampers shall be parallel blade design. Damper blades shall be gasketed with side seals to provide an air leakage rate of 4 cfm / square foot of damper area at 1" differential pressure per ASHRAE 90.1 Energy Standard. A barometric exhaust damper shall be provided to exhaust air out of the back of the unit. A bird screen shall be provided to prevent infiltration of rain and foreign materials. Exhaust damper blades shall be lined with vinyl gasketing on contact edges. Control of the dampers shall be by a factory installed direct coupled actuator. Damper actuator shall be of the modulating, spring return type. A comparative enthalpy control shall be provided to sense and compare enthalpy in both the outdoor and return air streams to determine if outdoor air is suitable for "free" cooling. If outdoor air is suitable for "free" cooling, the outdoor air dampers shall modulate in response to the unit's temperature control system.

2.10 EXHAUST FAN

A. Exhaust fan shall be a single width, single inlet (SWSI) airfoil centrifugal fan. The fan wheel shall be Class II construction with aluminum fan blades that are continuously welded to the hub plate and end rim. The exhaust fan shall be a direct drive fan mounted to the motor shaft

B. The fan motor shall be a totally enclosed EC motor that is speed controlled by the rooftop unit controller. The motor shall include thermal overload protection and protect the motor in the case of excessive motor temperatures. The motor shall have phase failure protection and prevent the motor from operation in the event of a loss of phase. Motors shall be premium efficiency.

C. Fan assembly shall be a slide out assembly for servicing and maintenance.

D. The unit DDC controller shall provide building static pressure control. The unit controller shall provide proportional control of the exhaust fans from 25% to 100% of the supply air fan designed airflow to maintain the adjustable building pressure setpoint. The field shall mount the required sensing tubing from the building to the factory mounted building static pressure sensor.

2.11 COOLING COIL

A. The indoor coil section shall be installed in a draw through configuration, upstream of the supply air fan. The coil section shall be complete with a factory piped cooling coil and an ASHRAE 62.1 compliant double sloped drain pan.

B. The direct expansion (DX) cooling coils shall be fabricated of seamless high efficiency copper tubing that is mechanically expanded into high efficiency aluminum plate fins. Coils shall be a multi-row, staggered tube design with a minimum of 3 rows. All cooling coils shall have an interlaced coil circuiting that keeps the full coil face active at all load conditions. All coils shall be factory leak tested with high pressure air under water.

C. The cooling coil shall have an electronic controlled expansion valve. The unit controller shall control the expansion valve to maintain liquid subcooling and the superheat of the refrigerant system.

D. The refrigerant suction lines shall be fully insulated from the expansion valve to the compressors.

E. The drain pan shall be stainless steel and positively sloped. The slope of the drain pan shall be in two directions and comply with ASHRAE Standard 62.1. The drain pan shall have a minimum slope of 1/8" per foot to provide positive draining. The drain pan shall extend beyond the leaving side of the coil. The drain pan shall have a threaded drain connection extending through the unit base.

2.12 HOT GAS REHEAT

A. Unit shall be equipped with a fully modulating hot gas reheat coil with hot gas coming from the unit condenser

B. Hot gas reheat coil shall be a Micro Channel design. The aluminum tube shall be a micro channel design with high efficiency aluminum fins. Fins shall be brazed to the tubing for a direct bond. The capacity of the reheat coil shall allow for a 20°F temperature rise at all operating conditions.

C. The modulating hot gas reheat systems shall allow for independent control of the cooling coil leaving air temperature and the reheat coil leaving air temperature. The

cooling coil and reheat coil leaving air temperature setpoints shall be adjustable through the unit controller. During the dehumidification cycle the unit shall be capable of 100% of the cooling capacity. The hot gas reheat coil shall provide discharge temperature control within +/- 2°F.

D. Each coil shall be factory leak tested with high-pressure air under water.

2.13 SUPPLY FAN

A. Supply fan shall be a single width, single inlet (SWSI) airfoil centrifugal fan. The fan wheel shall be Class II construction with aluminum fan blades that are continuously welded to the hub plate and end rim. The supply fan shall be a direct drive fan mounted to the motor shaft.

B. Fan assembly shall be a slide out assembly for servicing and maintenance

C. All fan assemblies shall be statically and dynamically balanced at the factory, including a final trim balance, prior to shipment.

D. The fan motor shall be a totally enclosed EC motor that is speed controlled by the rooftop unit controller. The motor shall include thermal overload protection and protect the motor in the case of excessive motor temperatures. The motor shall have phase failure protection and prevent the motor from operation in the event of a loss of phase. Motors shall be premium efficiency.

E. The supply fan shall be capable of airflow modulation from 30% to 100% of the scheduled designed airflow. The fan shall not operate in a state of surge at any point within the modulation range.

2.14 VARIABLE AIR VOLUME CONTROL

A. The unit controller shall proportionally control the Electronically Commutated Motors (ECM) on the supply and exhaust fans. The supply fan shall be controlled to maintain an adjustable duct pressure setpoint. A duct static pressure sensor shall be factory mounted in the control panel. The field shall furnish and install the pneumatic tubing for the duct static pressure sensor and the building pressure sensor. The field shall furnish and install the outdoor air pressure sensor.

B. The unit controller shall proportional control the ECM motors on the supply fan based on space temperature. The unit controller shall increase/decrease the speed of the supply fan in order to maintain the space temperature within its setpoint and deadband. The unit controller shall provide discharge air temperature control with the compressor modulation.

2.15 HEATING SECTION

A. Completely assembled and factory installed heating system shall be in the primary heating position located beneath the indoor fan assembly and be integral to unit and approved for use downstream from refrigerant cooling coils in units mounted outdoors. Threaded gas connection shall terminate at field provided manual shut-off valve. Provide capability for sidewall gas piping.

B. Heaters shall include high turn-down burners firing into individual stainless-steel tubular heat exchangers. Heat exchangers shall be constructed of type 439 stainless steel and be a high efficiency dimpled tubular design capable of draining internal condensate. Units with multiple heaters shall include one fully modulating high turndown heater with additional on-off heater sections. Total heater turndown shall be based on heater gas input capacity 5:1 when ≤150 MBH or a minimum of 10:1 when >150 MBH.

C. Heater outdoor air inlet shall be hooded and include internal baffle system to prevent rain blow thru. To prevent recirculation of flue gas and to prevent flue gas condensate from draining onto and obstructing the heater air inlet the inlet shall be hooded and shall be located a minimum of 8” beneath the flue outlet. Inlet hood shall include bird screen.

D. Heater flue outlet(s) shall include hooded outlet with wire cloth all constructed of Type 430 stainless steel. Hooded outlet shall be sealed to prevent flue gas recirculation.

E. Gas Burner Safety Controls: Provide safety controls for the proving of combustion air prior to ignition, continuous air proving monitoring following ignition and continuous electronic flame supervision.

F. Unit controls shall monitor heat output and shall discontinue all heating attempts and or unit operation in the event the heating section fails to ignite or fails to maintain programmed supply air temperature/time.

G. Inducer fan shall be direct drive high pressure centrifugal type with two speeds and shall include built- in thermal overload protection.

H. Limit controls: High temperature automatic reset limits shall be located on blower wall and in indoor fan chamber to shut off gas flow in the event of excessive temperatures resulting from restricted indoor airflow, or loss of indoor airflow.

I. Flame roll-out safeties shall provide continuous monitoring of proper burner operation.

2.16 CONDENSING SECTION

A. Outdoor coils shall have seamless copper tubes, mechanically bonded into aluminum plate-type fins. The fins shall have full drawn collars to completely cover the tubes. A sub-cooling coil shall be an integral part of the main outdoor air coil. Each outdoor air coil shall be factory leak tested with high-pressure air under water.

B. Outdoor air coils shall be protected from incidental contact to coil fins by a coil guard. Coil guard shall be constructed of cross wire welded steel with PVC coating.

C. Fan motors shall be an ECM type motor for proportional control. The unit controller shall proportionally control the speed of the condenser fan motors to maintain the head pressure of the refrigerant circuit from ambient condition of 0~125°F. Mechanical cooling shall be provided to 25º F. The motor shall include thermal overload protection and protect the motor in the case of excessive motor temperatures. The motor shall have phase failure protection and prevent the motor from operation in the event of a loss of phase.

D. The condenser fan shall be low noise blade design. Fan blade design shall be a dynamic profile for low tip speed. Fan blade shall be of a composite material.

E. The unit shall have scroll compressors. One of the compressors shall be an inverter compressor providing proportional control. The unit controller shall control the speed of the compressor to maintain the discharge air temperature.

F. Pressure transducers shall be provided for the suction pressure and head pressure. Temperature sensor shall be provided for the suction temperature and the refrigerant discharge temperature of the compressors. All of the above devices shall be an input to the unit controller and the values be displayed at the unit controller.

G. Refrigerant circuit shall have a bypass valve between the suction and discharge refrigerant lines for low head pressure compressor starting and increased compressor reliability. When there is a call for mechanical cooling the bypass, valve shall open to equalizing the suction and discharge pressures. When pressures are equalized the bypass, valve shall close and the compressor shall be allowed to start.

H. Each circuit shall be dehydrated and factory charged with R-410A Refrigerant and oil.

2.17 ELECTRICAL

A. Unit wiring shall comply with NEC requirements and with all applicable UL standards. All electrical components shall be UL recognized where applicable. All wiring and electrical components provided with the unit shall be number and color-coded and labeled according to the electrical diagram provided for easy identification. The unit shall be provided with a factory wired weatherproof control panel. Unit shall have a

single point power terminal block for main power connection. A terminal board shall be provided for low voltage control wiring. Branch short circuit protection, 115-volt control circuit transformer and fuse, system switches, and a high temperature sensor shall also be provided with the unit. Each compressor and condenser fan motor shall be furnished with contactors and inherent thermal overload protection. Supply fan motors shall have contactors and external overload protection. Knockouts shall be provided in the bottom of the main control panels for field wiring entrance.

B. A single non-fused disconnect switch shall be provided for disconnecting electrical power at the unit. Disconnect switches shall be mounted internally to the control panel and operated by an externally mounted handle.

2.18 CONTROLS

A. Control equipment and sequence of operation are specified in Division 15900 Section "Instrumentation and Control for HVAC."

B. Using Bacnet interface, connect to the existing automatic temperature control to interface with the rooftop units and/or energy recovery units.

C. Provide a complete integrated microprocessor based Direct Digital Control (DDC) system to control all unit functions including temperature control, scheduling, monitoring, unit safety protection, including compressor minimum run and minimum off times, and diagnostics. This system shall consist of all required temperature sensors, pressure sensors, controller and keypad/display operator interface. All MCBs and sensors shall be factory mounted, wired and tested.

D. The stand-alone DDC controllers shall not be dependent on communications with any on-site or remote PC or master control panel for proper unit operation. The microprocessor shall maintain existing set points and operate standalone if the unit loses either direct connect or network communications. The microprocessor memory shall be protected from voltage fluctuations as well as any extended power failures. All factory and user set schedules and control points shall be maintained in nonvolatile memory. No settings shall be lost, even during extended power shutdowns.

E. The DDC control system shall permit starting and stopping of the unit locally or remotely. The control system shall be capable of providing a remote alarm indication. The unit control system shall provide for outside air damper actuation, emergency shutdown, remote heat enable/disable, remote cool enable/disable, heat indication, cool indication, and fan operation.

F. All digital inputs and outputs shall be protected against damage from transients or incorrect voltages. All field wiring shall be terminated at a separate, clearly marked terminal strip

G. The DDC controller shall have a built-in time schedule. The schedule shall be programmable from the unit keypad interface. The schedule shall be maintained in nonvolatile memory to ensure that it is not lost during a power failure. There shall be one start/stop per day and a separate holiday schedule. The controller shall accept up to sixteen holidays each with up to a 5-day duration. Each unit shall also have the ability to accept a time schedule via BAS network communications.

H. The keypad interface shall allow convenient navigation and access to all control functions. The unit keypad/display character format shall be 4 lines x 20 characters. All control settings shall be password protected against unauthorized changes. For ease of service, the display format shall be English language readout. Coded formats with look-up tables will not be accepted. The user interaction with the display shall provide the following information as a minimum:

1. Return air temperature.
2. Discharge air temperature.
3. Outdoor air temperature.
4. Space air temperature.
5. Outdoor enthalpy, high/low.
6. Compressor suction temperature and pressure
7. Compressor head pressure and temperature
8. Expansion valve position
9. Condenser fan speed
10. Inverter compressor speed
11. Dirty filter indication.
12. Airflow verification.
13. Cooling status.
14. Control temperature (Changeover).
15. VAV box output status.
16. Cooling status/capacity.
17. Unit status.
18. All time schedules.
19. Active alarms with time and date.
20. Previous alarms with time and date.
21. Optimal start
22. Supply fan and exhaust fan speed.
23. System operating hours.

    a. Fan
    b. Exhaust fan
    c. Cooling
    d. Individual compressor
    e. Heating
    f. Economizer

g. Tenant override

I. The user interaction with the keypad shall provide the following:

1. Controls mode

    a. Off manual
    b. Auto
    c. Heat/Cool
    d. Cool only
    e. Heat only
    f. Fan only

2. Occupancy mode

    a. Auto
    b. Occupied
    c. Unoccupied
    d. Tenant override

3. Unit operation changeover control

    a. Return air temperature
    b. Space temperature
    c. Network signal

4. Cooling and heating change-over temperature with deadband
5. Cooling discharge air temperature (DAT)
6. Supply reset options

    a. Return air temperature
    b. Outdoor air temperature
    c. Space temperature
    d. Airflow (VAV)
    e. Network signal
    f. External (0-10 vdc)
    g. External (0-20 mA)

7. Temperature alarm limits

    a. High supply air temperature
    b. Low supply air temperature
    c. High return air temperature

8. Lockout control for compressors.
9. Compressor interstage timers
10. Night setback and setup space temperature.

11. Building static pressure.
12. Economizer changeover

    a. Enthalpy
    b. Drybulb temperature

13. Currently time and date
14. Tenant override time
15. Occupied/unoccupied time schedule
16. One event schedule
17. Holiday dates and duration
18. Adjustable set points
19. Service mode

    a. Timers normal (all time delays normal)
    b. Timers fast (all time delays 20 sec)

J. If the unit is to be programmed with a night setback or setup function, an optional space sensor shall be provided. Space sensors shall be available to support field selectable features. Sensor options shall include:

1. Zone sensor with tenant override switch
2. Zone sensor with tenant override switch plus heating and cooling set point adjustment. (Space Comfort Control systems only)

K. To increase the efficiency of the cooling system the DDC controller shall include a discharge air temperature reset program for part load operating conditions. The discharge air temperature shall be controlled between a minimum and a maximum discharge air temperature (DAT) based on one of the following inputs:

1. Airflow
2. Outside air temperature
3. Space temperature
4. Return air temperature
5. External signal of 1-5 vdc
6. External signal of 0-20 mA
7. Network signal

2.19 REFRIGERANT DETECTION SYSTEM (RDS)

A. Systems with refrigerant classified as A2L shall include RDS.

B. RDS shall engage mitigation measures at 12% of LFL.

C. Mitigation will continue for 5 minutes once the alarm is cleared.

D. Detection of refrigerant leak(s) in the airstream shall:
   1. De-energize compressors, UV Lights, heaters, and fan motors, excluding Indoor Fan Motor(s).
   2. Run indoor fan motor(s) at minimum Hz.
   3. For building comfort, to avoid freezing or overheating the space, the damper command will not change, and the unit will still provide full dilution of any leaked refrigerant.
      a. Except for units with 2 position dampers and no return duct. In which case the damper shall be commanded open.
   4. 24VAC status terminal will energize on OAUTS.

E. Detection of refrigerant leak(s) in a non-airstream compartment shall:
   1. De-energize all loads including: compressors, motors and heaters.
   2. Energize the mechanical ventilation fans internal to the unit.

F. E-stop shall be given priority control of the unit over that of the RDS.

2.20 LEAK DETECTION SENSORS

A. Unit shall be furnished with a leak detection system from the factory when a circuit refrigerant charge exceeds 3.91 lbs. The leak detection system shall consist of one or more refrigerant detection sensors. When the system detects a leak, the unit controller shall initiate mitigation actions.

2.21 ACCESSORIES (See Plan Schedule Notes)

2.22 ROOF CURBS

A. Roof curbs with vibration isolators and wind or seismic restraints are specified in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

B. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.

   1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

      a. Materials: ASTM C 1071, Type I or II.

   2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.

      a. Liner Adhesive: Comply with ASTM C 916, Type I.

b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
d. Liner Adhesive: Comply with ASTM C 916, Type I.

C. Curb Height: As required

D. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match RTU, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for wind-load requirements.

2.23 CAPACITIES AND CHARACTERISTICS (See Plan Schedule)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.

B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.

C. Examine roofs for suitable conditions where RTUs will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Division 7 Section "Roof Accessories." Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.

B. Unit Support: Install unit level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.

C. Install wind and seismic restraints according to manufacturer's written instructions. Wind and seismically restrained vibration isolation roof-curb rails are specified in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

D. Provide high water level sensor in unit condensate pan and wire cooling control circuit in series through N.C. contact.

3.3 CONNECTIONS

A. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or splash block at unit.

B. Install piping adjacent to RTUs to allow service and maintenance.

1. Gas Piping: Comply with applicable requirements in Division 15 Section "Facility Natural-Gas Piping." Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.

C. Duct installation requirements are specified in other Division 15 Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:

1. Install ducts to termination at top of roof curb.
2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
3. Connect supply ducts to RTUs with flexible duct connectors specified in Division 15 Section "Air Duct Accessories."
4. Install return-air duct continuously through roof structure.

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. Report results in writing.

B. Perform tests and inspections and prepare test reports.

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. Report results in writing.

C. Tests and Inspections:

1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace malfunctioning units and retest as specified above.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions and do the following:

1. Inspect for visible damage to unit casing.
2. Inspect for visible damage to furnace combustion chamber.
3. Inspect for visible damage to compressor, coils, and fans.
4. Inspect internal insulation.
5. Verify that labels are clearly visible.
6. Verify that clearances have been provided for servicing.
7. Verify that controls are connected and operable.
8. Verify that filters are installed.
9. Clean condenser coil and inspect for construction debris.
10. Clean furnace flue and inspect for construction debris.
11. Connect and purge gas line.
12. Remove packing from vibration isolators.
13. Inspect operation of barometric relief dampers.
14. Verify lubrication on fan and motor bearings.
15. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
16. Adjust fan belts to proper alignment and tension.
17. Start unit according to manufacturer's written instructions.

    a. Start refrigeration system.
    b. Do not operate below recommended low-ambient temperature.
    c. Complete startup sheets and attach copy with Contractor's startup report.

18. Inspect and record performance of interlocks and protective devices; verify sequences.

19. Operate unit for an initial period as recommended or required by manufacturer.
20. Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency.

    a. Measure gas pressure on manifold.
    b. Inspect operation of power vents.
    c. Measure combustion-air temperature at inlet to combustion chamber.
    d. Measure flue-gas temperature at furnace discharge.
    e. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
    f. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

21. Calibrate thermostats.
22. Adjust and inspect high-temperature limits.
23. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
24. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F above return-air temperature:

    a. Coil leaving-air, dry- and wet-bulb temperatures.
    b. Coil entering-air, dry- and wet-bulb temperatures.
    c. Outdoor-air, dry-bulb temperature.
    d. Outdoor-air-coil, discharge-air, dry-bulb temperature.

25. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
26. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.

    a. Supply-air volume.
    b. Return-air volume.
    c. Relief-air volume.
    d. Outdoor-air intake volume.

27. Simulate maximum cooling demand and inspect the following:

    a. Compressor refrigerant suction and hot-gas pressures.
    b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.

28. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:

    a. High-temperature limit on gas-fired heat exchanger.
    b. Low-temperature safety operation.

c. Filter high-pressure differential alarm.
d. Economizer to minimum outdoor-air changeover.
e. Relief-air fan operation.
f. Smoke and firestat alarms.

29. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

3.6 CLEANING AND 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 site during other-than-normal occupancy hours for this purpose.

B. After completing system installation and testing, adjusting, and balancing RTU 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 ERUs and RTUs. Refer to Division 1 Section "Demonstration and Training."

B. The Contractor shall provide general HVAC system training of 40 hours which shall include operating instruction, and review of wiring and control diagram showing complete layout of each system. Contractor shall engage a factory certified technician and ATC vendor to assist during training.

END OF SECTION 15733

SECTION 15764 - FIN-TUBE RADIATION

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 **hydronic fin-tube** radiation.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, and details.1
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 and dimensions of custom-fabricated enclosures.
4. Indicate location and size of each field connection.
5. Indicate location and arrangement of piping valves and specialties.
6. Indicate location and arrangement of integral controls.
7. Include enclosure joints, corner pieces, access doors, and other accessories.

C. Color Samples for Verification: For each type of exposed finish.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural members, including wall construction, to which fin-tube radiation will be attached.
2. Method of attaching fin-tube radiation to building structure.
3. Penetrations of fire-rated wall and floor assemblies.

B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 HOT-WATER FIN-TUBE RADIATION

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Slant/Fin Corp.
2. Sterling HVAC Products; a Mestek company.
3. Vulcan, a Mestek company.
4. Or approved equal.

B. Performance Ratings: Rate fin-tube radiation according to Hydronics Institute's "I=B=R Testing and Rating Standard for Fin-Tube (Commercial) Radiation."

C. Heating Elements: Copper tubing mechanically expanded into flanged collars of evenly spaced aluminum fins resting on element supports. One end of tube shall be belled.

D. Element Supports: Ball-bearing cradle type to permit longitudinal movement on enclosure brackets.

E. Front Panel: Minimum **0.0528-inch-** thick steel.

F. Rust-Resistant Front Panel: Minimum **0.064-inch-** thick, ASTM A 653/A 653M, G60 galvanized steel.

G. Wall-Mounted Back Panel: Minimum 0.0329-inch-thick steel, full height, with full-length channel support for front panel without exposed fasteners.

H. Floor-Mounted Pedestals: Conceal insulated piping at maximum 36-inch spacing. Pedestal-mounted back panel shall be solid panel matching front panel. Provide stainless-steel escutcheon for floor openings at pedestals.

I. Support Brackets: Locate at maximum 36-inch spacing to support front panel and element.

J. Finish: Baked- **epoxy** finish in manufacturer's **standard** and/or **custom** color as selected by Architect.

K. Damper: Knob-operated internal damper at enclosure outlet.

L. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches, integral with enclosure.

M. Styles, Types, Sizes, and Capacities: As scheduled on the Drawings.

N. Accessories: Filler sections, corners, relay sections, and splice plates all matching the enclosure and grille finishes.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive fin-tube radiation for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for **hydronic-piping** connections to verify actual locations before installation of fin-tube radiation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FIN-TUBE RADIATION INSTALLATION

A. Install units level and plumb.

B. Install enclosure continuously around corners, using outside and inside corner fittings.

C. Join sections with splice plates and filler pieces to provide continuous enclosure.

D. Install access doors for access to valves.

E. Install enclosure continuously from wall to wall.

F. Terminate enclosures with manufacturer's end caps except where enclosures are indicated to extend to adjoining walls.

G. Install valves within reach of access door provided in enclosure.

H. Install air-seal gasket between wall and recessed flanges or front cover of fully recessed unit.

I. Install piping within pedestals for freestanding units.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Specifications **"Hydronic Piping and Specialties"**. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect hot-water fin-tube radiation and components to piping according to Specification "Hydronic Piping and Specialties."

1. Install shutoff valves on inlet and outlet, and balancing valve on outlet.

C. Install control valves as required by Specification for automatic temperature controls.

D. Install piping adjacent to fin-tube radiation to allow service and maintenance.

3.4 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 15764

SECTION 15767 - UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes unit heaters.

1.3 SUBMITTALS

A. Product Data: Include specialties and accessories for each unit type and configuration.

B. Shop Drawings: Submit the following for each unit type and configuration:

1. Plans, elevations, sections, and details.
2. Details of anchorages and attachments to structure and to supported equipment.
3. Power, signal, and control wiring diagrams. Differentiate between manufacturer-installed and field-installed wiring.
4. Equipment schedules to include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

C. Field Test Reports: Written reports of tests specified in Part 3 of this Section.

D. Maintenance Data: For propeller unit heaters to include in maintenance manuals specified in Division 1. Include the following:

1. Maintenance schedules and repair parts lists for motors, coils, and integral controls.

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.

1.5 COORDINATION

A. Coordinate layout and installation of propeller unit heaters and suspension system components with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Hot Water Heat Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Sterling HVAC Products.
2. Airtherm.
3. Modine.
4. Trane.
5. Or approved equal.

B. Electric Heat Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Berko.
2. QMark.
3. Markel.
4. Modine.
5. Trane.
6. Or approved equal.

2.2 UNIT HEATERS

A. Description: An assembly including casing, coil, fan, motor and discharge configuration as indicated on the Drawings.

2.3 MATERIALS

A. Casing: Galvanized steel, with removable panels.

B. Cabinet Finish: Bonderize, phosphatize, and flow-coat with baked-on primer and manufacturer's standard paint applied to factory-assembled and -tested propeller unit heater before shipping.

2.4 HOT WATER COILS

A. Hot-Water Coil: Copper tube, 0.031-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering water temperature of 325 deg F, with manual air vent. Test for leaks to 375 psig underwater.

2.5 ELECTRIC-RESISTANCE HEATING ELEMENTS

A. Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium-oxide insulating refractory and sealed in high-mass steel or corrosion-resistant metallic sheath with fins no closer than 0.16 inch. Element ends shall be enclosed in terminal box. Fin surface temperature shall not exceed 550 deg F at any point during normal operation.

1. Circuit Protection: One-time fuses in terminal box for overcurrent protection and limit controls for overtemperature protection of heaters.
2. Wiring Terminations: Match conductor materials and sizes indicated.

2.6 FAN

A. Propeller with aluminum blades directly connected to motor.

2.7 FAN MOTORS

A. Multispeed motor with integral thermal-overload protection.

2.8 ACCESSORIES

A. Horizontal Configuration : Louver fin diffuser.

B. Vertical Configuration : Louver cone diffuser.

2.9 CONTROLS

A. Control Devices: Unit-mounted or wall-mounted fan-speed switch as indicated on the Drawings. Unit-mounted or wall-mounted thermostat as indicated on the Drawings.

2.10 SOURCE QUALITY CONTROL

A. Test propeller unit heater coils according to ASHRAE 33.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive propeller unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before propeller unit heater installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install propeller unit heaters level and plumb.

B. Install propeller unit heaters to comply with NFPA 90A.

C. Suspend propeller unit heaters from structure with rubber-in-shear vibration isolators (rubber hangers). Vibration isolators are specified in Section "Mechanical Vibration Controls and Seismic Restraints."

D. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other mechanical Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Unless otherwise indicated, install shutoff valve and union or flange on each connection.

C. Install piping adjacent to machine to allow service and maintenance.

D. Ground equipment.

E. 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.

3.4 FIELD QUALITY CONTROL

A. Testing: Perform the following field quality-control testing and report results in writing:

1. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safeties.

B. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.5 CLEANING

A. After installing units, inspect unit cabinet for damage to finish. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. After installing units, clean propeller unit heaters internally according to manufacturer's written instructions.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain propeller unit heaters.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
2. Review data in maintenance manuals. Refer to Division 1 Section "Closeout Procedures."
3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
4. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 15767

SECTION 15768 – SELF CONTAINED UNIT VENTILATOR

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes unit ventilators with the following heating and cooling elements:

1. Hot water heating coil.
2. DX cooling coil

1.3 SUBMITTALS

A. Product Data: Include specialties and accessories for each unit type and configuration.

B. Shop Drawings: Submit the following for each unit ventilator type and configuration:

1. Plans, elevations, sections, and details.
2. Details of anchorages and attachments to structure and to supported equipment.
3. Power, signal, and control wiring diagrams. Differentiate between manufacturer-installed and field-installed wiring.
4. Equipment schedules to include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

C. Field Test Reports: Written reports of tests specified in Part 3 of this Section.

D. Maintenance Data: For unit ventilators to include in maintenance manuals specified in Division 1. Include the following:

1. Maintenance schedules and repair parts lists for motors, coils, integral controls, and filters.

E. Warranties: Special warranties specified in this Section.

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. AHRI Compliance: Test and rate Self Contained Air Conditioner unit ventilator in accordance with AHRI Standard 390 “Single Packaged Vertical Air Conditioners and Heat Pumps”.

C. NFPA 70 – National Electrical Code; National Fire Protection Association; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2010, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

E. ANSI/ASHRAE/IES 90.1-2013 Compliance: Applicable requirements in ANSI/ASHRAE/IES 90.1-2013, Section 6 - "Heating, Ventilating, and Air-Conditioning."

F. Comply with ARI 440 for testing and rating units.

G. Comply with ASHRAE 33 for testing steam and hydronic coils.

H. Comply with NFPA 70 for components and installation.

1.5 COORDINATION

A. Coordinate layout and installation of horizontal unit ventilators and suspension system components with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate size and location of wall sleeves for outside-air intake and relief dampers.

1.6 WARRANTY

A. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Bid Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Bid Documents.

B. Special Warranty: Written warranty, executed by manufacturer agreeing to repair or replace components of compressor that fail in materials or workmanship within specified warranty period.

C. Warranty Period: Five years 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. Unit Ventilator Filters: Furnish **One** spare filter for each filter installed.
2. Fan Belts: Furnish **One** spare fan belt for each size unit installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Airedale.
2. Bard.
3. Or approved equal.

2.2 UNIT VENTILATORS

A. Description: A vertical, floor-mounting assembly (as indicated on the Drawings) including cabinet, filter, chassis, coil, fan, and motor in draw-through or blow-through configuration with the following:

1. Heating coil.
2. Cooling coil.
3. Temperature controls (coordinated with building automatic temperature control system).
4. Remote air-cooled condensing unit (for split system unit ventilators).
5. Integral air-cooled condensing unit (for self-contained unit ventilators).

2.3 CABINET

A. Insulation: 1-inch thick, acoustic Hushcloth Polyester/Polyurethane foam with density of 2-pounds per cubic foot containing no fibrous materials.
1. Fire-Hazard Classification: Insulation shall have a fire rating of UL94HF-1.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2010.

B. Cabinet Construction: Constructed from aluminized steel with 20 gauge panels, degreased and coated with electrostatically applied baked-on polyester powder paint.

C. Cabinet Interior: Interior right and left hand sides shall employ 20 gauge galvanized steel full double wall construction.

D. Cabinet Finish: The unit color shall be Beige (Hammertone Finish)
   1. Paint finish shall be easily cleanable and hard wearing to give maximum protection.

E. Service and Maintenance Access: All service and maintenance access shall be possible through the front of the unit only.

F. Return air openings shall be integrated into the cabinet sides and bottom of cabinet.

G. Access door is factory installed on the front of the unit. Face of door shall be absent of return air openings to allow for easy cleaning. Door shall be fully insulated to provide for superior noise deadening at front of unit. Door shall employ heavy duty ¼" zinc plated steel plunger hinges with a spring-loaded ¼" zinc plated steel pin to allow for easy removal, if required. Door is secured with two (2) key locks. Door swing designed to turn into itself allowing side of the unit to be installed directly against a wall in the corner of a room.

H. Condensate Connection: Factory installed condensate connection stub provided for connection to the field installed building condensate drain.

2.4 REFRIGERATION SYSTEM

A. Compressor: Two stage hermetic scroll compressor mounted on four (4) 125# all neoprene rubber 35-45 durometer vibration isolators for quiet operation. Compressor contains an internal unloading mechanism to provide capacity control and enable part load efficiencies to be increased.
   1. An internal overload protector included to protect compressor against excessive motor temperatures and currents.
   2. Compressor is equipped with a crankcase heater to guard against liquid flood-back conditions and the elimination of oil foaming upon start up.
   3. Factory set high and low-pressure switches, automatic reset high pressure cutout, and automatic reset low-pressure cutout.

B. Compressor Acoustic Wrap with Base: For improved sound attenuation, compressor casing consists of 18oz PVC barrier laminated to 1/2 inch non-woven polyester. Casing includes integral 4 inch foil backed fiberglass heat shield for use with crankcase heater. Compressor base consists of 2 pound EVA barrier with embedded ¼ inch layered closed cell foam. Cover is easily removable for service.

C. Refrigeration Circuit (Heat Pump): Heat pump systems shall utilize R-454B and contain a factory fitted thermal expansion device and filter drier. Fitted with factory set automatic reset high-pressure and low-pressure cut-out switches and a sight glass included for system observation. A factory set defrost control fitted allows defrosting of the outside coil when in heat pump mode. Fitted with factory set automatic reset high-pressure and low-pressure cut-out switches and a sight glass for system observation.

D. Indoor Coil: Coil shall be high capacity 4 row design with copper tubes and mechanically bonded aluminum fins at a spacing of 14 fins per inch. Coil shall be designed, tested and fabricated by unit ventilator manufacturer for optimal airflow and heat transfer specific to the unit. The quick draining coil shall be fitted to a non-corrosive stainless steel drain tray.

E. Outdoor Coil: Enhanced, high efficiency, cross rifled coil designed, tested and fabricated by unit ventilator manufacturer for optimal airflow and heat transfer specific to the unit. Coil is fitted to non-corrosive stainless steel drain trays.

F. A2L Refrigerant Leak Dissipation System
   1. Leak dissipation system shall consist of two A2L sensors certified to UL-60335-2-40.
   2. Sensors shall be designed for the life of the unit. Single use refrigerant leak sensors shall not be permitted.
   3. Dissipation system shall be automatic, ship pre-wired, and require no additional field connections to function.
   4. Refrigerant leak sensors shall be installed in UL-certified location and orientation. Sensors shall be self-correcting and resettable.
   5. When the system detects a leak, the following mitigation actions will be initiated until refrigerant has not been detected for at least 5 minutes:
      a. Energize the supply fan to deliver a required minimum amount of circulation airflow.
      b. Disable compressor operation.
      c. Provide an output to energize additional mechanical ventilation (if needed).
      d. Disable electric heat sources.
      e. Provide a 24V alarm dry contact to allow for external notification of leak detection.
      f. Ability to notify BAS system of dissipation event via readable alarm point through BACnet.
      g. Provide recallable dissipation alarm history on Modine Control System Carel controller.
      h. Building fire and smoke systems may override this function via the remote shut down terminals on the unit controls.

6. Dissipation system shall be “Fail Safe” per UL requirements. If a refrigerant sensor has a fault or is disconnected, the unit will initiate the mitigation actions.

2.5 HOT GAS REHEAT

A. Unit is equipped with a reclaim valve and a second condenser coil (reheat coil). When the unit enters the dehumidification mode, the reclaim valve will direct refrigerant to the reheat coil to maintain space dry bulb temperature. When the unit exits dehumidification mode, the valve will revert to directing refrigerant to the outdoor coil for rejection to the outside air.

2.6 FANS AND MOTORS

A. The indoor fan assembly consists of one blower inside teardrop housing assembly engineered specifically for optimal airflow with low noise and minimal power consumption. Blower is powered by electronically commutated motor (ECM). The DC motor features brushless, permanently lubricated ball bearing construction for maintenance free operation. A wide range of programmable speeds and torque characteristics is possible for ultra-high efficiency and low audible noise. The ECM provides constant airflow by automatically adjusting the speed if the external static pressure changes. Electrical and control wiring to fan assembly includes quick disconnect plug local to assembly.

B. Outdoor (Condenser) Fan Assembly: The outdoor fan assembly consists of one backward curved plug fan with centrifugal blower wheel powered by an electronically commutated motor (ECM). The DC motor features brushless, permanently lubricated ball bearing construction for maintenance free operation. A wide range of programmable speeds and torque characteristics are possible for ultra-high efficiency and low audible noise. Fan design capable of overcoming external static pressures brought on by rear extensions backs and duct work connected to the fan discharge opening. Fan is sized such that powered exhaust shall be integral to the unit to prevent over pressurization of the space when the unit is introducing outside air. Capable of exhausting 100% equivalent of the fresh air intake of the unit. Electrical and control wiring to fan assembly includes quick disconnect plug local to assembly.

2.7 FILTER

A. Filter: 2” thick and utilize 17.5 pleats per foot. Filter shall be constructed from 100% Synthetic media and be LEED/Green compliant. Minimum Efficiency Reporting Value of MERV 13 per ASHRAE standard 52.2. 99% Arrestance and 70-80% Dust Spot Efficiency based on the ASHRAE 52.1 - 1992 test method.

2.8 CONTROL PANEL

A. Control Panel: Located at top of the unit behind the front door for direct, centrally located access to controller, controller transformer (24V), and all necessary contactors, relays, and circuit breakers.

B. Wiring: Individually numbered terminal blocks and wires are to match job-specific wiring diagrams. All electrical wires in the control panel will run in an enclosed trough. Wiring outside the control panel to be contained in a protective sleeve. All controls and wiring is factory installed in a clean, organized arrangement.

C. Plug and Socket Wiring: Supply and Exhaust Fan decks, compressor, damper assembly, and energy wheel assembly (if applicable) wiring includes plugs local to the assembly allowing for quick wiring disconnect when the component requires removal for service.

2.9 ENERGY RECOVERY VENTILATOR WITH ECONOMIZER DAMPER

A. Energy recovery ventilation (ERV) provided within the unit through an enthalpy transfer wheel mounted in an insulated cassette frame complete with seals, drive motor, and belt. The rotary wheel is coated with silica gel desiccant and is sized to handle a maximum of 500 cfm of outside air. The entire assembly shall be a UL tested component. Performance shall be certified in accordance with the ASHRAE Standard 84 method of test and AHRI Rating Standard of 1060.

B. ERV Fans: ERV section employs dual electronically commutated ventilation fans to ensure precise control of airflow through energy wheel and provide optimal wheel frost protection as required.

C. Outside Air Damper: Separate outside air damper and actuator provided for protection from outdoor elements when unit is not in use.

D. Complete energy recovery ventilator installed on rails to allow the entire assembly to be slid out of the unit for service. Electrical and control wiring to damper assembly includes quick disconnect plug local to assembly.

E. Enhanced Economizer Mode: Includes the addition of an economizer damper with actuator. This enables enhanced economizer functionality allowing up to 75% volume of outside air during free cooling applications.

F. ERV Defrost Cycle: During occupied mode, if the outdoor air temperature falls below 15°F, the microprocessor controller will close the outdoor air damper and de-energize outside air ventilation fan while the wheel and exhaust air ventilation fan continue to run to properly defrost wheel.

2.10 CONTROLS

A. Modine Control System: The unit is fitted with a programmable microprocessor controller provided by the unit manufacturer mounted outside the air stream in the control panel. The controller is designed specifically for operating the unit in its most energy efficient manner using pre-engineered control strategies. The microprocessor determines mode of operation based on the factory installed return air and supply air temperature sensors.

B. The factory Microprocessor Control includes integral compatibility with a BACnet MS/TP control system.

C. Factory installed controls shall enable the unit to operate in the following modes:
   1. If occupancy control is to be initiated by contact closure by others, the contact must be a dry contact only.
   2. Free Cooling – using outside air in favorable conditions
   3. Stage One Mechanical Cooling: 67% capacity compressor, low speed supply fan, reversing valve closed
   4. Stage Two Mechanical Cooling: Controller adjusts compressor capacity and supply fan speed based on load conditions through a sequence that is proprietary to Modine Controls, reversing valve closed
   5. Stage Three Mechanical Cooling: 100% capacity compressor, high speed supply fan, reversing valve closed
   6. Dehumidification: Controller adjusts compressor capacity based on dehumidification requirements through a sequence that is proprietary to Modine Controls, low speed supply fan, hot gas reheat valve is opened, reversing valve closed

D. The microprocessor controller shall also modify the minimum damper position to compensate for mode of operation and fan speed.

E. Free Cooling Sequence: If the return air temperature is higher than the occupied set point and if the ambient air temperature is low enough to satisfy the cooling load in the occupied space, the microprocessor controller will de-energize the energy recovery ventilator. Outdoor air ventilation fan is 100% energized and economizer damper and return air damper will automatically modulate between 0-100% allowing up to 100% free cooling to maintain conditioned space temperature. The free cooling mode of operation leads to much reduced running time for the compressor leading to cost and equipment savings.

F. Wall Mounted Digital Thermostat with Humidity Sensor: Digital touchscreen thermostat used in conjunction with the Factory Microprocessor Control displays current room temperature, humidity, CO2 levels, cooling and heating setpoints, warmup time, occupancy override time as well as fan, unit, cooling, heating and dehumidification statuses. The display will also display a remote alarm from the

Microprocessor Control. Thermostat allows for occupied temperature and humidity set-point adjustment. The allowable set-point adjustment range can be limited by the Microprocessor Control. Thermostat allows for occupied override activation allowing user to select the amount of time the unit is to remain in the override state. Thermostat mounted remote from the unit.

G. Head Pressure Control Transducer (unit mounted): Installed on liquid line to maintain sufficient head pressure (setpoint is user adjustable), providing required Hot Gas Reheat capacity through condenser fan modulation.

H. The unit shall be provided with an internally mounted current sensor to monitor the status of the supply fan.

I. The unit shall be provided with an internally mounted pressure switch to monitor the status of the outdoor fan.

J. The unit shall be provided with an internally mounted current sensor to monitor the status of the energy wheel.

2.11 HOT WATER HEATING

A. Hot Water Coil (unit mounted): Unit is equipped with a one row hot water heating coil integral to the unit mounted in the reheat position relative to the evaporator coil. The coil is manufactured from refrigeration quality copper tubing mechanically bonded onto aluminum fins. Coil is fitted with both an air bleed and a drain plug.

B. The hot water coil shall include the following:
   1. 3/4” two way modulating valve for capacity control
   2. Two 3/4" manual shut-off valves
   3. 3/4" hot water strainer
   4. 3/4" hot water circuit setter
   5. 3/4" hot water drain with hose and bib
   6. 3/4" PT ports

2.12 ADDITIONAL FACTORY INSTALLED ACCESSORIES

A. Condensate Pump: Capable of 13gph flow rate at maximum discharge head of 16 feet of lift. Includes rustproof half-gallon ABS plastic reservoir, built-in thermal protection, built-in flow check valve, and a safety switch.

B. Disconnect Switch: Located on the control panel, a amp power disconnect switch sized for the full load amperage of the unit. Allows the unit to be disconnected from the power supply prior to any maintenance. In the off position the switch can be locked out.

2.13 FIELD INSTALLED ACCESSORIES

A. Wall Sleeve: Designed to provide a sealed plenum for the fresh air intake and exhaust air outlet on the back of the classroom unit to the outside of the building. Intake and exhaust airstreams are separated with an insulated horizontal splitter plate. A two-piece frame allows for the sleeve to adjust to wall depths between 8” and 14”. Includes double-sided gasket to create an air tight seal between the wall sleeves and the back of the unit.

B. Louver: An outdoor louver suitable for masonry, glass, or panel wall construction. The louvers are flanged style with the following finish:
   1. Aluminum with bird screen and a clear 2-Coat AAMA 2605 Kynar finish - Greenheck ESD435 Model - AMCA rated

C. Outside Air Rear Extension: Where site conditions do not permit the use of the standard locations for outside air intake and exhaust air discharge, an insulated outside air rear extension is supplied for site installation between the back of the unit and the outside wall by the Mechanical Subcontractor. The outside air rear extension is 6" deep and with adjustable panels to allow for the exhaust air discharge to be at a height from floor of 35"- 38".

D. Plenum: 28" discharge plenum mounted on top of the unit allowing for supply air to discharge through the top only. Lined with acoustic foam to minimize noise levels. Finished and painted to match the unit.

E. Supply Air Replacement Filters: The unit shall be provided with 1 set(s) of MERV 13 supply air replacement filters (Qty of 2).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive unit ventilators for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before unit ventilator installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install unit ventilators level and plumb.

B. Install unit ventilators to comply with NFPA 90A.

C. Suspend or support horizontal unit ventilators according to Section "Hangers and Supports."

D. Suspend horizontal unit ventilators from structure with rubber-in-shear vibration isolators (rubber hangers). Vibration isolators are specified in Section "Mechanical Vibration Controls and Seismic Restraints."

E. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other mechanical Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Unless otherwise indicated, install shutoff valve and union or flange at each connection.

C. Install float and thermostatic trap on condensate discharge.

D. Install piping adjacent to machine to allow service and maintenance.

E. Ground equipment.

F. 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.

3.4 FIELD QUALITY CONTROL

A. Testing: Perform the following field quality-control testing and report results in writing:

1. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safeties.

B. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.5 CLEANING

A. After installing units, inspect unit cabinet for damage to finish. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. After installing units, clean unit ventilators internally according to manufacturer's written instructions.

C. Install new filters in each unit ventilator within two weeks after Substantial Completion.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain unit ventilators.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
2. Review data in maintenance manuals. Refer to Division 1 for Closeout Procedures and Division 1 for Operation and Maintenance Data.
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

B. The Contractor shall provide general HVAC system training of 40 hours which shall include operating instruction, and review of wiring and control diagram showing complete layout of each system. Contractor shall engage a factory certified technician and ATC vendor to assist during training.

END OF SECTION 15768

SECTION 15815 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Double-wall rectangular ducts and fittings.
3. Single-wall round and flat-oval ducts and fittings.
4. Double-wall round and flat-oval ducts and fittings.
5. Sheet metal materials.
6. Duct liner.
7. Sealants and gaskets.
8. Hangers and supports.

B. Related Sections:

1. Division 15 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Division 15 Section "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of bottom 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.

C. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:

    a. Lighting fixtures.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Perimeter moldings.

D. Welding certificates.

E. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS 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."

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."

2.2 DOUBLE-WALL RECTANGULAR DUCTS AND FITTINGS

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. McGill AirFlow LLC.
2. Sheet Metal Connectors, Inc.
3. Or approved equal.

B. Rectangular Ducts: Fabricate ducts with indicated dimensions for the inner duct.

C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

D. 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."

E. 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."

F. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity: 0.24 Btu x in. /h x sq. ft. x deg F at 75 deg F mean temperature.
2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
3. Coat insulation with antimicrobial coating.
4. Cover insulation with polyester film complying with UL 181, Class 1.

G. Inner Duct: Minimum 0.028-inch perforated galvanized sheet steel having 3/32-inch-diameter perforations, with overall open area of 23 percent.

H. Formed-on Transverse Joints (Flanges): Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1,

"Rectangular Duct/Traverse 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."

I. 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."

2.3 SINGLE-WALL ROUND AND FLAT-OVAL 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.
f. Or approved equal.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

E. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 DOUBLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

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. Lindab Inc.
2. McGill AirFlow LLC.
3. SEMCO Incorporated.
4. Sheet Metal Connectors, Inc.
5. Or approved equal.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.

C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.

1. 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."

    a. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

2. 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."

a. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
b. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

3. 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."

D. Inner Duct: Minimum 0.028-inch perforated galvanized sheet steel having 3/32-inch-diameter perforations, with overall open area of 23 percent.

E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity: 0.24 Btu x in. /h x sq. ft. x deg F at 75 deg F mean temperature.
2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
3. Coat insulation with antimicrobial coating.
4. Cover insulation with polyester film complying with UL 181, Class 1.

2.5 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Carbon-Steel Sheets: ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

D. Stainless Steel: ASTM A 480/A 480M, Type 304 or 316; cold rolled, annealed sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the “Duct Schedule.”

E. Aluminum Sheets: ASTM B 209, alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

F. Factory- or Shop-Applied Antimicrobial Coating:

1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
4. 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.
5. Shop-Applied Coating Color: Black.
6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.

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-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.6 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, provide products by one of the following:

a. CertainTeed Corporation; Insulation Group.
b. Johns Manville.
c. Knauf Insulation.
d. Owens Corning.
e. Or approved equal.

2. Maximum Thermal Conductivity:

a. Type I Flexible: 0.24 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
b. 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. Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.

a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
b. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-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 aluminum; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

C. 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 or as recommended by manufacturer.
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.

2.7 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: 4 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, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
11. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

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. 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, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. 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.

2.8 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.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate clear inside dimension, 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. Increase sheet metal sizes to compensate for lining thickness.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round and flat-oval 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.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 15 Section "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."

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. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum 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 Division 15 Section "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.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

    a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

C. Duct system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.8 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing. Existing duct system(s) connected to new equipment shall also be cleaned.

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 Division 15 Section "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 Division 15 Section "Testing, Adjusting, and Balancing for HVAC."

3.10 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

B. Supply Return, exhaust and outdoor air ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

    a. Pressure Class: Positive or negative 2-inch wg.
    b. Minimum SMACNA Seal Class: B.
    c. SMACNA Leakage Class for Rectangular: 12.
    d. SMACNA Leakage Class for Round and Flat Oval: 12.

2. Ducts Connected to Constant-Volume Air-Handling Units:

    a. Pressure Class: Positive or negative 3-inch wg.
    b. Minimum SMACNA Seal Class: B.
    c. SMACNA Leakage Class for Rectangular: 12.
    d. SMACNA Leakage Class for Round and Flat Oval: 6.

3. Ducts Connected to Variable-Air-Volume Air-Handling Units:

    a. Pressure Class: Positive or negative 3-inch wg
    b. Minimum SMACNA Seal Class: B.
    c. SMACNA Leakage Class for Rectangular: 12.
    d. SMACNA Leakage Class for Round and Flat Oval: 6.

4. Ducts Connected to Equipment Not Listed Above:

    a. Pressure Class: Positive or negative 2-inch wg
    b. Minimum SMACNA Seal Class: B.
    c. SMACNA Leakage Class for Rectangular: 12.
    d. SMACNA Leakage Class for Round and Flat Oval: 12.

C. Duct Steam Humidifiers:

1. Furnish and install a four-foot section of Type 316 or 304, stainless-steel sheet with No. 4 or No. 3 finish. At the humidifier location, one foot of duct shall

extend against the airflow and three feet of duct shall extend with the airflow. Provide a duct access door located against the airflow of the humidifier location in order to inspect the steam jet discharging against the air stream.

D. 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 or galvanized sheet steel coated with zinc chromate.

E. Liner:

1. Unless otherwise indicated all supply, Return, and exhaust air ducts shall be lined as indicated.

a. Supply Air Ducts: Fibrous glass, Type I, 1 inch thick.
b. Return Air Ducts: Fibrous glass, Type I, 1 inch thick.
c. Exhaust Air Ducts: Fibrous glass, Type I, 1 inch thick.

2. Supply Fan Plenums: Fibrous glass, Type II 1-1/2 inches thick.
3. Return- and Exhaust-Fan Plenums: Fibrous glass, Type II 2 inches thick.
4. Transfer Ducts: Fibrous glass, Type I, 1 inch thick.

F. Double-Wall Duct Interstitial Insulation:

1. Supply Air Ducts: 1 inch thick.
2. Return Air Ducts: 1 inch thick.
3. Exhaust Air Ducts: 1 inch thick.

G. Elbow Configuration:

1. 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."

2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

    a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

        1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
        2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
        3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
        4) Radius-to Diameter Ratio: 1.5.

    b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
    c. Round Elbows, 14 Inches and Larger in Diameter: Welded.

H. 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 and Flat Oval: 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 15815

SECTION 15820 - 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 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Barometric relief dampers.
3. Manual volume dampers.
4. Control dampers.
5. Fire dampers.
6. Ceiling dampers.
7. Smoke dampers.
8. Combination fire and smoke dampers.
9. Flange connectors.
10. Turning vanes.
11. Duct-mounted access doors.
12. Flexible connectors.
13. Flexible ducts.
14. Duct accessory hardware.
15. Duct Silencers.

B. Related Sections:

1. Division 15 Section "HVAC Gravity Ventilators" for roof-mounted ventilator caps.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

2. Submit laboratory acoustic and aerodynamic performance obtained according to ASTM E477-13 and so certified when submitted for approval. The laboratory

must be currently NVLAP accredited for the ASTM E477-13 test standard. A copy of the accreditation certificate must be included with the submittals. Data from non-NVLAP accredited test facilities will not be accepted. Shop Drawings submitted without proper certifications will be rejected.

a. Submitted silencer pressure drops shall not exceed those listed in the silencer schedule. Silencer pressure drop measurements shall be made in accordance with the ASTM E477-13 test standard. Tests shall be conducted and reported on the identical units for which acoustical data is presented.

b. The manufacturer shall supply certified dynamic insertion loss and self-noise power level data for each scheduled silencer. The data shall match the project's air distribution system requirement for forward or reverse flow, and total system airflow. All ASTM E477-13 tests to obtain this data shall be conducted in the same facility and shall utilize the same silencer.

c. Silencer dynamic insertion loss shall not be less than that listed in the silencer schedule.

d. Silencer generated noise shall not be greater than that listed in the silencer schedule

3. The silencer manufacturer shall provide, for approval, acoustical system calculations for all duct systems with silencers to demonstrate that the submitted silencers will reduce mechanical fan noise to NC in the occupied space. Use sound power levels of actual equipment to be installed on project. Analysis shall include breakout noise calculations. In the absence of specified background sound level criteria, the guidelines as expressed in Table 1 of Chapter 48, "Noise and Vibration Control" of the 2015 ASHRAE Handbook - HVAC Applications, shall be used.
4. The silencer manufacturer shall test the silencer(s) as indicated in the silencer schedule. The Engineer shall be notified of the test date at least two weeks in advance and the test may be witnessed by the Engineer. Test shall show compliance with the project criteria and is subject to Engineer approval. Test facilities and test reports shall be open to inspection upon request from the Engineer.
5. For specific silencers indicated on the silencer schedule, the silencer manufacturer shall provide Computational Fluid Dynamics (CFD) aerodynamic analysis. The analysis shall include the attached ductwork, a minimum of 5 equivalent duct diameters up and downstream of the silencer, as shown on the Drawings, to determine silencer pressure drop, including system effects, at design airflow. The manufacturer must report and validate a converged solution domain of the CFD analysis to show the solution is independent of mesh refinement such that two models of different mesh refinement levels produce equivalent results, each with a maximum residual tolerance of 0.001. The

minimum cell count shall be 200,000 and the validation model shall have a cell count at least 50% higher. The manufacturer must report the selection of CFD parameters, including mesh type, mesh size, boundary conditions, convergence criteria, and turbulence model. Each CFD analysis shall also include additional post-processed information including number of iterations, convergence status, and resulting y+ values.

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

a. Special fittings.
b. Manual volume damper installations.
c. Control damper installations.
d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
e. Duct security bars.
f. Wiring Diagrams: For power, signal, and control wiring.

C. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

D. Source quality-control reports.

E. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.4 QUALITY ASSURANCE

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 AMCA 500-D testing for damper rating.

1.5 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. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 MATERIALS

A. 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.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G60.
2. Exposed-Surface Finish: Mill phosphatized.

C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

D. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inchesor less; 3/8-inchminimum diameter for lengths longer than 36 inches.

2.2 BACKDRAFT AND PRESSURE RELIEF 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. Air Balance Inc.; a division of Mestek, Inc.
2. Duro Dyne Inc.
3. Greenheck Fan Corporation.
4. Nailor Industries Inc.
5. Ruskin Company.
6. SEMCO Incorporated.
7. Or approved equal.

B. Description: Gravity balanced.

C. Maximum Air Velocity: 2000 fpm.

D. Maximum System Pressure: 1-inch wg

E. Frame: 0.052-inch-hick, galvanized sheet steel, with welded corners and mounting flange.

F. Blades: Multiple single-piece blades, center-pivoted, maximum 6-inchwidth.

G. Blade Action: Parallel.

H. Blade Seals: Neoprene, mechanically locked.

I. Blade Axles:

1. Material: Galvanized steel.
2. Diameter: 0.20 inch.

J. Tie Bars and Brackets: Galvanized steel.

K. Return Spring: Adjustable tension.

L. Bearings: Steel ball or synthetic pivot bushings.

M. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Electric actuators.
4. Chain pulls.
5. Screen Mounting: Front mounted in sleeve.

    a. Sleeve Thickness: 20-gage minimum.
    b. Sleeve Length: 6 inches minimum.

6. Screen Mounting: Rear mounted.
7. Screen Material: Aluminum.
8. Screen Type: Bird.
9. 90-degree stops.

2.3 BAROMETRIC RELIEF 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. Air Balance Inc.; a division of Mestek, Inc.
2. Duro Dyne Inc.
3. Greenheck Fan Corporation.
4. Nailor Industries Inc.
5. Ruskin Company.
6. SEMCO Incorporated.
7. Or approved equal.

B. Suitable for horizontal or vertical mounting.

C. Maximum Air Velocity: 2000 fpm.

D. Maximum System Pressure: 2-inch wg.

E. Frame: 0.064-inch-thick, galvanized sheet steel, with welded corners and mounting flange.

F. Blades:

1. Multiple, 0.025-inch-thick, roll-formed aluminum.
2. Maximum Width: 6 inches.
3. Action: Parallel.
4. Balance: Gravity.
5. Eccentrically pivoted.

G. Blade Seals: Neoprene.

H. Blade Axles: Galvanized steel.

I. Tie Bars and Brackets:

1. Material: Aluminum.
2. Rattle free with 90-degree stop.

J. Return Spring: Adjustable tension.

K. Bearings: Stainless steel.

L. Accessories:

1. Flange on intake.
2. Adjustment device to permit setting for varying differential static pressures.

2.4 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. Flexmaster U.S.A., Inc.
    c. McGill AirFlow LLC.
    d. METALAIRE, Inc.
    e. Nailor Industries Inc.
    f. Pottorff; a division of PCI Industries, Inc.
    g. Ruskin Company.
    h. Or approved equal.

2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames:

    a. Hat-shaped, galvanized-steel channels, 0.064-inchminimum thickness.
    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. Stiffen damper blades for stability.
    c. Galvanized-steel, 0.064 inchthick.

6. Blade Axles: Galvanized steel.
7. Bearings:

    a. Molded synthetic.
    b. Dampers in ducts with pressure classes of 3-inch wgor less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Galvanized steel.

2.5 CONTROL 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. Duro Dyne Inc.
3. Flexmaster U.S.A., Inc.

4. Greenheck Fan Corporation.
5. McGill AirFlow LLC.
6. METALAIRE, Inc.
7. Nailor Industries Inc.
8. Ruskin Company.
9. Young Regulator Company.
10. Or approved equal.

B. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.

C. Frames:

1. Hat shaped.
2. Galvanized-steel channels, 0.064 inch thick.
3. Mitered and welded corners.

D. Blades:

1. Multiple blade with maximum blade width of 8 inches.
2. Parallel- and opposed-blade design.
3. Stainless steel.
4. 0.064 inchthick.
5. Blade Edging: Closed-cell neoprene edging.
6. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.

E. Blade Axles: 1/2-inch-diameter; galvanized steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.

1. Operating Temperature Range: From minus 40 to plus 200 deg F.

F. Bearings:

1. Molded synthetic.
2. 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.
3. Thrust bearings at each end of every blade.

2.6 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. Air Balance Inc.; a division of Mestek, Inc.

2. Greenheck Fan Corporation.
3. Ruskin Company.
4. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
5. Or approved equal.

B. Type: Static and 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 4000-fpmvelocity.

D. Fire Rating: 1-1/2 hours.

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: 0.052 or 0.138-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. Heat-Responsive Device: Replaceable, 165 deg Frated, fusible links.

2.7 SEVERE ENVIRONMENT 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. Air Balance Inc.; a division of Mestek, Inc.
2. Greenheck Fan Corporation.
3. Ruskin Company.
4. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
5. Or approved equal.

B. Severe environment dampers shall be made of type 316 stainless steel and shall be corrosion-resistant. The heat responsive devices (for fire and/or smoke dampers) shall be UL compliant.

C. Applications include high humidity and mildly corrosive airstreams (swimming pools, laboratories, waste water treatment plants, food processing plants, and coastal/maritime buildings).

2.8 SMOKE 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. Ruskin Company.
2. Greenheck Fan Corporation.
3. Air Balance Inc.; a division of Mestek, Inc.
4. Or approved equal.

B. General Requirements: Label according to UL 555S by an NRTL.

C. Smoke Detector: Integral, factory wired for single-point connection.

D. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, with welded corners and mounting flange.

E. Blades: Roll-formed, horizontal, overlapping, 0.063-inch-thick, galvanized sheet steel.

F. Leakage: Class I.

G. Rated pressure and velocity to exceed design airflow conditions.

H. Mounting Sleeve: Factory-installed, 0.05-inch-thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.

I. Damper Motors: Modulating action.

J. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section "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. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section "Direct Digital Control (DDC) System for HVAC."
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.

4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
7. Electrical Connection: 115 V, single phase, 60 Hz.

K. Accessories:

1. Auxiliary switches for signaling fan control or position indication.
2. Test and reset switches, remote mounted.

2.9 COMBINATION FIRE AND SMOKE 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. Ruskin Company.
2. Greenheck Fan Corporation.
3. Air Balance Inc.; a division of Mestek, Inc.
4. Or approved equal.

B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S 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 and 3 hours.

E. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, with welded corners and mounting flange.

F. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

G. Smoke Detector: Integral, factory wired for single-point connection.

H. Blades: Roll-formed, horizontal, interlocking, 0.063-inch-thick, galvanized sheet steel.

I. Leakage: Class I.

J. Rated pressure and velocity to exceed design airflow conditions.

K. Mounting Sleeve: Factory-installed, 0.05-inch-thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.

L. Master control panel for use in dynamic smoke-management systems.

M. Damper Motors: Modulating action.

N. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section "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. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section "Direct Digital Control (DDC) System for HVAC."
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
7. Electrical Connection: 115 V, single phase, 60 Hz.

O. Accessories:

1. Auxiliary switches for signaling fan control or position indication.
2. Test and reset switches, remote mounted.

2.10 FLANGE 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. Nexus PDQ; Division of Shilco Holdings Inc.
3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

4. Or approved equal.

B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gage and Shape: Match connecting ductwork.

2.11 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. METALAIRE, Inc.
4. SEMCO Incorporated.
5. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
6. Or approved equal.

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.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

D. 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."

E. Vane Construction: Single wall.

F. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.12 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. Ductmate Industries, Inc.
2. Flexmaster U.S.A., Inc.
3. McGill AirFlow LLC.
4. Nailor Industries Inc.
5. Ventfabrics, Inc.
6. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
7. Or approved equal.

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. Vision panel.
d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: 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: Two hinges and two sash locks.
c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles.
d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

2.13 DUCT ACCESS PANEL ASSEMBLIES

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. Flame Gard, Inc.

3. 3M.
4. Or approved equal.

B. Labeled according to UL 1978 by an NRTL.

C. Panel and Frame: Minimum thickness 0.0528-inch steel.

D. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.

E. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.14 DUCT SILENCERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Vibro-Acoustics.
2. McGill AirFlow LLC.
3. Ruskin Company.
4. Pottorff.
5. Or approved equal.

B. General Requirements:

1. Factory fabricated.
2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Shape:

1. Rectangular straight with splitters or baffles.

D. Rectangular Silencer Outer Casing: ASTM A 653/A 653M, G90, galvanized sheet steel, 0.034 inchthick18 gauge. All acoustical splitters shall be internally radiused and aerodynamically designed for efficient turning of the air. Half and full splitters are required as necessary to achieve the scheduled insertion loss. All elbow silencers with a turning cross-section dimension greater than 48” shall have at least two half splitters and one full splitter.

E. Inner perforated metal liner: ASTM A 653/A 653M, G90 galvanized sheet steel.

1. Rectangular Silencers: 26 gauge.

2. Rectangular Elbow Silencers: 22 gauge.

3. Circular Silencers:

   a. Connection diameter up to 18 inches: 26 gauge.

   b. Connection diameter greater than 18 inches: 22 gauge.

4. Transitional Silencers: 22 gauge.

F. Special Construction: Suitable for outdoor use.

G. Connection Sizes: Match connecting ductwork unless otherwise indicated.

H. Principal Sound-Absorbing Mechanism:

1. Controlled impedance membranes and broadly tuned resonators without absorptive media.
2. Dissipative type with fill material.

   a. Fill Material: Inert and vermin-proof fibrous material, packed under not less than 15 percent compression Moisture-proof nonfibrous material.
   b. Erosion Barrier: Polymer bag enclosing fill, and heat sealed before assembly.

3. Lining: Mylar.

I. 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. Flange 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.

J. Accessories:

1. Factory-installed end caps to prevent contamination during shipping.
2. Removable splitters.

K. Capacities and Characteristics: See Plan Schedules.

2.15 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Ventfabrics, Inc.
4. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
5. Or approved equal.

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 5-3/4 inches wide attached to 2 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.

2.16 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.
3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
4. Or approved equal.

B. Noninsulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire.

1. Pressure Rating: 10-inch wgpositive and 1.0-inch wgnegative.
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 wgpositive and 1.0-inch wgnegative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 10 to plus 160 deg F.
4. Insulation R-value: Minimum R-6.

2.17 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 backdraft 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 and smoke dampers according to UL listing.

H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. Upstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
7. At each change in direction and at maximum 50-foot spacing.
8. Upstream from turning vanes.
9. Control devices requiring inspection.
10. Elsewhere as indicated.

I. Install access doors with swing against duct static pressure.

J. 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.

K. Label access doors according to Division 15 Section "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

L. Install flexible connectors to connect ducts to equipment.

M. For fans developing static pressures of 5-inch wgand more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

N. Connect terminal units to supply ducts with maximum 6-inch lengths of flexible duct. Do not use flexible ducts to change directions.

O. Connect diffusers or light troffer boots to ducts directly or with maximum 72-inchlengths of flexible duct clamped or strapped in place.

P. Connect flexible ducts to metal ducts with liquid adhesive plus tape and draw bands.

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.

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, smoke, and combination fire and smoke 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 15820

SECTION 15838 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

B.

1. Centrifugal roof ventilators.
2. Ceiling-mounted ventilators.

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on sea level.

B. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material thickness and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.
6. Roof curbs.
7. Fan speed controllers.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

2. Wiring Diagrams: For power, signal, and control wiring.
3. Sound ratings: Provide sound data measurements/ratings measured at same distance as basis of design specified equipment.

C. Delegated-Design Submittal: For unit hangars and supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified Professional Engineer responsible for their preparation.
1. 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.
2. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.

D. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
1. Roof framing and support members relative to duct penetrations.
2. Ceiling suspension assembly members.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

E. Field quality-control reports.

F. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

D. Sound Ratings shall be equal or better than basis of design. Any sound rating deviation shall be approved by Owner.

1.6 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate sizes and locations of concrete bases with actual equipment provided.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.7 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. Belts: One set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 CENTRIFUGAL ROOF VENTILATORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
   1. Carnes Company.
   2. Greenheck Fan Corporation
   3. Penn-Barry.
   4. Loren Cook Company.
   5. Or approved equal.

B. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.

C. Belt Drives:
   1. Resiliently mounted to housing.
   2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
   3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
   4. Pulleys: Cast-iron, adjustable-pitch motor pulley.
   5. Fan and motor isolated from exhaust airstream.

D. Accessories:
   1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
   2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

3. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.

E. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.
1. Configuration: Self-flashing without a cant strip, with mounting flange.
2. Overall Height: 12 inches.
3. Sound Curb: Curb with sound-absorbing insulation.
4. Pitch Mounting: Manufacture curb for roof slope.
5. Metal Liner: Galvanized steel.

F. Capacities and Characteristics (See Plan Schedules):

2.2 CEILING-MOUNTED OR INLINE VENTILATORS

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. Carnes Company.
2. Greenheck Fan Corporation.
3. Penn-Barry.
4. Loren Cook Company.
5. Or approved equal.

B. Housing: Steel, lined with acoustical insulation.

C. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.

D. Grille (where fan is not inline model): Plastic, Aluminum, or Painted aluminum, louvered grille with flange on intake and thumbscrew attachment to fan housing.

E. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

F. Accessories:
1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Ceiling Radiation Damper: Fire-rated assembly with ceramic blanket, stainless-steel springs, and fusible link (for fire-rated ceiling assemblies).
3. Filter: Washable aluminum to fit between fan and grille.
4. Isolation: Rubber-in-shear vibration isolators.
5. Manufacturer's standard wall cap, and transition fittings.

G. Capacities and Characteristics (See Plan Schedule):

2.3 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 16 Section "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. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 16 Sections.

B. Enclosure Type: Totally enclosed, fan cooled.

2.4 SOURCE QUALITY CONTROL

A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Support units using elastomeric mounts having a static deflection of 1 inch. Vibration- and seismic-control devices are specified in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
   1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.

C. Install floor-mounted units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

D. Install floor-mounted units on concrete bases designed to withstand, without damage to equipment, the seismic force required by code. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

E. Secure roof-mounted fans to roof curbs with cadmium-plated hardware. See Division 07 Section "Roof Accessories" for installation of roof curbs.

F. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

G. Support suspended units from structure using threaded steel rods and spring hangers having a static deflection of 1 inch. Vibration-control devices are specified in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

H. Install units with clearances for service and maintenance.

I. Label units according to requirements specified in Division 15 Section "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 15 Section "Air Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Division 16 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 16 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:
   1. Verify that shipping, blocking, and bracing are removed.
   2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that

proper thermal-overload protection is installed in motors, starters, and disconnect switches.

3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Comply with requirements in Division 15 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

END OF SECTION 15838

SECTION 15840 - 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Shutoff, single-duct air terminal units.
2. Series, fan-powered air terminal units.

1.3 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".

1.4 SUBMITTALS

A. Product Data: For each type of the following products, including rated capacities, furnished specialties, sound-power ratings, and accessories.

1. Air terminal units.

B. Shop Drawings: For air terminal units. 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.
3. Hangers and supports, including methods for duct and building attachment and vibration isolation.

C. Delegated-Design Submittal:

1. Materials, fabrication, assembly, and spacing of hangers and supports.

D. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Ceiling suspension assembly members.
2. Size and location of initial access modules for acoustic tile.
3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

E. Field quality-control reports.

F. Operation and Maintenance Data: For air terminal units 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 resetting minimum and maximum air volumes.
2. Instructions for adjusting software set points.

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: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

PART 2 - PRODUCTS

2.1 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Titus.
2. Environmental Technologies, Inc.
3. Nailor Industries Inc.
4. Price Industries.
5. Daikin.
6. Carnes.
7. Or approved equal.

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Casing: 0.034-inch steel wall.

1. Casing Lining: Adhesive attached, 1/2-inch- thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.

    a. Cover liner with nonporous foil.
2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: ARI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.
2. Damper Position: Normally open.

E. Direct Digital Controls: Bidirectional damper operators and microprocessor-based controller and room sensor. Control devices shall be compatible with temperature controls specified in Division 15 Section "Instrumentation and Control for HVAC" and shall have the following features:

1. Damper Actuator: 24 V, powered closed, spring return open.
2. Terminal Unit Controller: Pressure-independent, variable-air-volume controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:

    a. Occupied and unoccupied operating mode.
    b. Remote reset of airflow or temperature set points.
    c. Adjusting and monitoring with portable terminal.
    d. Communication with temperature-control system specified in Division 15 Section "Instrumentation and Control for HVAC."

3. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.

F. Control Sequence:

1. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg inlet static pressure.

2.2 SERIES FAN-POWERED AIR TERMINAL UNITS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Titus.
2. Environmental Technologies, Inc.
3. Nailor Industries Inc.
4. Price Industries.
5. Daikin.
6. Carnes.
7. Or approved equal.

B. Configuration: Volume-damper assembly and fan in series arrangement inside unit casing with control components inside a protective metal shroud for installation above a ceiling.

1. Designed for quiet operation.
2. Low-profile design.

C. Casing: 0.040-inch thick galvanized steel, single wall.

1. Casing Liner: Comply with requirements in "Casing Liner" Article for flexible elastomeric duct liner.
2. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
5. Fan: Forward-curved centrifugal.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Volume Damper: Galvanized steel with flow-sensing ring and peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, 1 percent of nominal airflow at 3-inch wg inlet static pressure.

E. Velocity Sensors: Multipoint array with velocity sensors in air inlets and air outlets.

F. Motor:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 16 "Common Motor Requirements for HVAC Equipment."
2. Type: Electronically commutated motor.
3. Fan-Motor Assembly Isolation: Rubber isolators.
4. Electrical Characteristics: See Drawing schedules.

G. Filters:

1. Minimum Efficiency Reporting Value and Average Arrestance: According to ASHRAE 52.2.
2. Minimum Efficiency Reporting Value: According to ASHRAE 52.2.
3. Material: Pleated cotton-polyester media MERV 7.
4. Thickness: 2 inches.

H. Attenuator Section: 0.034-inch (0.85-mm) galvanized steel.

1. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for fibrous-glass or flexible elastomeric duct liner.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

I. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

J. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.
1. Stage(s): 1, 2, or 3 as indicated on the Drawings.
2. SCR controlled (modulating) as indicated on the Drawings.
3. Access door interlocked disconnect switch.
4. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).
5. Nickel chrome 80/20 heating elements.
6. Airflow switch for proof of airflow.
7. Fan interlock contacts.
8. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
9. Magnetic contactor for each step of control (for three-phase coils).

K. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.

1. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
2. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized according to NFPA 70.
3. Disconnect Switch: Factory-mounted, fuse type.

L. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

M. Control devices shall be compatible with temperature controls system specified in Section 16 "Direct Digital Control (DDC) System for HVAC."

1. Electric Damper Actuator: 24 V, powered open, spring or capacitous return.
2. Electronic Damper Actuator: 24 V, powered open, spring or capacitous return.
3. Electric Thermostat: Wall-mounted electronic type with clock display, temperature display in Fahrenheit and Celsius, and space temperature set point.
4. Electronic Thermostat: Wall-mounted electronic type with temperature set-point display in Fahrenheit and Celsius.
5. Electronic Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
6. Terminal Unit Controller: Pressure-independent, VAV controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:

    a. Occupied and unoccupied operating mode.
    b. Remote reset of airflow or temperature set points.
    c. Adjusting and monitoring with portable terminal.
    d. Communication with temperature-control system specified in Division 15 Section "Instrumentation and Control for HVAC."

N. Control Sequence:

1. Occupied (Primary Airflow On):

    a. Operate as throttling control for cooling.
    b. As cooling requirement decreases, control valve throttles toward minimum airflow.

c. As heating requirement increases, fan energizes to draw in warm plenum air and:
   1) electric heat is energized in steps.
   2) electric heat modulates under SCR control.
   3) the hot-water coil valve is opened.

2. Unoccupied (Primary Airflow Off):

   a. When externally initiated, begin the morning warm-up/cool-down function. Damper drives to the fully open position without regard for the preset maximum.
   b. When pressure at primary inlet is zero or less, fan is de-energized.
   c. As heating requirement increases, fan energizes to draw in warm plenum air and:
      1) electric heat is energized in steps.
      2) electric heat modulates under SCR control.
      3) the hot-water coil valve is opened.

2.3 CASING LINER

A. Casing Liner: Fibrous-glass duct liner, complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Minimum Thickness: 1 inch.

   a. Maximum Thermal Conductivity:

      1) 0.24 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.

2. 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.
3. Solvent or Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.

B. Casing Liner: Flexible elastomeric duct liner fabricated of preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

1. Minimum Thickness: 3/4 inch (19 mm).
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.

2.4 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.

2.5 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, coil type, and ARI certification seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. Install air terminal units' level and plumb. Maintain sufficient clearance for normal service and maintenance.

C. Install wall-mounted thermostats.

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.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

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. Hot-Water Piping: In addition to requirements in Division 15 Section "Hydronic Piping," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

C. Connect ducts to air terminal units according to Division 15 Section "Metal Ducts."

D. Make connections to air terminal units with flexible connectors complying with requirements in Division 15 Section "Air Duct Accessories."

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 Division 15 Section "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. 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.

D. Tests and Inspections:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Air terminal unit will be considered defective if it does not pass tests and inspections.

F. 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 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 15840

SECTION 15855 - 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Rectangular and square ceiling diffusers.
2. Louver face diffusers.
3. Adjustable bar registers and grilles.
4. Fixed face grilles.

B. Related Sections:

1. Division 15 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
2. Division 15 Section "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 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.
3. Sound ratings: Provide sound data measurements/ratings measured at same distance as basis of design specified equipment.

B. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.

C. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.

D. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. Duct access panels.

E. Source quality-control reports.

PART 2 - PRODUCTS

2.1 CEILING DIFFUSERS

A. Rectangular and Square Ceiling Diffusers:

1. Manufacturers: Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

    a. Nailor Industries Inc.
    b. Price Industries.
    c. Titus.
    d. Or approved equal.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Steel.
4. Finish: Baked enamel, color selected by Architect.
5. Face Size: 24 by 24 inches or 12 by 12 inches.
6. Face Style: Three cone, Four cone, or Plaque.
7. Mounting: Surface, T-bar, or Mounting panel.
8. Pattern: Fixed or Adjustable.
9. Dampers: Combination damper and grid.
10. Accessories:

    a. Equalizing grid.
    b. Plaster ring.

B. Louver Face Diffuser:

1. Manufacturers: Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

    a. Nailor Industries Inc.
    b. Price Industries.
    c. Titus.
    d. Or approved equal.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Steel.
4. Finish: Baked enamel, color selected by Architect.
5. Mounting: Surface, T-bar, or Mounting panel.
6. Pattern: One-way, Four-way, or Adjustable core style.
7. Dampers: Combination damper and grid.
8. Accessories:

    a. Square to round neck adaptor.
    b. Adjustable pattern vanes.
    c. Equalizing grid.
    d. Plaster ring.

2.2 REGISTERS AND GRILLES

A. Adjustable Bar Register:

1. Manufacturers: Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

    a. Nailor Industries Inc.
    b. Price Industries.
    c. Titus.
    d. Or approved equal.

2. Material: Steel.
3. Finish: Baked enamel, color selected by Architect.
4. Face Blade Arrangement: Horizontal spaced 3/4 inch.
5. Core Construction: Removable.
6. Rear-Blade Arrangement: Vertical spaced 3/4 inch apart.
7. Frame: 1 inch wide.
8. Mounting: Countersunk screw or Lay in.
9. Damper Type: Adjustable opposed blade.
10. Accessories:

a. Front or Rear-blade gang operator.

B. Adjustable Bar Grille:

1. Manufacturers: Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

a. Nailor Industries Inc.
b. Price Industries.
c. Titus.
d. Or approved equal.

2. Material: Steel.
3. Finish: Baked enamel, color selected by Architect.
4. Face Blade Arrangement: Horizontal 3/4 inch apart.
5. Core Construction: Removable.
6. Rear-Blade Arrangement: Vertical spaced 3/4 inch apart.
7. Frame: 1 inch wide.
8. Mounting: Countersunk screw or Lay in.

2.3 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."

B. Sound Ratings shall be equal or better than basis of design. Any sound rating deviation shall be approved by Owner.

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 15855

SECTION 15856 - HVAC GRAVITY VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Roof hood type gravity ventilators.
2. Goosenecks

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design ventilators, including comprehensive engineering analysis by a qualified Professional Engineer, using structural and seismic performance requirements and design criteria indicated.

B. Structural Performance: Ventilators shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of ventilator components, noise or metal fatigue caused by ventilator blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act normal to the face of the building.

1. Wind Loads: Determine loads based on a uniform pressure of 20 lbf/sq. ft., acting inward or outward.

C. Seismic Performance: Ventilators, including attachments to other construction, shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes, without buckling, opening of joints, overstressing of components, failure of connections, or other detrimental effects.

1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.

E. Water Entrainment: Limit water penetration through unit to comply with ASHRAE 62.1.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. For louvered-penthouse ventilators specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.

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: For gravity ventilators. Include plans, elevations, sections, details, ventilator attachments to curbs, and curb attachments to roof structure.

1. Show weep paths, gaskets, flashing, sealant, and other means of preventing water intrusion.

D. Delegated-Design Submittal: For shop-fabricated ventilators 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 shop-fabricated ventilators.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Roof framing plans and other details, 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. Structural members to which roof curbs and ventilators will be attached.
2. Sizes and locations of roof openings.

B. Seismic Qualification Certificates: For ventilators, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Welding certificates.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
2. AWS D1.3, "Structural Welding Code - Sheet Steel."

1.7 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Aluminum Extrusions: ASTM B 221, Alloy 6063-T5 or T-52.

B. Aluminum Sheet: ASTM B 209, Alloy 3003 or 5005 with temper as required for forming or as otherwise recommended by metal producer for required finish.

C. Galvanized-Steel Sheet: ASTM A 653/A 653M, G90 zinc coating, mill phosphatized.

D. Stainless-Steel Sheet: ASTM A 666, Type 304, with No. 4 or 6 finish.

E. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel unless otherwise indicated. Do not use metals that are incompatible with joined materials.

1. Use types and sizes to suit unit installation conditions.
2. Use Phillips flat or hex-head or Phillips pan-head screws for exposed fasteners unless otherwise indicated.

F. Post-Installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors made from stainless-steel components, with capability to sustain without failure a load equal to 4 times the loads imposed for concrete, or 6 times the load imposed for masonry, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.

G. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.2 FABRICATION, GENERAL

A. Factory or shop fabricate gravity ventilators to minimize field splicing and assembly. Disassemble units to the minimum extent as necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.

B. Fabricate frames, including integral bases, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.

C. Fabricate units with closely fitted joints and exposed connections accurately located and secured.

D. Fabricate supports, anchorages, and accessories required for complete assembly.

E. Perform shop welding by AWS-certified procedures and personnel.

2.3 ROOF HOOD TYPE GRAVITY VENTILATORS

A. Manufacturers:

1. Greenheck, Loren Cook, or PennBarry.

2. Or approved equal.

B. Factory or shop fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figures 6-6 and 6-7.

C. Materials: Galvanized-steel sheet, minimum 0.064-inch- thick base and 0.040-inch-thick hood or Aluminum sheet, minimum 0.063-inch- thick base and 0.050-inch- thick hood; suitably reinforced.

D. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch-thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to fit roof opening and ventilator base.

1. Configuration: Verify with Roofing Subcontractor: Self-flashing without a cant strip or Built-in cant or Built-in raised cant with mounting flange.
2. Overall Height: 12 inches for relief and 18 inches for intake.

E. Bird Screening: Galvanized-steel, 1/2-inch- square mesh, 0.041-inch wire or Aluminum, 1/2-inch- square mesh, 0.063-inch wire.

F. Galvanized-Steel Sheet Finish:

1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A 780. Apply a conversion coating suited to the organic coating to be applied over it.
2. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.
3. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil for topcoat and an overall minimum dry film thickness of 2 mils.

    a. Color and Gloss: As indicated by manufacturer's designations or As selected by Architect from manufacturer's full range (if custom color is required).

G. Capacities and Characteristics:

1. See equipment schedules on Drawings for details.

2.4 GOOSENECKS

A. Factory or shop fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 6-5; with a minimum of 0.052-inch- thick, galvanized-steel sheet.

B. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch-thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to fit roof opening and ventilator base.

1. Configuration: Verify with Roofing Subcontractor: Self-flashing without a cant strip or Built-in cant or Built-in raised cant with mounting flange.
2. Overall Height: 12 inches for relief and 18 inches for intake.

C. Bird Screening: Galvanized-steel, 1/2-inch- square mesh, 0.041-inch wire or Aluminum, 1/2-inch- square mesh, 0.063-inch wire.

D. Galvanized-Steel Sheet Finish:

1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A 780. Apply a conversion coating suited to the organic coating to be applied over it.
2. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.

3. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil for topcoat and an overall minimum dry film thickness of 2 mils.

    a. Color and Gloss: As indicated by manufacturer's designations or As selected by Architect from manufacturer's full range (if custom color is required).

E. Capacities and Characteristics:

1. See equipment schedules on Drawings for details.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.

B. Install goosenecks on curb base where throat size exceeds 9 by 9 inches.

C. Install gravity ventilators with clearances for service and maintenance.

D. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

E. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses. Comply with Section 07 "Joint Sealants" for sealants applied during installation.

F. Label gravity ventilators according to requirements specified in Section 15077 "Identification for HVAC Piping and Equipment."

G. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

H. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in Section 15815 "Metal Ducts." Drawings indicate general arrangement of ducts and duct accessories.

3.3 ADJUSTING

A. Adjust damper linkages for proper damper operation.

END OF SECTION 15856

SECTION 15900 - HVAC INSTRUMENTATION AND CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes a complete web-based, interoperable Building Management System (BMS) based on server/thin client architecture. In addition to other capabilities described hereinafter, the BMS shall include full programmability of all connected nodes (controllers) via the web for an authorized user. The BMS shall also include override capability of all controller outputs via the web for an authorized user. An authorized user shall also be able to create/ edit graphic screens, trends and alarms on-site using the specified hardware and software.

B. The BMS system shall interface seamlessly with the existing Honeywell Niagara 4 Platform Building Solutions automation system which currently serving the Princeton Public Schools facilities. All new controllers shall interface with the School's existing Network Control Panel and accessed through the District's existing BAS workstation.

C. This Section includes a complete web-based, interoperable Building Management System (BMS). In addition to other capabilities described hereinafter, the BMS shall include full programmability of all connected nodes (controllers) via the web for an authorized user. The BMS shall also include override capability of all controller outputs via the web for an authorized user. An authorized user shall also be able to create/ edit graphic screens, trends and alarms on-site using the specified hardware and software.

D. Network level components of the system – workstations, servers, etc. shall communicate using the BACnet protocol, as defined by ASHRAE Standard 135-2004. No gateways shall be used for communication to controllers furnished under this section.

E. Except as otherwise noted, the control system shall consist of all necessary Ethernet Network Controllers, Standalone Digital Control Units, Room Controllers, workstations, software, sensors, transducers, relays, valves, dampers, damper operators, control panels, and other accessory equipment, along with a complete system of electrical interlocking wiring to fill the intent of the Specification and provide for a complete and operable system. Except as otherwise specified, provide operators for equipment such

as dampers if the equipment manufacturer does not provide these. Coordinate requirements with the various Contractors.

F. The BMS Contractor shall coordinate with HVAC equipment & system manufacturers for factory installation of their controllers & devices to assure seamless system operation.

G. All interlocking wiring, wiring and installation of control devices associated with the equipment listed below shall be provided under this Contract. When the BAS system is fully installed and operational, the BAS system supplier and representatives of the Owner will review and check out the system – see System Acceptance and Testing section of this document. At that time, the BAS system supplier shall demonstrate the operation of the system and prove that it complies with the intent of the Drawings and Specifications.

H. Provide services and manpower necessary for commissioning of the system in coordination with the HVAC Contractor, Balancing Contractor and Owner's representative.

I. All Work performed under this section of the Specifications will comply with all governing codes, laws and governing bodies. If the Drawings and/or Specifications are in conflict with governing codes, the Contractor, with guidance from the Engineer, shall submit a proposal with appropriate modifications to the project to meet code restrictions. If this Specification and associated Drawings exceed governing code requirements, the Specification will govern. The Contractor shall obtain and pay for all necessary construction permits and licenses.

J. Related Sections include the following:

1. This Section includes the Building Management System (BMS) control equipment for HVAC systems and components, including open protocol control components for terminal heating and cooling units. Depending on the scope of the project, the complete Specification may have numerous sections that interface to this section, including several from Division 25, 16, & 28.

2. Section 15940 - Sequence of Operation.
3. Section 15058 - Common Motor Requirements for HVAC Equipment.
4. Section 15950 - Testing, Adjusting, and Balancing for HVAC
5. Section 16051 - Common Work Results for Electrical.
6. Section 16120 - Low Voltage Electrical Power Conductors & Cables.
7. Section 16140 - Wiring Devices.

1.3 DEFINITIONS

A. Standard

1. ASHRAE: American Society Heating, Refrigeration, Air Conditioning Engineers.
2. AHU: Air Handling Unit.
3. BACnet: Building Automation Controls Network.
4. BMS: Building Management System.
5. DDC: Direct Digital Control.
6. EIA: Electronic Industries Alliance.
7. GUI: Graphical User Interface.
8. HVAC: Heating, Ventilation, and Air Conditioning.
9. EEE: Institute Electrical Electronic Engineers.
10. VAV: Variable Air Volume Box.

B. Communications and Protocols

1. ARP: Address Resolution Protocol.
2. CORBA: Common Object Request Broker Architecture.
3. CSMA/CD: Carrier Sense Multiple Access/Collision Detect.
4. DDE: Dynamic Data Exchange.
5. FTT: Free Topology Transceivers.
6. HRDB: Hierarchical Real-Time Database.
7. HTTP: Hyper Text Transfer Protocol.
8. LAN: Local Area Network.
9. MS/TP: Master Slave Token Passing.
10. ODBC: Open Database Connectivity.
11. SNVT: Standard Network Variable Types.
12. SQL: Structured Query Language.
13. XML: exTensible Markup Language.

C. Controllers

1. ASC: Application Specific Controller.
2. ASD: Application Specific Device.
3. CAC: Custom Application Controller.
4. LNC: LON Network Controller.
5. ENC: Enterprise Network Controller.
6. VAVDC: Variable Air Volume Digital Controller.

D. Tools and Software

1. PES: Portable Engineering Station

1.4 SYSTEM DESCRIPTION

A. OVERVIEW: This section contains the design intent and functionality of the BMS. The BMSC shall provide an direct extension of the existing Honeywell Niagara 4 Platform

based Building Management System Utilizing Direct Digital Control (DDC), for the heating and cooling air conditioning systems and shall interface with other building microprocessor based subsystems as shown on the project documents, point lists, drawings and as described in these specifications. This scope of work shall include a complete working system including all engineering, programming, controls and installation materials, installation labor, commissioning and start-up, training, final project documentation and warranty.

B. It is the intent of this contract to provide the Princeton School District with an integrated and updated DDC control system utilizing the existing District Wide existing Honeywell Niagara 4 Platform based Building Management System and providing new DDC controls that are ANSI/ASHRAE Standard 195-2004 BACnet compliant for this project. Contractor shall update all graphics on operator terminals and web interface to provide full integration with owner's existing Honeywell Niagara 4 Platform based Building Management System. New graphics shall match existing to provide a seamless interface and appearance.

C. PROJECT DRAWINGS AND SPECIFICATIONS: The work of the single BMSC shall be as defined individually and collectively in all Sections of this Division's specifications together with the associated project drawings and the associated interfacing work as referenced in the related documents. The project BMS diagrams and drawings are diagrammatic only and shall not be utilized for installation configuration or mounting.

D. BMS DESIGN SCOPE INTENT: The intent of this specification Section is to provide the following features, functionality, and interface services:

E. SCOPE OF WORK: Furnish all labor, materials, and equipment necessary for a complete and operating extension of the existing Honeywell Building Management System, utilizing Niagara 4 Direct Digital Controls as shown on the drawings and as described herein. The projects control diagrams and drawings are diagrammatic only and are provided to show overall design intent. All DDC controllers furnished in this section shall communicate on a peer-to-peer bus over an open protocol bus (Examples: LonTalk, BACnet, Modbus). The intent of this specification is to provide a system that is consistent with BMS systems throughout the owner's facilities running the Niagara4 Framework.

F. BMS SUPERVISORY NETWORK CONTROLLER OPEN PROTOCOLS: The BMS architecture shall fully support a multi-vendor environment and be able to integrate third party systems via existing vendor protocols including, as a minimum, LonTalk, BACnet and Modbus. An Open System architecture shall provide secure Web access using MS Internet Explorer from any computer on the owner's LAN. Each Supervisory Network Controller and DDC controller shall be peer-to-peer BACnet™ Open Systems protocol communication and shall communicate via the district's Wide Area Network (WAN) using BACnet™ open protocol.

G. UNIT MANUFACTURER (UM) EQUIPMENT: Fully integrate the UM DDC equipment into the BMS via a communications interface. Provide hardware, software, and wiring to provide communication interfaces.

H. OCCUPIED SPACES: All work in occupied spaces or which adversely affect occupants shall be performed during coordinated with the Facilities Department to occur during unoccupied times, or after-hours at no additional cost.

I. EMBEDDED PROGRAMMING TOOLSET: All control devices furnished with this Section shall be programmable directly from the Niagara 4 Workbench. The use of configurable or programmable controllers that require additional software tools for post-installation maintenance shall not be acceptable.

J. INSTALLATION: The Building Management System shall be complete in all respects including labor, materials, equipment, and services necessary, and shall be installed by personnel regularly employed by the Building Management System Contractor (BMSC) . The Building Management System Contractor shall utilize Union electrician labor for all the system installation.

K. GRAPHICS: All graphics and navigation schemes for this project shall meet the standard of the Honeywell Niagara4 Framework server. Include all extension of software licensures and software maintenance which is required to modify the existing BMS programs and graphics.

L. FULL CLEARENCE AND SYSTEM ACCESS: The Owner shall receive Administrator level login and passwords for at first training session. The Owner shall have full licensing and full access rights for all network management, operating system server, engineering and programming software required for the ongoing maintenance and operation of the BMS. All of the BMS I/O points along with their associated control parameters, calculations and variables shall be accessible via any Web Browser through a secured connection to the BMS.

M. OPEN SOURCE: The BMS shall Open Source, consisting of materials and components which are available through Open Source product procurement suppliers. Single source exclusivity or other conditions which inhibit the Owner from obtaining both materials and support services from less than three independent procurement avenues of shall not be acceptable. The BMSC shall at the request of the A-E provide the Open Source names, addresses and contact information of at three (3) additional independent sources of acquiring the BMS products.

N. NIAGARA OPEN SYSTEM PLATFORM (BACnet): Only a BMS that utilizes the Niagara 4 Framework shall satisfy the requirements of this section. Any BMSC that requires additional server software shall be unacceptable. The BMSC shall furnish and install a complete Honeywell Niagara N4 Frameworks BMS including all necessary hardware, all operating and applications software necessary to perform the control sequences as called for in Section 15 “Sequence of Operation for HVAC Equipment”, BMS Diagrammatic Details, as shown on the project drawings. The new DDC controllers furnished in this section shall be an Open System platform. All programming of the shall utilize the Open Niagara N4 Platform embedded software package and communicate peer-to-peer via the Open ASHRAE 135 BACnet communications protocol.

O. NIAGARA INTERFACE CONFORMANCE STATEMENTS (NICS): All NICS shall follow the Open Niagara Interface Conformance specifications. All JACE hardware licenses and certificates shall be stored on local MicroSD memory card employing encrypted “safe boot” technology. To ensure quality, any additional JACE hardware products used on this project shall come through the Tridium Richmond, VA shipping facility. JACE hardware products not meeting these requirements shall not be allowed.

P. PEER TO PEER COMMUNICATIONS: The BMS architecture shall fully support a multi-vendor environment and be able to integrate third party systems via existing vendor protocols including, as a minimum BACnet MS/TP, BACnet IP, LonTalk, N2 and MODBUS RTU.

Q. WEB-BASED GRAPHICAL USER INTERFACE: The Operator shall be able manage the BMS through a connected web-browser software without additional applets or software required from an open web-browser. The BMSC shall provide 3-Dimensional web-based color and animated graphics. The graphics shall include floor plans showing the location of the controlled equipment and links to the individual equipment graphics. Copies of the web graphics shall be retained in the BMS Archival Data Server.

R. LOCAL AND REMOTE CONNECTIVITY: The BMS shall provide the Owner with a secure remote and local access shall be through an internal TCP/IP network connection. Alarm notification to designated stations and personnel through the TCP/IP network connection.

S. INFORMATION TECHNOLOGY (IT) COMPLIANCE: The BMS shall be designed for use with the Owner's current enterprise level IT system. The BMS TCP/IP devices located in IT rooms shall be fully IT compatible devices that communicate directly on the IT infrastructure in the facility.

T. BUILDING LEVEL DDC CONTROLLERS (B-BC): Building Level Controllers (B-BC) shall be provided for HVAC equipment and shall be networked together using CAT-6 Ethernet cable. Provide 1 Gigabit communication between BMS servers and clients. Provide 100 Megabit Peer-to-Peer communications among B-BC responsible for HVAC equipment Control. B-BC controllers shall be utilized on the Central Plant Systems (e.g., Chilled Water Systems, Heating Systems, etc.…).

U. ADVANCED APPLICATION CONTROLLERS (B-AAC): B-AAC Controllers shall communicate across a floor level MS/TP communications network. Application of the B-AAC shall be required where the standard sequence of operation is outside the capability of a B-ASC. A B-AAC shall not be utilized on Central Plant Systems.

V. APPLICATION SPECIFIC CONTROLLERS (B-ASC): B-ASC Controllers shall communicate across a floor level MS/TP communications network. Typical applications include Fan Coil Units, Heat Pump Units, Unit Ventilators, Constant and/or Variable Air Volume Boxes and Exhaust Fans. A B-ASC shall not be utilized on Central Plant Systems.

W. BUILDING MANAGEMENT SYSTEM DESIGN: The BMS design shall be by the BMSC's in-house engineers.

X. STANDARD COMPONENTS: All material and equipment shall be standard components, regularly manufactured for this and/or other systems and not custom designed specifically for this project. All devices and components shall have been thoroughly tested and proven in actual use for at least two years prior to this project.

Y. SCALABILITY: The system shall be scalable in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, DDC Controllers, and operator interface devices.

Z. SINGLE FAULT INDEPENDENCE: The network riser architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC controller shall operate independently by performing its own specified control, alarm management, operator I/O, and data collection. The failure of any single component or network connection shall not interrupt the execution of any control strategy, reporting, alarming, and trending function, or any function at any operator interface device.

AA. PEER-TO-PEER: DDC Controllers shall be able to access any data from, or send to control commands and alarm reports to, any other DDC Controller or combination of DDC controllers on the network without dependence upon a central or intermediate processing device.

BB. ALARMS: DDC Controllers shall also be able to send alarm reports to multiple operator workstations without dependence upon a central or intermediate processing device.

CC. SECURITY: DDC Controllers shall be able to assign password access and control priorities to each point individually. The Logon password shall enable the operator to monitor, adjust or control only the points that the operator is authorized. All other points shall not be displayed at the PC workstation or portable terminal. Passwords and priority levels for every point shall be fully programmable and adjustable.

DD. SPARE CAPACITY: All DDC controllers shall be installed with 20% spare I/O points of each type (minimum 1) and a 50% spare memory capacity.

EE. BUILDING MANAGEMENT SYSTEM CONTRACTOR (BMSC)'S RESPONSIBILITY:

1. The Building Management System Contractor (BMSC)) shall only use in house employees who are skilled, experienced, factory trained, and familiar with the specific equipment, software, standards, and configurations to be provided for this Project.
2. The BMSC shall provide a complete, neat, and workmanlike installation using only directly employed who are skilled, experienced, trained, and familiar with the specific equipment, software, standards, and configurations to be provided for this Project.
3. The BMSC shall manage and coordinate the BMS work in a timely manner in consideration of the Project schedules and shall coordinate with the associated work of other trades so as to not impede or delay the work of associated trades.
4. The BMSC shall provision all labor, materials, tools, equipment, software, software licenses, software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, samples, submittals, testing, commissioning, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, temporary protection, cleaning, cutting and patching, warranties, services, and items, even though these may not be specifically mentioned in this section which are required for the complete, fully functional BMS.

FF. AGENCY APPROVALS: The BMS shall be provided with the following agency approvals. Products not currently offering the above approvals are not acceptable. Verification that the approvals exist for all submitted products shall be provided on request.

1. Federal Communications Commission (FCC) Rules and Regulations, Vol II – 1986 Part 15 Class A, Subpart B, Class B, Subpart C, Subpart J, Class A
2. Underwriter Laboratories (UL): UL 916 - Energy Management Systems All.
3. Institute of Electrical and Electronic Engineers (IEEE) C62.41
4. National Electrical Manufacturers Associations NEMA 250 - Enclosures.

1.5 COORDINATION AND WORK RESPONSIBILITY AND MATRIX

A. TRADE RESPONSIBILITIES MATRIX: The demarcation of work and responsibilities between the BMSC and other related trades shall be as outlined in the "Coordination and Work Responsibility Matrix" below:

Coordination and Work Responsibility Matrix Work Description	Furnish	Install	Low Voltage Wiring	Line or Power Wiring
BMS N4 DDC Controllers	BMSC	BMSC	BMSC	-
BMS control wiring	BMSC	BMSC	BMSC	BMSC
BMS power wiring	BMSC	BMSC	BMSC	16
BMS communications wiring	BMSC	BMSC	BMSC	-
BMS enclosures	BMSC	BMSC	BMSC	16
BMS conduits and raceway	BMSC	BMSC	-	-
Equipment Interface	UM	BMSC	BMSC	-
Roof Top Unit controls	BMSC	BMSC	BMSC	16
HVAC Unit controls	BMSC	BMSC	BMSC	16
Unit Ventilator control	BMSC	BMSC	BMSC	16
AC Unit Controls	UM	BMSC	BMSC	16
Remote Condenser Unit wiring	BMSC	BMSC	BMSC	16
Convector controls	BMSC	UM	BMSC	16
Control Panels (Wall)	BMSC	BMSC	BMSC	16*
Control Dampers – External to units	15	SM	-	-
Control Dampers Actuators	15	BMSC	BMSC	-
Pipe insertion devices and taps	BMSC	15	-	-
Concrete equipment pads	15	15	-	-
Seismic bracing	15	15	-	-
Control Valves and Actuator	15*	15	BMSC	-
Manual Valves	15	15	-	-
Variable Frequency Drives - HVAC	15	16	BMSC	16

Coordination and Work Responsibility Matrix Work Description	Furnish	Install	Low Voltage Wiring	Line or Power Wiring
Motor Starters	15	16	BMSC	16
*Reference Equipment Unit Schedule and specification, BMS Diagrams and Specification Section 15. Responsibility or work is additionally specified under separate subsections.				
DIV15	Division 15 Mechanical Contractor			
DIV16	Division 16 Electrical Contractor			
BMSC	Division 15 Building Management System Contractor			
SMC	Division 15 Sheet Metal Contractor			
UM	Equipment Unit Manufacturer			

B. BMSC ELECTRICAL WORK: The BMSC shall provide electrical work as required in the specification, including:

1. Installation of all control wiring by a New Jersey licensed Electrical Contractor.
2. All BMS electrical work, except as otherwise specified, or shown on the Division 16 Electrical specifications or drawings.
3. Installation of control wiring may include line voltage and low voltage wiring, as required.
4. Power wiring (120VAC) for the BMS, including control panels, DDC controllers, actuators, and sensors from a designated circuit furnished by the Division 16 Electrical Contractor.
5. All control wiring in mechanical equipment spaces shall be installed in EMT. The conduit for power systems may be used for running control line voltage wiring. Low voltage plenum rated wiring can be run exposed above accessible ceiling and shall be supported per code and not laid on ceiling tile grid.
6. Low voltage wiring shall be concealed in finished rooms. If any wiring must be exposed in rooms, it shall be installed in wiremold raceway.
7. A monitoring point from the smoke detectors to the DDC controller for status. Where multiple detectors are provided, one signal shall be provided.
8. All safety devices wiring through the Hand and Auto positions of motor starting devices.

C. DIVISION 16 ELECTRICAL WORK (DIV16): The Division 16 Electrical Contractor Work shall be responsible for all interlock and wiring on the Division 16 Electrical specifications or drawings. The Division 16 Electrical Contractor shall coordination with the BMSC for any required field control panel circuit feeds. The Division 16 Electrical Contractor, as part of its contract, shall provide 1P-20A circuit breakers. The Division 16 Electrical Contractor shall also provide power wiring to motors, heat trace, junction boxes for power to BMS panels and all work related to smoke detectors, smoke dampers, and the fire alarm system.

D. DIVISION 15 MECHANICAL WORK (DIV15) The Division 15 Mechanical Contractor (MC) shall be responsible for the Installation of automatic control valves, threadolet, thermowells, flow meters/switches, pressure sensor taps and associated shut-off/bypass cocks, or any other devices required in the piping. Any Motor starters furnished by the Mechanical Contractor shall have control transformers and one set of auxiliary contacts, as required for interlocks.

E. DIVISION 15 SHEET METAL (SMC): The Division 15 Sheet Metal Contractor shall be responsible for providing and installing of automatic control dampers, external to the equipment, smoke dampers, duct smoke detectors and access doors as required. The Division 15 Sheet Metal Contractor shall also install any duct airflow measuring stations or other devices required to be installed into the ductwork and as otherwise determined by tradeline jurisdictions.

1.6 PROJECT SITE CONDITIONS:

A. COOPERATION WITH OTHER TRADES: Coordinate the Work of this section with that of other sections to ensure that the Work shall be carried out in an orderly fashion. It shall be the BMSC's responsibility to check the Project and Contract Documents for possible conflicts between his Work and that of other crafts in equipment location, pipe, duct, and conduit runs, electrical outlets and fixtures, air diffusers and structural

and architectural features. The BMSC shall repair any damage caused by his work to the building(s) and equipment at no additional cost to the owner.

B. PROJECT SEQUENCING: Ensure that products of this section are supplied to affected trades in time to prevent interruption of construction progress.

C. COMPONENT INSTALLATION: Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

D. POWER SOURCE: Coordinate the supply of conditioned electrical branch circuits for control units and operator workstation with the Division 16 Electrical contractor. Coordinate equipment with the appropriate Divisions of the Electrical Specifications for Power, Wiring, Conduit, Fire Alarm, Motor Control Centers, etc. to achieve compliance, compatibility, and interfaces.

E. THIRD PARTY BMS INTEGRATION: Coordinate equipment with the appropriate Divisions of the Mechanical Specifications for Motor Controllers, Manufacturer Supplied Controls, etc. to achieve compliance, compatibility, and interfaces.

F. CHANGES IN SCOPE OF WORK: Any changes in the scope of work must be authorized by a written Change Order, and issued by the customer, in accordance with Contract conditions.

G. CORRECTION OF WORK: The BMSC shall promptly correct all BMS work found to be defective or failing to conform to the Contract Documents at no additional cost.

1.7 PERFORMANCE STANDARDS

A. STANDARD MATERIAL/PRODUCTS: All material and equipment used shall be standard components, regularly manufactured and available, and not custom designed especially for this project

B. MODULAR DESIGN: The system architecture shall be fully modular permitting expansion of application software, system peripherals, and field hardware.

C. PERFORMANCE: The system, upon completion of the installation and prior to acceptance of the project, shall perform all operating functions as detailed in this specification.

D. SINGLE SYSTEM ARCHITECTURE: The BMS shall be consistent with BMS system throughout the owner's facilities running the Niagara 4 Framework. The BMS shall fully integrate the unit manufacturer HVAC controls systems into a new Open Source - Open System Niagara Frameworks BMS. The BMS shall fully integrate any remaining legacy DDC controls systems into a new Open Source - Open System Niagara Frameworks BMS. All BMS DDC controllers shall be available through avenues for procurement and from multiple sources (Open Source).

E. OPEN SYSTEM: OPEN PROTOCOL BMS COMMUNICATIONS: The entire BMS shall be in compliance with the ANSI/ASHRAE 135 BACnet standard. BACnet protocols and LAN types shall be used throughout and exclusively. Non-BACnet compliant or propriety equipment or systems (including gateways) shall not be acceptable and are specifically prohibited. As part of BMS submittal package the BMSC shall provide Product Information Conformance (PIC) statement for each Niagara N4 DDC Controller, indicating the DDC controller’s Niagara and BTL conformity to ASHRAE BACnet standard. The BMS shall conform to the industry network standards utilizing TCP/IP connections. The Building Management System product-lines, which are based on a proprietary operating system, utilizing proprietary networks, baud-rates or variants which cannot be extended by third party DDC System manufacturers, will not be acceptable. (i.e., BACnet over ARCnet 156K)

F. OPEN SOURCE: WEB BASED DIRECT DIGITAL CONTROLS: The BMS shall consist of Open Source BACnet Direct Digital Controllers (DDC). All of the BACnet DDC controllers shall be integrated into a distributed network system communicating over a single communications network. All web graphics shall be generated for interface with a standard web browser. The Operator shall interface with the BMS from any standard browser over a TCP/IP connection, including over the Internet. All programming and

system software shall be licensed to the Owner with full password capability and access. Under no circumstances shall any part of the BMS or software be licensed or controlled by the BMSC. Upon completion of the project, the BMSC shall provide to the Owner the entire programming software including original installation discs.

G. WEB BASED 3-DIMENSIONAL COLOR GRAPHICS: The BMS shall be tested using manufacturer's recommended hardware and software for Operator Workstation (Web Server and web browser). All Web Based Graphics shall be generated on the workstation for use over the Web. The web browser shall depict the equipment's animated graphics, scheduler graphics, alarm screens, point and click setpoint adjustments, point and click alarm acknowledgements and resets and other graphics displays required by Operator. The BMS System architecture shall provide secure Web access using any of the current versions of web browsers from any computer on the Owner's LAN. The BMS connected equipment to be monitored, controlled, and scheduled from web client computers onsite and remote sites. The units shall be dynamically depicted in 3 dimension aspect, with animated components in real time. All BMS interface points shall be on standard PC web browsers that do not require any special software from the BMS manufacturer for use as a GUI.

H. WEB GRAPHIC DISPLAY: The Graphics screens may have up to 20 dynamic points with current data, display this data within 10 seconds. The Graphic screens shall automatically refresh every 15 seconds.

I. PROGRAM EXECUTION FREQUENCY: The DDC controllers shall be able to completely execute PID loops at a frequency down to once per second, consistent with the mechanical process under control.

J. RESPONSE TIMES:

1. OBJECT SCANNING: Transmit change of values to requesting device within six seconds.
2. OBJECT COMMAND: Device response of less than two seconds after command.
3. ALARM RESPONSE TIME. Annunciation at the workstation within 15 seconds.
4. RESTORATION OF POWER: Restart of DDC controllers within 180 seconds.

5. CONFIGURATION AND TUNING SCREENS: Automatically refresh within 6 seconds.

K. REPORTING ACCURACY OF CONTROL: Report values and maintain measured variables within tolerances as follows:

TABLE 1: Reporting Accuracy	
Measured Variable	Reported Accuracy
Space Temperature	plus, or minus 1 degree F
Ducted Air Temperature	plus, or minus 1 degree F
Outside Air Temperature	plus, or minus 2 degree F
Dew Point Temperature	plus, or minus 3 degree F
Water Temperature	plus, or minus 1 degree F
Relative Humidity	plus, or minus 5 percent
Air Pressure (ducts)	plus, or minus 0.1 in. w.c.
Carbon Dioxide (CO2)	plus, or minus 50 ppm

1.8 INSTALLATION OF PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION.

A. Section 15820 – Ductwork Accessories:

1. Automatic Dampers.
2. Airflow Stations.
3. Terminal Unit Controls.

1.9 SUBMITTALS

A. INDEX OF SUBMITTALS: Submit under provisions of Section 01 33 23 Shop Drawings, Product Data, and Samples. Prepare an index of all submittals and shop drawings for

the installation. Index shall include a shop drawing identification number, Contract Documents reference and item description. The submittal packages shall be as approved and reviewed by the Architect and Engineer (A-E) for contract compliance.

1. Contractor Qualification Submittal
2. BMS Software and Hardware Submittals
3. Graphics Submittal
4. Operation & Maintenance Manual Submittal

B. SUBMISSION: Submittals shall be in defined packages. Each submittal package shall be complete and shall only reference itself and previously submitted packages. Provide drawings as AutoCAD compatible files on optical disk (file format: .dwg, .dxf, .vsd, or comparable) or hard copies on 11" x 17" prints of each drawing.

C. SUBMISSION PERIOD: The BMSC shall submit a list of projected dates of required submittals within thirty (30) days of contract award.

D. SUBMITTAL QUANTITY: The BMSC shall submit Electronic copies (PDF) of shop drawings of the entire control system shall be submitted with two (2) hardcopies of each submittal type submitted for review prior to ordering or fabrication of the equipment.

E. DEVIATIONS: Any deviations from these specifications or the work indicated on the drawings shall be clearly identified in the Submittals.

F. SUBMITTAL REVIEW PERIOD: Allow 15 working days for the review of each package by the Architect and Engineer in the scheduling of the total BMS design work.

G. SUBMITTAL APPROVAL: Submittals shall be approved before any equipment is installed. Begin no work until submittals have been approved for conformity with design intent.

H. CORRECTION – RESUBMISSION: The BMSC shall correct any errors or omissions noted in the first A-E review, and provide a resubmission for approval, showing corrections

prior to installation. Any further subsequent resubmissions for errors or corrections previously noted shall be at the expense of the BMSC.

I. CONTRACTOR QUALIFICATION SUBMITTAL: Submit documentation of BMS Manufacturers and BMSC's qualifications, including those indicated in this Section's "Quality Assurance" if so, requested by the A-E.

J. ACTION SUBMITTALS: When manufacturer's cutsheets apply to a product series rather than a specific product, clearly indicate applicable data by highlighting or by other means. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements.

K. CONTROL DIAGRAMS: BMS network architecture diagrams: Riser diagrams showing network switch locations, network topology including control network layout, communication protocol, and wire types. Showing including all nodes and interconnections. Schematic diagrams of all control, communication, and power wiring for central system installation. Show interface wiring to control system.

L. SEQUENCE OF OPERATIONS: Complete description of control system operation including sequences of operation. Include and reference schematic diagram of controlled system.

M. SYSTEMS SCHEMATICS: Schematic wiring diagram of each controlled system. Label control elements and terminals. Where a control element is also shown on control system schematic use the same name.

N. BMS LEGEND: Provide a list of BMS point naming convention. Indicate the format, structure, and standards of typical point names. Each Field Tag shall be 6-10 characters in length and incorporate industry standard designations. The project plan designation of the equipment &/or room will be utilized. The naming convention shall follow the "BUILDING.FLOOR.ROOM.EQUIPMENT.POINT" format. Such that the specific point for the Supply Air Temperature on AHU 1 on the 3rd floor of Building A3 would be

addressed as A3.FLR03.AHU01.SAT. Where a VAV in Room C313 would to be named "FLR3.AHU04.VAV.C313:Room Temp"

O. POINT SCHEDULES: Points schedule for each point in the ATC, including Point Type, Object Name, Expanded ID, Display Units, Controller type, and Address. Point list for each system controller including both inputs and outputs (I/O), point numbers, controlled device associated with each I/O point, and location of I/O device.

P. USER INTERFACE GRAPHICS: Provide samples of the graphic display screen types and associated menus. Provide a sample graphic of each controlled system with labeled control points and graphically show locations of control elements. Provide floor plan schematic diagrams indicating control panel and space temperature sensor locations. Provide the sample color graphics on 11 x 17" prints for each typical system indicating conceptual layout of pictures and data for each graphic. List of color graphics to be provided showing or explaining which other graphics can be directly accessed.

Q. BILL OF MATERIALS: Provide a complete bill of material indicating quantity, manufacturer, model number, and relevant technical data of equipment used. Show the manufacturer's description, technical data such as product specifications for relevant items furnished under this contract. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

R. PRODUCT DATA SHEETS: Provide data sheets or marked catalog pages including part number, photo and description for all products including software. Show manufacturer's description and technical data, such as product specification sheets, installation, and maintenance instructions for items. Provide construction details, material descriptions, dimensions of individual components and profiles, and finishes. Provide Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range,

default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity. Show Product description with complete technical data, performance curves, product specification sheets, installation, operation, and maintenance instructions including factors effecting performance.

S. MULTIPLE SUBMISSIONS: If multiple submissions are required to execute work within schedule, first submit a coordinated schedule clearly defining intent of multiple submissions. Include a proposed date of each submission with a detailed description of submittal content to be included in each submission. Clearly identify each submittal requirement indicated and in which submission the information shall be provided. Include an updated schedule in each subsequent submission with changes highlighted to easily track the changes made to previous submitted schedule.

T. GRAPHICS SUBMITTAL: Provide graphical samples of standard and custom 3 dimensional, high Definition color Web Based graphic screens for floor plans of the building(s) and all mechanical system(s). For each Web screen, provide a conceptual layout of the equipment along with monitoring and control parameters if so, requested by the A-E.

U. HARDWARE SUBMITTAL: Shop Drawings shall include and consist of a complete list of equipment and materials, including manufacturers' catalog data sheets and installation instructions. Submit in printed and electronic format. Examples of written Unit Controller Checkout Sheets and Performance Verification Procedures for applications similar in scope shall be included for approval. Shop Drawings shall include the following requirements:

1. Prepare an index sheet of all submittals and shop drawings for the installation. Index shall include a shop drawing identification number, Contract Documents reference and item description.

2. Prepare all shop drawings in the latest version of AutoCAD Software. The BMSC shall furnish an electronic copy with the submittal.
3. The BMS Riser Diagrams shall depict the locations of all controllers and workstations, with associated network wiring.
4. System Schematics of each mechanical system shall show all connected input/output control points, controllers, power supplies, system diagram, end device details, termination points and wire and type required from control panel to end device with reference to their associated controller.
    a. Typical drawings shall be allowed where appropriate.
5. Shop drawings shall also contain complete wiring and schematic diagrams, sequences of operation, control system bus layout and any other details required to demonstrate that the system has been coordinated and shall properly function as a system.
6. Shop drawings shall Specific Terminal identification for all control wiring shall be shown on the shop drawings (i.e., point to point diagram).

V. PRODUCT DATA: Manufacturer's data sheets on each product to be used. Data shall contain manufacturer's data on all hardware and software products required by the specification including:
1. NICs for each BMS controller
2. PICs for each BACnet controller
3. Preparation instructions and recommendations.
4. Storage and handling requirements and recommendations.
5. Installation methods.
6. Product Certificates: Compliance with Article, Quality Assurance.

W. AUTOMATIC CONTROL VALVE SCHEDULES:
1. Indicate control valve size
2. Indicate flow pattern
3. Indicate control valve connections and ratings
4. Indicate control flow rate

5. Indicate control valve pressure drop
6. Indicate control valve CV rating
7. Indicate control body material
8. Indicate control valve temperature and pressure rating
9. Indicate control valve location
10. Indicate control valve tagging
11. Indicate Leakage flow at maximum system pressure differential.
12. Indicate Torque required at worst case condition for sizing actuator.
13. Indicate actuator selection indicating torque provided.
14. Indicate Maximum close-off pressure.
15. Indicate actuator signal to control valve (on, close or modulate).
16. Indicate actuator position on loss of power.
17. Indicate actuator position on loss of control signal.
18. Indicate control valve actuator power requirements

X. INTERFACE SCHEDULE: Provide details of all BMS interfaces and connections to the work of other trades. Provide a Master Integration Plan which shall include the Network communications Topology between interfaced systems, Network Protocol, Alarmed Points, and the Sequence of Operations.

Y. LOCAL APPROVAL: Control devices and specific BMS which require approval of the local authorities having jurisdiction shall comply with such regulations. The BMS shall obtain approval of such prior to installation. Where filing is necessary, the expense shall be borne by the BMSC. Provide a copy of all related correspondence and permits/approvals to the Owner and A-E.

Z. ASBUILT DRAWINGS: Any revisions made during the installation, start-up, or acceptance portion of the project, shall be accurately reflected in the "as-builts". All BMS drawings shall be reviewed after the final system checkout and updated or corrected to provide 'Asbuilt' drawings to show exact BMS installation. All shop drawings shall be acknowledged in writing by the owner before installation is started

and again after the final checkout of the system. The BMS installation shall not be considered complete until the 'asbuilt' drawings have received their final approval.

AA. OPERATION AND MAINTENANCE (O&M) MANUAL: Upon completion of the work of this Section, six (6) Hard and Two (2) Electronic copies of the Operation and Maintenance Manuals shall be provided to the Owner's Representative. The O&M manual electronic media shall be self-contained, and include all necessary software required to access the product data sheets. A logically organized table of contents shall provide dynamic links to view and print all product data sheets. Viewer software shall provide the ability to display, zoom, and search all documents.

1. POINT OF CONTACT: The O&M manual shall contain the names, address and 24 hour telephone numbers of the BMSC and service representative.
2. GUI SECTION: This section of the O&M Manual shall contain Step by step procedures for each operator function, including login, Creating, modifying, or deleting schedules, Uploading/Downloading to the field hardware, Creating historical trends, collecting trend data, and generating trend graphs, Enabling/Assigning alarms, and messages to reporting actions/groups, Report generation and ‘third party software’ and Backing up software and data files. All Color Printout of graphic screens shall be included.
3. BMS CONTROL DIAGRAMS: This section shall contain the BMS architecture overview and networking configuration, equipment controllers and diagrams, and the BMS software and hardware cut-sheets with product descriptions.
4. HARDWARE: Installation, mounting and connection details for all field hardware and accessories
5. COMMISSIONING: This section shall contain Commissioning, setup, and backup procedures for all control modules/accessories, BMS server software, and database. Provide the final testing and commissioning reports along with the device checklists.

6. MESSAGES AND ALARMS: This section shall contain a Listing of basic terminology, alarms/messages, error messages and frequently used commands or shortcuts. All alarm messages for equipment and operator action required.
7. SOFTWARE: This section shall contain System Software Documentation of all Graphical Language Programs, detailing their application to specific HVAC equipment, together library detailing the function. It shall include the Graphical relationship of the projects mechanical equipment hierarchy.
    1) Software Operating manuals.
    2) Control Device address lists
    3) Color Printout of software applications
    4) All Software licenses.
8. SYSTEM MAINTENANCE REQUIREMENTS: This section shall contain Maintenance instructions, recommended preventive maintenance procedures for all system components including a schedule of tasks (inspection, cleaning, calibration, etc.), time between tasks, and task descriptions. Provide a lists of spare parts for each type of control device, interconnection wiring diagrams with identified system components and devices. Provide the Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances. Include Calibration records and list of set points.
9. LICENSE AND WARRANTY: This section shall contain all BMS Licenses, Guarantee, and Warranty documents for all equipment and systems.
10. NOTICE OF COMPLETION: This section shall contain a document stating the date when the BMS is accepted for beneficial use and placed under warranty. At this time, the consultant shall issue a “notice of completion” and the warranty period shall start.
11. PRODUCT CERTIFICATES: Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with ASHRAE 135. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with LonWorks.

1.10 QUALITY ASSURANCE

A. All bidders must be building automation Contractors in the business of installing direct digital control building automation systems for a minimum of 3 years.

   1. The Building Management System Contractor shall have a full service facility within 50 miles of the project that is staffed with Engineers trained and certified by the manufacturer in the configuration, programming and service of the automation system. The Contractor's technicians shall be fully capable of providing instructions and routine emergency maintenance service on all system components.

B. All bidders must be authorized distributors or branch offices of the manufacturers specified.

C. Each point in the system shall be tested for both hardware and software functionality. In addition, each mechanical and electrical system under control of the BAS will be tested against the appropriate sequence of operation specified herein. Successful completion of the system test shall constitute the beginning of the warranty period. A written report will be submitted to the Owner indicating that the installed system functions in accordance with the plans and Specifications.

D. The BAS system supplier shall commission and set in operating condition all major equipment and systems, such as the chilled water, hot water and all air handling systems, in the presence of the equipment manufacturer's representatives, as applicable, and the Owner and Architect's representatives. If the vendor is providing an AFDD/CC system, use of the analytics shall be used to help commission the system.

E. The BAS system supplier shall provide a technician for 2 days manpower and engineering services required to assist the HVAC Contractor and Balancing Contractor in testing, adjusting, and balancing all systems in the building. The BAS system supplier shall coordinate all requirements to provide a complete air balance with the Balancing Contractor and shall include all labor and materials in his Contract.

F. Startup Testing shall be performed for each task on the startup test checklist, which shall be initialed by the technician and dated upon test was completion along with any recorded data such as voltages, offsets or tuning parameters. Any deviations from the submitted installation plan shall also be recorded.

G. Required elements of the startup testing include:
   1. Measurement of voltage sources, primary and secondary
   2. Verification of proper controller power wiring.
   3. Verification of component inventory when compared to the submittals.
   4. Verification of labeling on components and wiring.

5. Verification of connection integrity and quality (loose strands and tight connections).
6. Verification of bus topology, grounding of shields and installation of termination devices.
7. Verification of point checkout.
8. Each I/O device is landed per the submittals and functions per the sequence of control.
9. Analog sensors are properly scaled and a value is reported
10. Binary sensors have the correct normal position and the state is correctly reported.
11. Analog outputs have the correct normal position and move full stroke when so commanded.
12. Binary outputs have the correct normal state and respond appropriately to energize/de-energize commands.
13. Documentation of analog sensor calibration (measured value, reported value and calculated offset).
14. Documentation of Loop tuning (sample rate, gain and integral time constant).

H. A performance verification test shall also be completed for the operator interaction with the system. Test elements shall be written to require the verification of all operator interaction tasks including, but not limited to the following.
1. Graphics navigation.
2. Trend data collection and presentation.
3. Alarm handling, acknowledgement and routing.
4. Time schedule editing.
5. Application parameter adjustment.
6. Manual control.
7. Report execution.
8. Automatic backups.
9. Web Client access.

I. A Startup Testing Report and a Performance Verification Testing Report shall be provided upon test completion.

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 unit manufacturer.

1.12 COORDINATION

1. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.
2. Coordinate equipment from other divisions including "Intrusion Detection," "Lighting Controls," "Motor-Control Centers," "Panelboards," and "Fire Alarm" to achieve compatibility with equipment that interfaces with those systems.
3. Coordinate supply of conditioned electrical circuits for control units and operator workstation.
4. Coordinate location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete".
5. Coordinate with the Owner's IT department on locations for ENC's, Ethernet communication cabling and TCP/IP addresses.

1.13 WARRANTY AND MAINTENANCE.

A. WARRANTY PERIOD: Labor and materials for control systems shall be warranted for a period as specified under Warranty in Section 00 72 00, General Conditions. Provide a two year labor and material warranty on the BMS. If within twenty four (24) months from the date of acceptance of product, upon written notice from the owner, it is found to be defective in operation, workmanship, or materials, it shall be replaced, repaired, or adjusted at the option of the BMSC at the cost of the BMSC. THE BMSC shall maintain an adequate supply of repair devices within 50 miles of the Project site such that replacement of key parts and labor support, including programming. Warranty work shall be done during BMSC's normal business hours.

B. START OF WARRANTY DATE: After the Engineer determines that equipment and systems operate satisfactorily at the end of final start-up, testing, and commissioning phase, the Engineer shall certify in writing that control system operation has been tested and accepted in accordance with the terms of this specification. The BMSC shall provide the owner in writing the Date of acceptance and the beginning of the warranty period.

C. SOFTWARE WARRANTY: The BMSC shall provide updates to operator workstation software, project-specific software, graphic software, database software, and firmware

that resolve identified software deficiencies at no charge during warranty period. Do not install updates or upgrades without Owner's written authorization.

D. WARRANTY - REMOTE SERVICE SUPPORT: As part of the warranty response, the BMSC shall be required to remotely connect to the facility's BMS during the warranty period. This remote connection to the facility shall be within two (2) hours of the time that the problem is reported to the BMSC. This coverage shall include normal or after business hours, weekends, and holidays. If the problem cannot be resolved with remote support services, the BMSC shall dispatch the qualified personnel to the project site to resolve the problem within 24 hours.

1.14 OWNERSHIP OF PROJECT MATERIAL.

A. The Owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition off this Contractor. Such license shall grant use of all programs and application software to the Owner as defined by the manufacturer's license agreement, but shall protect the manufacturer's rights to disclosure of Trade Secrets contained within such software.

B. The licensing agreement shall not preclude the use of the software by individuals under Contract to the Owner for commissioning, servicing or altering the system in the future. Use of the software by individuals under Contract to the Owner shall be restricted to use on the Owner's computers and only for the purpose of commissioning, servicing, or altering the installed system.

C. All project developed software, files and documentation shall become the property of the Owner. These include but are not limited to:

1. Server and workstation software
2. Application programming tools
3. Configuration tools
4. Network diagnostic tools
5. Addressing tools
6. Application files
7. Configuration files
8. Graphic files
9. Report files
10. Graphic symbol libraries
11. All documentation

1.15 WORK BY OTHERS

A. The BAS system supplier shall cooperate with other Contractors performing work on this project necessary to achieve a complete and neat installation. To that end, each Contractor shall consult the Drawings and Specifications for all trades to determine the nature and extent of others' work.

B. The BAS system supplier shall furnish all Control Valves, Flow Meters, Flow Switches, Sensor Wells for installation by the Mechanical Contractor and/or others.

C. The BAS system supplier shall provide field supervision to the designated Contractor for the installation of the following:
   1. Automatic control dampers
   2. Blank-off plates for dampers that are smaller than duct size.
   3. Sheet metal baffles plates to eliminate stratification.
   4. The Electrical Contractor shall provide:
      a. All 120VAC power wiring to motors, heat trace, junction boxes for power to BAS panels.
      b. Furnish smoke detectors and wire to the building fire alarm system. HVAC Contractor to mount devices. BAS system supplier to hardwire to fan shut down.
      c. Auxiliary contact (pulse initiator) on the electric meter for central monitoring of kWh and KW. Electrical Contractor shall provide the pulse rate for remote readout to the BAS. BAS system supplier to coordinate this with the electrical Contractor.

D. Prior to delivery to the Project site, ensure that suitable storage space is available to store materials in a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, humidity, and corrosive atmospheres. Materials shall be protected during delivery and storage and shall not exceed the manufacturer stated storage requirements. As a minimum, store indoors in clean, dry space with uniform temperature to prevent condensation. In addition, protect electronics from all forms of electrical and magnetic energy that could reasonably cause damage.

E. Deliver materials to the Project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name, material or product brand name, and equipment tag number or service name as identified within the Bid Documents.

F. Inspect and report any concealed damage or violation of delivery storage, and handling requirements to the Engineer.

PART 2 - PRODUCTS

2.1 BUILDING MANAGEMENT SYSTEM MANUFACTURERS

A. MATERIAL SAMPLES: Due to the unique nature of the project, all equipment for this building will be special, minimal size, and with special colors. All components for the project will require samples as part of the approval process.

B. ACCEPTABLE MANUFACTURERS: The BMS architecture shall consist of the products of a manufacturer regularly engaged in the production of DDC Control Systems and shall be the BMS manufacturer's latest standard of design at the time of bid. All controls, other than relays, transformers and panels shall be the product of the same manufacturer. The basis of design for the BMS is the Niagara Platform as manufactured by Honeywell Controls (Forge-WEBs-N4) as provided by an ACI-DIRECT.

C. NON-COMPLIANT AND UNACCEPTABLE SYSTEMS: Any BMS provided by single sourced, or equipment manufacturer provided control systems (e.g., York, Carrier, Daikin, Trane, etc...), any of the approved BMS manufacturers which utilize proprietary controls, Non-Open Source or Not-Open Systems or requests which have not received the Engineers written approval as detailed in Part 1 of this section shall not be acceptable.

2.2 SYSTEM DESCRIPTION

A. OVERVIEW: The BMS specified in this document shall be Web-based, utilizing the Open Source – Open System Niagara Platform. The Building Management System (BMS) shall be comprised of interoperable SNC, AAC, ASC DDC Controllers, customized 3-D graphics and graphical process programming direct digital controllers, software, and other control devices for a complete BMS as specified herein. The BMS shall use a Niagara N4 Platform architecture and shall integrate a wide variety of third-party devices and applications. UM's DDC devices shall be integrated to the N4 Platform through a common protocol. Equipment graphics shall be generated and included on the Web-based Graphical User Interface.

B. SPECIFIC PROJECT REQUIREMENTS:

1. No Proprietary communications protocol at any level.
2. All Hot Water valves shall fail open to the coil.
3. All valve actuators shall have a mechanism for local manual override at the unit.
4. All modulating control valves shall be 0-10VDC or 4-20mA.
5. All System Equipment Graphics, including Floor plans shall be depicted in a 3-D aspect.
6. All Graphical Floor plans shall be thermographic, changing color as deviation from setpoint.
7. High Priority alarms, as defined by the Owner, shall provide an escalation text or email.

C. ENVIRONMENTAL CONDITIONS FOR DEVICES: Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.

D. DDC SYSTEM RELIABILITY: Design, install and configure DDC controllers, gateways, routers to yield a MTBF of at least 20,000 hours, based on a confidence level of at least 90 %. MTBF value shall include any failure for any reason to any part of products indicated. If required to comply with MTBF indicated, include DDC system and product redundancy to maintain DCC system, and associated systems and equipment that are being controlled, operational and under automatic control. Critical systems and equipment that require a higher degree of DDC system redundancy than MTBF indicated shall be indicated on Drawings.

E. ELECTRIC POWER QUALITY: Protect primary network and critical system DDC controllers which are connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41. Fuses shall not be utilized for surge protection.

F. POWER CONDITIONING: Protect primary network and critical system DDC controllers which are connected to AC power circuits from irregularities and noise rejection. Characteristics of power-line conditioner shall be such that at 85 % load, output voltage shall not deviate by more than plus or minus 1 % of nominal when input voltage fluctuates between minus 20 % to plus 10 % of nominal. During load changes from zero to full load, output voltage shall not deviate by more than plus or minus 3 % of nominal. Accomplish full correction of load switching disturbances within five cycles, and 95 % correction within two cycles of onset of disturbance. Total harmonic distortion shall not exceed 3-1/2 % at full load.

G. GROUND FAULT: Protect products from ground fault by providing suitable grounding. Products shall not fail due to ground fault condition.

H. BACKUP POWER SOURCE: HVAC systems and equipment served by a backup power source shall have the associated DDC controllers/devices providing control of them also served from a backup power source.

I. UNINTERRUPTABLE POWER SUPPLIES (UPS): UPS units shall provide emergency transfer power to critical DDC system including DDC controllers, input and output device and sensors and actuators. Typical equipment include Archival Servers, SNC, Critical System DDC controllers, Graphical Operator Workstations, Alarm Printers, Network Routers and System Gateways.

J. OPERATION AFTER ELECTRIC POWER INTERRUPTION: Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems shall automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.3 BUILDING MANAGEMENT SYSTEM NETWORK ARCHITECTURE

A. GENERAL: The BMS shall be comprised of a network of interoperable, standalone digital controllers, a network area controller, graphics and programming and other control devices for a complete system as specified herein. The BMS shall provide secure password access to all features, functions and data contained in the overall BMS. The BMS is based in the Honeywell (WEBs-N4) BACnet architecture. The BMS shall integrate a wide variety of third party devices and applications. The system shall be designed for use on the Internet, or intranets using off the shelf, industry standard technology compatible with other Owner provided networks.

B. NETWORK ARCHITECTURE: The system shall utilize an open architecture consisting of no more than three (3) network tiers capable of the following:

1. Utilizing TCP/IP communications operating at a minimum speed of 100 Mb/sec.
2. ANSI/ASHRAE BACnet Standard 135 protocol shall be sole and native protocol used throughout entire DDC system.
3. If used, gateways shall connect to the system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
4. Operator Workstations, controllers and other network devices shall be tested and listed by BACnet Testing Laboratories.
5. The networks shall utilize only copper and optical fiber communication media as appropriate and shall comply with applicable codes, ordinances, and regulations.
6. All necessary TCP/IP connections and Internet Services shall be provided by the Owner.
7. The Tier one (1) LAN shall connect network controllers and operator workstations.
8. The Tier two (2) LAN shall connect programmable application controllers to other programmable application controllers, and to network controllers.
9. The Tier three (3) LAN shall connect application-specific controllers to programmable application controllers and/or network sensors.

10. Portions of the system networks integration may use an Open implementation of network devices and technology complying with Modbus Application Protocol Specification V1.1b.

C. COMMUNICATION SPEED:

1.	LAN Connecting OWS and SNC:	100 Mbps.
2.	LAN Connecting BC:	100 kbps.
3.	LAN Connecting AAC and ASC:	76,800 bps.

D. DEDICATED NETWORK: The BMS shall consist of dedicated and separated LANs that are not shared with other building systems and tenant data and communication networks.

E. EXPANSION CAPABILITY: The BMS's architecture shall be modular and have inherent capability to expand to not less than two times system size indicated with no impact to performance. The BMS shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers, and operator devices. A sufficient number of DDC controllers shall be supplied to fully meet the project requirements of this Specification. The BMS network shall support 25% expansion capacity of all types of Niagara N4 DDC controllers, and all point types included in the initial installation.

F. TRANSPARENCY: The number of LANs and associated communication shall be transparent to the Operator. All I/O points residing on any LAN shall be capable of global sharing between LANs.

G. INDEPENDENT CONTROL AND RESILIENCY: The BMS's network design shall eliminate dependence upon any single device for alarm reporting and control execution. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices. Each Niagara N4 DDC controller shall operate independently, performing its' own control, alarm management and historical data collection. The individual elements and component

subsystems shall be minimum requirements and shall be augmented as necessary by the BMSC to achieve compliance with all applicable codes and standards.

H. The BMS shall consist of the following:

1. System Network Controllers(s)(SNC)
2. Operator Workstations (OWS)
3. Graphical User Interface(s)(GUI)
4. Local Display Device(s)(LCD)
5. Building, Advanced and Application System Controllers (B-BC/B-AAC/B-ASC)
6. Input/Output Module(s)(IOM)
7. Network communications equipment
8. Other components required for a complete and working BMS

2.4 OPEN, INTEGRATED, AND INTEROPERABLE.

A. OVERVIEW: The design intent is to provide an Open Source - Open BMS utilizing distributed web based direct digital controls which communicate over a BACnet communications network. The BMS's BACnet controllers, materials and components furnished shall be unrestricted and available for acquisition by the Owner through multiple independent sources and service providers. The Contractor shall provide the sources and providers to the M-E-P, upon request.

B. NETWORK COMMUNICATIONS PROTOCOL: Network communication protocol(s) used throughout entire DDC system shall be open and available to other companies for use in making future modifications to DDC system. The Honeywell WEBs-N4 DDC Controllers shall reside on the BACnet communications sub-network.

C. HIERARCHICAL NETWORK TOPOLOGY: A hierarchical network topology is required to assure reasonable system response times and to manage the flow and sharing of data, without unduly burdening the Owner's internal Intranet network.

D. PEER TO PEER DDC CONTROLLERS: All DDC controllers supplied under this Contract shall be true "peer to peer" communicating devices. DDC controllers requiring "polling" by a host to pass data shall not be acceptable

E. OPEN GRAPHICAL OBJECTS: The BMS GPL software shall employ object oriented technology (OOT) for representation of all data and control devices within the system.

F. OPEN DATABASE CONNECTIVITY: An Open Database Connectivity (ODBC) or Structured Query Language (SQL) server database is required for all data storage. The BMS system shall incorporate the ability to access all data using HTML5 enabled browsers without requiring proprietary interface, programs, or browser plugins. Any BMS system which provides or requires a proprietary database or user interface program shall not be acceptable.

2.5 WEB BROWSER BACnet ADVANCED OPERATOR WORKSTATION (B-AWS)

A. OVERVIEW: The Advanced Operator Workstation shall provide the Operator comprehensive control and monitoring of the BMS via a standard Web Browser interface by using a collection of web pages. The Web pages shall be constructed to "feel" like a single application and provide a complete and intuitive control of the BMS. The intent is to provide the operator(s) complete access to the BMS system via a web browser. The web browser shall be operating system agnostic, meaning it shall support HTML5 enabled browsers without requiring proprietary operator interface and configuration programs or browser plugins. The web browser GUI shall provide a completely interactive user interface for navigation, and display of dynamic animated graphics, schedules, alarms/events, live graphic programs, active graphic setpoint controls, configuration menus, data archiving, reports and reporting actions.

B. SOFTWARE COMPONENTS: The system software shall be latest version as part of this project and shall include:

1. Server Software and Database Software
2. Embedded Web Graphics.

3. Embedded System Configuration Utilities for future modifications
4. Embedded Graphical Programming Tools.
5. Embedded Direct Digital Control software.
6. Embedded Application Software.
7. A five (5) Year Software Maintenance license shall be included. Labor to implement shall be additional.

C. USER LOGIN: A Web link shall direct the web-browser to the BMS's domain name or IP address, Login web page. The Operator shall be required to enter their unique login name and strong password to gain access.

D. NAVIGATION: Navigation within system shall be dependent on the Operator's assigned Role Based application control privileges. Navigation shall be accomplished by selecting the navigation tree which consists of expandable and collapsible tree control and/or by selecting dynamic links to other system graphics. The Navigation tree shall as a minimum provide the following views:
1. A Geographic View which displays a logical geographic hierarchy of the system including cities, sites, buildings, building systems, floors, equipment, and objects.
2. A Network View which displays a logical Network hierarchy of the BMS including B-BCs, B-ASCs, B-VAVs.
3. A Group View which displays the Scheduled Groups and any Custom reports.
4. A Configuration View which displays all the interface categories, including Operators, Schedule, Events, Reporting, and Roles

E. ACTION PANE: Web Graphics shall use a 3-D perspective graphics format suitable for display in a web browser, the system graphics shall include an overall site/building/campus views, building floor plans, equipment Drawings, active graphic setpoint controls, web content and other valid HTML elements. The data on each graphic page shall automatically refresh.
1. Dashboards shall allow the Operator to interface with customizable data using drag and drop HTML5 elements. The elements shall include Web Charts, Gauges,

and other custom developed widgets for use in a web browser. The Operator shall have ability to save custom dashboards.

2. Search feature shall provide the Operator with options for searching data based upon tags, associated equipment, real time data, properties, and trends.
3. Properties of the system shall include graphic controls, locking or overriding objects, demand strategies, and any other valid data required for setup. Changes made to the properties pages shall require the Operator to depress an 'accept/cancel' button.
4. Schedules shall provide the Operator to create, modify/edit and view schedules based on the systems hierarchy.
5. Alarms shall provide the Operator alarm information geographically, acknowledge alarms, sort alarms by category, actions and verify reporting actions.
6. Charting shall provide the Operator a display of associated trend and historical data, modify colors, date range, axis, and scaling. The Operator shall have ability to create HTML charts through web browser without utilizing chart builder. The Operator shall be able to drag and drop data points, schedules, and apply status colors for analysis.
7. Logic - Live Graphical Language Programs shall displayed dynamically 'live', for each of the control algorithm, (micro-block programming) for the system selected in the navigation tree.
8. Other actions such as Print, Help, Command, and Logout shall be available via a drop down window.

F. CUSTOMIZED 3 DIMENSIONAL COLOR GRAPHICS: Tools required to create Web Browser graphics shall be non-proprietary and conform to the following basic criteria, as a minimum:

1. The Web pages shall make extensive use of color to communicate information related to the system setpoints and controls parameters.

2. Animated gifs or jpg, vector scalable, active set point graphic controls shall be used to enhance usability.
3. The Web-page display shall be uniform in size and depth of color, a standardized graphically display shall be 1024 by 768 pixels, 24 bit True Color.
4. System Graphics Requirements (minimum):
    a. An area map or individual Building Overview graphic shall be provided which shall show locations of controlled buildings in relation to local landmarks.
    b. Detailed Floor Plans graphics shall show heating and cooling zones throughout the buildings in a range of colors, as selected by Owner. Provide a visual display of temperature relative to their respective set points. The colors shall be updated dynamically as a zone's actual comfort condition changes.
    c. Unique Mechanical Systems graphics shall show the type of mechanical system components serving any zone through the use of a pictorial representation of components. Selected I/O points being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Animation shall be used for rotation or moving mechanical components to enhance usability.

G. SECURITY ACCESS: Access to the system shall require a Login Name and Strong Password. Access to different areas of the system shall be by the defined Operator Role and Access Control privileges.
1. Operator Roles shall reflect the expected interface Roles of Operators of the system. Each Operator Role shall comprise a set of privileges defined in terms of Viewing, Editing or Functions.
2. Operator View Privileges shall comprise Navigation, Network, and Configuration Trees, Operators, Roles and Privileges, Alarm/Event Template and Reporting Action.

3. Operator Edit Privileges shall comprise Setpoint, Tuning and Logic, Manual Override, and Point Assignment Parameters.
4. Operator Function Privileges shall comprise Alarm/Event Acknowledgement, Control Module Memory Download, Upload, Schedules, Schedule Groups, Manual Commands, Print and Alarm/Event Maintenance.
5. Operator Geographic Assignment of Roles shall be assigned using a similar geographically expandable/collapsible navigation tree. I.e. it shall be possible to assign two HVAC Technicians with similar defined HVAC Roles, differing system geographical areas access.

H. HIERARCHICAL SCHEDULES: Utilizing the Navigation Tree displayed in the web browser GUI, an Operator shall be able to define a Normal, Holiday or Override schedule for an individual piece of equipment or room or choose to apply a hierarchical schedule to the entire system, site, or floor area. I.e. Independence Day ' Holiday' for every level in the system would be created by clicking at the top of the geographic hierarchy defined in the Navigation Tree. No further operator intervention would be required and every control module in the system with would be automatically downloaded with the ' Independence Day' Holiday. All schedules that affect the system /area / equipment shall be highlighted in the Navigation Tree and shown in a summary schedule table and graph.

1. Schedules Types & Standards: Schedules shall comply with the BACnet LonWorks standards. (Schedule Object, Calendar Object, Weekly Schedule property and Exception Schedule property) and shall allow events to be scheduled based on:
    a. Types of schedule shall be Normal, Holiday or Override.
    b. A specific date or a range of dates.
    c. Any combination of Month of Year, Week of Month, or Day of Week .
    d. Wildcard (i.e. allow combinations like second Tuesday of every month).
2. Schedule Categories: The system shall allow operators to define and edit scheduling categories (different types of "things" to be scheduled; for example,

lighting, HVAC occupancy, etc.). The categories shall include name, description, icon (to display in the hierarchy tree when icon option is selected) and type of value to be scheduled.

3. Schedule Groups: Operators shall be able to define functional Schedule Groups, comprised of an arbitrary group of areas/rooms/equipment scattered throughout the facility and site.
4. Intelligent Scheduling: The system shall automatically turn on any supporting equipment needed to control the environment in an occupied space.
5. Partial Day Exceptions: Events shall be able to accommodate a time range specified by the operator.
6. Summary Schedule Graph: The schedule summary graph shall show Normal versus Holiday versus Override Schedules and the net operating schedule that results from all contributing schedules.

I. ALARMS (OR EVENTS): Alarms associated with a specific system, area, or equipment selected in the Navigation Tree, shall be displayed in the Action Pane by selecting an ' Alarms' view. Alarms, and reporting actions shall have the following capabilities:

1. An Alarm View which shall display the Alarms Category with a unique icon, the date/time of occurrence, current status, alarm report and a URL link to the associated graphic for the selected system, area, or equipment. The URL link shall indicate the system location, address, and other pertinent information. An Operator shall easily be able to sort events, edit event templates and categories, acknowledge, or force a return to normal in the Events View.
2. An Alarm Categories which shall allow an Operator to create, edit or delete alarm categories such as HVAC, Maintenance, Fire, or Generator. A unique icon shall be associated with each alarm category.
3. An Alarm Template which shall allow an Operator to define the type of alarm and its properties. The Alarm properties shall include a reference name, a verbose description, the severity of alarm, any acknowledgement requirements, and limits and out of range information.

4. An Alarm Area which shall allow an Operator to assign specific Alarm Categories to specific Alarm Reporting Actions.
5. An Alarm Time/Date Stamp which shall be generated by the controller's RTC Time/Date.
6. Alarm Configuration which shall allow an Operator to define the type of Alarm generated per object.
7. Alarm Summary Counter shall allow a view of Alarms in the Graphic Pane with a numeric counter, indicating how many Alarms are active, require acknowledgement and total number of Alarms in the Archival database.
8. Alarm Auto Deletion that are acknowledged and closed shall be auto deleted from the database and archived to a text file after an Operator defined period.

J. ALARM REPORTING ACTIONS: Alarm Reporting Actions specified shall be automatically launched (under certain conditions) after an Alarm is received by the system. The system Operators shall be able to define the Reporting Actions using the Navigation Tree and Graphic Pane through the web browser GUI. Reporting Actions shall inform the Operator of an Alarm by the following actions:
1. A hard-copy printing to a network printer.
2. An E-mail sent to one or more email accounts on a POP3 compatible server.
3. An alphanumeric paging services, where POP3 email servers support pagers.
4. An ASCII File write reporting action to append Operator defined alarm information to through a text file.
5. A write property value in a system network controller.
6. A Simple Network Management Protocol (SNMP) to an SNMP trap.
7. Run an external software program

K. GRAPHICAL TRENDS: Trends shall be enabled for all controller hard I/O points. Point Data shall be collected locally by the controller, the data shall be uploaded to the data archival server periodically. The Operator shall have the ability to view 'Live' and historical trend data. The Trend data shall be comprised of analog, digital or calculated points, allowing for configuration and displaying multiple trends simultaneously trends

through a web-browser. Each point shall have the ability to be collected at different trend intervals. The Trend resolution shall automatically scale the X-axis and Y-axis when multiple trend points are selected which have different trend intervals or ranges. When Trend data collection is viewed 'Live', the Trend graphic shall update dynamically. The Trend Graphic shall allow the Operator to zoom in on a particular section of a trend and scroll through' historical archived data graphically. The data value shall be imposed on the Trend graphic when any the point sample is selected. The Operator shall through the use of standard keystrokes (CTRL+C, CTRL+V), be able to copy the data.

2.6 GRAPHICAL PROGRAMMING LANGUAGE (GPL)

A. OVERVIEW: The Graphic Programming Language (GPL) for all DDC control algorithms shall be resident in all of the BMS controller modules. Any BMS that does not use a drag and drop method of graphical icon programming shall not be acceptable.

B. GPL PROGRAM DESIGN: All BMS systems shall use a GPL method used to create a sequence of operations by assembling graphic microblocks that represent each of the commands or functions necessary to complete a control sequence. Microblocks represent common logical control devices used in conventional control systems, such as relays, switches, high signal selectors etc., in addition to the more complex DDC and energy management strategies such as PID loops and optimum start. Each microblock shall be interactive and contain the programming necessary to execute the function of the device it represents. Graphic programming shall be performed while on screen and using a mouse; each microblock shall be selected from a microblock library and assembled with other microblocks necessary to complete the specified sequence. Microblocks are then interconnected on screen using graphic "wires," each forming a logical connection. Once assembled, each logical grouping of microblocks and their interconnecting wires then forms a graphic function block which may be used to control any piece of equipment with a similar point configuration and sequence of operation.

C. GRAPHIC SEQUENCE: The clarity of the graphic sequence shall be such that the operator has the ability to verify that system programming meets the Specifications, without having to learn or interpret a manufacturer's unique programming language. The graphic programming shall be self-documenting and provide the operator with an understandable and exact representation of each sequence of operation.

D. GRAPHICAL PROGRAMMING LANGUAGE (GPL) CAPABILITIES: The following is a minimum definition of the capabilities of the GPL software:

1. Function Block (FB): A collection of points, microblocks and wires which have been connected together for the specific purpose of controlling a piece of HVAC equipment or a single mechanical system.
2. Logical I/O: Input/Output points shall interface with the control modules in order to read various signals and/or values or to transmit signal or values to controlled devices.
3. Microblocks: A software device that are represented graphically and may be connected together to perform a specified sequence.
4. Wires: Graphical elements used to form logical connections between microblocks and between logical I/O.
5. Reference Labels: Similar to wires, in that they are used to form logical connections between two points. Labels shall form a connection by reference instead of a visual connection, i.e. two points labeled 'A' on a Drawing are logically connected even though there is no wire between them.
6. Parameter: A value that may be tied to the input of a microblock.
7. Properties: Dialog boxes shall appear after a microblock has been inserted which has editable parameters associated with it. Default parameter dialog boxes shall contain various editable and non-editable fields and shall contain 'push buttons' for the purpose of selecting default parameter settings.
8. Icon: A graphic representation of a software program. Each graphic microblock has an icon associated with it that graphically describes its function.

9. Menu bar Icon: An icon that is displayed on the menu bar on the GPL screen, which represents its associated graphic microblock.
10. Live Graphical Programs: All input/output data, calculated data and set points shall be displayed in a 'live' real time mode.

2.7 SYSTEM NETWORK DEVICES

A. Operator Workstation (OWS):
   1. Processor: I7 Quad core 3.2 GHz.
   2. Onboard RAM: Capacity: 2x16 GB.
      a. Speed and Type: DDR4 1800 MHz
      b. Expandable Capacity: 64 GB
   3. Internal Hard Drives: (1) 2 TB.
      a. Minimum Average Seek Time: <10ms.
      b. Cache Buffer Size: 256K.
      c. MTBF of 100,000 power-on hours.
   4. Backup BD/RW Drive: (1)
      a. 2 MB of data buffer.
      b. Average access time of 150 ms or less.
      c. MTBF of 100,000 power-on hours.
   5. Graphics Card: 1920 x 1080 pixels at 60 Hz. Energy Star compliant.
   6. Network Card: (1) 100/1000 Mb TCP/IP adapter.
   7. Ports: (4) 2.0 USB (2) 3.0 USB
   8. Interface accessories:
      a. Wireless 101 enhanced Keyboard, Full upper- and lowercase ASCII keyset, numeric keypad, and 12 programmable function keys.
      b. Wireless 3 Button Mouse, w scroll wheel, Optical.
      c. Wireless operation within up to 72 inches in front of workstation.

B. Graphics Monitor:
   1. LED Color display with 24” diagonal viewable area.

2. Resolution: 1920 x 1080 pixels at 60 Hz.
3. Input signal: HDMI
4. Aspect Ratio: 16 to 9.
5. Antiglare display.
6. Dynamic Contrast Ratio: 50000 to 1.
7. Brightness: 250 cd/sq. m.
8. Tilt adjustable base.
9. Energy Star compliant.
10. Include applicable cabling to connect devices.

C. THIN CLIENT WEB STATIONS (TCWS): A current released open browser (Explorer/Firefox/Chrome) shall only be required as the GUI and a valid connection to the server network. No installation of any custom or special software shall be required to be installed to access the BMS via a web browser. Local and Remote interface shall from a Web Browser and the BMS shall be over a TCP/IP LAN or WAN connection and offer encryption using 128 bit encryption within Secure Socket Layers (SSL). Communication protocol shall be Hyper Text Transfer Protocol (HTTP). The Thin Client Web stations shall include the following components:

1. Microsoft Internet Explorer (10.0 or later) running on Microsoft 7+.
2. Graphical Display: Video card & LCD monitor 1024 x 768 resolution or greater.
3. Network Support: 100/1000 Mb TCP/IP adapter.
4. Processor, Memory and Hard Drive capacities: As desired by Owner.

D. ROUTER AND SWITCHES (100/1000 MBPS): The BMS network router/switches shall connect directly to the architecture using standard TCP/IP protocol at a minimum of 100 mbps and shall provide communication connections between individual SNCs, Servers, OWS and other TCP/IP networked devices.

1. Manufacturers:
    a. Cisco.
    b. Or approved equal.

2.8 UNINTERRUPTABLE POWER SUPPLY (UPS):

A. BACKUP POWER CAPACITY SIZING: The Uninterruptable Power Supply shall be sized to provide the equipment with a minimum backup power for 15 minutes at full load. The UPS shall conform to Class 2 overcurrent protection.

B. POWER LINE FILTERING: The UPS shall have combined 1 percent line and load regulation with 100 micro-second response time for 50 percent load changes. Built in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure. 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.

C. Manufacturers:

1. Approved equal.

2.9 SUPERVISORY NETWORK BUILDING CONTROLLER (SNC)

A. OVERVIEW: The Supervisory Network Building Controller(s) (SNC) are designed to manage communications between itself and other peer-to-peer Supervisory Network Controllers (SNC) and with any BMS BACnet TCP/IP, SNMP and Niagara 4 Fox networked connected Operator workstations (OWS) that are part of the BMS. Additionally, the Supervisory Network Building Controller(s) (SNC) are to manage the communications between its communications sub-network Building Level controller(s) (B-BC), Advanced Application Controller(s) (B-AAC), and Application Specific Controller(s) (B-ASC). The SNC shall perform control and operating strategies for the various HVAC and integrated systems controlled utilizing information from any of the distributed DDC controllers connected to the BMS. The SNC shall be fully programmable to meet the unique requirements of the facility. The use of a

proprietary communication protocol for peer to peer communications between SNC's shall not be acceptable.

B. OPEN PROTOCOLS (STANDARD): The SNC shall be provided with BACnet, LON, Modbus, N2, SNMP, KNx Open Communications protocols by default.

C. EMBEDDED SOFTWARE: The SNC shall have embedded "Setup Wizards" controller programming software

D. STANDARD PROGRAMS: The SNC shall be capable of executing application control programs to provide:
   1. Calendar functions.
   2. Scheduling.
   3. Trending.
   4. Alarm monitoring and routing.
   5. Time synchronization.
   6. Integration of LonWorks, BACnet, and MODBUS controller data.
   7. Network management functions for all SNC, PEC and ASC networked devices.

E. HARDWARE FEATURES: The SNC shall provide the following hardware features as a minimum:
   1. Ports: Two 10/100 Mbps Ethernet ports/ Two Isolated RS-485 ports with biasing switches.
   2. One USB Flash Drive
   3. Onboard Memory: 1 GB RAM / 4 GB Flash Total Storage / 2 GB User Storage
   4. MicroSD Memory Card with Encrypted Safe Boot Technology
   5. Wireless: Wi Fi (Client or WAP)
   6. Expansion Bus: High Speed Field Bus Expansion
   7. Operating Temperature: Minus 4 to 140 degrees F Ambient
   8. Integrated 24 VAC/DC Power Supply

F. CONNECTIVITY: The SNC shall support standard Web browser access via the LAN/WAN network, supporting a minimum of 16 simultaneous users.

G. ALARMING: The SNC shall provide alarm recognition, storage, routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers. The SNC shall be able to route any alarm condition to any defined user location whether connected to a local network, remote via cellular modem, or wide area network. Alarm generation shall be selectable for annunciation type and acknowledgement requirements. Alarms shall be annunciated in any of the following manners as defined by the user:

H. DEVICE SECURITY: The SNC shall support the following security functions. Module code signing to verify the author of programming tool and confirm that the code has not been altered or corrupted. Role Broadcast Access Control (RBAC) for managing user roles and permissions. Require users to use strong credentials. Data in Motion and Sensitive Data at Rest be encrypted. LDAP and Kerberos integration of access management.

I. DATA STRUCTURES: The SNC shall support the following data modeling structures to utilize Search; Hierarchy; Template; and Permission functionality: Metadata: Descriptive tags to define the structure of properties. Tagging: Process to apply metadata to components. Tag Dictionary

J. DATA TEMPLATES: The SNC shall employ template functionality. Templates are a containerized set of configured data tags, graphics, histories, alarms... that are set to be deployed as a unit controlled upon manufacturer's controller and relationships. All lower level communicating controllers (PEC, AUC, AVAV, VFD…) shall have an associated template file for reuse on future project additions.

K. SOFTWARE SUPPORT: The SNC shall be provided with a 5 Year Software Maintenance license. Labor to implement not included.

2.10 BACNET APPLICATION SPECIFIC CONTROLLER (B-ASC)

A. Controller Applications: Application of the B-ASC controller include Unit Ventilators, Fan or Blower Coil Units, Heat Pump Units, Natural Convection units, Radiant panels, Room Pressure control (Regulated volume (pressurization/de-pressurization), Temperature, humidity, dispersed CO2, occupancy, and emergency control.

B. The Application Specific Controller (B-ASC) shall be designed specifically to allow for specific application with the capability for custom programming to control the BMS's equipment.

C. All B-ASC programming shall comply with standard application programmable and shall at all times maintain their certification. All control sequences within or programmed into the B-AAC shall be stored in non-volatile memory. Device dependent upon the presence of a battery for memory retainage shall not be acceptable.

D. Minimum Hardware Functional Requirements: The B-ASC shall be capable of either integrating with other devices or standalone room level control operation. The B-ASC shall have an internal time clock with the ability to automatically revert from a master time clock on failure.

E. BACnet: The control of the equipment shall be accomplished using a BACnet direct digital controlled devices with BTL listed PICS.

F. PROGRAMMING FUNCTIONAL REQUIREMENTS:

1. Minimum Programming Functional Requirements: The B-ASC shall not require any external configuration tool or programming tool. All configuration and programming tasks shall be accomplished and accessible from within the Niagara 4 environment. B-ASC s shall support at minimum the following control sequences:
    a. General purpose control loops, linear and non-linear
    b. Demand Limit Control strategies,
    c. Setpoint reset

d. Adaptive intelligent recovery

e. Time of Day Reset.

f. Start/Stop/Status loops.

g. Boolean Logic functions (i.e. If/Then/Else ladder logic)

h. Math Function loops.

2. The B-ASC controller shall have standard and custom HVAC programs which shall be modifiable to provide the Division 15 Section “HVAC Equipment Sequence of Operations".

3. The B-ASC controller shall maintain the Native Graphical Programming Language and graphics, fully programmable and configurable from any Niagara N4 Framework™ platform, not requiring any external configuration or programming tool. The Native programming software and “Setup Wizard” shall be embedded within the controller.

4. The B-ASC controller shall allow downloads and uploads from any Niagara N4 Framework™ platform, including providing offline program simulation.

5. The B-ASC controller shall be part of a networked system or allow for standalone operation.

6. The B-ASC controller shall provide continuous Adaptive Integral Algorithm Control Loop tuning.

7. The B-ASC controller shall have a loop execution response time of 1 second.

8. The B-ASC controller shall have a software notifications, when connected to a network:

   a. Significant Event Notification

   b. System Periodic Update

   c. Detection of Network Failure.

9. The B-ASC controller shall provide for “user defined” Network Variables (NV) for customized configurations and naming using Niagara N4 Framework™.

10. The B-ASC controller shall support 240 Network Variables with a byte count of 31 per variable.

11. The B-ASC controller shall support 960 separate data values.

G. Hardware Functional Requirements:

1. Control Processors: The B-ASC controller shall have two microprocessors, Host and Comm. The Host processor shall provide FLASH memory for HVAC application programming, with RAM memory for HVAC program execution and data storage. The FLASH memory shall be retained for a minimum of ten years, a battery for memory retainage shall not be acceptable. The Comm processor shall manage the network communications.
2. Environmental Ratings: The B-ASC controller shall be function within an operating environment of 32 to 122 degrees F and 5 to 95 percent relative humidity, non-condensing.
3. Approvals and Listings: The B-ASC controller shall have the following certifications, listings, and approvals:
    a. BACnet Application Specific Controller (B-ASC)
    b. FCC Part 15, Subpart B, Class B (radiated emissions) requirements.
    c. UL916 (Open Energy Management Equipment) with plenum rating.
    d. CSA (LR95329-3) Listed
    e. Canadian Standard C108.8 (radiated emissions).
    f. European Consortium standards: EN 61000-6-1; 2001 EN 61000-6-3; 2001
4. Device Status Indication (Host): A visible LED shall provide indication of the internal program functional status.
    a. Controller - Operating normally.
    b. Controller - In process of program download.
    c. Controller - In manual mode, under control of software tool.
    d. Controller - Lost Configuration.
    e. Controller – Low or No power, possible damage
    f. Controller - Host Processor not operating.
5. Bus Status Indication (Comm): A visible LED shall provide indication of the B-ASC controller’s communication status:
    a. Bootloader running - MS/TP communication is present.
    b. Bootloader running - MS/TP token is not present.

c. Bootloader not running - Processor missing bootloader image.

d. Communications - Processor is not running

6. Internal Real Time Clock (RTC): The B-ASC controller shall have an internal Real Time Clock (RTC). The RTC shall allow for stand-alone operation or reference if Network Master Time clock communication function is interrupted. The RTC shall provide 24 hours, 365 days, multi-year calendar, day of week, including automatic daylight savings, configured for start and stop dates scheduling. The RTC shall have a time accuracy of plus or minus 1 minute per month at 77 degrees F and shall maintain its settings upon a loss of device power for a minimum of 24 hours at 32 to 122 degrees F.
7. Housing: The housing shall be UL plenum rated, with panel of din rail mounting.
8. Terminal Connections: The B-ASC controller's wire connectors shall allow for quick disconnection of external wiring, without removing the wire from the connector. The wire connectors shall have color coded labels.
9. Field Wire connections: The B-ASC controller shall have Digital Inputs (DI), Digital Outputs (DO), Analog Outputs (AO), Universal Inputs (UI), Internal Velocity Pressure sensor, and damper actuator (optional), as required to meet the Sequence of operations.
    a. The Universal inputs (UI) shall be configurable as binary N.O./N.C. inputs, analog resistive inputs (0 to 10K or 20K ohm NTC), analog voltage inputs (0 to 10 VDC), or analog current inputs (4 to 20 mA).
    b. The Digital Inputs (DI) shall be configurable as N.O., N.C or 15 Hz pulse counters.
    c. The Analog outputs (AO) shall be configurable as 0 or 2 to 10 Vdc or as 4 to 20 mA.
    d. The Digital Outputs (DO) shall be configurable as N.O. or N.C. and rated to switch 30 Vac/Vdc at 500 mA, or Relay outputs, (RO) rated for 1 Amp.
10. Communications Field Bus: The B-ASC controller shall a two wire, polarity insensitive communication via bus which provides 18 Vdc power and communications between enabled devices

11. Onboard Power VDC Supply: The B-ASC controller shall have one (1) integral 20 VDC 75 mA power supply, plus or minus 10 percent for external sensors. If the controller lacks a comparable internal power supply, a fully isolated, enclosed, current limited and regulated UL listed DC power supply for each shall be provided.

2.11 SYSTEM INPUT SENSORS

A. GENERAL REQUIREMENTS: Installation, testing, and calibration of all sensors, transmitters, and other input devices shall be provided to meet the system requirements.

B. TEMPERATURE SENSORS (TS): Room Temperature sensors shall be provided as shown on project plans, or where temperature control is required for the equipment. Room Temperature sensors shall have a decorative cover provided for surface or wall box mounting. A metal ventilated plate type cover shall be provided, where conditions indicate damage is most likely to occur. Room Temperature sensors shall have a range of 30 to 90 degrees F, with an accuracy of plus or minus 0.5 degrees F.

1. Acceptable Room temperature sensor types are:
    a. 1000 ohm nickel thermistor
    b. 1000 ohm platinum thermistor.
    c. 20K ohm thermistor
2. Where local adjustment are required, an LCD display with four button keypad shall provide the following capabilities:
    a. Display room and outside air temperatures.
    b. Display and adjust room comfort setpoint.
    c. Display and adjust fan operation status.
    d. Timed override request push button with LED status
    e. Display controller mode.
    f. Password selectable adjustment of setpoint and override modes.
    g. A communication port.

3. Acceptable Manufacturers:
    a. Honeywell Controls.
    b. Or approved equal.

C. IMMERSION TEMPERATURE SENSORS (TS-I): Immersion Temperature sensor shall contain an 20K ohm thermistor to monitor water temperature.
1. Acceptable Manufacturers:
    a. Honeywell Controls.
    b. Or approved equal.

D. OUTSIDE AIR TEMPERATURE SENSOR (OAT): Outdoor Air Temperature Transmitter shall contain a 20K ohm thermistor temperature sensors with an accuracy of plus or minus ; 0.5 degrees F mounted in an enclosure rated for outdoor use. A solar shield shall be provided for each sensor. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate that surrounds the sensor element. These devices shall have accuracy of plus or minus 0.5 degrees F over the entire range.
1. Acceptable Manufacturers:
    a. Honeywell Controls.
    b. Or approved equal.

E. TEMPERATURE SENSORS - DUCT MOUNTED PROBE (TS-D): Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair.
1. Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.
2. Duct Type Temperature sensor shall be 20K ohm thermistor temperature sensors with an accuracy of plus or minus ; 0.5 degrees F, moisture resistant for mounting into a duct.
3. Duct mounted sensors shall have an insertion measuring probe of a length appropriate for the duct size, with a temperature range of minus 40 to 160 degrees F. Duct sensors shall be rigid or averaging as shown on the project BMS

diagrams. Averaging sensors shall be a minimum of 5 feet in length. For all mixed air and preheat air applications, install bendable averaging duct sensors with a minimum 8 feet long sensor element

4. The operating range shall be as indicated with an accuracy of plus 1 percent over the full range. The output shall be compatible with the panel it serves.
5. For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.
6. Acceptable Manufacturers:
    a. Honeywell Controls.
    b. Or approved equal.

F. TEMPERATURE SENSOR – DUCT MOUNTED AVERAGING (TS-A): For ductwork greater in any dimension that 48 inches and/or where air temperature stratification exists, an averaging sensor with multiple sensing points shall be used.

1. For plenum applications, such as mixed air temperature measurements, a string of sensors mounted across the plenum shall be used to account for stratification and/or air turbulence. The averaging string shall have a minimum of 4 sensing points per 12 foot long segment.
2. Capillary supports at the sides of the duct shall be provided to support the sensing string.
3. Duct Averaging Type Temperature Transmitter shall be a general purpose RTD sensing element, moisture resistant transmitter for mounting into a duct. The operating range shall be as indicated with an accuracy of plus 1 percent over the full range. The output shall be compatible with the panel it serves. Transmitter shall be with 17 feet of sensor capillary.
4. Manufacturers:
    a. Honeywell Controls.
    b. Or approved equal.

G. STATIC PRESSURE TRANSMITTERS, AIR (SPT): Stainless steel diaphragm construction, Suitable for service medium, Non-directional sensor with suitable range for expected input, and temperature compensated.

1. Action: Direct acting.
2. Accuracy: 2 percent full scale with repeatability of 0.5 percent.
3. Output: 4 to 20 mA.
4. Building Range: 0 to 0.25 inch wg.
5. Duct Range: 0 to 5 inch wg.
6. Acceptable Manufacturers:
    a. Honeywell Controls.
    b. Or approved equal.

H. DIFFERENTIAL PRESSURE TRANSMITTERS (DPT):

1. General Pressure Transmitter Requirements:
    a. Range: Selection to provide full coverage of the to the measured range.
    b. Over Pressure protection: 100 percent pressure range
    c. Outputs: 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA output signal.
    d. Housing: Rated for local environment, minimum NEMA-1.
    e. Reference Accuracy: ± 1 percent of full scale.
    f. Zero & span: .04 percent linearity, hysteresis, and repeatability.
    g. Accuracy Range: 20 to 1 ratio turndown.
    h. Thermal Effects: less than .033 ° F over 40 to 100 ° F.
    i. Static Pressure Effect: 0.5 percent fill scale.
    j. Features: Non-interactive zero and span adjustments adjustable from the outside cover.
    k. Auxiliary devices: Air bleed and bypass valve assembly with shut off valves in the sensing lines.
2. Acceptable Manufacturers:
    a. Honeywell Controls.

b. Veris.

c. Setra.

d. Or approved equal.

I. CARBON DIOXIDE SENSOR (CO2): The carbon dioxide sensor (CO2) shall be rated for the design application. The CO2 sensor shall measure the carbon dioxide concentrations and shall work on the non-dispersive infrared (NDIR) operating principle with either an ambient or duct gas sampling method. The CO2 sensor shall be monitored by the BMS. The CO2 sensors shall have a local LED readout of the ppm of CO2.The BMS shall trend the CO2 concentration of each system over a 24 hour period.

1. Wall Carbon Dioxide Sensors

a. Wall Carbon Dioxide Sensors shall utilize Non-dispersive infrared technology (N.D.I.R.) with the following features:

1) Response time: less than one minute.

2) Range: 0 to 2000 PPM CO2

3) Accuracy: plus, or minus 5 percent or 75 PPM

4) Output: Jumper Selectable: 0 or 4 to 20 mA, 0 to 10 VDC.

5) Operational Temperature: 15 to 130 degrees F

6) Housing: High impact plastic enclosure.

b. Relay Output (Optional)

1) Contact Rating: N.O. or N.C. operation, Max 30 VAC, 0.5 A, Class 2.

2) Resolution: 10 ppm

c. Recommended External Load:

1) Current Output: 4-20mA, Maximum 500 ohm load resistance.

2) Voltage Output: 0-5VDC, Minimum 1,000 ohm load resistance.

d. Power Supply Range: 20 to 30 VAC (18 to 30 VDC), Class 2.

e. Operating Life Expectancy: 10 Years

2. Duct mount CO2 transmitter:

a. Duct Carbon Dioxide Sensors shall utilize Non-dispersive infrared technology (N.D.I.R.) with the following features:

1) Response time: less than one minute.

2) Range: 0 to 2000 PPM CO2

3) Accuracy: plus, or minus 5 percent or 75 PPM, whichever is greater.

4) Output: Jumper Selectable: 0 to 20 mA, 4 to 20 mA, 0 to 10 VDC.

5) Operational Temperature: 15 to 130 degrees F

6) Housing: High impact plastic enclosure.

b. Relay Output (Optional)

1) Contact Rating: Maximum 30 VAC, 0.5 A, Class 2.

2) Resolution: 10 ppm

c. Recommended External Load:

1) Current Output: Maximum 500 ohm load resistance.

2) Voltage Output: Minimum 1,000 ohm load resistance.

d. Power Supply Range: 20 to 30 VAC (18 to 30 VDC), Class 2.

e. Operating Life Expectancy: 10 Years

3. Acceptable Manufacturers:

a. Honeywell Controls.

b. Senva.

c. Or approved equal.

J. CURRENT SWITCHES (CS):

1. Current actuated switches shall be self-powered, solid state with an adjustable trip current.

2. The switches shall be selected by the BMSC to match the application and output requirements of the DDC system.

3. The current sensing switch shall be self-powered with solid state circuitry and a dry contact output.

4. It shall consist of a current transformer, a solid state current sensing circuit, adjustable trip point, solid state switch, SPDT relay, and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device.
5. It shall accept over current up to twice its trip point range.
6. Approved applications of current sensing switches include monitoring of run status for fans, pumps, and other miscellaneous motor loads.
7. The Current sensing switches shall be calibrated to show a positive run status only when the motor is operating under load. A motor running with a broken belt or coupling shall indicate a negative run status.
8. Acceptable manufacturers:
    a. Honeywell.
    b. Senva.
    c. Veris Industries.
    d. Or approved equal.

2.12 SYSTEM OUTPUT CONTROLLED DEVICES

A. PILOT CONTROL RELAYS: Pilot Control relays shall provide either momentary or maintained switching action as appropriate for the application. Relay contact configuration, amp, voltage, and coil ratings shall be suitable for application. All panel mounted control relays shall:
    a. Be plugged in type with an interchangeable module (Ice Cube)
    b. Be mounted on a subbase and wired to numbered terminals strips.
    c. Be DPDT with indicating lamp.
2. Remotely mounted pilot control relays (outside of the panel) shall be enclosed in a NEMA enclosure suitable for the location. RIB style relays shall be acceptable for remote control.
3. All control relays shall be labeled with UR symbol and UL listed.
4. Acceptable Manufacturers:

a. Functional Devices.

b. Veris.

c. IDEC.

d. Or approved equal.

B. ACTUATORS, CONTROL DAMPER: The control damper actuator shall be sized for sufficient force to operate the damper under normal conditions and sized for torque required to guarantee tight close off of dampers, as specified. Two position control damper actuators shall provide auxiliary end-switch. Control damper actuators shall be electronic, 24 VAC or 120 VAC, as selected by the Contractor and have internal electronic overload protection or digital rotation sensing circuitry. Modulating control damper actuators shall be controlled from a 2 to 10 VDC or 4 to 20 mA. VAV control damper actuators shall be "drive open; drive closed" type. Control damper actuators shall be selected for specified control (modulating or two position) and Fail Safe position, spring return mechanism, as specified.

1. Control damper actuator coupling shall be by a V bolt and V shaped; toothed cradle designed for minimum 60,000 full stroke cycles at rated torque. The control damper actuator run time for a commanded full stroke operation shall not exceed 120 seconds, if the actuator is spring returned, a return to the failsafe position shall take no longer than 10 seconds closed. Provide external, manual gear release on non-spring return actuators.
2. Control damper actuator casings shall be made of die cast metal.
3. Control damper actuators shall have position indication.
4. Control damper actuators exposed to low temperatures shall have a crankcase heater.
5. Control damper actuator enclosures shall be rated for the mounting environment
6. Pneumatic control damper actuators pilot positioners shall be installed to ensure positioning.

7. Control dampers actuators shall be selected for running torque calculated as follows:
    a. Parallel Blade Damper w/o Edge Seals: 4 inch-lb. /sq. ft. of damper.
    b. Parallel Blade Damper w/ Edge Seals: 7 inch-lb. /sq. ft. of damper.
    c. Opposed Blade Damper w/o Edge Seals: 3 inch-lb. /sq. ft. of damper.
    d. Opposed Blade Damper w/ Edge Seals: 5 inch-lb. /sq. ft. of damper.
    e. Additional damper actuator torque calculation per square foot damper surface area:
        1) Pressure Drop of 2 to 3 inch w.g.: Add 1.5 inch-lb
        2) Pressure Drop of between 3 to 4 inch w.g.: Add 2.0 inch-lb
        3) Face Velocities of 1000 to 2500 fpm: Add 1.5 inch-lb
        4) Face Velocities of 2500 to 3000 fpm: Add 2.0 inch-lb
8. Acceptable Manufacturers:
    a. Honeywell Controls.
    b. Belimo Aircontrols (USA), Inc.
    c. Or approved equal.

C. ACTUATORS, CONTROL VALVE

1. Actuator sizing: The control valve actuator shall be sized for sufficient force to operate the valve under all conditions and sized for torque required to guarantee tight close off of valves, as specified, against system differential pressure encountered. Two way control valve actuators shall provide a close off rating exceeding the maximum pressure difference between the valve outlet and inlet.
2. Power Requirements: Actuators shall be electronic, 24 VAC or 120 VAC, class 2 as directed by the application, and as selected by the Contractor. Actuators shall have internal electronic overload protection or digital rotation sensing circuitry. End switches to deactivate at the end of rotation or magnetic clutches are not acceptable. Power consumption shall not exceed 10 VA for AC.

3. Modulating Control Signal: Spring return actuators shall be capable of CW or CCW mounting orientation. Actuators shall be controlled from a 2 to 10 VDC or 4 to 20 mA. Actuators for VAV applications shall be "drive open; drive closed" type.
4. Noise Generation: Spring return actuators shall not produce more than 62 dbA when powered or positioning. Non-spring return actuators shall have a maximum noise rating of 45 dbA with power on or in the running or driving mode.
5. Fail Safe Operation: Spring return actuators shall be selected for modulating or two position, with a Fail Safe position, as specified. Spring return actuators shall upon a loss of control signal, fail to the minimum control signal. Non-spring return actuator shall maintain the last position upon loss of power. Control valve actuators using “on-board” capacitors or other non-mechanical forms of fail-safe operation are unacceptable.
6. Coupling: Control valve actuators shall be of a Direct coupled type designed for minimum 60,000 full stroke cycles at rated torque.
7. Operation Time: The run time for full stroke operation shall not exceed 120 seconds. Spring return to the failsafe position shall take no longer than 10 seconds closed. Non-spring return actuators greater than 60 in-lb of torque shall have a local external, manual gear release.
8. Construction: Control valve actuator casings shall be made of die cast metal.
9. Position Indication: Actuators on valves larger than 2 inch shall have a visual position indication. When required by the control sequence, two sets of DPDT switches with fully adjustable setpoints shall be provided.
10. Environment Rating: Actuator enclosures shall be rated for the mounting environment. Actuators shall have an operating range of minus 22 to 122 degrees F. Actuators exposed to low temperatures shall have a crankcase heater.
11. Acceptable Manufacturers:
    a. Honeywell Controls.
    b. Belimo Aircontrols (USA), Inc.

c. Or approved equal.

2.13 FIELD DEVICES

A. CONTROL POWER TRANSFORMERS & POWER SUPPLIES: Control power transformers shall be UL listed, Class 2 current limiting type, or shall be furnished with over current protection with primary and secondary circuits for Class 2 service. Unit power output shall match the required output current and voltage requirements. Current output shall allow for a 50 percent safety factor. Output ripple shall be 3.0 mV maximum Peak to Peak. Regulation shall be 0 to 10 percent line and load combined, with 50 microsecond response time for 50 percent load changes. Unit shall have built in over voltage protection. Unit shall operate between 32 to 120 degrees F. Unit shall be UL recognized.

1. Acceptable Manufacturers:
   a. Honeywell Controls.
   b. Functional Devices.
   c. Or approved equal.

B. CONTROL VALVES: Control valves shall be factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated. The control valve nominal body rating shall be not less than 125 PSI. Control valve body pressure rating and connection type (sweat, screwed, or flanged) shall conform to the pipe schedule in this Specification. The control valves shall be sized by the Contractor to produce the required flow capacity at a pressure loss not exceeding the allowable pressure drop. The control valve body and packing selected shall be sized to withstand the system static head plus the pump head, and the temperatures of the control medium. All control valves shall be suitable for the system flow conditions and close against the differential pressures involved. Flow Characteristics: Two way valves shall have equal percentage characteristics; Three way valves shall have linear characteristics. Connections: Control valve sizes up

to, including 2 inch shall be "screwed" configuration. Control valve sizes 2 1/2 inch and larger shall be "flanged" configuration.

1. Control Valve Selection and Sizing Guidelines: 2-way or 3-way control valves serving Variable Air Equipment coils, shall be sized for a pressure drop equal to the actual coil pressure drop, but no less than 5 PSI. 3-way control valves serving Constant Air Equipment coils, with secondary loop pumps shall be sized for a pressure drop equal to 25 percent of the actual coil pressure drop, but no less than 2 PSI. 3-way mixing control valves serving secondary water loops shall be sized for a pressure drop of no less than 5 PSI. All control valve sizes less than 2 inches shall be globe valves. Control valves for terminal reheat coils shall be sized for no less than a 2 PSIG pressure drop, but no more than a 5 PSI drop.
2. Ball Valves (w/characterized disk): shall be used for hot and chilled water applications, water terminal reheats coils, radiant panels, unit heaters, package air conditioning units, and fan coil units. Hot water control valves shall fail Normally Open to the coil. Chilled water control valves shall be fail Normally Closed to the coil. Steam control valves shall fail Normally Closed to the coil or as stated in the sequences.
3. Modulating plug valves: Single seat type Equal percentage shall be used for approved applications. Valve discs shall be composition type. Valve stems shall be stainless steel.
4. Acceptable Manufacturers:
    a. Honeywell, Belimo Controls (USA), Inc.
    b. Or approved equal.

C. LOCAL CONTROL ENCLOSURES AND PANELS:

1. All enclosures shall be rated for the mounted environment. Unless otherwise shown, all indoor control enclosure cabinets shall be fully enclosed NEMA 1 steel construction, with a baked enamel finish. A hinged door key lock latch and removable sub panels shall be provided for non-unitary equipment. A single key shall be common to all field panels and sub panels.

2. Interconnections between internal and face mounted devices shall be prewired with color coded stranded conductors neatly installed in plastic troughs and/or tie wrapped. Terminals for field connections shall be UL listed for 600 volt service, individually identified per control/ interlock Drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control Drawings.
3. Provide ON/OFF power switch with over current protection for control power sources to each local panel.
4. A convenience 120 VAC duplex receptacle shall be provided in each enclosure, fused on/off power switch, and required transformers.
5. All control panels shall be factory constructed, incorporating the BMS manufacturer's standard designs and layouts.
6. All control panels shall be UL inspected and listed as an assembly and carries a UL 508 label listing compliance. Control panels shall be fully enclosed, with perforated sub-panel, hinged door, and slotted flush latch.
7. In general, the control panels shall consist of the BACnet DDC controller(s), display module as specified and indicated on the plans, and I/O devices—such as relays, transducers, and so forth—that are not required to be located external to the control panel due to function. Where specified the display module shall be flush mounted in the panel face unless otherwise noted.
8. All I/O connections on the BACnet DDC controller shall be provide via removable or fixed screw terminals.
9. Low and line voltage wiring shall be segregated. All provided terminal strips and wiring shall be UL listed 300 volt service and provide adequate clearance for field wiring.
10. All wiring shall be neatly installed in plastic trays or tie wrapped.
11. Control Panels shall be rated for the environment in which they are located.
12. Acceptable manufacturers
    a. Honeywell Controls.
    b. Or approved equal.

D. BMS CONTROL CABLING

1. General: Provide copper wiring, plenum cable, and raceways as specified in the applicable sections of Division 16 unless otherwise noted herein. All insulated wire to be copper conductors, UL labeled for 90 degrees C minimum service. Electronic and fiber optic cables for control wiring are specified in Electrical Section "Voice and Data Communication Cabling."
2. Communication and Control Wiring: Wire Sizing and Insulation shall comply with minimum wire size and insulation based on services listed below:
3.

Service		Minimum Gage/Type	Insulation Class
a.	AC 24 VAC	Power 12 Ga Solid	600 Volt
b.	DC 24 VDC	Power 10 Ga Solid	600 Volt
c.	Class 1	14 Ga Stranded	600 Volt
d.	Class 2	18 Ga Stranded	300 Volt
e.	Class 3	18 Ga Stranded	300 Volt

   f. Open plenum rated cable is permitted in supply or return air plenum where allowed.
4. Power Wiring:
   a. 115 VAC power circuit wiring > 100 feet distance shall use minimum 10 gage.
   b. 24 VAC control power wiring > 200 feet distance shall use minimum 12 gage.
5. Control Wiring:
   a. Digital Input/Output wiring shall use Class 2 twisted pair, insulated.
   b. Analog inputs shall use Class 2 twisted shielded pair, insulated, and jacketed and require a grounded shield.
6. Communication Wiring:
   a. Ethernet Cable shall be minimum CAT5e minimum
   b. Secondary level network shall be 24 gage, TSP, low capacitance cable
7. Approved Cable Manufacturers:
   a. Anixter.

b. Belden.

c. Or approved equal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that conditioned power supply is available to control units and operator workstation.

B. Verify that duct, pipe, and equipment mounted devices and wiring are installed before proceeding with installation.

3.2 INSTALLATION

A. Install equipment level and plumb.

B. Install software in control units and operator workstation. Implement all features of programs to specified requirements and as appropriate to sequence of operation.

C. Connect and configure equipment and software to achieve sequence of operation specified.

D. Verify location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation. Locate all 60 inches above the floor.

1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

E. Install guards or tamper proof enclosures on thermostats in the following locations:

1. Entrances.
2. Public areas.
3. Where indicated.

F. Install automatic dampers according to Division 15 Section "Duct Accessories.

G. Install damper actuators on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

H. Install labels and nameplates to identify control components according to Division 15 Section "Basic Mechanical Materials and Methods."

I. Install labels and nameplates to identify control components according to Division 15 Section "Mechanical Identification."

J. Install hydronic instrument wells, valves, and other accessories according to Division 15 Section "Hydronic Piping."

K. Install steam and condensate instrument wells, valves, and other accessories according to Division 15 Section "Steam and Condensate Piping."

L. Install refrigerant instrument wells, valves, and other accessories according to Division 15 Section "Refrigerant Piping."

M. Install duct volume-control dampers according to Division 15 Sections specifying air ducts.

N. Install electronic and fiber-optic cables according to Division 16 Section "Control/Signal Transmission Media."

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Division 16 Section "Raceways and Boxes."

B. Install building wire and cable according to Division 16 Section "Conductors and Cables."

C. Install signal and communication cable according to Division 16 Section "Control/Signal Transmission Media."

1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
2. Install exposed cable in raceway.
3. Install concealed cable in raceway.
4. Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path.
5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.

D. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Install piping adjacent to machine to allow service and maintenance.

B. Ground equipment.

1. 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.

3.5 FIELD QUALITY CONTROL

A. 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. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment, and retest.
3. Calibration and test electric/electronic thermostats by disconnecting input sensors and stimulating operation with compatible signal generator.

B. Replace damaged or malfunctioning controls and equipment.

1. Start, test, and adjust control systems.
2. Demonstrate compliance with requirements, including calibration and testing, and control sequences.
3. Adjust, calibrate, and fine tune circuits and equipment to achieve sequence of operation specified.

C. Verify DDC as follows:

1. Verify software including automatic restart, control sequences, scheduling, reset controls, and occupied/unoccupied cycles.
2. Verify operation of operator workstation.
3. Verify local control units including self-diagnostics.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain control systems and components.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
2. Provide operator training on data display, alarm and status descriptors, requesting data, executing commands, calibrating and adjusting devices, resetting default values, and requesting logs.
3. Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."
4. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
5. Schedule training with Owner, through Architect, with at least seven days' advance notice.

3.7 ON-SITE ASSISTANCE

A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide up to three Project site visits, when requested by Owner, to adjust and calibrate components and to assist Owner's personnel in making program changes and in adjusting sensors and controls to suit actual conditions.

3.8 TRAINING

A. Provide a minimum of 24 hours of on-site or classroom training throughout the Contract period for personnel designated by the Owner. Each session shall be a minimum of four hours in length and must be coordinated with the building Owner. Train the designated staff of Owners Representative and Owner to enable them to:

1. Proficiently operate the system
2. Understand control system architecture and configuration
3. Understand DDC system components
4. Understand system operation, including DDC system control and optimizing routines (algorithms)
5. Operate the workstation and peripherals
6. Log on and off the system
7. Access graphics, point reports, and logs
8. Adjust and change system set points, time schedules, and holiday schedules
9. Recognize malfunctions of the system by observation of the printed copy and graphical visual signals
10. Understand system Drawings, and Operation and Maintenance manual

11. Understand the job layout and location of control components
12. Access data from DDC controllers
13. Operate portable operator's terminals

END OF SECTION 15900

SECTION 15940 - SEQUENCE OF OPERATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings & general provisions of the Contract, including General and Supplementary Conditions & Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes control sequences for HVAC systems, subsystems, and equipment.

B. See Division 15 Section "HVAC Instrumentation and Controls" for control equipment and devices and for submittal requirements.

C. Reference the BAS diagrams for Unit configuration, BAS devices, point types & locations

1.3 DEFINITIONS & ABBREVIATIONS

A. Analog: A continuously variable system or value not having discrete levels.

B. Binary: A two-state condition, i.e. “ON” or “OFF”.

C. Floating: A timed spanned signal using a binary input/output to operate a variable positioned actuator.

D. Automatic Temperature Control System: The total integrated system of fully operational and functional elements, including equipment, software, programming, and associated materials, to be provided by this Division BAS Contractor and to be interfaced to the associated Work of other related trades.

E. BAS Contractor (BAS): The single Contractor to provide the Work of this Division. This Contractor shall be the primary manufacturer, installer, commissioner and ongoing service provider for the BAS Work.

F. Control Sequence: A pre-programmed arrangement of software algorithms, logical computation, target values and limits as required attaining the defined operational control objectives.

G. Direct Digital Control: The digital algorithms and pre-defined arrangements included in the BAS software to provide direct closed-loop control for the designated equipment and controlled variables. Inclusive of Proportional, Derivative & Integral control algorithms together with target values, limits, logical functions, arithmetic functions, constant values, timing considerations and the like.

H. BAS Network: The total digital on-line real-time interconnected configuration of BAS digital processing units, workstations, panels, sub-panels, controllers, devices and associated elements individually known as network nodes. May exist as one or more fully interfaced and integrated sub-networks, LAN, WAN or the like.

I. BAS Integration: The complete functional and operational interconnection and interfacing of all BAS Work elements and nodes in compliance with all applicable codes, standards and ordinances so as to provide a single coherent BAS as required by this Division.

J. Provide: The term “Provide” and its derivatives when used in this Division shall mean to furnish, install in place, connect, calibrate, test, commission, warrant, document and supply the associated required services ready for operation.

K. Furnish: The term “Furnish” and its derivatives when used in this Division shall mean supply at the BAS Contractor’s cost to the designated third party trade Contractor for installation. BAS Contractor shall connect furnished items to the BAS, calibrate, test, commission, warrant and document.

L. Install: The term “Install” and its derivatives when used in this Division shall mean receive at the jobsite and mount.

M. Wiring: The term “Wiring” and its derivatives when used in this Division shall mean provide the BAS wiring and terminations.

N. Protocol: The term “protocol” and its derivatives when used in this Division shall mean a defined set of rules and standards governing the on-line exchange of data between BAS network nodes.

O. Software: The term “software” and its derivatives when used in this Division shall mean all of programmed digital processor software, preprogrammed firmware and project specific digital process programming and database entries and definitions as generally understood in the BAS industry for real-time, on-line, integrated BAS configurations.

P. Singular usage: The use of words in the singular in these Division documents shall not be considered as limiting when other indications in these documents denote that more than one such item is being referenced.

Q. Interpretation Aids: Headings, paragraph numbers, titles, shading, bolding, underscores, clouds and other symbolic interpretation aids included in the Division documents are for general information only and are to assist in the reading and interpretation of these Documents.

R. The following abbreviations and acronyms may be used in describing the Work of this Division, Additional acronyms shall be declared throughout the Specifications:

1. Organization and Project entities

a. ASHRAE - American Society of Heating, Refrig. & Air Cond. Engineers
b. BAS - Division 15 Building Automation System Contractor
c. EC - Division 16 Electrical Contractor
d. GC - General Contractor
e. IEEE - Institute of Electrical and Electronics Engineers
f. MC - Division 15 Mechanical Contractor
g. SM - Division 15 Sheet Metal Contractor
h. UM - Unit Manufacturer, Equipment

2. Direct Digital Controls Abbreviations

a. ANALOG - A variable signal (4-20mA, 2-10VDC etc.)
b. BINARY - A 2 state signal (On/Off, Open/Closed etc.)
c. FLOATING - A timed digital signal
d. AI / AO - Analog Input / Analog Output
e. CI / CO - Configurable Input / Configurable Output
f. DI / DO - Digital Input / Digital Output
g. DDC - Direct Digital Control
h. I/O - Input/Output point
i. LOOP - A control algorithm, with an analog input and output
j. PID - Proportional, Integral, Derivative
k. NO / NC - Normally Open / Normally Closed
l. SR/NSR - Spring Returned / Non-Spring Returned

3. Computer or Electronics

a. CPU - Central Processing Unit
b. EEPROM - Electronically Erasable Programmable Read Only Memory
c. GUI - Graphical User Interface
d. LAN/WAN - Local Area Network/Wide Area Network
e. PC/OWS - Personal Computer/Operator Workstation
f. RAM / ROM - Random Access Memory / Read Only Memory
g. TCP/IP - Transmission Control Protocol/Internet Protocol
h. UPS - Uninterruptible Power Supply

4. Cooling Plant Abbreviations

    a. CHWP - Chilled Water Pump, Primary (P-), Secondary (S-)
    b. CHWS/R - Chilled Water Supply/Return
    c. CH/ACCH - Chiller, Water or Air Cooled

5. Heating Plant Abbreviations

    a. B or BLR - Boiler, Hot Water or Low Pressure Steam
    b. BHWP - Boiler Hot Water Pump, Inline
    c. HWP - Hot Water Pump, Primary (P-), Secondary (S-)
    d. HWS/R - Hot Water Supply/Return
    e. MER - Mechanical Equipment Room

6. Primary HVAC Equipment Abbreviations

    a. ERU / ERV - Energy Recovery Unit / Energy Recovery Ventilator
    b. BCU / FCU - Blower Coil Unit / Fan Coil Unit
    c. MAU- Makeup Air Unit
    d. RTU - Roof Top Unit

7. Ancillary HVAC Equipment Abbreviations

    a. EDH - Electric Duct Heater
    b. EF - Exhaust Fan
    c. FP/VAV - Fan Powered/Variable Air Volume
    d. HP - Heat Pump
    e. CAV/VAV - Constant Air Volume Box / Variable Air Volume Box

8. Field Devices Abbreviations

    a. AQ - Thermostat, pipe mounted SPDT
    b. CT/CS - Current transducer/ Current Switch
    c. F/SD - Fire/Smoke Damper
    d. FAS/FACP - Fire Alarm Detection System/Fire Alarm Control Panel
    e. HOA - Hand-Off-Auto
    f. LPS/HPS - Low Pressure Switch / High Pressure Switch
    g. ES - End-Switch
    h. LDS - Liquid Detection Switch
    i. LCD / LED - Liquid Crystal Display / Light Emitting Diode
    j. LLS - Low Limit Temperature Switch, (SPST) or (SPDT)
    k. LWCO - Low Water Cutout switch
    l. MD - Actuator Operated Damper
    m. MS / VFD - Motor Starter / Variable Frequency Drive
    n. OCC - Occupancy Sensor

o. PDT - Pressure Differential Transducer
p. PDS - Pressure Differential Switch
q. R- Control Pilot Relay
r. SD - Smoke Detector or Smoke Damper
s. SPDT / SPST - Single Pole Double Throw / Single Pole Single Throw
t. SW - Switch
u. T/TS - Temperature / Temperature Sensor
v. TC - Thermostat switch
w. 2W/3W - 2-Way or 3-way
x. CV - Constant Air Volume or Flow Coefficient of a Control Valve
y. SCV - Self-contained control valve
z. V- Valve, Temperature Control

9. Power and Energy Abbreviations

a. AWG- American Wire Gauge
b. KW/KWH - Kilo-Watts (Power)/ Kilo-Watt-Hours
c. mA - milli-ampere
d. VA - Voltage-Ampere
e. VAC/VDC - Volts, Alternating Current / Volts, Direct Current

10. Project delineation and information Abbreviations

a. NIC / FBO - Not In Contract / Furnished by Others
b. TBA/TBD - To Be Advised / To Be Determined

11. Control Media Abbreviations

a. SAT/SAH- Supply Air Temperature/ Supply Air Temperature
b. DAT/DAH - Discharge Air Temperature/ Discharge Air Temperature
c. MAT - Mixed Air Temperature
d. RAT/RAH - Return Air Temperature/Return Air Humidity
e. OAT/OAH - Outdoor Air Temperature / Outdoor Air Humidity
f. RH - Relative Humidity
g. CO/CO2 - Carbon Monoxide / Carbon Dioxide

1.4 COORDINATED SEQUENCES & BAS DIAGRAMS

A. Project BAS Diagrams

1. The Sequences of Operations detailed below are predicated on the specific Project BAS diagrams.
2. Reference the BAS Diagrams for the Unit configuration, BAS control devices, point types & locations for each device.

B. Control Sequence Descriptions:

1. The control sequences below describe all necessary equipment operation including those operations that are provided by the HVAC Equipment Unit manufacturers (UM) & those as part of the Automatic Temperature Controls system (BAS).

1.5 RESPONSIBILITIES

A. Automatic Temperature Control (BAS) Contractor's Responsibilities:

1. The BAS Contractor (BAS) shall provide, field install & wire all necessary software & hardware, wiring, & computing equipment in compliance with this Specification. The BAS Contractor shall also provide programming, interface design, startup services by competent technicians that regularly employed by the BAS Contractor with full responsibility for proper operation of the control system including debugging & proper calibration of each component in the entire system
2. The BAS Contractor (BAS) shall provide power supply wiring to all external control panels, actuators (valves, dampers, etc.), including low voltage transformers, including the power for devices required for operation of BACnet communication as provided as part of complete HVAC Equipment Unit Manufacturer provided BACnet packaged.

B. Mechanical Contractors (MC) Responsibilities:

1. The Mechanical Contractor (MC) shall provide coordination between the HVAC Equipment Unit Manufacturers (UM) & the BAS Contractor (BAS) to provide a fully coordinated & operational Automatic Temperature Controls system

    a. Refer to this & the specific equipment Specifications & schedules for devices provided, installed & wired by the HVAC equipment Unit manufacturers (UM) & those by the BAS contactor (BAS).

C. HVAC Equipment Unit Manufacturer (UM) Responsibilities

1. The HVAC Equipment Unit Manufacturer (UM) shall provide the equipment and field start-up & commissioning labor to meet the sequence requirements of this Specification & schedules sections.
2. The HVAC Equipment Unit Manufacturer (UM) shall provide factory installation & wiring of the BAS provided controls, when specified to be factory installed
3. The HVAC Equipment Unit Manufacturer (UM) shall provide BACnet controller wiring details for the UM provided controls at time of award to allow BAS Contractor to complete submittal Drawings.

1.6 OPERATOR INTERFACE REQUIREMENTS

A. The BMS Control Diagrams and the tables below shall provide for Operator Control of the HVAC equipment through an accurate depiction of the device(s) within the unit, along with the I/O points, parameters and alarms shall be displayed on a customized 3-dimensional web-based graphic.

1.7 SYSTEM TRENDS

A. DATA COLLECTION: Unless noted otherwise, the BMS shall record the Analog Trend data samples every 5 minutes. Binary Trends shall record data samples every Change of Value (COV).

1.8 SUPREVISORY NETWORK CONTROLLER (SNC):

A. COORDINATION: The BMSC shall provide an additional SNC network controller with the specificied capacity. This shall include new graphics and programs; integrate all of the new DDC equipment to the existing BMS network.

B. COMMUNICATIONS OFFLINE ALARM (COMM): Anytime communication is lost to a BMS DDC Controller a Communication Lost Alarm (COMM) shall be sent to the GUI.

1. Alarms

Supervisory Network Controller	Alarms and Conditions		
Alarm Name	Point	Normal	Alarm
BACnet Interface Alarms			
Communications Offline Alarm	Comm		

1.9 HEATING SYSTEM

A. GENERAL DESCRIPTION: Reference the BMS diagrams for configuration, device(s), point types and locations.

B. COORDINATION:

1. The BMSC shall provide, field install and wire a Building Level BACnet DDC controller (B-BC), control valves, sensor(s), relays, status sensor(s) and damper(s) actuators.
2. The Unit's shall be provided as outlined under the equipment schedules.
3. The Mechanical Contractor (MC) shall provide coordination between the OEM and the BMSC for a complete integrated system.

C. HEATING SYSTEM ENABLE:

1. The Heating System shall be Enabled when:

a. The Outside Air Temperature (OAT) less than 55 °F (adj.), regardless of schedule or
b. If the Outside Air Temperature (OAT) is less than the Heating Enable Setpoint (HTGENBSP) of 65 °F (adj.) and the building is scheduled (SCHED) to "Occupied".

D. ENABLE OVERRIDE:
1. A Heating System override "On" switch (HTGOVR) on the GUI shall allow manual enabling of the Central Plant Heating System.

E. BOILER CONTROL PANEL (BCP)
1. COORDINATION:
a. The BMSC shall provide installation of wiring for the Boiler Control Panel. The Unit's shall be provided as outlined under the equipment schedules.
2. BCP INTEGRATION:
a. The BMSC shall provide the communications wiring to the BCP communications board; provide all time to integrate the BCP points, parameters, and alarms.
3. BOILER CONTROL PANEL HARD-WIRED POINTS:
a. The BMSC shall wire the following BCP Hardware Input/Output points to the BMS system.
1) BCP Enable (BCPENB)
2) BCP HWS Setpoint (HWSP)
4. BOILER ISOLATION CONTROL VALVES:
a. The OEM manufacturer shall provide the individiual Boilers Isolation control valves. The Boiler Isolation Control valves shall be interlocked to Open whenever the applicable Boiler is enable to run.

F. HOT WATER TEMPERATURE SETPOINT (HWSP)
1. The Outside Air Temperature sensor (OAT) shall allow the BMS to reset the Hot Water Setpoint (HWSP). This shall be a proportional inverse function.
a. When the OAT is 20 °F, the HWSP shall be 180 °F (adj.)
b. When the OAT is 65 °F, the HWSP shall be 115 °F (adj.)
c. The HWSP shall be limited between 115 °F and 180 °F. (adj.)
2. The BCP's Outside Air Temperature sensor (OAT) shall allow the BCP to reset the BCP Hot Water Setpoint (HWSP).

G. HOT WATER SUPPLY TEMPERATURE CONTROL
1. ENABLE:
a. When any of the Hot Water Pump status (HWP#ST) indicates "on".
2. TEMPERATURE CONTROL:
a. The Boiler Control Panel (BCP) shall be enabled to control the Hot Water Supply Temperature (HWS) at the Hot Water Setpoint (HWSP).
3. HOT WATER SUPPLY TEMPERATURE (TEMP) ALARM:

a. If the Hot Water Supply Temperature (HWS) is greater than 10°F (adj.) from the Hot Water Supply Temperature Setpoint (HWSP). A Hot Water Supply Temperature Alarm (TEMP) shall be sent to the GUI.

4. TEMPERATURE SENSOR FAILURE (SENSOR):
   a. Anytime the value of a Temperature Sensor is greater or less than the operational limitations of the sensor, and Temperature Sensor Failure alarm (SENSOR) shall be sent to the GUI.

H. HOT WATER PUMP CONTROL
1. HOT WATER PUMP START COMMAND:
   a. The selected Hot Water Pump (P#SS) shall be commanded to “start” when the Heating System is enabled.
2. HOT WATER PUMP STOP COMMAND:
   a. The selected Hot Water Pump (P#SS) shall be commanded to “stop” 30 minutes have passed after the Heating System has been commanded to “stop” or if after a delay of 30 seconds of the Hot Water pump status (P#ST) not proving on
3. LEAD HOT WATER PUMP ROTATION:
   a. The Lead Hot Water Pump (LEADHWP) shall be rotated every 168 hours of accumulated Run time or as selected from the GUI.
4. LAG HOT WATER PUMP START:
   a. The Lag Hot Water Pump (HWP#SS) shall be commanded to “start” if the selected Lead Hot Water Pump (HWP#ST) fails to “start” after a delay of 30 seconds.
5. HOT WATER PUMP FAILURE ALARM (FAIL):
   a. If the Hot Water Pump command (P#SS) is on, but the Hot Water Pump status (P#ST) is “off”, a Pump Failure (FAIL) alarm shall be sent to the GUI.
6. HOT WATER PUMP IN HAND ALARM (HAND):
   a. If the Hot Water Pump command (P#SS) is commanded to “stop”, but the Hot Water Pump status (P#ST) is “on”, a Pump-in-Hand (HAND) alarm shall be sent to the GUI.

I. HOT WATER SYSTEM DIFFERENTIAL PRESSURE CONTROL
1. HOT WATER PUMP VFD SPEED CONTROL:
   a. The lowest of Hot Water Differential Pressure sensor(s) (HWDP) shall be utilized to modulate Hot Water Pump speed (HP#SPD).
   b. Upon the initial “start” of the Hot Water Pump (HP#SS), the Hot Water Pump speed (HWP#SPD) shall slowly increase over a 2 minute period.
   c. The Hot Water Pump speed (HWP#SPD) shall modulate to maintain the Hot Water System Differential Pressure (HWDP) at the Hot Water System Differential Pressure Setpoint (HWDPSP).
1. HOT WATER SYSTEM PRESSURE BYPASS VALVE:
   a. When the Hot Water Pump Speed (HP#SPD) is at its minimum speed, the Hot Water Bypass control valve (HWBYP) modulate to maintain the Hot

Water System Differential Pressure (HWDP) at the Hot Water System Differential Pressure Setpoint (HWDPSP).

2. HOT WATER SYSTEM PRESSURE ALARM (HWDPT):
   a. If the Heating System (HTGENB) System is enabled, after a 15 minute (adj.) delay, the Hot Water System Differential Pressure (HWDP) is not within +/- 10% of the Hot Water System Differential Pressure Setpoint (HWDPSP), a HW System DP alarm (HWDPT) shall be sent to the GUI.

J. BOILER MINIMUM FLOW CONTROL
   1. COORDINATION: The BMSC shall provide and wire a Hot Water Flow sensor (HWGPM). THE MC shall provide installation of the sensor
   2. VARIABLE FREQUENCY DRIVE MINIMUM SPEED CONTROL: The Hot Water Pump VFD speed (CHWP#SPD) shall maintain the minimum Hot Water System Flow (HWGPM) above the Boiler Minimum Flow Setpoint (FLOSP). When the Hot Water System Flow (HWGPM) less than the Boiler Minimum Flow Setpoint (HWGPMSP), the VFD speed shall be limited to maintain the minimum flow (HWGPM).
   3. HOT WATER SYSTEM FLOW BYPASS VALVE: The BMSC shall provide and wire a Hot Water Bypass control valve (HWBYP). The Hot Water Bypass control valve (HWBYP) shall maintain the minimum Hot Water System Flow (HWFLO) above the Boiler Minimum Flow Setpoint (HWFLOSP). When the Hot Water System Flow (HWGPM) less than the Boiler Minimum Flow Setpoint (HWFLOSP), the Hot Water Bypass control valve (HWBYP) shall modulate “open”. When the Hot Water System Flow (HWGPM) greater than the Boiler Minimum Flow Setpoint (HWFLOSP), the Hot Water Bypass control valve (HWBYP) shall modulate to “close”.
   4. HOT WATER SYSTEM FLOW ALARM (HWLOFLO): If the Heating System (HTGENB) System is enabled, after a 5 minute (adj.) delay, the Hot Water System Flow (HWGPM) is not greater than the Boiler Minimum Flow Setpoint (HWFLOSP), a HW System Low Flow alarm (HWLOFLO) shall be sent to the GUI.

K. OPERATOR INTERFACE REQUIREMENTS:
   1. Input/Output Points:

Heating System	**I/O Points**						
Point Name/Description/Legend X = DDC I/O L = Local Control A = Adjustable O = Override	AI	AO	BI	BO	Trend	GUI	Device
Outside Air Temperature (OAT)	X				X	X	TS-O
HW Supply Temperature sensor (HWS)	X				X	X	TS-I
BCP HWS Supply Temp (BHWS)	L						UMD
Outside Air Temperature (BOAT)	L						UMD
BCP Enable (BCPENB)							
Hot Water Pump Start/Stop (P#SS)				O	X	X	R
Hot Water Pump Status (P#ST)			X		X	X	CS

Heating System	I/O Points						
Point Name/Description/Legend X = DDC I/O L = Local Control A = Adjustable O = Override	AI	AO	BI	BO	Trend	GUI	Device
Hot Water Pump speed (HWP#SPD)		O			X	X	VFD
HW System Differential Pressure (HWDP)	X				X	X	DPT
Hot Water Bypass control valve (HWBYP)		X			X	X	CV
HW System Flow (HWFLO)	X				X	X	WFS

2. Control Parameters and Settings

Heating System	Parameters and Settings			
Parameter Name/Description X = Display on GUI A = Adjustable	AV	Trend	GUI	Initial-Setting
Building Schedule (SCHED)	A	X	X	
Heating System Enabled (HTGENB)	X	X	X	
Minimum Run Time (MINRUN)	A	X	X	
Hot Water System Override (HTGOVR)	A	X	X	
HW System Enable setpoint (HTGENAB)	A	X	X	
HW Supply Temperature Setpoint (HWSP)	A	X	X	See sequence
HW System DP Setpoint (HWDPSP)	A	X	X	15 psid
Boiler Minimum Flow Setpoint (HWFLOSP)	A	X	X	By OEM settings

3. Alarms

Heating System	Alarms and Conditions		
Alarm Name	Point	Normal	Alarm
HW System in Override (OVERRIDE)	(CLGOVR)	OFF	ON
HWS Temp alarm (TEMP)	HWS		HWS >+/- 10°F HWSP
Temp Sensor Failure (SENSOR)	Varies	-10°F < Input Input < 240°F	-10°F > Input Input > 240°F
Pump Failure Alarm (FAIL)	P#SS P#ST	P#SS = ON P#ST = ON	P#SS = ON P#ST = OFF
Pump in Hand Alarm (HAND)	P#SS P#ST	P#SS=OFF P#ST=OFF	P#SS=OFF P#ST=ON
HW Sys DP alarm (HWDPT)	HWDP		>+/- 10% HWDPSP
HW Sys Lo Flow alarm (HWLOFLO)	HWGPM	> HWFLOSP	< HWFLOSP

1.10 ROOF TOP UNITS (HOT WATER HEATING COIL)

A. COORDINATION

1. The Building Management System Contractor (BMSC) shall provide, field install and wire a BACnet DDC controller, control valves, sensor(s), relays, status sensor(s) and damper(s) actuators. The Unit's shall be provided as outlined under the equipment schedules.
2. The Mechanical contractor (MC) shall provide coordination between the OEM and the BMSC for a complete integrated system.

B. SCHEDULING
1. The unit's schedule (SCHED) is as established in the BMS GUI and shall be communicated to the Unit's DDC controller
2. "OPTIMAL START / STOP": The DDC controller shall calculate how long it will take to go to the next scheduled setpoint based on the heating or cooling capacity and the outside air temperature. The system will not adjust the starting or stopping by more than 2 hours.
3. The unit's DDC controller shall have a built-in timeclock.

C. SCHEDULE OVERRIDE:
1. A schedule Override Pushbutton (OVRD) on the Space Temperature Sensor (RMT) shall override the schedule.
2. An LED shall indicate that the Unit is overridden to "Occupied" for up to 3 hours (adj.).
3. The Unit shall revert to its scheduled mode upon the time expiration of the override or upon further depression of the Override Pushbutton (OVRD).

D. SPACE TEMPERATURE SENSOR (RMT):
1. The Space Temperature Sensor(s) (RMT) shall have an LCD screen depicting the Temperature and Setpoints.
2. The Space Temperature sensor(s) (RMT) located in public areas shall have a blank faces.
3. The Space Temperature sensor(s) (RMT) located in public areas shall have a blank vented stainless-steel design.

E. SPACE TEMPERATURE SETPOINTS:
1. The Space Heating (HSP/UHSP) and Cooling (CSP/UCSP) shall be controlled from the GUI. The setpoints shall initially be 72 °F (adj.) for heating (HSP) and 74 °F (adj.) for cooling (CSP) with a setpoint adjustment span setting of ± 4 °F (adj.).

F. Critical note:
1. The Roof Top Unit with Refrigerant Leak Detection capabilities shall signal the associated Variable Air Volume Boxes upon the Refrigerant Detection alarming feature.
2. The following mitigation actions shall be completed in not more than 15 seconds after the initiation of the Refrigeration Leak Alarm signal, and shall be maintained for at least 5 minutes after the output signal has reset:

3. The Roof Top Unit shall energize the air circulation fan(s) of the equipment per the manufacturer's instructions.

G. "PROOF OF OPERATION":
   1. A current switch shall monitor the Unit's Supply fan status (SFST).
   2. The unit shall remain in "Unoccupied" until the Supply Fan status (SFST) indicates on.

H. MODE INHIBIT:
   1. During the any cooling mode all heating modes shall be disabled.
   2. During the any heating mode all cooling modes shall be disabled.

I. "UNOCCUPIED":
   1. When the Unit is scheduled to "Un-Occupied" (SCHED),
      a. The Unit's Supply Fan (SFSS) shall be commanded to "stop".
      b. The Unit's Return Fan (RFSS) shall be commanded to "stop".
      c. Any associated Exhaust Fan(s) (EFSS) shall be commanded to "stop".
   2. The Outside Air Damper(s) (OAD)) shall be commanded to "close".
   3. The Return Air Damper(s) (RAD) shall be commanded to "open".
   4. The Exhaust Air Damper(s) (EAD) shall be commanded to "close".
   5. The Direct eXpansion Cooling (CLG) shall be commanded "off".
   6. When the Outside Air Temperature (OAT) is less than 48 Deg F, the Heating control valve (HTG) shall modulate to maintain a Discharge Air Temperature (DAT) at the Unoccupied Discharge Air Setpoint (UDASP) of 55°F (adj.).
   7. The Heating Coil(HTG) shall be "off".

J. "OCCUPIED":
   1. When the Unit is scheduled to "Occupied" (SCHED),
      a. The Unit's Supply fan (SFSS) shall be commanded to "start".
      b. Upon the transition of the unit to "Occupied" mode, a 10-minute ramp shall be implemented before the Outside damper(s) (OAD) can go fully "open". The Outside Air Damper(s) (OAD) shall "modulate open" to the Minimum Outside Air setting (adj.)(OAMINSP). The Return Air Damper(s) (RAD) shall "modulate closed" to the Minimum Outside Air setting (adj.)(OAMINSP).

K. MINIMUM OUTSIDE AIR:
   1. The unit's Outside Air Damper (OAD) and Return Air Damper (RAD) shall be positioned as required per the sequence of operations.
   2. The TAB shall adjust and set the Minimum Outside Air setting (MINOA).

L. "WARM-UP":
   1. During the "Warm-Up", the Unit's dampers shall remain in the "UnOccupied position.
   2. The Unit will be in "Warmup":

a. When the Space Temperature (RMT) is greater than 5 °F (adj.) below the Space Heating Setpoint (HSP) or the Return Air Temperature (RAT) is less than the "Warm-up" setpoint (WUSP) of 66 °F (adj.).

3. The Heating control (HTG) shall be modulated to maintain a Discharge Air Setpoint (DASP) of 85 °F (Adj.).
   a. When the Space Temperature (RMT) returns within 2 °F of the Space Heating Setpoint (HSP) the Unit shall revert to the scheduled operation and the Return Air Temperature (RAT) rises 2 °F (adj.) above the "Warm-up" setpoint (WUSP) the Unit shall revert to the scheduled operation.

M. HOT WATER COIL PUMPS:
1. The Unit's coil pump (CPSS) shall be commanded to "start" when the Outside Air temperature (OAT) is below 45 °F (adj.) or the low-limit switch (LLS) has tripped.

N. "HEATING":
1. When the Space Temperature (RMT) is less than the scheduled "Heating" Setpoint (HSP/UHSP).
   a. The Supply fan (SFSS) shall be commanded to "start". After the Supply Fan status switch (SFST) has proven the fan "on"
   b. The Heating control valve (HTG) shall be modulated "open" to the coil.
2. When the Space Temperature (RMT) rises above the scheduled "Heating" Setpoint (HSP/UHSP) hysteresis,
   a. The Heating control valve (HTG) shall be modulated "closed" to the coil.

O. DISCHARGE AIR TEMPERATURE LOW LIMIT:
1. The Heating control (HTG) shall modulate to maintain the Discharge Air Temperature sensor (DAT) above Discharge Air Temperature Low Limit Setpoint (DALL) of 60°F (adj.).
   a. When the Discharge Air Temperature (DAT) is less than the Discharge Air Temperature Low Limit Setpoint (DALL) the Heating control(HTG) shall modulate "open" to the coil.
   b. When the Discharge Air Temperature (DAT) is greater than the Discharge Air Temperature Low Limit Setpoint (DALL) the Heating control (HTG) shall modulate to "close" to the coil.

P. "COOL-DOWN":
1. During the "Cool-down", the Unit's dampers shall remain in the "UnOccupied position.
2. The Unit will be in "Cooldown":
   a. When the Space Temperature (RMT) is greater than 5 °F (adj.) above the Space Cooling Setpoint (CSP) or the Return Air Temperature (RAT) is greater than the "Cool-Down" setpoint (CDSP) of 78 °F (adj.).
3. The Cooling control (CLG) shall be modulated to maintain a Discharge Air Setpoint (DASP) of 50 °F (Adj.).

a. When the Space Temperature (RMT) returns within 2 °F of the Space Cooling Setpoint (CSP) and the Return Air Temperature (RAT) decreases 2 °F (adj.) below the "Cool-down" setpoint (CDSP) the Unit shall revert to the scheduled operation.

Q. "MECHANICAL COOLING":
1. When the Space Temperature (RMT) is greater than the scheduled "Cooling" Setpoint (CSP/UCSP) and conditional use of mechanical cooling air conditions is allowed,
   a. The Supply fan (SFSS) shall be commanded to "start". After the Supply Fan status switch (SFST) has proven the fan "on"
   b. The Direct eXpansion Cooling shall modulate "on".
2. When the Space Temperature (RMT) decreases below the scheduled "Cooling" Setpoint (CSP/UCSP) hysteresis:
   a. The Direct eXpansion (DX) Cooling shall modulate "off".
   b. The Unit's Fans and dampers shall revert to their scheduled condition.

R. LIQUID DETECTION (LIQUID) SENSOR:
1. A Liquid Detection (LDS) switch shall be located to detect accumulated liquids in the Drip Pan.

S. "ECONOMIZER COOLING":
1. When the Outside Air temperature (OAT) is less than the Space Temperature (RMT) by greater than 8 °F (adj.) the use of the Free Cooling economizer shall be used to cool the Space Temperature (RMT) as required,
   a. When the Space Temperature (RMT) is greater than the Space Cooling Setpoint (CSP) the Outside (OAD) damper(s) shall be modulated "open" the Outside Air Damper (OAD) and Return Air Damper(s) (RAD) shall modulate "open" from the minimum Outside Air setpoint (MINOASP).
   b. When the Space Temperature (RMT) is less than the Space Cooling Setpoint (CSP) the Outside (OAD) damper(s) shall be modulated to "closed" to the minimum Outside Air setpoint. (MINOASP).
   c. "INADEQUATE FREE COOLING ECONOMIZER" (RMT):
      1) If the Space Temperature (RMT) remains above the Space Cooling Setpoint (CSP) for greater than 15 minutes, the Outside Air damper (OAD) and Return Air damper (RAD) damper(s) shall return to the Minimum Outside Air position (MINOASP) and the mechanical cooling shall be utilized.

T. DEMAND CONTROL VENTILATION:
1. A space CO2 sensor (CO2) shall monitor CO2 levels.
2. The Outside Air damper (OAD), Exhaust Air damper (EAD) and Return Air damper (RAD) shall modulate to maintain the space CO2 setpoint (CO2SP) of 900 ppm.

3. When the space CO2 (CO2) is greater than the CO2 setpoint (CO2SP), the Outside Air Damper(s) (OAD) shall modulate “open”, and the Return Air Damper(s) (RAD) shall modulate to “close”.
4. When the CO2 (CO2) is less than the CO2 setpoint (CO2SP), the Outside Air Damper(s) (OAD) and the Return Air Damper(s) (RAD shall revert back to schedule mode.

U. “DEHUMIDIFICATION”
1. “DEHUMIDIFICATION” (DIRECT EXPANSION): When the Return Humidity (RARH) is greater than the Relative Humidity Setpoint (RHSP) the Direct eXpansion Cooling (DX) shall be sequenced “on”, and the Hot Gas reheat coil (HGRH) shall be commanded “on”. When the Return Humidity (RARH) is less than the Relative Humidity Setpoint (RHSP) hysteresis, the Direct eXpansion Cooling (DX) shall be sequenced “off”, and the Hot Gas reheat coil (HGRH) shall be commanded “off”.

V. AIR FILTER (FILTER):
1. DPS - Each filter bank shall be monitored by a Filter Differential Pressure Switch (FILTER) that shall be locally set per the filter rating for a dirty filter. When the Filter Differential Pressure Switch (FILTER) exceeds this rating, a Filter maintenance (FILTER) alarm shall be sent to the GUI. A software reset shall be required to silence/reset the timer function.

W. EQUIPMENT ALARMS
1. SPACE TEMPERATURE (TEMP) ALARM:
   a. If the Space temperature (RMT) is greater than 4 Deg F(adj.) from the scheduled setpoints a Space Temperature Alarm (TEMP) shall be sent to the GUI.
2. SPACE HUMIDITY (RH) ALARM:
   a. When the Unit’s Supply Fan (SFSS) is commanded “on” and If the Space Humidity (RMRH) is more than 10%r.h. (adj.) from the Relative Humidity Setpoint (RHSP) setpoints, a Space Humidity Alarm (HUMIDITY) shall be sent to the GUI.
3. LOW LIMIT SWITCH (LLSTRIP) ALARM:
   a. A Low Temperature Limit Switch (LLS) shall be located on the leaving airside of the Heating Coil.
   b. If the Low Temperature Limit Switch (LLS) senses a coil discharge temperature below the local device setting of 38 °F:
      1) The Unit’s Fan (SFSS) shall be commanded to “stop”.
      2) The Unit’s Return Fan (RFSS) shall be commanded to “stop”.
      3) The Outside Air Damper (OAD) shall be commanded to “close”
      4) The Return Air Damper (RAD) shall be commanded to “open”.
      5) The Exhaust Air Damper (EAD) shall be commanded to “close”
      6) The Heating Coil control valve (HTG) shall “open” to the coil.
      7) The unit’s cooling sequences shall be disabled.

8) A Low-Limit Switch Tripped (LLSTRIP) shall be sent to the GUI.

c. The Low Temperature Limit Switch (LLS) shall be reset from the GUI.

4. LIQUID DETECTION (LIQUID) ALARM:
   a. A Liquid Detection (LDS) switch shall be located to detect accumulated liquids in the Drip Pan.
   b. Upon detection of a liquid:
      1) The Unit's Supply Fan (SFSS) shall be commanded to "stop".
      2) The Unit's Return Fan (RFSS) shall be commanded to "stop".
      3) The Return Air damper (RAD) shall be commanded to "open".
      4) The Exhaust Air damper (EAD) shall be commanded to "close".
      5) The Outside Air Damper (OAD) shall be commanded to "close".
      6) The Unit's cooling sequences shall be disabled.
      7) The Heating Coil control valve (HTG) shall be commanded "open" to the coil.
      8) A Drip Pan Liquid Detection (LIQUID) alarm shall be sent to the GUI.
   c. The alarm shall be reset through a software switch from the GUI.
5. COOLING FAILURE ALARM (COOLFAIL - DAT):
   a. If the Discharge Air Temperature (DAT) remains within 4°F (adj.) of the Mixed Air Temperature (MAT) after with the cooling mode is utilized (for greater than 5 minutes).
   b. A Cooling Failure alarm (COOLFAIL) shall be sent to the GUI.
   c. This alarm shall not be enabled until the Supply Fan status (SFST) has been "on" for 10 minutes (adj.).
6. COOLING FAILURE ALARM (COOLFAIL - RMT):
   a. If the Supply Air Temperature (SAT) remains within 4°F (adj.) of the Space Temperature (RMT) after with the cooling mode is utilized (for greater than 5 minutes).
   b. A Cooling Failure alarm (COOLFAIL) shall be sent to the GUI.
   c. This alarm shall not be enabled until the Supply Fan status (SFST) has been "on" for 10 minutes (adj.).
7. HEATING FAILURE ALARM (HEATFAIL - SAT):
   a. This alarm shall not be enabled until the Supply Fan status (SFST) has been "on" for 10 minutes (adj.).
   b. If the Supply Air Temperature (SAT) remains within 4°F (adj.) of the Mixed Air Temperature (MAT) after of the heating signal is greater than 10% "open" (For greater than 5 minutes)
   c. A Heating Failure alarm (HEATFAIL) shall be sent to the GUI.
8. HEATING FAILURE ALARM (HEATFAIL - RMT):
   a. This alarm shall not be enabled until the Supply Fan status (SFST) has been "on" for 10 minutes (adj.).
   b. If the Discharge Air Temperature (DAT) remains within 4°F (adj.) of the Space Temperature (RMT) after of the heating signal is greater than 10% "open" (For greater than 5 minutes)
   c. A Heating Failure alarm (HEATFAIL) shall be sent to the GUI.

9. DISCHARGE AIR LOW ALARM (DATLO):
    a. This alarm and sequence shall be disabled during the mechanical cooling mode(s) of operation.
    b. If the Discharge Air Temperature (DAT) decreases below the Discharge Air Temperature Low Limit Setpoint (DALL) or 45°F (adj.),
        1) The Outside Air Damper (OAD) shall be commanded to “close”.
        2) The Return Air Damper (RAD) commanded to “open”.
        3) The Exhaust Air Damper (EAD) shall be commanded to “close”.
        4) An alarm (DATLO) shall be sent to the GUI.
10. MIXED AIR TEMPERATURE ALARM (DAMPER):
    a. If the Outside Air Temperature (OAT) is lower than the Mixed Air Temperature Setpoint (MASP), and then if the Mixed Air Temperature (MAT) fails to be with 4°F of the Mixed Air Temperature Setpoint (MASP) or if the Mixed Air Temperature (MAT) is greater than 80 °F(adj.) or less than 45°F (adj.), then an alarm (DAMPER) shall be sent to the GUI.
11. FAN FAILURE ALARM (FAIL):
    a. If a Fan (i.e., SFSS, RFSS, etc..) is commanded to “start”, but the Fan status (i.e., SFST, RFST, etc..) is “off”, a Fan Failure (FAIL) alarm shall be sent to the GUI.
12. FAN IN HAND ALARM (HAND):
    a. If a Fan command (i.e., SFSS, RFSS, etc..) is commanded to “stop”, but the Fan status (i.e., SFST, RFST, etc..) is “on”, a Fan-in-Hand (HAND) alarm shall be sent to the GUI.
13. CARBON-DIOXIDE ALARM (DCV):
    a. When the Unit’s Supply Fan (SFSS) is commanded “on”,
        1) if the Carbon-Dioxide level (CO2) remains above 1100 ppm (adj.) for more than 1 hour,
        2) or if the Carbon-Dioxide level (CO2) levels exceed 1400 ppm
        3) a Demand Control Ventilation alarm (DCV) shall be sent to the GUI.
14. TEMPERATURE SENSOR FAILURE (SENSOR):
    a. Anytime the value of a Temperature Sensor is greater or less than the operational limitations of the sensor.
    b. A Temperature Sensor Failure alarm (SENSOR) shall be sent to the GUI.
15. DUCT SMOKE DETECTION (SMOKE):
    a. A spare set of dry-contact(s) on the Unit’s Smoke Detectors (SDD)(F.B.O.) shall signal the BMS DDC controller to disable control loops during a smoke condition.
    b. A Smoke Detection alarm (SMOKE) shall be sent to the GUI.

X. OPERATOR INTERFACE REQUIREMENTS:
1. Input/Output Points:

UNIT	I/O Points

Point Name/Description/Legend X = DDC I/O L = Local Control A = Adjustable O = Override	AI	AO	BI	BO	Trend	GUI	Device
BACnet Communication Interface Points	X	X	X	X	X	X	UMD
Supply Fan Start/Stop (SFSS)				O	X	X	R
Supply Fan Status (SFST)			X		X	X	CS
Exhaust Fan Start/Stop (EFSS)				O	X	X	R
Exhaust Fan Status (EFST)			X		X	X	CS
Coil Pump Start/Stop (PSS)				X	X	X	R
Coil Pump Status (PST)			X		X	X	CS
Direct eXpansion Cooling (CLG)		O		O	X	X	
Heating Coil control valve (HTG)		O		O	X	X	
Space Temperature (RMT)	X				X	X	TS-W
Space Relative Humidity (RMRH)	X				X	X	RH-W
Space Carbon-Dioxide level (RMCO2)	X				X	X	CO2-W
Return Air Humidity (RAH)	X				X	X	RH-D
Return Air CO2 (RACO2)	X				X	X	CO2-D
Discharge Air Temperature (DAT)	X				X	X	TS-D
Mixed Air Temperature (MAT)	X				X	X	TS-A
Return Air Temperature Setpoint (RAT)	X				X	X	TS-D
Outside Air Damper (OAD)		O		X	X	X	M
Return Air Damper (RAD)		O		X	X	X	M
Exhaust Air Damper (EAD)		O		X	X	X	M
Filter (FLTR)			X		X	X	DPS
Low Limit Switch (LLS)		X			X	X	LLS
Liquid Detection Sensor (LDS)			X		X	X	LDS
Analog Trends shall record data samples every 5 minutes, unless noted otherwise. Binary Trends shall record data samples every Change of Value (COV)							

2. Control Parameters and Settings

UNIT	Parameters and Settings			
Parameter Name/Description X = Display on GUI A = Adjustable	AV	Trend	GUI	Initial-Setting
BACnet Interface Parameters	A	X	X	
Occupancy Schedules (SCHED)	X	X	X	
“Occupied” Space Heating Setpoint (HSP)	A	X	X	70 °F
“Occupied” Space Cooling Setpoint (CSP)	A	X	X	72 °F
“Unoccupied” Space Heating Setpoint (UHSP)	A	X	X	65 °F
“Unoccupied” Space Cooling Setpoint (UCSP)	A	X	X	78 °F

Relative Humidity Setpoint (RHSP)	A	X	X	50 %r.h.
Discharge Air Temperature Setpoint (DASP)	A	X	X	See Sequence
Discharge Air Temperature Low Limit (DALL)	A	X	C	55°F
Mixed Air Temperature Setpoint (MASP)				See Sequence
Duct Static Pressure Setpoint (DPSP)	A	X		1.5 inches w.c.
Building Pressure Setpoint (BPSP)	A	X		0.05 inches w.c.
Space Temp "Warm-up" Setpoint (WUSP)	A	X	C	2 °F (WUSP – HSP)
Filter Replacement Timer (FILTERSP)				1000 hours
Minimum Outside Air damper (MINOA)				Set by Balancer
OA Intake CFM Setpoint (OACFMSP)	A	X	X	Set by Balancer
Exhaust Air CFM Offset (EADIF)	A		X	Set by Balancer
All Alarm Setpoints and/or Parameters	A	X	C	Alarm settings
Alarm Reset	A	X	X	
Analog Trends shall record data samples every 5 minutes, unless noted otherwise. Binary Trends shall record data samples every Change of Value (COV)				

3. Alarms

UNIT	Alarms and Conditions		
Alarm Name	Point	Normal	Alarm
BACnet Interface Alarms	Varies	Varies	Varies
Filter Maintenance (FILTER)	FLTR	OFF	ON
Space Temperature (TEMP)	RMT	< +/- 4°F SP	> +/-4°F SP
Humidity Alarm (HUMIDITY)	RMRH	<10%r.h. SP	>10%r.h. SP
Low Limit Switch (LLSTRIP)	LLS	OFF	ON
Liquid Detection (LIQUID)	LDS	OFF	ON
Cooling Failure (COOLFAIL)	See Sequence of Operations		
Heating Failure (HEATFAIL)	See Sequence of Operations		
Discharge Air Temp (DATLO)	DAT	> 45 °F	< 45 °F
Mixed Air Temperature (MATLO)	MAT	See Sequence of Operations	
Fan Failure (FAIL)	#FSS #FSTS	#FSS = ON #FST = ON	#FSS = ON #FST = OFF
Fan in Hand (HAND)	#FSS #FSt	#FSS = OFF #FST = OFF	#FSS = OFF #FST = ON
Fan Fault Alarm (FAULT)	#FFLT	OFF	ON
Duct Static Pressure alarm	DSP		>+/- 10% SP
Building Static Pressure alarm	BSP		>+/- 10% SP
Air Flow	#ACFM		+/- 5% Set by TAB
High CO2 (HCO2)			> 1100 ppm 1 hour
High Air Temperature	#AT		#AT greater than #ASP+5 °F

Low Air Temperature	#AT		#AT -5 °F less than #ASP
Temp Sensor Failure (SENSOR)	Varies	-10°F < Input Input < 220°F	-10°F > Input Input > 220°F
Duct Smoke Detector (SMOKE)			

1.11 ROOF TOP UNIT (HOT WATER HEATING COIL) (CONNECTED TO VAV TERMINAL UNIT)

A. Reference the ATC diagrams for Heating & Ventilating Unit configuration, ATC devices, point types & locations

B. Coordination:
   1. The Unit Manufacturer (UM) shall provide the units as outlined under the equipment specifications & schedules.
   2. The Unit Manufacturer (UM) shall provide, factory install & wire a BACnet DDC controller, sensors, relays, status sensors & dampers actuators.
   3. The Mechanical contractor (MC) shall provide coordination between the Unit Manufacturer (UM) & the ATC contractor (ATC) for a complete integrated system.
   4. The following sequence of operations shall be the responsibility of the Unit Manufacturer (UM).

C. Scheduling
   1. The schedule shall be communicated to the Unit's BACnet MS/TP DDC controller as established in the GUI.
   2. The Unit shall remain in the "Unoccupied" mode until the Supply Fans status has been proven to be on by the Supply Fan Current Switch (CS).

D. Space Temperature Sensor (TS)-(Associated VAV Box Sensors)
   1. The Space Temperature sensor (TS) shall have a locally adjustable Heating and Cooling setpoint with an Override Pushbutton; when the button is depressed, the LED shall light & the Unit shall be scheduled into the "Occupied" mode for up to 3 hours (adj.); upon the expiration of the override, the Unit shall revert to its scheduled mode
   2. The setpoints shall be initially set at 72 °F (adj.) for heating (HSP) & 74 °F (adj.) for cooling (CSP) with a setpoint adjustment span setting of ± 4 °F (adj.).

E. Critical note:
   1. The Roof Top Unit with Refrigerant Leak Detection capabilities shall signal the associated Variable Air Volume Boxes upon the Refrigerant Detection alarming feature.

2. The following mitigation actions shall be completed in not more than 15 seconds after the initiation of the Refrigeration Leak Alarm signal, and shall be maintained for at least 5 minutes after the output signal has reset:
3. The Roof Top Unit shall energize the air circulation fan(s) of the equipment per the manufacturer's instructions.

F. HOT WATER COIL PUMPS:
1. The Unit's coil pump (CPSS) shall be commanded to "start" when the Outside Air temperature (OAT) is below 45 °F (adj.) or the low-limit switch (LLS) has tripped.

G. "Unoccupied" mode:
1. When the Unit is scheduled in the "Unoccupied" mode the Unit's Supply, Return and any associated exhaust fans Fan shall be off; the Outside (OAD) damper; the Return damper (RAD) shall be open; the Direct eXpansion Cooling shall be off. The Heating Control (HTG#) shall be off.
2. "Unoccupied Cooling" mode:
    a. When the Space Temperature Sensor (TS) is > the "Unoccupied Cooling" Setpoint (UCSP) of 90 °F (adj.) & conditional use of mechanical cooling air conditions is allowed, the Rooftop Unit's Supply fan shall start and maintain the duct static pressure set point of 1.5 " w.c.. Any associated exhaust fans shall remain off. When the Supply Fan has been proven on by the Supply Fan Current Switch (CS), the Direct eXpansion Cooling (DX) shall be modulated on to maintain a Discharge Air Setpoint (DASP) of 55 °F. When the Space Temperature (TS) lowers below the "Unoccupied Cooling" Setpoint (UCSP) hysteresis, the Direct eXpansion Cooling (DX) shall be modulated off. The Rooftop Unit's Supply fan shall stop.
    b. The Heating Control (HTG#) shall remain off.
    c. The owner shall have the ability to disable this feature via software.
3. "Unoccupied Heating" mode:
    a. When any Space Temperature Sensor (TS) is < the "Unoccupied Heating" Setpoint (UHSP) of 60 °F (adj.), the Rooftop Unit's Supply fan shall start and maintain the duct static pressure set point of 1.5 " w.c.. Any associated exhaust fans shall remain off. When the Supply Fan has been proven on by the Supply Fan Current Switch (CS), the Heating Control Valve (HTG#) shall be modulated on to maintain a Discharge Air Setpoint (DASP) of 85 °F. When the Space Temperature (TS) is > the "Unoccupied Heating" Setpoint (UHSP) Hysteresis, the Heating Control Valve (HTG#) shall be modulated off and the Rooftop Unit's Supply fan shall stop.

H. "Occupied" mode:
1. When the unit is scheduled in the "Occupied" mode, the unit's Supply fan shall start & run continuously and all associated VAV Boxes shall fully open. The Outside (OAD) & Return (RAD) dampers shall open to the Minimum Outside Air setting (adj.)(OAMINSP)

2. Upon the transition of the unit to “Occupied” mode, a 10 minute ramp shall be implemented before the Outside dampers (OAD) can go fully open.
3. Morning “Warm-up” mode:
    a. The Unit shall be placed in “Warm-up” mode when any Space Temperature (TS) is > 5 °F (adj.) below the Space Heating Setpoint (HSP) or the Return Air Temperature (RAT) is < the “Warm-up” setpoint (WUSP) of 66 °F (adj.) (WUSP).
    b. When the Unit is placed in warm-up mode all associated Exhaust fans shall stop; the Outside (OAD) damper shall be closed. The Return damper (RAD) shall be opened, the Heating Control Valve (HTG#) shall be modulated on to maintain a Discharge Air Setpoint (DASP) of 85 °F (adj.).
    c. The Unit shall be released from “Warm-up” mode when the Return Air Temperature (RAT) > the “Warm-up” Setpoint (WASP) Hysteresis or all Space Temperature (TS) is < 2 °F (adj.) below the Space Heating Setpoint (HSP).
    d. When the Unit is released from warm-up mode the Outside (OAD) & Return (RAD) dampers, the Heating Control (HTG#) and associated VAV Boxes shall revert to their scheduled mode.
4. Heating Mode Control:
    a. The Discharge Air Temperature Sensor (DAT), through the BACnet DDC controller, shall modulate the Heating Control (HTG#) to maintain the Discharge Air Setpoint (DASP).
    b. When the Discharge Air Sensor (DAT) is < the Discharge Air Setpoint (DASP), the BACnet DDC controller shall modulated the Heating Control (HTG#) on.
    c. When the Discharge Air Sensor (DAT) is > the Discharge Air Setpoint (DASP), the BACnet DDC controller shall modulated the Heating Control (HTG#) off.
5. Cooling mode Selection:
    a. Free Cooling Economizer: When the Outside Air temperature (OAT) is < the Return Air Temperature (RAT) by > 8 °F (adj.)
    b. Mechanical Cooling: When the Outside Air Temperature (OAT) is > 45 °F (adj.) & is < 8°F below the Return Air Temperature (RAT)
6. Free Cooling Economizer mode:
    a. The use of the Free Cooling economizer shall be used to cool the Space Temperature (TS) as required. A Mixed Air Temperature sensor (MAT) shall, through the Rooftop Unit BACnet DDC controller, modulate the Outside (OAD) & Return (RAD) dampers to maintain Mixed Air Temperature Setpoint (MASP) - 10°F to the Space Cooling Setpoint (CSP). When the Space Temperature (TS) is > the Space Cooling Setpoint (CSP) the Outside (OAD) damper shall be modulated open; the Return (RAD) dampers modulated closed. When the Space Temperature (TS) is < the Space Cooling Setpoint (CSP) the Outside (OAD) damper shall be modulated closed; the Return (RAD) damper modulated open.

7. Lack of Adequate Free Cooling Operation
    a. When the Space Temperature (TS) remains above the Space Cooling Setpoint (CSP) for > 15 minutes, the Outside (OAD) & Return (RAD) dampers shall return to the Minimum Outside Air Setting (OAMINSP) & the mechanical cooling shall be utilized.
8. Mechanical Cooling mode:
    a. The Outside (OAD) & Return (RAD) dampers shall be fixed at the Minimum Outside Air setting (OAMINSP); the Direct eXpansion Cooling shall modulate sequence to maintain the Space Cooling Setpoint (CSP). When the Space Temperature (TS) is > Space Cooling Setpoint (CSP), the Direct eXpansion Cooling (DX) shall modulate on, When the Space Temperature (TS) is < Space Cooling Setpoint (CSP), the Direct eXpansion Cooling (DX) shall modulate off. During the Mechanical Cooling mode the Heating mode shall be disabled.
9. Discharge Air Temperature Low-Limit:
    a. The Discharge Air Temperature sensor (DAT) shall, through the BACnet DDC controller, override the Heating Control (HTG#) to maintain the Discharge Air Low Limit (DALL) of 45 °F (adj.). When the Discharge Air Temperature (DAT) fails to increase above 45 °F after the Heating Control (HTG#) is fully on, the Outside damper (OAD) shall be modulated closed & an alarm shall be generated. (DATLO). This sequence shall be inhibited when the Rooftop Unit is in mechanical cooling.
10. Demand Control Ventilation
    a. The CO2 (CO2) levels shall, through the BACnet DDC controller, adjust the Outside (OAD) & Return (RAD) dampers position in order to maintain a CO2 setpoint (CO2SP) of 900 ppm. When the CO2 (CO2) is > the CO2 setpoint (CO2SP), the Outside (OAD) dampers shall modulate open and the Return (RAD) damper shall modulate closed. When the CO2 (CO2) is < the CO2 setpoint (CO2SP), the Outside (OAD) & Return (RAD) dampers shall revert back to schedule mode.

I. Modulating hot gas reheat
    1. The unit is provided with fully modulating, sub cooling, hot gas reheat coil. The control sequence used for dehumidification in a unit uses two separate points of control. The first point is the leaving coil temperature sensor (LCT), and the second point is the discharge air temperature sensor (DAT). During dehumidification the refrigeration circuit controls the compressor(s) to maintain the LCT setpoint (adjustable) and the reheat coil is controlled to maintain the supply air reheat setpoint. The supply air reheat setpoint changes based on the whether there is a call for <u>both cooling and dehumidification</u> or a call for <u>dehumidification only</u>. When a call for both cooling and dehumidification is made the reheat setpoint is set as the cooling DAT setpoint. During a call for dehumidification only the reheat setpoint is reset in a linear manner between two endpoints referred to as the min and max reheat setpoints (adjustable).

This reset is based on the cooling and heating setpoints for the RTU. This logic will send warmer supply air when the space is approaching the heating changeover setpoint and cooler supply air when the space is approaching cooling changeover setpoint. This logic prevents unnecessary fluctuations between cooling and heating states.

2. Unit dehumidification controls allow the unit to cool and dehumidify simultaneously or just dehumidify if no cooling is needed.
3. To enable the dehumidification sequence the following options are available:
    a. Relative Humidity : Dehumidification will be activated when the relative humidity in the return duct, space, or outdoor air rises above the dehumidification set point.
    b. Dew Point: Dehumidification will be activated when the dew point in the return duct, space, or outdoor air rises above the dehumidification set point.
    c. Reheat Always: The unit will always overcool the air to the LCT setpoint and reheat it to the reheat setpoint unless the unit is in the heating state.
4. Notes
    a. The option for dew point dehumidification uses a relative humidity sensor.
    b. The user must define the location of the sensor in the unit controller as Space, OAT, or RAT.
    c. The unit controller will reference the temperature sensor in the specified location and calculate the dew point based on that temperature and the reading from the relative humidity sensor.
    d. This is the most commonly used option for 100% outside air units used to provide neutral air.
    e. Enabling dehumidification based on outside air dew point is the second most common option for 100% outside air units.

J. Air Filter Monitoring
1. A Differential Pressure Switch (DPS) at each filter bank shall be set as per the manufacturers rating for a dirty filter. When the filter exceeds this rating, the filter switch shall indicate a dirty filter alarm (FILTERSP) at the GUI.

K. Leak Detection
1. A Condensate Pan switch shall provide an alarm to the BMS when there is liquid detected in the drain pan.

L. Duct Smoke Detection
1. The Division 16 Electrical Contractor (EC) shall provide the interlock wiring for the Unit shut down; provide the smoke detectors with a spare contact for use by the ATC system; provide, field install & wire the Fire Alarm System shutdown/purge from the FACP panel.
2. The Division 15 Mechanical Contractor shall be install the smoke detectors

M. Alarms & Unit Safeties Monitoring

1. Fan Failure (FANFAIL): Commanded on, but the status (CS) is off.
2. Fan in Hand (FANHAND): Commanded off, but the status (CS) is on.
3. Hi/Low Space Air Temp: When the Space Temperature (TS) is > 85 °F (adj.) < 55 °F (adj.).
4. Hi/Low Discharge Air Temp: When the Discharge Air Temperature (DAT) is > 120 °F (adj.) < 50 °F (adj.).
5. Hi/Lo Mixed Air Temp: When the Mixed Air Temperature is > 85°F (adj.) < 45°F (adj.).
6. High Filter Differential Pressure: When the pressure exceeds the set limit (adj.).
7. Smoke Detector: (SMOKE) when the smoke detector sensing smoke.
8. Cooling Failure (COOLFAIL): An alarm shall be generated when the Discharge Air Temperature (DAT) remains within 4°F (adj.) of the mixed air temperature, with the mechanical cooling utilized (for > 5 minutes). This alarm shall not be enabled until the zone has been on for 10 minutes (adj.).
9. Heating Failure (HEATFAIL): An alarm shall be generated when the Discharge Air Temperature (DAT) remains within 4°F (adj.) of the heating setpoint (HSP) & the heating signal is > 10% open (For > 5 minutes) This alarm shall not be enabled until the zone has been on for 10 minutes (adj.).

N. Operator & Graphical User Interface requirements

1. The ATC Control Diagrams & the table below shall provide for Operator Control of the HVAC equipment:

Rooftop Unit (Hot Water Heating)	I/O Points				Software Point						
Point Name/Description/Legend X = DDC I/O L=Local Control A = Adjustable O = Override	AI	AO	BI	BO	AV	BV	Sched-ule	Trend	Alarm	GUI	Initial-Alarm Setting
BACnet Communications Interface Points	X	X	X	X	X	X	X	X	X	X	
Supply Fan Start/Stop (SFSS)				O						X	
Supply Fan Status (SFCS)			X						X	X	
Direct eXpansion Stages (CLG#)				O						X	
Heating Control Valve (HTG#)				X		X		X		X	
Discharge Air Temperature (DAT)	X							X	X	X	
Mixed Air Temperature (MAT)	X							X	X	X	
Return Air Temperature (RAT)	X							X	X	X	
Return Air Humidity (RAH)	X							X	X	X	
Return Air Damper (RAD)		X						X		X	
Outside Air Damper (OAD)		X						X		X	
Filter (FLTR)			X					X	X	X	
Smoke Detector (SD)			X						X	X	On
Discharge Air Temp Setpoint (DASP)					X					X	(Seq.)
Discharge Air Temp. Low Limit (DALL)					X					X	55°F

Mixed Air Temperature Setpoint (MASP)					X					X	(Seq.)
“Warm-up” Setpoint (WUSP)					X					X	68°F
Outside damper Min Posi-tion(OAMINSP)					X					X	by Bal
Alarm Reset			X			X		X	X	X	
Fan Failure (FANFAIL)						X			X	X	On
Fan in Hand (FANHAND)						X			X	X	ON
Space Temperature High Alarm (STHI)					A				A	X	>78°F
Space Temperature Low Alarm (STLO)					A				A	X	<55°F
Discharge Temp High Alarm (DATHI)					A				A	X	>110°F
Discharge Temp Low Alarm (DATLO)					A				A	X	<55°F
Mixed Temperature Hi Alarm (MATHI)					A				A	X	>85°F
Mixed Temperature Lo Alarm (MATLO)					A				A	X	<45°F
Dirty Filter (FLTR)						X			X	X	On
Cooling Failure (CLGFAIL)					A				A	X	On
Heating Failure (HEATFAIL)					A				A	X	On
Duct Smoke (SMOKE)						X			X	X	On
Leak Detection (LD)			X						X	X	

1.12 ENERGY RECOVERY UNIT (GAS FURNACE)

A. Reference the ATC diagrams for Unit configuration, ATC devices, point types & locations

B. Coordination:
   1. The Unit Manufacturer (UM) shall provide the units as outlined under the equipment specifications & schedules.
   2. The Unit Manufacturer (UM) shall provide, factory install & wire a BACnet DDC controller, sensors, relays, status sensors & dampers actuators.
   3. The Mechanical contractor (MC) shall provide coordination between the Unit Manufacturer (UM) & the ATC contractor (ATC) for a complete integrated system.
   4. The following sequence of operations shall be the responsibility of the Unit Manufacturer (UM).

C. Scheduling
   1. The schedule shall be communicated to the Honeywell Niagara 4 Platform BACnet IP DDC controller as established in the GUI.
   2. The unit shall remain in the “Unoccupied” mode until the Supply Fans status has been proven to be on by the Supply Fan Current Switch (CS)

D. SPACE TEMPERATURE SENSOR (RMT):
   1. The Space Temperature Sensor(s) (RMT) shall have an LCD screen depicting the Temperature and Setpoints.
   2. The Space Temperature sensor(s) (RMT) located in public areas shall have a blank faces.
   3. The Space Temperature sensor(s) (RMT) located in public areas shall have a blank vented stainless-steel design.

E. SPACE TEMPERATURE SETPOINTS:
   1. The Space Heating (HSP/UHSP) and Cooling (CSP/UCSP) shall be controlled from the GUI. The setpoints shall initially be 72 °F (adj.) for heating (HSP) and 74 °F (adj.) for cooling (CSP) with a setpoint adjustment span setting of ± 4 °F (adj.).

F. Critical note:
   1. The ERU with Refrigerant Leak Detection capabilities shall signal the associated Variable Air Volume Boxes upon the Refrigerant Detection alarming feature.
   2. The following mitigation actions shall be completed in not more than 15 seconds after the initiation of the Refrigeration Leak Alarm signal, and shall be maintained for at least 5 minutes after the output signal has reset:
   3. The ERU shall energize the air circulation fan(s) of the equipment per the manufacturer's instructions.

G. "Unoccupied" Mode:
   1. During the unoccupied mode, the Energy Recovery unit's Supply & Exhaust Fans shall be off, the energy recovery wheel shall be off, the outdoor air damper and exhaust dampers shall be closed and the associated heating coil and cooling coil shall remain off.

H. "Occupied" Mode:
   1. During the occupied mode of operations the outside air damper and the exhaust air damper shall open, the Supply and Exhaust Fans shall be energized and the energy recovery wheel shall be energized.
   2. Occupied Heating Mode:
      a. The gas heating control valve shall modulate to maintain discharge air temperature (via BMS Communcations) setpoint (DATSP) of 60°F (adj.).
   3. Occupied Cooling Mode:
      a. The DX cooling coil shall modulate to maintain discharge air temperature (via BMS Communications) set point (DATSP) of 64°F (adj.).

I. Supply Fan and Exhaust Fan Variable Frequency Drives (VFDs)

   1. During Normal Operations:
      a. The Supply Fan and Exhaust Fan VFDs shall run continuously.
      b. The Exhaust Fan VFD shall track the Supply Fan VFD speed.
   2. During High Space Carbon Dioxide Levels

a. The Supply Fan VFD shall speed up to provide more outdoor air into the space. Once space carbon dioxide levels are below the carbon dioxide level set point of 900 ppm (adj.), the Supply Fan VFD shall revert back to normal operations.

b. Exhaust fan control:

1) Exhaust fans are direct drive electrically commutated motor(s) (ECM). Powered exhaust control options are as follows:

2) Building pressure Control: A differential pressure transducer shall compare the indoor building pressure to ambient atmospheric pressure. The exhaust fan(s) shall modulate to maintain the building pressure set point.

3) Speed Control: The exhaust fan(s) will run at a constant speed.

4) Network Control: Exhaust fan speed is commanded from the building automation system.

5) Outdoor Air Damper Tracking (Mixed air units only): The exhaust fan(s) will activate based on the outside air damper position and will modulate between an adjustable minimum and maximum as the OA damper opens to provide relief.

J. Modulating hot gas reheat

1. The unit is provided with fully modulating, sub cooling, hot gas reheat coil. The control sequence used for dehumidification in a unit uses two separate points of control. The first point is the leaving coil temperature sensor (LCT), and the second point is the discharge air temperature sensor (DAT). During dehumidification the refrigeration circuit controls the compressor(s) to maintain the LCT setpoint (adjustable) and the reheat coil is controlled to maintain the supply air reheat setpoint. The supply air reheat setpoint changes based on the whether there is a call for <u>both cooling and dehumidification</u> or a call for <u>dehumidification only</u>. When a call for both cooling and dehumidification is made the reheat setpoint is set as the cooling DAT setpoint. During a call for dehumidification only the reheat setpoint is reset in a linear manner between two endpoints referred to as the min and max reheat setpoints (adjustable). This reset is based on the cooling and heating setpoints for the ERU. This logic will send warmer supply air when the space is approaching the heating changeover setpoint and cooler supply air when the space is approaching cooling changeover setpoint. This logic prevents unnecessary fluctuations between cooling and heating states.
2. Unit dehumidification controls allow the unit to cool and dehumidify simultaneously or just dehumidify if no cooling is needed.
3. To enable the dehumidification sequence the following options are available:
   a. <u>Relative Humidity</u> : Dehumidification will be activated when the relative humidity in the return duct, space, or outdoor air rises above the dehumidification set point.

b. Dew Point: Dehumidification will be activated when the dew point in the return duct, space, or outdoor air rises above the dehumidification set point.
c. Reheat Always: The unit will always overcool the air to the LCT setpoint and reheat it to the reheat setpoint unless the unit is in the heating state.

4. Notes
   a. The option for dew point dehumidification uses a relative humidity sensor.
   b. The user must define the location of the sensor in the unit controller as Space, OAT, or RAT.
   c. The unit controller will reference the temperature sensor in the specified location and calculate the dew point based on that temperature and the reading from the relative humidity sensor.
   d. This is the most commonly used option for 100% outside air units used to provide neutral air.
   e. Enabling dehumidification based on outside air dew point is the second most common option for 100% outside air units.

K. Low Leak Detector
1. The unit manufacturer shall provide a low leak condensate detector. Upon activation the ERU shall send an alarm to the BMS front-end and shutdown the ERU unit.

L. Dirty Filter Switches
1. The unit manufacturer shall provide a differential pressure switch across both the exhaust and supply filters. Upon activation the ERU shall send an alarm to the BMS front-end.

M. Duct Smoke Detection
1. The Division 16 Electrical Contractor (EC) shall provide the interlock wiring for the Unit shut down; provide the smoke detectors with a spare contact for use by the ATC system; provide, field install & wire the Fire Alarm System shutdown/purge from the FACP panel.
2. The Division 15 Mechanical Contractor shall be install the smoke detectors

N. Alarms & Safeties Monitoring:
1. Fan Failure (FANFAIL): Commanded on, but the status (CS) is off.
2. Fan in Hand (FANHAND): Commanded off, but the status (CS) is on.
3. Hi/Low Discharge Air Temp: When the Discharge Air Temperature (DAT) is > 120 °F (adj.) < 50 °F (adj.).
4. Heating Failure (HEATFAIL): An alarm shall be generated when the Discharge Air Temperature (DAT) remains within 4°F (adj.) of the heating setpoint (HSP) & the heating signal is > 10% open (For > 5 minutes) This alarm shall not be enabled until the zone has been on for 10 minutes (adj.).

5. Cooling Failure (COOLFAIL): An alarm shall be generated when the Discharge Air Temperature (DAT) remains within 4°F (adj.) of the mixed air temperature, with the mechanical cooling utilized (for > 5 minutes). This alarm shall not be enabled until the zone has been on for 10 minutes (adj.).
6. Smoke Detector: (SMOKE) when the smoke detector sensing smoke.
7. High Filter Differential Pressure: When the pressure exceeds the set limit (adj.).

O. Operator & Graphical User Interface requirements

1. The ATC Control Diagrams & the table below shall provide for Operator Control of the HVAC equipment:

Energy Recovery Unit(s) ERU-1	I/O Points				Software Point						
Point Name/Description/Legend X = DDC I/O L=Local Control A = Adjustable O = Override	AI	AO	BI	BO	AV	BV	Sched-ule	Trend	Alarm	GUI	Initial-Alarm Setting
Supply Fan Start/Stop (SFSS)				O						X	
Supply Fan VFD Signal (SFS)		X								X	
Supply Fan VFD Alarm Status (SFAS)			X							X	
Supply Fan Status (SFCS)			X						X	X	
Exhaust Fan Start/Stop (EFSS)				X						X	
Exhaust Fan VFD Signal (EFS)		X								X	
Exhaust Fan VFD Alarm Status (EFAS)			X							X	
Exhaust Fan Status (EFCS)			X						X	X	
Discharge Air Temperature (DAT)	X							X	X	X	
Outside Air Damper (OAD)				X						X	
Exhaust Air Damper (EAD)				X						X	
Discharge Air Temp. Setpoint (DASP)					X					X	(Seq.)
Alarm Reset			X			X		X	X	X	
Fan Failure (FANFAIL)						X			X	X	On
Fan in Hand (FANHAND)						X			X	X	ON
Discharge Temp High Alarm (DATHI)					A				A	X	>110°F
Discharge Temp Low Alarm (DATLO)					A				A	X	<55°F
Heating Failure (HEATFAIL)					A				A	X	On
Gas Heating Coil Enable/Disable(HED)				X						X	
Gas Heating Control Signal (GHCS)		X								X	
DX Cooling Enable/Disable (DXED)				X						X	
DX Cooling Control Signal (DXCS)		X								X	
Hot Gas Reheat Enable/Disable (HGRHED)				X						X	
Hot Gas Reheat Control Signal (HGRHCS)		X								X	
Return Air Temp. (RAT)	X									X	
Exhaust Air Temp (EAT)	X									X	

Energy Recovery Wheel Enable/Disable (ERWED)				X						X	
Engergy Recovery Wheel Control Signal (ERWCS)		X								X	
Exhaust Air Filter (EAF)			X							X	
Outdoor Air Filter (OAF)			X							X	
Leak Detector (LD)			X							X	

1.13 ENERGY RECOVERY UNIT (GAS FURNACE) (ERU-2 ONLY MAXIMUM VENTILATION)

A. GENERAL DESCRIPTION: Reference the BMS diagrams for Unit configuration, BMS device(s), point types and locations.

B. COORDINATION: The BMSC shall provide, install, wire, and monitor a mushroom pushbutton switch with a protective flip cover. This device shall be located in the main office and shall initiate a “Maximum Ventilation Purge” command to the OEM Equipment .

C. “MAXIMUM VENTILATION”: When the “Maximum Ventilation Purge ” pushbutton status (PPBST) is manually actuated, A hard-wired command shall be sent to all of the OEM equipment to be enabled. The Outside Air damper (OAD) and Exhaust Air damper (EAD) of OEM controlled equipment’s shall be commanded “open” and the Return Air damper (RAD) commanded to “close”. The HVAC equipment shall otherwise perform their normal “Occupied” temperature control functions. All safeties shall remain active and enabled. The Central Heating Plant shall be enabled.

D. “RETURN TO NORMAL”: When the “Maximum Ventilation Purge” pushbutton (PPBST) is reset to its normal position, the OEM Equipment shall return to scheduled operations.

E. “MAXIMUM VENTILATION PURGE” ALARM (PURGE): If the Maximum Ventilation Purge pushbutton status (PPBST) indicates it is not in its Normal condition, an “Maximum Ventilation Purge alarm (PURGE) shall be sent to the GUI.

F. OPERATOR INTERFACE REQUIREMENTS:

1. Input/Output Points:

Ventilation	I/O Points						
Point Name/Description/Legend X = DDC I/O L = Local Control A = Adjustable O = Override	BAV	BAV	BBV	BBBV	Trend	GUI	Device
Maximum Ventilation Purge pushbutton (PPBST)			X		X	X	PB

2. Control Parameters and Settings

Global – BMS Emergency Purge	Parameters and Settings

Parameter Name/Description X = Display on GUI A = Adjustable	AV	Trend	GUI	Initial- Setting
Maximum Ventilation Purge (PURGE)	A	X	X	
Alarm Reset	A	X	X	

3. Alarms

Global – BMS Emergency Purge	Alarms and Conditions		
Alarm Name	Point	Normal	Alarm
BMS - Emergency Purge Alarm	PPBST	OFF	ON

1.14 ROOF TOP UNIT (GAS FURNACE) (CONNECTED TO VAV TERMINAL UNIT)

A. Reference the ATC diagrams for Heating & Ventilating Unit configuration, ATC devices, point types & locations

B. Coordination:
   1. The Unit Manufacturer (UM) shall provide the units as outlined under the equipment specifications & schedules.
   2. The Unit Manufacturer (UM) shall provide, factory install & wire a BACnet DDC controller, sensors, relays, status sensors & dampers actuators.
   3. The Mechanical contractor (MC) shall provide coordination between the Unit Manufacturer (UM) & the ATC contractor (ATC) for a complete integrated system.
   4. The following sequence of operations shall be the responsibility of the Unit Manufacturer (UM).

C. Scheduling
   1. The schedule shall be communicated to the Unit's BACnet MS/TP DDC controller as established in the GUI.
   2. The Unit shall remain in the "Unoccupied" mode until the Supply Fans status has been proven to be on by the Supply Fan Current Switch (CS).

D. Space Temperature Sensor (TS)-(Associated VAV Box Sensors)
   1. The Space Temperature sensor (TS) shall have a locally adjustable Heating and Cooling setpoint with an Override Pushbutton; when the button is depressed, the LED shall light & the Unit shall be scheduled into the "Occupied" mode for up to 3 hours (adj.); upon the expiration of the override, the Unit shall revert to its scheduled mode
   2. The setpoints shall be initially set at 72 °F (adj.) for heating (HSP) & 74 °F (adj.) for cooling (CSP) with a setpoint adjustment span setting of ± 4 °F (adj.).

E. Critical note:

1. The Roof Top Unit with Refrigerant Leak Detection capabilities shall signal the associated Variable Air Volume Boxes upon the Refrigerant Detection alarming feature.
2. The following mitigation actions shall be completed in not more than 15 seconds after the initiation of the Refrigeration Leak Alarm signal, and shall be maintained for at least 5 minutes after the output signal has reset:
3. The Roof Top Unit shall energize the air circulation fan(s) of the equipment per the manufacturer's instructions.

F. "Unoccupied" mode:
1. When the Unit is scheduled in the "Unoccupied" mode the Unit's Supply, Return and any associated exhaust fans Fan shall be off; the Outside (OAD) damper; the Return damper (RAD) shall be open; the Direct eXpansion Cooling shall be off. The Gas Heating (HTG#) shall be off.
2. "Unoccupied Cooling" mode:
   a. When the Space Temperature Sensor (TS) is > the "Unoccupied Cooling" Setpoint (UCSP) of 90 °F (adj.) & conditional use of mechanical cooling air conditions is allowed, the Rooftop Unit's Supply fan shall start and maintain the duct static pressure set point of 1.5 " w.c.. Any associated exhaust fans shall remain off. When the Supply Fan has been proven on by the Supply Fan Current Switch (CS), the Direct eXpansion Cooling (DX) shall be modulated on to maintain a Discharge Air Setpoint (DASP) of 55 °F. When the Space Temperature (TS) lowers below the "Unoccupied Cooling" Setpoint (UCSP) hysteresis, the Direct eXpansion Cooling (DX) shall be modulated off. The Rooftop Unit's Supply fan shall stop.
   b. The Gas Heating (HTG#) shall remain off.
   c. The owner shall have the ability to disable this feature via software.
3. "Unoccupied Heating" mode:
   a. When any Space Temperature Sensor (TS) is < the "Unoccupied Heating" Setpoint (UHSP) of 60 °F (adj.), the Rooftop Unit's Supply fan shall start and maintain the duct static pressure set point of 1.5 " w.c.. Any associated exhaust fans shall remain off. When the Supply Fan has been proven on by the Supply Fan Current Switch (CS), the Gas Heating (HTG#) shall be modulated on to maintain a Discharge Air Setpoint (DASP) of 85 °F. When the Space Temperature (TS) is > the "Unoccupied Heating" Setpoint (UHSP) Hysteresis, the Gas Heating (HTG#) shall be modulated off and the Rooftop Unit's Supply fan shall stop.

G. "Occupied" mode:
1. When the unit is scheduled in the "Occupied" mode, the unit's Supply fan shall start & run continuously and all associated VAV Boxes shall fully open. The Outside (OAD) & Return (RAD) dampers shall open to the Minimum Outside Air setting (adj.)(OAMINSP)

2. Upon the transition of the unit to “Occupied” mode, a 10 minute ramp shall be implemented before the Outside dampers (OAD) can go fully open.
3. Morning “Warm-up” mode:
    a. The Unit shall be placed in “Warm-up” mode when any Space Temperature (TS) is > 5 °F (adj.) below the Space Heating Setpoint (HSP) or the Return Air Temperature (RAT) is < the “Warm-up” setpoint (WUSP) of 66 °F (adj.) (WUSP).
    b. When the Unit is placed in warm-up mode all associated Exhaust fans shall stop; the Outside (OAD) damper shall be closed. The Return damper (RAD) shall be opened, the Gas Heating (HTG#) shall be modulated on to maintain a Discharge Air Setpoint (DASP) of 85 °F (adj.).
    c. The Unit shall be released from “Warm-up” mode when the Return Air Temperature (RAT) > the “Warm-up” Setpoint (WASP) Hysteresis or all Space Temperature (TS) is < 2 °F (adj.) below the Space Heating Setpoint (HSP).
    d. When the Unit is released from warm-up mode the Outside (OAD) & Return (RAD) dampers, the Gas Heating (HTG#) and associated VAV Boxes shall revert to their scheduled mode.
4. Heating Mode Control:
    a. The Discharge Air Temperature Sensor (DAT), through the BACnet DDC controller, shall modulate the Gas Heating (HTG#) to maintain the Discharge Air Setpoint (DASP).
    b. When the Discharge Air Sensor (DAT) is < the Discharge Air Setpoint (DASP), the BACnet DDC controller shall modulated the Gas Heating (HTG#) on.
    c. When the Discharge Air Sensor (DAT) is > the Discharge Air Setpoint (DASP), the BACnet DDC controller shall modulated the Gas Heating (HTG#) off.
5. Cooling mode Selection:
    a. Free Cooling Economizer: When the Outside Air temperature (OAT) is < the Return Air Temperature (RAT) by > 8 °F (adj.)
    b. Mechanical Cooling: When the Outside Air Temperature (OAT) is > 45 °F (adj.) & is < 8°F below the Return Air Temperature (RAT)
6. Free Cooling Economizer mode:
    a. The use of the Free Cooling economizer shall be used to cool the Space Temperature (TS) as required. A Mixed Air Temperature sensor (MAT) shall, through the Rooftop Unit BACnet DDC controller, modulate the Outside (OAD) & Return (RAD) dampers to maintain Mixed Air Temperature Setpoint (MASP) - 10°F to the Space Cooling Setpoint (CSP). When the Space Temperature (TS) is > the Space Cooling Setpoint (CSP) the Outside (OAD) damper shall be modulated open; the Return (RAD) dampers modulated closed. When the Space Temperature (TS) is < the Space Cooling Setpoint (CSP) the Outside (OAD) damper shall be modulated closed; the Return (RAD) damper modulated open.

7. Lack of Adequate Free Cooling Operation
    a. When the Space Temperature (TS) remains above the Space Cooling Setpoint (CSP) for > 15 minutes, the Outside (OAD) & Return (RAD) dampers shall return to the Minimum Outside Air Setting (OAMINSP) & the mechanical cooling shall be utilized.
8. Mechanical Cooling mode:
    a. The Outside (OAD) & Return (RAD) dampers shall be fixed at the Minimum Outside Air setting (OAMINSP); the Direct eXpansion Cooling shall modulate sequence to maintain the Space Cooling Setpoint (CSP). When the Space Temperature (TS) is > Space Cooling Setpoint (CSP), the Direct eXpansion Cooling (DX) shall modulate on, When the Space Temperature (TS) is < Space Cooling Setpoint (CSP), the Direct eXpansion Cooling (DX) shall modulate off. During the Mechanical Cooling mode the Heating mode shall be disabled.
9. Discharge Air Temperature Low-Limit:
    a. The Discharge Air Temperature sensor (DAT) shall, through the BACnet DDC controller, override the Gas Heating (HTG#) to maintain the Discharge Air Low Limit (DALL) of 45 °F (adj.). When the Discharge Air Temperature (DAT) fails to increase above 45 °F after the Gas Heating (HTG#) is fully on, the Outside damper (OAD) shall be modulated closed & an alarm shall be generated. (DATLO). This sequence shall be inhibited when the Rooftop Unit is in mechanical cooling.
10. Demand Control Ventilation
    a. The CO2 (CO2) levels shall, through the BACnet DDC controller, adjust the Outside (OAD) & Return (RAD) dampers position in order to maintain a CO2 setpoint (CO2SP) of 900 ppm. When the CO2 (CO2) is > the CO2 setpoint (CO2SP), the Outside (OAD) dampers shall modulate open and the Return (RAD) damper shall modulate closed. When the CO2 (CO2) is < the CO2 setpoint (CO2SP), the Outside (OAD) & Return (RAD) dampers shall revert back to schedule mode.

H. Modulating hot gas reheat
    1. The unit is provided with fully modulating, sub cooling, hot gas reheat coil. The control sequence used for dehumidification in a unit uses two separate points of control. The first point is the leaving coil temperature sensor (LCT), and the second point is the discharge air temperature sensor (DAT). During dehumidification the refrigeration circuit controls the compressor(s) to maintain the LCT setpoint (adjustable) and the reheat coil is controlled to maintain the supply air reheat setpoint. The supply air reheat setpoint changes based on the whether there is a call for <u>both cooling and dehumidification</u> or a call for <u>dehumidification only</u>. When a call for both cooling and dehumidification is made the reheat setpoint is set as the cooling DAT setpoint. During a call for dehumidification only the reheat setpoint is reset in a linear manner between two endpoints referred to as the min and max reheat setpoints (adjustable).

This reset is based on the cooling and heating setpoints for the RTU. This logic will send warmer supply air when the space is approaching the heating changeover setpoint and cooler supply air when the space is approaching cooling changeover setpoint. This logic prevents unnecessary fluctuations between cooling and heating states.

2. Unit dehumidification controls allow the unit to cool and dehumidify simultaneously or just dehumidify if no cooling is needed.
3. To enable the dehumidification sequence the following options are available:
    a. Relative Humidity : Dehumidification will be activated when the relative humidity in the return duct, space, or outdoor air rises above the dehumidification set point.
    b. Dew Point: Dehumidification will be activated when the dew point in the return duct, space, or outdoor air rises above the dehumidification set point.
    c. Reheat Always: The unit will always overcool the air to the LCT setpoint and reheat it to the reheat setpoint unless the unit is in the heating state.
4. Notes
    a. The option for dew point dehumidification uses a relative humidity sensor.
    b. The user must define the location of the sensor in the unit controller as Space, OAT, or RAT.
    c. The unit controller will reference the temperature sensor in the specified location and calculate the dew point based on that temperature and the reading from the relative humidity sensor.
    d. This is the most commonly used option for 100% outside air units used to provide neutral air.
    e. Enabling dehumidification based on outside air dew point is the second most common option for 100% outside air units.

I. Air Filter Monitoring
1. A Differential Pressure Switch (DPS) at each filter bank shall be set as per the manufacturers rating for a dirty filter. When the filter exceeds this rating, the filter switch shall indicate a dirty filter alarm (FILTERSP) at the GUI.

J. Leak Detection
1. A Condensate Pan switch shall provide an alarm to the BMS when there is liquid detected in the drain pan.

K. Duct Smoke Detection
1. The Division 16 Electrical Contractor (EC) shall provide the interlock wiring for the Unit shut down; provide the smoke detectors with a spare contact for use by the ATC system; provide, field install & wire the Fire Alarm System shutdown/purge from the FACP panel.
2. The Division 15 Mechanical Contractor shall be install the smoke detectors

L. Alarms & Unit Safeties Monitoring

1. Fan Failure (FANFAIL): Commanded on, but the status (CS) is off.
2. Fan in Hand (FANHAND): Commanded off, but the status (CS) is on.
3. Hi/Low Space Air Temp: When the Space Temperature (TS) is > 85 °F (adj.) < 55 °F (adj.).
4. Hi/Low Discharge Air Temp: When the Discharge Air Temperature (DAT) is > 120 °F (adj.) < 50 °F (adj.).
5. Hi/Lo Mixed Air Temp: When the Mixed Air Temperature is > 85°F (adj.) < 45°F (adj.).
6. High Filter Differential Pressure: When the pressure exceeds the set limit (adj.).
7. Smoke Detector: (SMOKE) when the smoke detector sensing smoke.
8. Cooling Failure (COOLFAIL): An alarm shall be generated when the Discharge Air Temperature (DAT) remains within 4°F (adj.) of the mixed air temperature, with the mechanical cooling utilized (for > 5 minutes). This alarm shall not be enabled until the zone has been on for 10 minutes (adj.).
9. Heating Failure (HEATFAIL): An alarm shall be generated when the Discharge Air Temperature (DAT) remains within 4°F (adj.) of the heating setpoint (HSP) & the heating signal is > 10% open (For > 5 minutes) This alarm shall not be enabled until the zone has been on for 10 minutes (adj.).

M. Operator & Graphical User Interface requirements

1. The ATC Control Diagrams & the table below shall provide for Operator Control of the HVAC equipment:

Rooftop Unit (GAS FIRED)	I/O Points				Software Point						
Point Name/Description/Legend X = DDC I/O L=Local Control A = Adjustable O = Override	AI	AO	BI	BO	AV	BV	Sched-ule	Trend	Alarm	GUI	Initial-Alarm Setting
BACnet Communications Interface Points	X	X	X	X	X	X	X	X	X	X	
Supply Fan Start/Stop (SFSS)				O						X	
Supply Fan Status (SFCS)			X						X	X	
Direct eXpansion Stages (CLG#)				O						X	
Gas Heating (HTG#)				X		X		X		X	
Discharge Air Temperature (DAT)	X							X	X	X	
Mixed Air Temperature (MAT)	X							X	X	X	
Return Air Temperature (RAT)	X							X	X	X	
Return Air Humidity (RAH)	X							X	X	X	
Return Air Damper (RAD)		X						X		X	
Outside Air Damper (OAD)		X						X		X	
Filter (FLTR)			X					X	X	X	
Smoke Detector (SD)			X						X	X	On
Discharge Air Temp Setpoint (DASP)					X					X	(Seq.)
Discharge Air Temp. Low Limit (DALL)					X					X	55°F

Mixed Air Temperature Setpoint (MASP)					X					X	(Seq.)
"Warm-up" Setpoint (WUSP)					X					X	68°F
Outside damper Min Posi-tion(OAMINSP)					X					X	by Bal
Alarm Reset			X			X		X	X	X	
Fan Failure (FANFAIL)						X			X	X	On
Fan in Hand (FANHAND)						X			X	X	ON
Space Temperature High Alarm (STHI)					A				A	X	>78°F
Space Temperature Low Alarm (STLO)					A				A	X	<55°F
Discharge Temp High Alarm (DATHI)					A				A	X	>110°F
Discharge Temp Low Alarm (DATLO)					A				A	X	<55°F
Mixed Temperature Hi Alarm (MATHI)					A				A	X	>85°F
Mixed Temperature Lo Alarm (MATLO)					A				A	X	<45°F
Dirty Filter (FLTR)						X			X	X	On
Cooling Failure (CLGFAIL)					A				A	X	On
Heating Failure (HEATFAIL)					A				A	X	On
Duct Smoke (SMOKE)						X			X	X	On
Leak Detection (LD)			X						X	X	

1.15 SINGLE ZONE ROOF TOP UNIT (GAS FURNACE)

A. Reference the ATC diagrams for Heating & Ventilating Unit configuration, ATC devices, point types & locations

B. Coordination:
   1. The Unit Manufacturer (UM) shall provide the units as outlined under the equipment specifications & schedules.
   2. The Unit Manufacturer (UM) shall provide, factory install & wire a BACnet DDC controller, sensors, relays, status sensors & dampers actuators.
   3. The Mechanical contractor (MC) shall provide coordination between the Unit Manufacturer (UM) & the ATC contractor (ATC) for a complete integrated system.
   4. The following sequence of operations shall be the responsibility of the Unit Manufacturer (UM).

C. Scheduling
   1. The schedule shall be communicated to the Unit's BACnet MS/TP DDC controller as established in the GUI.
   2. The Unit shall remain in the "Unoccupied" mode until the Supply Fans status has been proven to be on by the Supply Fan Current Switch (CS).

D. SPACE TEMPERATURE SENSOR (RMT):
   1. The Space Temperature Sensor(s) (RMT) shall have an LCD screen depicting the Temperature and Setpoints.
   2. The Space Temperature sensor(s) (RMT) located in public areas shall have a blank faces.
   3. The Space Temperature sensor(s) (RMT) located in public areas shall have a blank vented stainless-steel design.

E. SPACE TEMPERATURE SETPOINTS:
   1. The Space Heating (HSP/UHSP) and Cooling (CSP/UCSP) shall be controlled from the GUI. The setpoints shall initially be 72 °F (adj.) for heating (HSP) and 74 °F (adj.) for cooling (CSP) with a setpoint adjustment span setting of ± 4 °F (adj.).

F. Critical note:
   1. The Roof Top Unit with Refrigerant Leak Detection capabilities shall signal the associated Variable Air Volume Boxes upon the Refrigerant Detection alarming feature.
   2. The following mitigation actions shall be completed in not more than 15 seconds after the initiation of the Refrigeration Leak Alarm signal, and shall be maintained for at least 5 minutes after the output signal has reset:
   3. The Roof Top Unit shall energize the air circulation fan(s) of the equipment per the manufacturer's instructions.

G. "Unoccupied" Mode:

   1. Whenever the associated Existing Air Handling Unit ((E) AHU-3) is in the unoccupied mode, the Rooftop Unit (RTU-1) shall be in the unoccupied mode.

   2. During the unoccupied mode, the Rooftop unit's Supply & Exhaust Fans shall be off, the outdoor air damper and exhaust dampers shall be closed, the return air damper shall be open and the associated heating coil and cooling coil shall remain off.

H. "Occupied" Mode:

   1. Whenever the assocated Existing Air Handling Unit ((E) AHU-3) is in the occupied mode, the Rooftop Unit (RTU-1) shall be in the occupied mode.

   2. During the occupied mode of operations the outside air damper and return air dampers shall be open to the minimum outside air position, and the Supply and Exhaust Fans shall be energized to run continuously.

   3. Occupied Heating Mode:
      a. The gas heating control valve shall modulate to maintain the space temperature set point (determined by the associated existing VAV box

serving the same area (via BACnet communications). Note: Associated existing VAV box served by existing Air Handling Unit (E) AHU-3).

4. Occupied Cooling Mode:
    a. The DX cooling coil shall modulate to maintain the space temperature set point (determined by the associated existing VAV box serving the same area (via BACnet communications). Note: Associated existing VAV box served by existing Air Handling Unit (E) AHU-3).

I. Demand Control Ventilation
    a. The CO2 (CO2) levels shall, through the BACnet DDC controller, adjust the Outside (OAD) & Return (RAD) dampers position in order to maintain a CO2 setpoint (CO2SP) of 900 ppm. When the CO2 (CO2) is > the CO2 setpoint (CO2SP), the Outside (OAD) dampers shall modulate open and the Return (RAD) damper shall modulate closed. When the CO2 (CO2) is < the CO2 setpoint (CO2SP), the Outside (OAD) & Return (RAD) dampers shall revert back to schedule mode.

J. Modulating hot gas reheat
1. The unit is provided with fully modulating, sub cooling, hot gas reheat coil. The control sequence used for dehumidification in a unit uses two separate points of control. The first point is the leaving coil temperature sensor (LCT), and the second point is the discharge air temperature sensor (DAT). During dehumidification the refrigeration circuit controls the compressor(s) to maintain the LCT setpoint (adjustable) and the reheat coil is controlled to maintain the supply air reheat setpoint. The supply air reheat setpoint changes based on the whether there is a call for <u>both cooling and dehumidification</u> or a call for <u>dehumidification only</u>. When a call for both cooling and dehumidification is made the reheat setpoint is set as the cooling DAT setpoint. During a call for dehumidification only the reheat setpoint is reset in a linear manner between two endpoints referred to as the min and max reheat setpoints (adjustable). This reset is based on the cooling and heating setpoints for the RTU. This logic will send warmer supply air when the space is approaching the heating changeover setpoint and cooler supply air when the space is approaching cooling changeover setpoint. This logic prevents unnecessary fluctuations between cooling and heating states.
2. Unit dehumidification controls allow the unit to cool and dehumidify simultaneously or just dehumidify if no cooling is needed.
3. To enable the dehumidification sequence the following options are available:
    a. <u>Relative Humidity</u> : Dehumidification will be activated when the relative humidity in the return duct, space, or outdoor air rises above the dehumidification set point.
    b. <u>Dew Point</u>: Dehumidification will be activated when the dew point in the return duct, space, or outdoor air rises above the dehumidification set point.

c. Reheat Always: The unit will always overcool the air to the LCT setpoint and reheat it to the reheat setpoint unless the unit is in the heating state.

4. Notes
   a. The option for dew point dehumidification uses a relative humidity sensor.
   b. The user must define the location of the sensor in the unit controller as Space, OAT, or RAT.
   c. The unit controller will reference the temperature sensor in the specified location and calculate the dew point based on that temperature and the reading from the relative humidity sensor.
   d. This is the most commonly used option for 100% outside air units used to provide neutral air.
   e. Enabling dehumidification based on outside air dew point is the second most common option for 100% outside air units.

K. Low Leak Detector
   1. The unit manufacturer shall provide a low leak condensate detector. Upon activation the ERU shall send an alarm to the BMS front-end and shutdown the ERU unit.

L. Dirty Filter Switches
   1. The unit manufacturer shall provide a differential pressure switch across both the exhaust and supply filters. Upon activation the ERU shall send an alarm to the BMS front-end.

M. Duct Smoke Detection
   1. The Division 16 Electrical Contractor (EC) shall provide the interlock wiring for the Unit shut down; provide the smoke detectors with a spare contact for use by the ATC system; provide, field install & wire the Fire Alarm System shutdown/purge from the FACP panel.
   2. The Division 15 Mechanical Contractor shall be install the smoke detectors

N. Alarms & Unit Safeties Monitoring
   1. Fan Failure (FANFAIL): Commanded on, but the status (CS) is off.
   2. Fan in Hand (FANHAND): Commanded off, but the status (CS) is on.
   3. Hi/Low Space Air Temp: When the Space Temperature (TS) is > 85 °F (adj.) < 55 °F (adj.).
   4. Hi/Low Discharge Air Temp: When the Discharge Air Temperature (DAT) is > 120 °F (adj.) < 50 °F (adj.).
   5. Hi/Lo Mixed Air Temp: When the Mixed Air Temperature is > 85°F (adj.) < 45°F (adj.).
   6. High Filter Differential Pressure: When the pressure exceeds the set limit (adj.).
   7. Smoke Detector: (SMOKE) when the smoke detector sensing smoke.
   8. Cooling Failure (COOLFAIL): An alarm shall be generated when the Discharge Air Temperature (DAT) remains within 4°F (adj.) of the mixed air temperature, with

the mechanical cooling utilized (for > 5 minutes). This alarm shall not be enabled until the zone has been on for 10 minutes (adj.).

9. Heating Failure (HEATFAIL): An alarm shall be generated when the Discharge Air Temperature (DAT) remains within 4°F (adj.) of the heating setpoint (HSP) & the heating signal is > 10% open (For > 5 minutes) This alarm shall not be enabled until the zone has been on for 10 minutes (adj.).

O. Operator & Graphical User Interface requirements

1. The ATC Control Diagrams & the table below shall provide for Operator Control of the HVAC equipment:

Rooftop Unit (RTU-1)	I/O Points				Software Point						
Point Name/Description/Legend X = DDC I/O L=Local Control A = Adjustable O = Override	AI	AO	BI	BO	AV	BV	Sched-ule	Trend	Alarm	GUI	Initial-Alarm Setting
BACnet Communications Interface Points	X	X	X	X	X	X	X	X	X	X	
Supply Fan Start/Stop (SFSS)				O						X	
Supply Fan Status (SFCS)			X						X	X	
Direct eXpansion Stages (CLG#)				O						X	
Gas Heating (HTG#)				X		X		X		X	
Discharge Air Temperature (DAT)	X							X	X	X	
Mixed Air Temperature (MAT)	X							X	X	X	
Return Air Temperature (RAT)	X							X	X	X	
Return Air Humidity (RAH)	X							X	X	X	
Return Air Damper (RAD)		X						X		X	
Outside Air Damper (OAD)		X						X		X	
Filter (FLTR)			X					X	X	X	
Smoke Detector (SD)			X						X	X	On
Discharge Air Temp Setpoint (DASP)					X					X	(Seq.)
Discharge Air Temp. Low Limit (DALL)					X					X	55°F
Mixed Air Temperature Setpoint (MASP)					X					X	(Seq.)
“Warm-up” Setpoint (WUSP)					X					X	68°F
Outside damper Min Posi-tion(OAMINSP)					X					X	by Bal
Alarm Reset			X			X		X	X	X	
Fan Failure (FANFAIL)						X			X	X	On
Fan in Hand (FANHAND)						X			X	X	ON
Space Temperature (ST)	X							X	X	X	
Space Temperature High Alarm (STHI)					A				A	X	>78°F
Space Temperature Low Alarm (STLO)					A				A	X	<55°F
Space Carbon Dioxide Levels (SCO2)	X							X	X	X	900ppm

Discharge Temp High Alarm (DATHI)					A				A	X	>110°F
Discharge Temp Low Alarm (DATLO)					A				A	X	<55°F
Mixed Temperature Hi Alarm (MATHI)					A				A	X	>85°F
Mixed Temperature Lo Alarm (MATLO)					A				A	X	<45°F
Dirty Filter (FLTR)						X			X	X	On
Cooling Failure (CLGFAIL)					A				A	X	On
Heating Failure (HEATFAIL)					A				A	X	On
Duct Smoke (SMOKE)						X			X	X	On
Leak Detection (LD)			X						X	X	

1.16 EXHAUST FAN (EF)

A. COORDINATION: The BMSC shall provide, install, and wire a control device(s) including a control relay (EFSS) and current sensor (EFST). The Unit shall be provided as outlined under the equipment schedules. The Division 16 Electrical contractor (DIV16) shall provide all line voltage wiring.

B. SCHEDULING: The Unit's operation shall be hard-wired interlocked with the associated equipment schedule.

C. "RUN INHIBIT": The Exhaust Fan (EFSS) shall be commanded to "stop" during "Unoccupied" and "Warm-up" sequences of operations.

D. "OCCUPIED": When the associated HVAC Equipment is scheduled (SCHED) to "Occupied", the Exhaust Fan (EFSS) shall be commanded to "start"

E. "PROOF OF OPERATION": A current switch shall monitor the Exhaust Fan status (EFST).

F. FAN FAILURE ALARM (FAIL): If the Exhaust Fan (EFSS) is commanded to "start", but the Exhaust Fan status (EFST) is "off", a Fan Failure (FAIL) alarm shall be sent to the GUI.

G. FAN IN HAND ALARM (HAND): If the Exhaust Fan (EFSS) is commanded to "stop", but the Exhaust Fan status (EFST) is "on", a Fan-in-Hand (HAND) alarm shall be sent to the GUI.

H. OPERATOR INTERFACE REQUIREMENTS:

1. Input/Output Points:

Exhaust Fan – Interlocked	**I/O Points**						
Point Name/Description/Legend X = DDC I/O L = Local Control A = Adjustable O = Override	AI	AO	BI	BO	Trend	GUI	Device
Exhaust Fan Start/Stop (EFSS)				O	X	X	R
Exhaust Fan Status (EFST)			X		X	X	CS

2. Control Parameters and Settings

Exhaust Fan – Interlocked	Parameters and Settings			
Parameter Name/Description X = Display on GUI A = Adjustable	AV	Trend	GUI	Initial- Setting
Occupancy Schedules (SCHED)	X	X	X	
All Alarm Setpoints and/or Parameters	A	X	C	Alarm settings
Alarm Reset	A	X	X	

3. Alarms

Exhaust Fan – Interlocked	**Alarms and Conditions**		
Alarm Name	Point	Normal	Alarm
Fan Failure (FAIL)	EFSS EFST	EFSS = ON EFST = ON	EFSS = ON EFST = OFF
Fan in Hand (HAND)	EFSS EFST	EFSS = OFF EFST = OFF	EFSS = OFF EFST = ON

1.17 FAN COIL UNIT (FCU-1/CU-1/EDH-1/OAI-1)

A. COORDINATION: The BMSC shall provide, field install and wire a B-ASC DDC controller, sensor(s), relays, control valves and all necessary equipment required to meet the control sequence requirements. Additionally, the BMSC shall provide the field interlock wiring to associated controlled equipment. The Unit's shall be provided as outlined under the equipment schedules. The MC shall provide coordination between the OEM and BMSC for a complete functional system.

B. SCHEDULING: The Unit's schedule is as established in the GUI and shall be communicated to the Unit's DDC controller. The unit's DDC controller shall have a built-in timeclock.

C. SCHEDULE OVERRIDE : A schedule Override on the Space Temperature Sensor (RMT) shall override the schedule (SCHED) when the button is depressed. An LED shall indicate that the Unit is overridden into the "Occupied" mode for up to 3 hours (adj.). The Unit shall revert to its scheduled (SCHED) upon the time expiration of the override or upon further depression of the button.

D. SPACE TEMPERATURE SENSOR (RMT): The Space Temperature Sensor(s) (RMT) shall have an LCD screen depicting the Temperature (RMT) and Setpoints (CSP/HSP).

E. SPACE TEMPERATURE / RELATIVE HUMIDITY SENSOR (RMT/RMRH): The Space Temperature / Humidity Sensor(s) (RMT/RMRH) shall have an LCD screen depicting the Temperature (RMT), Temperature Setpoints (CSP/HSP) and Relative Humidity (RMRH). Space Temperature Sensor(s) (RMT) in public areas shall have a blank vented stainless steel design. The Space Heating (HSP/UHSP) and Cooling (CSP/UCSP) shall be controlled from the GUI.

F. SPACE TEMPERATURE SETPOINTS: The setpoints shall initially be 72 °F (adj.) for heating (HSP) and 74 °F (adj.) for cooling (CSP) with a setpoint adjustment span setting of ± 4 °F (adj.).

G. “PROOF OF OPERATION”: A current switch shall monitor the Unit’s Supply fan status (SFST). The unit shall remain in the “Unoccupied” mode until the Supply Fan status (SFST) indicates “on”.

H. MODE INHIBIT: During the any cooling mode all heating modes shall be disabled. During the any heating mode all cooling modes shall be disabled.

I. “UNOCCUPIED”: When the Unit is scheduled (SCHED) to “Unoccupied”, the Unit’s Fan (FSS) shall be commanded to “stop”. Any associated Exhaust Fan(s) (EFSS) shall be commanded to “stop”; the Outside Air damper(s) (OAD) shall be commanded to “close”;, the Direct eXpansion Cooling stages (DX) and Electric Duct Heater (HTG) shall be commanded “off”.

J. “OCCUPIED”: When the Unit is scheduled to “Occupied”, the Unit’s fan (FSS) shall be commanded to “start”; the Outside Damper (OAD) shall be commanded to “open”. Any associated Exhaust Fan (EFSS) shall be commanded to “start”.

K. “INTAKE AIR HEATING”: When the Intake Air Temperature is less than the “Local Heating” Setpoint the Intake Air Heating Coil control (HTG) shall cycle “on”. When the Intake Air Temperature is greater than the “Local Heating” Setpoint hysteresis, the Intake Air Heating Coil control (HTG) shall cycle “off”.

L. “COOLING”: When the Space Temperature (RMT) is greater than the scheduled “Cooling” Setpoint (CSP)(UCSP), the Unit’s Fan (FSS) shall be commanded to “start”; the Heating Coil (HTG) shall be commanded to “off”.; When the current switch on the Unit’s Fan Current Switch (FST) indicates “on”, the Direct eXpansion Cooling stage(s) (CLG) shall be sequenced “on”. When the Space Temperature (RMT) is less than the “Cooling” Setpoint (CSP)(UCSP) hysteresis, the Direct eXpansion Cooling stages (CLG) shall be sequenced “off”. The Unit’s Fan (FSS) amd Heating Coil control (HTG) shall revert back to the scheduled sequence. The owner shall have the ability to disable this feature via software.

M. FILTER MAINTENANCE (FILTER): The Unit’s Supply fan status (SFST) shall be monitored and shall provide a maintenance reminder (FILTER) at the GUI when the Filter Replacement Timer Setting (FILTERSP) has been reached. A software reset shall be required to silence/reset the timer function.

N. SPACE TEMPERATURE (TEMP) ALARM: If the Space Temperature (RMT) is greater than 4°F (adj.) from the scheduled setpoints. A Space Temperature Alarm (TEMP) shall be sent to the GUI.

O. LIQUID DETECTION SENSOR (LIQUID) ALARM: A Liquid Detection Sensor (LDS) switch shall be located to detect accumulated liquids in the Drip Pan. Upon detection of a liquid the Unit's Supply Fan (SFSS) shall be commanded to "stop"; the Outside Air damper (OAD) shall be commanded to "close"; the Return Air damper (RAD) commanded "open".; The unit's cooling sequences shall be disabled. The Heating Coil control valve (HTG) shall be commanded "open" to the coil. A Drip Pan Liquid Detection (LIQUID) alarm shall be sent to the GUI. The alarm shall be reset through a software switch from the GUI.

P. COOLING FAILURE ALARM (COOLFAIL): If the Discharge Air Temperature (DAT) remains within 4°F (adj.) of the Space Temperature (RMT) after with the mechanical cooling is utilized (for greater than 5 minutes). A Cooling Failure (COOLFAIL) alarm shall be sent to the GUI. This alarm shall not be enabled until the Supply Fan status (SFST) has been "on" for 10 minutes (adj.).

Q. FAN FAILURE ALARM (FAIL): If the Supply Fan command (SFSS) is commanded to "start", but the Supply Fan status (SFST) is "off", a Fan Failure (FAIL) alarm shall be sent to the GUI.

R. FAN IN HAND ALARM (HAND): If the Supply Fan command (SFSS) is commanded to "stop", but the Supply Fan status (SFST) is "on", a Fan-in-Hand (HAND) alarm shall be sent to the GUI.

S. CARBON-DIOXIDE ALARM (DCV): When the Unit's Supply Fan (SFSS) is commanded to "start", and the Carbon-Dioxide level (CO2) remains above 1100 ppm (adj.) for more than 1 hour, or if the Carbon-Dioxide level (CO2) levels exceed 1400 ppm. A Demand Control Ventilation (DCV) alarm shall be sent to the GUI.

T. TEMPERATURE SENSOR FAILURE (SENSOR): Anytime the value of a Temperature Sensor is greater or less than the operational limitations of the sensor, and Temperature Sensor Failure (SENSOR) alarm shall be sent to the GUI.

U. OPERATOR INTERFACE REQUIREMENTS:

1. Input/Output Points:

Fan Coil Unit	**I/O Points**						
Point Name/Description/Legend X = DDC I/O L = Local Control A = Adjustable O = Override	AI	AO	BI	BO	Trend	GUI	Device
Fan Start/Stop (FSS)				O	X	X	R
Fan Status (FST)			X		X	X	CS
Direct eXpansion Cooling (CLG)		O		O	X	X	
Heating Coil control (HTG)		O		O	X	X	
Space Temperature (RMT)	X				X	X	TS-W
Space Relative Humidity (RMRH)	X				X	X	RH-W

Space Carbon-Dioxide level (RMCO2)	X				X	X	CO2-W
Discharge Air Temperature (DAT)	X				X	X	TS-D
Outside Air Damper (OAD)				X	X	X	M
Filter (FLTR)			X		X	X	DPS
Liquid Detection Sensor (LDS)			X		X	X	LDS

2. Control Parameters and Settings

Fan Coil Unit	**Parameters and Settings**			
Parameter Name/Description X = Display on GUI A = Adjustable	AV	Trend	GUI	Initial- Setting
Occupancy Schedules (SCHED)	X	X	X	
"Occupied" Space Heating Setpoint (HSP)	A	X	X	70 °F
"Occupied" Space Cooling Setpoint (CSP)	A	X	X	72 °F
"Unoccupied" Space Heating Setpoint (UHSP)	A	X	X	65 °F
"Unoccupied" Space Cooling Setpoint (UCSP)	A	X	X	78 °F
Relative Humidity Setpoint (RHSP)	A	X	X	50 %r.h.
Filter Replacement Timer (FILTERSP)				1000 hours
All Alarm Setpoints and/or Parameters	A	X	C	Alarm settings
Alarm Reset	A	X	X	

3. Alarms

Fan Coil Unit / Unit Ventilator	**Alarms and Conditions**		
Alarm Name	Point	Normal	Alarm
Filter Maintenance	FLTR	OFF	ON
Space Temperature (TEMP)	RMT	< +/- 4°F SP	> +/-4°F SP
High Humidity (HUMIDITY)	RMRH	<10%r.h. SP	>10%r.h. SP
Liquid Detection Sensor (LIQUID)	LDS	OFF	ON
Cooling Failure (COOLFAIL)	See Sequence of Operations		
Heating Failure (HEATFAIL)	See Sequence of Operations		
Fan Failure (FAIL)	#FSS #FSTS	#FSS = ON #FST = ON	#FSS = ON #FST = OFF
Fan in Hand (HAND)	#FSS #FSt	#FSS = OFF #FST = OFF	#FSS = OFF #FST = ON
High CO2 (DCV)			> 1100 ppm 1 hour
Temp Sensor Failure (SENSOR)	Varies	-10°F < Input Input < 220°F	-10°F > Input Input > 220°F

1.18 FINTUBE RADIATION (FTR)

A. COORDINATION: The BMSC shall provide the control valve with field installation and interlock wiring to the interlocked equipment. The Unit's shall be provided as outlined under the equipment schedules. The Mechanical contractor (MC) shall install all control valves and provide coordination between the OEM and the BMSC for a complete integrated system.

B. SCHEDULING (SCHED): The Fintube Radiation control valve (FTR)'s schedule shall be identical to the interlocked equipment's schedule.

C. SPACE TEMPERATURE SENSOR (RMT): The Fintube Radiation control valve (FTR) shall utilize the associated equipment's Space Temperature Sensor(s) (RMT) Temperature and Setpoints.

D. "UNOCCUPIED": When the Unit is scheduled (SCHED) to "Unoccupied, the Fintube Radiation control valve (FTR) shall be "closed".

E. "HEATING": When the Space Temperature (RMT) less than the scheduled "Heating" Setpoint (HSP/UHSP) the Fintube Radiation control valve (FTR) shall be commanded "open". When the Space Temperature (RMT) greater than the scheduled "Heating" Setpoint (HSP/UHSP) hysteresis, the Fintube Radiation control valve (FTR) shall be commanded "closed".

F. SPACE TEMPERATURE (TEMP) ALARM: If the Space temperature (RMT) is greater than 4°F (adj.) from the scheduled setpoints. A Space Temperature Alarm (TEMP) shall be sent to the GUI.

G. OPERATOR INTERFACE REQUIREMENTS:

1. Input/Output Points:

Fintube Radiation Control	**I/O Points**						
Point Name/Description/Legend X = DDC I/O L = Local Control A = Adjustable O = Override	AI	AO	BI	BO	Trend	GUI	Device
Heating Coil control valve (HTG)				O	X	X	
Space Temperature (RMT)	X				X	X	TS-W

2. Control Parameters and Settings

Fintube Radiation Control	**Parameters and Settings**			
Parameter Name/Description X = Display on GUI A = Adjustable	AV	Trend	GUI	Initial- Setting
Occupancy Schedules (SCHED)	X	X	X	
"Occupied" Space Heating Setpoint (HSP)	A	X	X	70 °F
"Unoccupied" Space Heating Setpoint (UHSP)	A	X	X	65 °F

All Alarm Setpoints and/or Parameters	A	X	C	Alarm settings
Alarm Reset	A	X	X	

3. Alarms

Fintube Radiation Control	**Alarms and Conditions**		
Alarm Name	Point	Normal	Alarm
Space Temperature Alarm	RMT	< +/- 4°F SP	> +/-4°F SP

1.19 CABINET HEATER / UNIT HEATER – HOT WATER

A. Coordination:
   1. Reference the BMS diagrams for Unit configuration, BMS devices, point types & locations
   2. The Unit Manufacturer (UM) shall provide the Unit with integral controls as outlined under the Equipment specifications & schedules.

B. The BMS shall monitor the temperature in the space served by the CUH or UH.

C. The BMS shall monitor the HWS status - if hot water above 120 °F is not available, the heaters will not operate.

D. When the space temperature drop below setpoint (68 °F occupied / 60 °F unoccupied), the hot water valve will open and the unit fan will start.

E. When the space reaches setpoint, the hot water valve will close and the fan will shut off.

F. Upon a loss of power the hot water valve will spring open.

G. If temperature in the space falls 5 °F below setpoint, an alarm will be generated at the BMS graphic.

1.20 CABINET/UNIT HEATER (CUH-DDC)

A. COORDINATION: The BMSC shall provide, field install and wire a B-ASC DDC controller, sensor(s), relays, control valves and all necessary equipment required to meet the control sequence requirements. The Unit's shall be provided as outlined under the equipment schedules. The MC shall provide coordination between the OEM and BMSC for a complete functional system.

B. SCHEDULING: The Unit's schedule is as established in the GUI and shall be communicated to the Unit's DDC controller.

C. SPACE TEMPERATURE SENSOR (RMT): Space Temperature Sensor(s) (RMT) in public areas shall have a blank vented stainless steel design. The Space Heating (HSP/UHSP) and Cooling (CSP/UCSP) shall be controlled from the GUI.

D. SPACE TEMPERATURE SETPOINTS: The initial Heating setpoints shall 72 °F (adj.)(HSP) and 60 °F (UHSP).

E. "UNOCCUPIED": When the Unit is not "Enabled" or when the Unit is scheduled (SCHED) to "Unoccupied", the Hot Water control valve (HTG) shall be commanded to "close", the Unit's Supply Fan (SFSS) shall be commanded to "stop".

F. "HEATING": When the the Space Temperature (RMT) is less than the scheduled "Heating" Setpoint (HSP/UHSP) of 60 °F (adj.), the Hot Water control valve (HTG) shall be commanded to "Open". When the the Space Temperature (RMT) is greater than the scheduled "Heating" Setpoint (HSP/UHSP) hysteresis (adj.), the Hot Water control valve (HTG) shall be commanded to "close".

G. "ENABLE": An aquastat (AQS) shall be mounted on the hot water pipe. When the Aquastat switch (AQS) detects the presence of Hot Water greater than the Aquastat Setpoint (AQSP), the Unit's fan shall be "Enabled" to operate.

H. "START": When "Enabled" and a call for "HEATING", the Unit's fan (FSS) shall be commanded to "start";

I. "STOP": When not "Enabled" or when the Space Temperature (RMT) is greater than the scheduled "Heating" Setpoint (HSP/UHSP) hysteresis, the Unit's fan (FSS) shall be commanded to "stop". The owner shall have the ability to disable this feature via software.

J. SPACE TEMPERATURE (TEMP) ALARM: If the Space Temperature (RMT) is greater than 4°F (adj.) from the scheduled setpoints. A Space Temperature Alarm (TEMP) shall be sent to the GUI.

K. TEMPERATURE SENSOR FAILURE (SENSOR): Anytime the value of a Temperature Sensor is greater or less than the operational limitations of the sensor, and Temperature Sensor Failure (SENSOR) alarm shall be sent to the GUI.

L. OPERATOR INTERFACE REQUIREMENTS:

1. Input/Output Points:

Cabinet/Unit Heater-DDC	**I/O Points**						
Point Name/Description/Legend X = DDC I/O L = Local Control A = Adjustable O = Override	AI	AO	BI	BO	Trend	GUI	Device
Fan Start/Stop (FSS)				O	X	X	R
Space Temperature (RMT)	X				X	X	TS-W

Aquastatic Temperature Switch (AQS)			L				AQS

2. Control Parameters and Settings

Cabinet/Unit Heater-DDC	**Parameters and Settings**			
Parameter Name/Description X = Display on GUI A = Adjustable	AV	Trend	GUI	Initial- Setting
Occupancy Schedules (SCHED)	X	X	X	
"Occupied" Space Heating Setpoint (HSP)	A	X	X	70 °F
"Unoccupied" Space Heating Setpoint (UHSP)	A	X	X	65 °F
Alarm Reset	A	X	X	

3. Alarms

Cabinet/Unit Heater-DDC	**Alarms and Conditions**		
Alarm Name	Point	Normal	Alarm
Space Temperature (TEMP)	RMT	< +/- 4°F SP	> +/-4°F SP
Temp Sensor Failure (SENSOR)	Varies	-10°F < Input Input < 220°F	-10°F > Input Input > 220°F

1.21 OUTSIDE AIR INTAKES (OAI)

A. COORDINATION: The BMSC shall provide damper actuators, and all necessary equipment required to meet this specification and mechanical system control sequence requirements.

B. SCHEDULING: A motorized damper shall "open"/"Close" the OAI as scheduled from the interlocked BACnet DDC controller.

1.22 RADIANT PANEL (RP)

A. COORDINATION: The BMSC shall provide, field install and wire a B-ASC DDC controller, control transformer and enclosure, a Space Temperature Sensor (RMT), and all necessary device(s) required to meet the sequence requirements. The Unit's shall be provided as outlined under the equipment schedules. The MC shall provide coordination between the OEM and BMSC for a complete functional system.

B. SCHEDULING: The unit's schedule is as established in the GUI and shall be communicated to the Unit's B-ASC DDC controller. The unit's DDC controller shall have a built-in timeclock.

C. SCHEDULE OVERRIDE : An Override (OVRD) on the Space Temperature Sensor (RMT) shall override the schedule when the button is depressed. An LED shall indicate that

the Unit is overridden to “Occupied” for up to 3 hours (adj.). The Unit shall revert to its scheduled mode upon the time expiration or upon further depression of the button.

D. SPACE TEMPERATURE SENSOR (RMT): The Space Temperature Sensor(s) (RMT) shall have an LCD screen depicting the Temperature and Setpoints.

E. SPACE TEMPERATURE SENSOR (RMT): Space Temperature Sensor(s) (RMT) in public areas shall have a blank vented stainless steel design. The Space Heating (HSP/UHSP) shall be controlled from the GUI.

F. SPACE TEMPERATURE SETPOINTS: The setpoint shall initially be 72 °F (adj.) for heating (HSP) with a setpoint adjustment span setting of ± 4 °F (adj.).

G. “UNOCCUPIED”: When scheduled to “Unoccupied”, the Electric Heating Coil (HTG) shall be controlled to maintain the Space Temperature (RMT) at the “Unoccupied Heating” Setpoint (UHSP) of 60 °F (adj.).

H. “OCCUPIED”: When scheduled to “Occupied”, The Electric Heating Coil (HTG) shall be controlled to maintain the Space Temperature (RMT) at the “Occupied Heating” Setpoint (HSP) of 72 °F (adj.).

I. “HEATING”: When the Space Temperature (RMT) is less than the scheduled “Heating” Setpoint (HSP)(UHSP), the Electric Heating Coil (HTG) shall be commanded to “on”. When the Space Temperature (RMT) is greater than the “Heating” Setpoint (HSP)(UHSP) hysteresis, the Electric Heating Coil (HTG) shall be commanded “off”.

J. SPACE TEMPERATURE (TEMP) ALARM: If the space temperature is greater than 4°F (adj.) from the scheduled setpoints. A Space Temperature (TEMP) alarm shall be sent to the GUI.

K. TEMPERATURE SENSOR FAILURE (SENSOR): Anytime the value of a Temperature Sensor is greater or less than the operational limitations of the sensor, and Temperature Sensor Failure (SENSOR) alarm shall be sent to the GUI.

L. OPERATOR INTERFACE REQUIREMENTS:

1. Input/Output Points:

Radiant Panel – Electric SCR	**I/O Points**						
Point Name/Description/Legend X = DDC I/O L = Local Control A = Adjustable O = Override	AI	AO	BI	BO	Trend	GUI	Device
Electric Heating Coil (HTG)		O		O	X	X	
Space Temperature (RMT)	X				X	X	TS-W

2. Control Parameters and Settings

Radiant Panel – Electric SCR	**Parameters and Settings**

Parameter Name/Description X = Display on GUI A = Adjustable	AV	Trend	GUI	Initial- Setting
Occupancy Schedules (SCHED)	X	X	X	
“Occupied” Space Heating Setpoint (HSP)	A	X	X	70 °F
“Unoccupied” Space Heating Setpoint (UHSP)	A	X	X	65 °F
All Alarm Setpoints and/or Parameters	A	X	C	Alarm settings
Alarm Reset	A	X	X	

3. Alarms

Radiant Panel – Electric SCR	**Alarms and Conditions**		
Alarm Name	Point	Normal	Alarm
Space Temperature (TEMP)	RMT	< +/- 4°F SP	> +/-4°F SP
Temp Sensor Failure (SENSOR)	Varies	-10°F < Input Input < 220°F	-10°F > Input Input > 220°F

1.23 UNIT VENTILATOR (UV)

A. COORDINATION: The BMSC shall provide, field install and wire a B-ASC DDC controller, sensor(s), relays, control valves and all necessary equipment required to meet the control sequence requirements. Additionally, the BMSC shall provide the field interlock wiring to associated controlled equipment. The Unit’s shall be provided as outlined under the equipment schedules. The MC shall provide coordination between the OEM and BMSC for a complete functional system.

B. SCHEDULING: The Unit’s schedule is as established in the GUI and shall be communicated to the Unit’s DDC controller. The unit’s DDC controller shall have a built-in timeclock.

C. SCHEDULE OVERRIDE : A schedule Override on the Space Temperature Sensor (RMT) shall override the schedule (SCHED) when the button is depressed. An LED shall indicate that the Unit is overridden into the “Occupied” mode for up to 3 hours (adj.). The Unit shall revert to its scheduled (SCHED) upon the time expiration of the override or upon further depression of the button.

D. SPACE TEMPERATURE SENSOR (RMT): The Space Temperature Sensor(s) (RMT) shall have an LCD screen depicting the Temperature (RMT) and Setpoints (CSP/HSP).

E. SPACE TEMPERATURE / RELATIVE HUMIDITY SENSOR (RMT/RMRH): The Space Temperature / Humidity Sensor(s) (RMT/RMRH) shall have an LCD screen depicting the Temperature (RMT), Temperature Setpoints (CSP/HSP) and Relative Humidity (RMRH).

F. SPACE TEMPERATURE SENSOR (RMT): Space Temperature Sensor(s) (RMT) in public areas shall have a blank vented stainless steel design. The Space Heating (HSP/UHSP) and Cooling (CSP/UCSP) shall be controlled from the GUI.

G. SPACE TEMPERATURE SETPOINTS: The setpoints shall initially be 72 °F (adj.) for heating (HSP) and 74 °F (adj.) for cooling (CSP) with a setpoint adjustment span setting of ± 4 °F (adj.).

H. "PROOF OF OPERATION": A current switch shall monitor the Unit's Supply fan status (SFST). The unit shall remain in "Unoccupied" until the Supply Fan status (SFST) indicates "on".

I. MODE INHIBIT: During the any Cooling mode, all Heating modes shall be "disabled". During the any Heating mode, all Cooling modes shall be "disabled".

J. "UNOCCUPIED": When the Unit is scheduled (SCHED) to "Unoccupied":
   1. The Unit's Supply Fan (SFSS) shall be commanded to "stop".
   2. Any associated Exhaust Fan(s) (EFSS) shall be commanded to "stop";
   3. The Outside Air damper(s) (OAD) shall be commanded to "close"
   4. The Return Air damper(s) (RAD) commanded to "open".
   5. When the Outside Air Temperature (OAT) is less than 48 °F, the Heating Coil control valve (HTG) shall modulate to maintain a Discharge Air Temperature at the Unoccupied Discharge Air Setpoint (UDASP) of 55°F (adj.).
   6. The Direct eXpansion Cooling stages (DX) shall be commanded "off"
   7. The Hot Water control valve (HWV) shall be commanded to "open".
   8. The associated Fintube Radiation control valve (FTR) shall be commanded "open"

K. "OCCUPIED": When the Unit is scheduled to "Occupied", the Unit's fan (SFSS) shall be commanded to "start"; the Outside Damper (OAD) shall be commanded to the Minimum Outside Air setting (MINOA). Any associated exhaust fan(s) (EFSS) shall be commanded to "start". Upon the transition of the unit to "Occupied" mode, a 10 minute ramp shall be implemented before the Outside damper(s) (OAD) can go fully "open".

L. "COOLING": When the Space Temperature (RMT) is greater than the scheduled "Cooling" Setpoint (CSP)(UCSP), the Unit's Supply fan (SFSS) shall be commanded to "start"; the Heating Coil control valve (HTG) shall be commanded to "close".; When the current switch on the Unit's Supply Fan Current Switch (SFST) indicates "on", the Direct eXpansion Cooling stage(s) (CLG) shall be sequenced "on". When the Space Temperature (RMT) is less than the scheduled "Cooling" Setpoint (CSP)(UCSP) hysteresis, the Direct eXpansion Cooling stages (CLG) shall be sequenced "off". The the Unit's Supply fan (SFSS) and Heating Coil control valve (HTG) shall revert back to the scheduled sequence. The owner shall have the ability to disable this feature via software.

M. “HEATING”: When the Space Temperature (RMT) is less than the scheduled “Heating” Setpoint (HSP)(UHSP), the associated Fintube Radiation control valve (FTR) shall be commanded “open”. A further rise above the scheduled “Heating” setpoint and the Unit’s fan (SFSS) shall be commanded to “start”; when the Unit’s Supply Fan Current Switch (SFST) has been proven the fan “on”, the Heating Coil control valve (HTG) shall be commanded “open” to the coil. When the Space Temperature (RMT) is greater than the scheduled “Heating” Setpoint (HSP)(UHSP) hysteresis, the associated Fintube Radiation control valve (FTR) shall be commanded “close”, the Unit’s fan (SFSS) and Heating Coil control valve (HTG) shall revert back to the scheduled sequence. The owner shall have the ability to disable this feature via software.

N. “WARM-UP”: The Unit will be in “Warmup” when the Space Temperature (RMT) is greater than 5 °F (adj.) below the Space Heating Setpoint (HSP). During the “Warm-Up” mode, the Outside Damper(s) (OAD) shall be commanded to “close”; The Heating Coil control valve (HTG) shall be modulated to maintain a Discharge Air Setpoint (DASP) of 85 °F (Adj.). When the Space Temperature (RMT) returns within 2 °F of the Space Heating Setpoint (HSP) the Unit shall revert to the scheduled operation.

O. DISCHARGE AIR TEMPERATURE LOW LIMIT: The Heating Coil control valve (HTG) shall modulate to maintain the Discharge Air Temperature sensor (DAT) above Discharge Air Temperature Low Limit Setpoint (DALL) of 60°F (adj.). When the Discharge Air Temperature (DAT) is less than the Discharge Air Temperature Low Limit Setpoint (DALL) the Heating Coil control valve (HTG) shall modulate “open” to the coil. When the Discharge Air Temperature (DAT) is greater than the Discharge Air Temperature Low Limit Setpoint (DALL) the Heating Coil control valve (HTG) shall modulate to “close” to the coil.

P. MINIMUM OUTSIDE AIR: The TAB shall adjust and set the Minimum Outside Air settings (MINOA). The Unit’s Outside Air Damper (OAD) and Return Air Damper (RAD) shall be positioned as required per the sequence of operations.

Q. “FREE COOLING ECONOMIZER”: When the Outside Air Temperature (OAT) is less than the Space Temperature (RMT) by greater than 8 °F (adj.) the use of the Free Cooling economizer shall be used to cool the Space Temperature (RMT), as required, the Outside Air Damper (OAD) and Return Air Damper(s) (RAD) shall modulate from the Minimum Outside Air setting (MINOA) to maintain the Space Cooling Setpoint (CSP). When the Space Temperature (RMT) is greater than the Space Cooling Setpoint (CSP) the Outside (OAD) damper(s) shall be modulated “open”, Return Air damper (RAD) modulated “close”. When the Space Temperature (RMT) is less than the Space Cooling Setpoint (CSP) the Outside Air Damper (OAD) and Return Air Damper(s) (RAD) shall modulate to the Minimum Outside Air setting (MINOA).

R. “INADEQUATE FREE COOLING” (RMT): If the Space Temperature (RMT) remains above the Space Cooling Setpoint (CSP) for greater than 15 minutes, the Outside Air damper

(OAD) and Return Air damper (RAD) damper(s) shall return to the Minimum Outside Air setting (MINOA) and the mechanical cooling shall be utilized.

S. DEMAND CONTROL VENTILATION: A CO2 sensor (CO2) shall monitor CO2 levels. The Outside Air Damper (OAD) and Return Air Damper (RAD) shall modulate to maintain the space CO2 setpoint (CO2SP) of 900 ppm. When the space CO2 (CO2) is greater than the CO2 setpoint (CO2SP), the Outside Air Damper(s) (OAD) shall modulate "open", and the Return Air Damper(s) (RAD) shall modulate to "close". When the CO2 (CO2) is less than the CO2 setpoint (CO2SP), the Outside Air Damper(s) (OAD) and the Return Air Damper(s) (RAD shall revert back to schedule mode.

T. FILTER MAINTENANCE (FILTER): The Unit's Supply fan status (SFST) shall be monitored and shall provide a maintenance reminder (FILTER) at the GUI when the Filter Replacement Timer Setting (FILTERSP) has been reached. A software reset shall be required to silence/reset the timer function.

U. SPACE TEMPERATURE (TEMP) ALARM: If the Space Temperature (RMT) is greater than 4°F (adj.) from the scheduled setpoints. A Space Temperature Alarm (TEMP) shall be sent to the GUI.

V. LOW LIMIT SWITCH (LLSTRIP) ALARM: A Low Temperature Limit Switch (LLS) shall be located on the leaving airside of the Heating Coil. If the Low Temperature Limit Switch (LLS) detects a temperature below the local device setting of 38 °F (adj.); the Unit's Fan (SFSS) shall be commanded to "stop"; the Outside Air damper (OAD) shall be commanded to "close"; the Return Air damper (RAD) shall be commanded to "open". The Heating Coil control valve (HTG) shall be commanded to "open" to the coil. The Unit's cooling sequences shall be "disabled". A Low-Limit Switch Tripped (LLSTRIP) alarm shall be sent to the GUI. The Low Temperature Limit Switch (LLS) shall be reset from the GUI.

W. LIQUID DETECTION SENSOR (LIQUID) ALARM: A Liquid Detection Sensor (LDS) switch shall be located to detect accumulated liquids in the Drip Pan. Upon detection of a liquid the Unit's Supply Fan (SFSS) shall be commanded to "stop"; the Outside Air damper (OAD) shall be commanded to "close"; the Return Air damper (RAD) commanded "open".; The unit's cooling sequences shall be disabled. The Heating Coil control valve (HTG) shall be commanded "open" to the coil. A Drip Pan Liquid Detection (LIQUID) alarm shall be sent to the GUI. The alarm shall be reset through a software switch from the GUI.

X. COOLING FAILURE ALARM (COOLFAIL): If the Discharge Air Temperature (DAT) remains within 4°F (adj.) of the Space Temperature (RMT) after with the mechanical cooling is utilized (for greater than 5 minutes). A Cooling Failure (COOLFAIL) alarm shall be sent to the GUI. This alarm shall not be enabled until the Supply Fan status (SFST) has been "on" for 10 minutes (adj.).

Y. HEATING FAILURE ALARM (HEATFAIL): If the Discharge Air Temperature (DAT) remains within 4°F (adj.) of the Space Temperature (RMT) after of the heating signal is greater than 10% “open” (For greater than 5 minutes). A Heating Failure (HEATFAIL) alarm shall be sent to the GUI. This alarm shall not be enabled until the Supply Fan status (SFST) has been “on” for 10 minutes (adj.).

Z. DISCHARGE AIR LOW ALARM (DATLO): If the Discharge Air Temperature (DAT) decreases below the Discharge Air Temperature Low Limit Setpoint (DALL), the Outside Air damper (OAD) shall be commanded to “close”; the Return Air damper (RAD) shall be commanded to “open”. and a Discharge Air Temperature Low (DATLO) alarm shall be sent to the GUI. This sequence shall be disabled during any mechanical cooling operation.

AA. FAN FAILURE ALARM (FAIL): If the Supply Fan command (SFSS) is commanded to “start”, but the Supply Fan status (SFST) is “off”, a Fan Failure (FAIL) alarm shall be sent to the GUI.

BB. FAN IN HAND ALARM (HAND): If the Supply Fan command (SFSS) is commanded to “stop”, but the Supply Fan status (SFST) is “on”, a Fan-in-Hand (HAND) alarm shall be sent to the GUI.

CC. CARBON-DIOXIDE ALARM (DCV): When the Unit’s Supply Fan (SFSS) is commanded to “start”, and the Carbon-Dioxide level (CO2) remains above 1100 ppm (adj.) for more than 1 hour, or if the Carbon-Dioxide level (CO2) levels exceed 1400 ppm. A Demand Control Ventilation (DCV) alarm shall be sent to the GUI.

DD. TEMPERATURE SENSOR FAILURE (SENSOR): Anytime the value of a Temperature Sensor is greater or less than the operational limitations of the sensor, and Temperature Sensor Failure (SENSOR) alarm shall be sent to the GUI.

EE. OPERATOR INTERFACE REQUIREMENTS:

1. Input/Output Points:

Unit Ventilator	**I/O Points**						
Point Name/Description/Legend X = DDC I/O L = Local Control A = Adjustable O = Override	AI	AO	BI	BO	Trend	GUI	Device
Supply Fan Start/Stop (SFSS)				O	X	X	R
Supply Fan Status (SFST)			X		X	X	CS
Direct eXpansion Cooling (CLG)		O		O	X	X	
Heating Coil control (HTG)		O		O	X	X	
Heating Coil control valve (HTG)		O		O	X	X	
Space Temperature (RMT)	X				X	X	TS-W
Space Relative Humidity (RMRH)	X				X	X	RH-W
Space Carbon-Dioxide level (RMCO2)	X				X	X	CO2-W

Discharge Air Temperature (DAT)	X				X	X	TS-D
Outside/Return Air Damper (OAD/RAD)		O			X	X	M
Filter (FLTR)			X		X	X	DPS
Low Limit Switch (LLS)		X			X	X	LLS
Liquid Detection Sensor (LDS)			X		X	X	LDS

2. Control Parameters and Settings

Fan Coil Unit / Unit Ventilator	**Parameters and Settings**			
Parameter Name/Description X = Display on GUI A = Adjustable	AV	Trend	GUI	Initial- Setting
Occupancy Schedules (SCHED)	X	X	X	
“Occupied” Space Heating Setpoint (HSP)	A	X	X	70 °F
“Occupied” Space Cooling Setpoint (CSP)	A	X	X	72 °F
“Unoccupied” Space Heating Setpoint (UHSP)	A	X	X	65 °F
“Unoccupied” Space Cooling Setpoint (UCSP)	A	X	X	78 °F
Relative Humidity Setpoint (RHSP)	A	X	X	50 %r.h.
Discharge Air Temperature Low Limit (DALL)	A	X	C	55°F
Space Temp “Warm-up” Setpoint (WUSP)	A	X	C	2 °F (WUSP – HSP)
Filter Replacement Timer (FILTERSP)				1000 hours
Minimum Outside Air setting (MINOA)				Set by Balancer
All Alarm Setpoints and/or Parameters	A	X	C	Alarm settings
Alarm Reset	A	X	X	

3. Alarms

Unit Ventilator	**Alarms and Conditions**		
Alarm Name	Point	Normal	Alarm
Filter Maintenance	FLTR	OFF	ON
Space Temperature (TEMP)	RMT	< +/- 4°F SP	> +/-4°F SP
High Humidity (HUMIDITY)	RMRH	<10%r.h. SP	>10%r.h. SP
Low Limit Alarm (LLSTRIP)	LLS	OFF	ON
Liquid Detection Sensor (LIQUID)	LDS	OFF	ON
Cooling Failure (COOLFAIL)	See Sequence of Operations		
Heating Failure (HEATFAIL)	See Sequence of Operations		
Discharge Air Temp (DATLO)	DAT	> 45 °F	< 45 °F
Fan Failure (FAIL)	#FSS #FSTS	#FSS = ON #FST = ON	#FSS = ON #FST = OFF
Fan in Hand (HAND)	#FSS #FSt	#FSS = OFF #FST = OFF	#FSS = OFF #FST = ON
High CO2 (DCV)			> 1100 ppm 1 hour

Temp Sensor Failure (SENSOR)	Varies	-10°F < Input Input < 220°F	-10°F > Input Input > 220°F

1.24 VARIABLE AIR VOLUME BOX – COOLING ONLY (VAV)

A. GENERAL: The variable volume (VAV) terminal unit is controlled independent of system pressure fluctuations by an Application Specific DDC controller using electric actuation. The space served by the VAV terminal unit is controlled in Occupied and Unoccupied modes. Provide one B-ASC DDC controller, one duct air temperature sensor and one temperature sensor for each VAV box.

B. Critical note:
   1. Where served by an associated Roof Top Unit with Refrigerant Leak Detection capabilities, the Variable Air Volume Boxes shall have fast acting damper actuators and shall be interlocked with the same Roof Top Units refrigerant alarming feature.
   2. The following mitigation actions shall be completed in not more than 15 seconds after the initiation of the Refrigeration Leak Alarm signal, and shall be maintained for at least 5 minutes after the output signal has reset:
      a. The Roof Top Unit shall energize the air circulation fan(s) of the equipment per the manufacturer's instructions.
      b. The VAV dampers to shall be set to full airflow setpoint, that are installed in the air ducts connected to the refrigeration system.

C. COORDINATION: The BMSC shall provide a B-ASC VAV DDC controller, with integral actuator to the VAV Box Manufacturer's (OEM) factory for mounting and wiring. Additionally, the BMSC shall provide, install, and wire a Space Temperature Sensor (RMT) and duct mounted Discharge Air Temperature (DAT) sensor. The Unit's shall be provided as outlined under the equipment schedules to include a cross flow sensor, a control power transformer and enclosure. The OEM shall provide factory installation of the BMS DDC controller. The Testing and Balancing contractor (TAB) shall measure, calibrate, and adjust the VAV box air flow to the scheduled air flow setpoints.

D. SCHEDULING: The unit's schedule is as established in the BMS GUI and shall be communicated to the Unit's DDC controller. The unit's DDC controller shall have a built-in timeclock.

E. SCHEDULE OVERRIDE: A schedule Override on the Space Temperature Sensor (RMT) shall override the schedule when the button is depressed. An LED shall indicate that the Unit is overridden into the "Occupied" mode for up to 3 hours (adj.). The Unit shall revert to its scheduled mode upon the time expiration of the override or upon further depression of the button.

F. SPACE TEMPERATURE SENSOR: The Space Temperature Sensor(s) (RMT) shall have an LCD screen depicting the Temperature and Setpoints.

G. SPACE TEMPERATURE SENSOR: Space Temperature Sensor(s) (RMT) in public areas shall have a blank vented stainless steel design. The Space Heating (HSP/UHSP) and Cooling (CSP/UCSP) shall be controlled from the GUI.

H. SPACE TEMPERATURE SETPOINTS: The setpoints shall initially be 72 °F (adj.) for heating (HSP) and 74 °F (adj.) for cooling (CSP) with a setpoint adjustment span setting of ± 4 °F (adj.).

I. SOURCE TEMPERATURE OPTIMIZATION: The Duct Heating Coil's B-ASC DDC controller shall provide requests according to the STO sequence of operations.

J. CALCULATED AIRFLOW SETPOINT: The Calculated Airflow Setpoint (CFMSP) is calculated from the temperature differential between the Space Temperature (RMT) and the Heating / Cooling Setpoints (HSP/CSP). The Calculated Air Flow Setpoint (CFMSP) shall be reset between the Maximum Airflow Setting (CFMMAX) and Minimum Airflow Setting (CFMMIN).

K. "UNOCCUPIED": When scheduled to "Unoccupied", the VAV Box damper (DMPR) shall be commanded to "open".

L. "OCCUPIED": When scheduled to "Occupied", The Variable Air Volume Box damper shall modulate to maintain the airflow (CFM) at the Calculated Air Flow Setpoint (CFMSP).

M. "COOLING": When the Space Temperature (RMT) is greater than the scheduled "Cooling" Setpoint (CSP)(UCSP) a request shall be sent to the Supply Air Source HVAC Equipment to "start" and provide cooling. The VAV Box damper(s) shall be modulated to maintain the maximum air flow (CFMMAX). When the Space Temperature (RMT) has reached the "Cooling" Setpoint (CSP)(UCSP) a cooling request shall be no longer be sent to the Supply Air Source HVAC Equipment. The VAV Box damper shall revert to its scheduled position.

N. "HEATING": When the Space Temperature (RMT) is greater than the scheduled "Heating" Setpoint (HSP)(UHSP) a request shall be sent to the Supply Air Source HVAC Equipment to "start" and provide heating. Any associated Fintube Radiation (FTR) control valves shall be commanded "open". The VAV Box damper(s) shall be modulated to maintain the minimum airflow (CFMMIN). When the Space Temperature (RMT) has reached the "Heating" Setpoint (HSP) (UHSP) a heating request shall be no longer be sent to the Supply Air Source HVAC Equipment. Any associated Fintube Radiation (FTR) control valves shall be commanded to "close". The VAV Box damper shall revert to its scheduled position.

O. “WARM-UP”: When a “Warmup” signal is received from the Supply Air Source HVAC Equipment or if the Discharge Air Temperature (DAT) is more than 3°F higher than the Space Temperature (RMT), the VAV Box operation shall be reversed. When the “Warm-up” is complete the VAV Box shall revert back to its scheduled operation. The VAV Box shall modulate the airflow (CFM) between the minimum airflow (CFMMIN) and the heating maximum airflow (CFMMAX).

P. MINIMAL CORRECTION: The B-ASC DDC controller damper shall not move for less than one second; if the damper position correction is required to meet the calculated flow setpoint (CFMSP) which will take less than a one (1) second of damper movement, the damper shall not adjust its position.

Q. EXCESSIVE CORRECTION: The B-ASC DDC controller shall monitor the total quantity of damper movements (open or close) during each 24 hour period. If the total quantity of movements in a period exceeds 700, which could indicate a control stability problem and cause excess damper motor wear, the zone will generate an alarm.

R. DEMAND CONTROL VENTILATION: A space carbon-dioxide sensor shall monitor the space carbon-dioxide levels (CO2). The space carbon-dioxide levels (CO2). Shall be sent to the Supply Air Source HVAC Equipment for Demand Control Ventilation (DCV) sequences.

S. SPACE TEMPERATURE (TEMP) ALARM: If the Space temperature (RMT) is greater than 4°F (adj.) from the scheduled setpoints. A Space Temperature Alarm (TEMP) shall be sent to the GUI.

T. SPACE CARBON-DIOXIDE ALARM (DCV): If the Space Carbon-Dioxide level (CO2) exceed 900 ppm. A Demand Control Ventilation alarm (DCV) shall be sent to the GUI.

U. AIR FLOW ALARM (AIRFLOW)(VAV): If the Airflow (CFM) is greater than 10% (adj.) from the Calculated Airflow Setpoint (CFMSP). An Airflow Alarm (AIRFLOW) shall be sent to the GUI.

V. SENSOR FAILURE (SENSOR): Anytime the value of a Sensor is greater or less than the operational limitations of the sensor, a Sensor Failure alarm (SENSOR) shall be sent to the GUI.

W. EXCESSIVE CORRECTION: The B-ASC DDC controller shall monitor the total quantity of damper movements (open or close) during each 24 hour period. If the total quantity of movements in a period exceeds 700, which could indicate a control stability problem and cause excess damper motor wear, the zone will generate an alarm.

X. OPERATOR INTERFACE REQUIREMENTS: The BMS Control Diagrams and the tables below shall provide for Operator Control of the HVAC equipment through an accurate

depiction of the device(s) within the unit, along with the I/O points, parameters and alarms shall be displayed on a customized 3-dimensional web-based graphic.

1. Input/Output Points:

VAV – Cooling Only	I/O Points						
Point Name/Description/Legend X = DDC I/O L = Local Control A = Adjustable O = Override	AI	AO	BI	BO	Trend	GUI	Device
BACnet Communication Interface Points	X	X	X	X	X	X	UMD
Duct Velocity Pressure (DVP)	X				X	X	DPT
Damper Position (DAMPER)		X			X	X	ASC
Space Temperature (RMT)	X				X	X	TS-W
Space Relative Humidity (RMRH)	X				X	X	RH-W
Space Carbon-Dioxide level (RMCO2)	X				X	X	CO2-W
Discharge Air Temperature (DAT)	X				X	X	TS-D

2. Control Parameters and Settings

VAV – Cooling Only	Parameters and Settings			
Parameter Name/Description X = Display on GUI A = Adjustable	AV	Trend	GUI	Initial-Setting
BACnet Interface Parameters	A	X	X	
Occupancy Schedules (SCHED)	X	X	X	
“Occupied” Space Heating Setpoint (HSP)	A	X	X	70 °F
“Occupied” Space Cooling Setpoint (CSP)	A	X	X	72 °F
“Unoccupied” Space Heating Setpoint (UHSP)	A	X	X	65 °F
“Unoccupied” Space Cooling Setpoint (UCSP)	A	X	X	78 °F
Relative Humidity Setpoint (RHSP)	A	X	X	50 %r.h.
Space Temp “Warm-up” Setpoint (WUSP)	A	X	C	2 °F (WUSP – HSP)
Airflow (CFM)	A	X	X	By Balancer
CFM Minimum Setting (CFMMIN)	A	X	X	By Balancer
CFM Maximum Setting (CFMMAX)	A	X	X	By Balancer
CFM Heating Setting (CFMHTG)	A	X	X	By Balancer
CFM Setpoint (CFMSP)	A	X	X	Calc
Alarm Reset	A	X	X	

3. Alarms

VAV – Cooling Only	Alarms and Conditions		
Alarm Name	Point	Normal	Alarm
BACnet Interface Alarms	Varies	Varies	Varies
Space Temperature (TEMP)	RMT	< +/- 4°F SP	> +/-4°F SP
Humidity Alarm (HUMIDITY)	RMRH	<10%r.h. SP	>10%r.h. SP

Air Flow	#ACFM		+/- 10% Set by TAB
High CO2 (DCV)			> 1100 ppm 1 hour
Temp Sensor Failure (SENSOR)	Varies	-10°F < Input Input < 220°F	-10°F > Input Input > 220°F

1.25 VARIABLE AIR VOLUME BOX – WITH REHEAT COIL (VAV w/RHC)

A. GENERAL: The variable volume (VAV) terminal unit is controlled independent of system pressure fluctuations by an Application Specific DDC controller using electric actuation. The space served by the VAV terminal unit is controlled in Occupied and Unoccupied modes. Provide one B-ASC DDC controller, one duct air temperature sensor, one heating coil control valve and one temperature sensor for each VAV box.

B. CRITICAL NOTE:
   1. Where served by an associated Roof Top Unit with Refrigerant Leak Detection capabilities, the Variable Air Volume Boxes shall have fast acting damper actuators and shall be interlocked with the same Roof Top Units refrigerant alarming feature.
   2. The following mitigation actions shall be completed in not more than 15 seconds after the initiation of the Refrigeration Leak Alarm signal, and shall be maintained for at least 5 minutes after the output signal has reset:
      a. The Roof Top Unit shall energize the air circulation fan(s) of the equipment per the manufacturer's instructions.
      b. The VAV dampers to shall be set to full airflow setpoint, that are installed in the air ducts connected to the refrigeration system.
      c. The VAV shall energize the hot water heating coil valve to fully open installed in the air duct that is connected to the refrigeration system.

C. COORDINATION: The BMSC shall provide a BACnet DDC controller, with integral actuator to the VAV Box Manufacturer's (OEM) factory for mounting and wiring. Additionally, the BMSC shall provide, install, and wire a Space Temperature Sensor (RMT), Heating Coil control valve (HTG) and duct mounted Discharge Air Temperature (DAT) sensor. The Units shall be provided as outlined under the equipment schedules to include a cross flow sensor, a control power transformer and enclosure. The OEM shall provide factory installation of the BMS DDC controller. The Testing and Balancing contractor (TAB) shall measure, calibrate, and adjust the VAV box air flow to the scheduled air flow setpoints.

D. SCHEDULING: The unit's schedule is as established in the BMS GUI and shall be communicated to the Unit's DDC controller. The unit's DDC controller shall have a built-in timeclock.

E. SCHEDULE OVERRIDE : A schedule Override on the Space Temperature Sensor (RMT) shall override the schedule when the button is depressed. An LED shall indicate that the Unit is overridden into the “Occupied” mode for up to 3 hours (adj.). The Unit shall revert to its scheduled mode upon the time expiration of the override or upon further depression of the button.

F. SPACE TEMPERATURE SENSOR: The Space Temperature Sensor(s) (RMT) shall have an LCD screen depicting the Temperature and Setpoints.

G. SPACE TEMPERATURE SENSOR: Space Temperature Sensor(s) (RMT) in public areas shall have a blank vented stainless steel design. The Space Heating (HSP/UHSP) and Cooling (CSP/UCSP) shall be controlled from the GUI.

H. SPACE TEMPERATURE SETPOINTS: The setpoints shall initially be 72 °F (adj.) for heating (HSP) and 74 °F (adj.) for cooling (CSP) with a setpoint adjustment span setting of ± 4 °F (adj.).

I. SOURCE TEMPERATURE OPTIMIZATION: The Duct Heating Coil’s B-ASC DDC controller shall provide requests according to the STO sequence of operations.

J. CALCULATED AIRFLOW SETPOINT: The Calculated Airflow Setpoint (CFMSP) is calculated from the temperature differential between the Space Temperature (RMT) and the Heating / Cooling Setpoints (HSP/CSP). The Calculated Air Flow Setpoint (CFMSP) shall be reset between the Maximum Airflow Setting (CFMMAX) and Minimum Airflow Setting (CFMMIN).

K. “UNOCCUPIED”: The VAV Box damper shall be commanded “open”, the Heating Coil control valve (HTG) shall modulate to maintain a Discharge Air Temperature (DAT) at the Unoccupied Discharge Air Setpoint (UDASP) of 55°F (adj.).

L. “OCCUPIED”: The Variable Air Volume Box damper shall modulate to maintain the airflow (CFM) at the Calculated Air Flow Setpoint (CFMSP).

M. “COOLING”: When the Space Temperature (RMT) is greater than the scheduled “Cooling” Setpoint(CSP)(UCSP) a request shall be sent to the Supply Air Source HVAC Equipment to “start” and provide cooling. The Heating Coil control valve (HTG) shall be commanded to “close”. The VAV Box damper(s) shall be modulated to maintain the maximum air flow (CFMMAX). When the Space Temperature (RMT) has reached the “Cooling” Setpoint (CSP)(UCSP) a cooling request shall be no longer be sent to the Supply Air Source HVAC Equipment. The VAV Box damper shall revert to its scheduled position.

N. “HEATING”: When the Space Temperature (RMT) is less than the scheduled “Heating” Setpoint (HSP)(UHSP) a request shall be sent to the Supply Air Source HVAC Equipment to “start” and provide heating. Any associated Fintube Radiation (FTR) control valves

shall be commanded “open”. The VAV Box damper(s) shall be modulated to maintain the minimum airflow (CFMMIN). The Heating Coil control valve (HTG) shall be modulated “open” to provide a Discharge Air Temperature setpoint (DASP) of 85°F. When the Space Temperature (RMT) has reached the scheduled “Heating” Setpoint ((HSP)UHSP) a heating request shall be no longer be sent to the Supply Air Source HVAC Equipment. Any associated Fintube Radiation (FTR) control valves shall be commanded to “close”. The VAV Box damper shall revert to its scheduled position.

O. “WARM-UP”: When a “Warmup” signal is received from the Supply Air Source HVAC Equipment or if the Discharge Air Temperature (DAT) is more than 3°F higher than the Space Temperature (RMT), the VAV Box operation shall be reversed. When the “Warm-up” is complete the VAV Box shall revert back to its scheduled operation. The VAV Box shall modulate the airflow (CFM) between the minimum airflow (CFMMIN) and the heating maximum airflow (CFMMAX).

P. DEMAND CONTROL VENTILATION: A space carbon-dioxide sensor shall monitor the space carbon-dioxide levels (CO2). The space carbon-dioxide levels (CO2). Shall be sent to the Supply Air Source HVAC Equipment for Demand Control Ventilation (DCV) sequences.

Q. SPACE TEMPERATURE (TEMP) ALARM: If the Space temperature (RMT) is greater than 4°F (adj.) from the scheduled setpoints. A Space Temperature Alarm (TEMP) shall be sent to the GUI.

R. SPACE CARBON-DIOXIDE ALARM (DCV): If the Space Carbon-Dioxide level (CO2) exceed 900 ppm. A Demand Control Ventilation alarm (DCV) shall be sent to the GUI.

S. HEATING FAILURE ALARM (HEATFAIL – DAT): If the Discharge Air Temperature (DAT) remains within 4°F (adj.) of the Mixed Air Temperature (MAT) after of the heating signal is greater than 10% “open” (For greater than 5 minutes) This alarm shall not be enabled until the zone has been “on” for 10 minutes (adj.). A Heating Failure alarm (HEATFAIL) shall be sent to the GUI. This alarm shall not be enabled until the Supply Fan status (SFST) has been “on” for 10 minutes (adj.).

T. HEATING FAILURE ALARM (HEATFAIL – RMT): If the Discharge Air Temperature (DAT) remains within 4°F (adj.) of the Space Temperature (RMT) after of the heating signal is greater than 10% “open” (For greater than 5 minutes) This alarm shall not be enabled until the zone has been “on” for 10 minutes (adj.). A Heating Failure alarm (HEATFAIL) shall be sent to the GUI. This alarm shall not be enabled until the Supply Fan status (SFST) has been “on” for 10 minutes (adj.).

U. AIR FLOW ALARM (AIRFLOW)(VAV): If the Airflow (CFM) is greater than 10% (adj.) from the Calculated Airflow Setpoint (CFMSP). An Airflow Alarm (AIRFLOW) shall be sent to the GUI.

V. SENSOR FAILURE (SENSOR): Anytime the value of a Sensor is greater or less than the operational limitations of the sensor, a Sensor Failure alarm (SENSOR) shall be sent to the GUI.

W. OPERATOR INTERFACE REQUIREMENTS:

1. Input/Output Points:

VAV – w/ Reheat Coil	I/O Points						
Point Name/Description/Legend X = DDC I/O L = Local Control A = Adjustable O = Override	AI	AO	BI	BO	Trend	GUI	Device
BACnet Communication Interface Points	X	X	X	X	X	X	UMD
Duct Velocity Pressure (DVP)	X				X	X	DPT
Damper Position (DAMPER)		X			X	X	ASC
Heating Coil control valve (HTG)		X			X	X	CV
Heating Coil control (HTG)		X			X	X	SCR
Space Temperature (RMT)	X				X	X	TS-W
Space Relative Humidity (RMRH)	X				X	X	RH-W
Space Carbon-Dioxide level (RMCO2)	X				X	X	CO2-W
Discharge Air Temperature (DAT)	X				X	X	TS-D

2. Control Parameters and Settings

VAV – w/ Reheat Coil	Parameters and Settings			
Parameter Name/Description X = Display on GUI A = Adjustable	AV	Trend	GUI	Initial-Setting
BACnet Interface Parameters	A	X	X	
Occupancy Schedules (SCHED)	X	X	X	
“Occupied” Space Heating Setpoint (HSP)	A	X	X	70 °F
“Occupied” Space Cooling Setpoint (CSP)	A	X	X	72 °F
“Unoccupied” Space Heating Setpoint (UHSP)	A	X	X	65 °F
“Unoccupied” Space Cooling Setpoint (UCSP)	A	X	X	78 °F
Space Temp “Warm-up” Setpoint (WUSP)	A	X	C	2 °F (WUSP – HSP)
Airflow (CFM)	A	X	X	By Balancer
CFM Minimum Setting (CFMMIN)	A	X	X	By Balancer
CFM Maximum Setting (CFMMAX)	A	X	X	By Balancer
CFM Heating Setting (CFMHTG)	A	X	X	By Balancer
CFM Setpoint (CFMSP)	A	X	X	Calc
Alarm Reset	A	X	X	

3. Alarms

VAV – w/ Reheat Coil	Alarms and Conditions		
Alarm Name	Point	Normal	Alarm

BACnet Interface Alarms	Varies	Varies	Varies
Space Temperature (TEMP)	RMT	< +/- 4°F SP	> +/-4°F SP
Air Flow	#ACFM		+/- 10% Set by TAB
High CO2 (DCV)			> 1100 ppm 1 hour
Heating Failure Alarm (HEATFAIL)			
Temp Sensor Failure (SENSOR)	Varies	-10°F < Input Input < 220°F	-10°F > Input Input > 220°F

1.26 CONDENSATE PUMPS

A. The ATC contractor (ATC) shall provide a Control Relay (R), Low Leak Detector & a Current Switch (CS) to monitor the status of the Condensate Pump. An alarm shall be generated when either the status of the pump does not meet the commanded sequence after 30 seconds or when the Low Leak Detector Alarm is activated.

1. The Condensate Pump shall be energized when there is a detection of a leak in the condensate drain pain.

2. A Low Leak Detector Switch shall activate an alarm if energized.

B. Operator & Graphical User Interface requirements

1. The ATC Control Diagrams & the table below shall provide for Operator Control of the HVAC equipment:

Condensate Pump	I/O Points				Software Point						
Point Name/Description/Legend X = DDC I/O L=Local Control A = Adjustable O = Override	AI	AO	BI	BO	AV	BV	Sched-...l	Trend	Alarm	GUI	Initial-Alarm Setting
Condensate Pump Status (CPS)			X						X	X	
Low Leak Detector Status (LLDS)			X						X	X	

1.27 CONSTANT and VARIABLE AIR BOX BALANCING

A. COORDINATION: The TAB shall provide for their own use, a laptop computer for use of the BMS Balancing Software. Provide the initial air balancing and setting of the design minimum and maximum air flow for each box. The BMSC shall provide the BMS balancing software to the TAB for balancing the VAV boxes, along with eight (8) hours of instruction and support to the air balancer.

1.28 SOURCE TEMPERATURE OPTIMIZATION (STO)

A. Description: The Discharge Air Temperature (DAT) shall automatically be optimized for all Air Handling Units in response to the load needs of other downstream pieces of equipment, by increasing or decreasing Discharge Air Setpoint (DASP). The STO shall also provide for “start” / ”stop” of the primary mechanical equipment based on zone occupancy and/or zone load conditions. The setpoint shall be calculated based on the quantity of heating or cooling requests which are currently being received from the equipment served.

B. Optimized Temperature Setpoint Reset Example: An Air Handling Unit is the source of cold air for a quantity of Variable Air Volume boxes. The initial settings of the STO program for the Air Handling Unit have the following parameters. The initial Discharge Air Setpoint (DASP) is 60.00 °F, with a Maximum setpoint of 65.00 °F and a Minimum setpoint 55.00 °F. Every two minutes, all of the Variable Air Volume box cooling requests and calculate will be totaled and a new Discharge Air Setpoint (DASP) will be calculated by performing the following algorithm. The DASP shall be increased by 0.25 °F and then decreased by 0.50 °F for each cooling request, but by no more than 2.0 °F. Current DASP + 'trim by' + ('respond by' x no. of req.) = New DASP If 8 cooling requests were received and the previous setpoint was 57.00 °F, the new DASP would be 57.00 °F + 0.25 °F + (-0.50 °F x 8) = 57.00°F + 0.25°F - 2.00°F (this is limited) = New DASP of 55.25 °F; 2 minutes later the process would repeat. If there are 0 cooling requests and the previous setpoint was 57.00 °F, the new DASP would be: 57.00 °F + 0.25 °F + (-0.50 °F x 0) = 57.00°F + 0.25°F - 0°F = New DASP of 57.25 °F; 2 minutes later the process would repeat.

1.29 OUTSIDE AIR CONDITIONS

A. COORDINATION: The BMSC shall provide, install, and wire an Outside Air sensor(s) with weather and sunshields on a northern exposure of the building.

B. SENSOR FAILURE (SENSOR): Anytime the value of a Sensor is greater or less than the operational limitations of the sensor, a Sensor Failure alarm (SENSOR) shall be sent to the GUI.

C. OPERATOR INTERFACE REQUIREMENTS:

1. Input/Output Points:

Outside Air Conditions	**I/O Points**						
Point Name/Description/Legend X = DDC I/O L = Local Control A = Adjustable O = Override	AI	AO	BI	BO	Trend	GUI	Device
Outside Air Temperature (OAT)	X				X	X	TS-O
Outside Air Humidity (OARH)	X				X	X	RH-O
Outside Air CO2 (OACO2)	X				X	X	CO2-O

2. Control Parameters and Settings

Outside Air Conditions	**Parameters and Settings**			
Parameter Name/Description X = Display on GUI A = Adjustable	AV	Trend	GUI	Initial- Setting
Calculated Degree Day – Heating	X	X	X	
Calculated Degree Day – Cooling	X	X	X	
Highest Value (Past 24 hours)	X	X	X	
Lowest Value (Past 24 hours)	X	X	X	
All Alarm Setpoints and/or Parameters	A	X	C	Alarm settings
Alarm Reset	A	X	X	

3. Alarms

Outside Air Conditions	**Alarms and Conditions**		
Alarm Name	Point	Normal	Alarm
Temp Sensor Failure (SENSOR)	Varies	Sensor Out of Operational Range	

1.30 SYSTEM STARTUP

A. The BMSC shall provide BMS factory trained and certified technicians to setup, check and adjust the BMS device(s) utilized on the project. The BMS technicians shall be experienced in the type of HVAC systems associated with this project.

1.31 GRAPHICAL USER INTERFACE (GUI)

A. WEB-CLIENT WORKSTATION: The BMSC shall provide a TCP/IP connected Workstation with the ability to read, adjust and override the various parameters for system control; provide each of the DDC controlled equipment with graphics with a minimum of the complete I/O point listing, their associated setpoints and any other variable for the adjustment and operation of the system.

1.32 SYSTEM DEMONSTRATION:

A. After the startup has been completed on the BMS, the BMSC shall provide a thorough demonstration of the Sequence of Operation for each BMS controlled system(s) to the Architect or their Representative.

1.33 GRAPHICAL USER INTERFACE (GUI) DEMONSTRATION:

A. COORDINATION:
   1. BMSC shall demonstrate the Graphics, trending, and communications setup to the Owner prior to acceptance of the system.

B. ALARM NOTIFICATION:
   1. The BMS shall notify the Owner of an alarming condition via a Visual Alerts and Audible sounds locally at the GUI.
   2. If connected via a TCP/IP connection, an e-mail sent depending on user configuration.
   3. Any maintenance worker shall be capable of interrogating the alarm using the Laptop workstation browsers (via. the internet)

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 15940

SECTION 15950 - 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Balancing Air Systems:

a. Constant-volume air systems.
b. Variable-air-volume systems.

2. Balancing Hydronic Piping Systems:

a. Variable-flow hydronic systems.
b. Primary-secondary hydronic systems.

1.3 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.

1.4 SUBMITTALS

A. Qualification Data: 30 days of Contractor's Notice to Proceed, submit documentation that the TAB Subcontractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Bid Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Bid Documents review report as specified in Part 3.

C. 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.

D. Certified TAB reports.

E. Sample report forms.

F. 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 Subcontractor Qualifications: Engage a TAB entity certified by AABC, NEBB or TABB.

1. TAB Field Supervisor: Employee of the TAB Subcontractor and certified by AABC, NEBB or TABB.
2. TAB Technician: Employee of the TAB Subcontractor and who is certified by AABC, NEBB or TABB as a TAB technician.

B. TAB Conference: Meet with Architect or Owner 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 Bid 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 Subcontractor's forms approved by Architect or Commissioning Authority.

E. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

1.6 PROJECT CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.7 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 Subcontractors that may be engaged include, but are not limited to, the following:

1. USC Environmental Inc.

2. Or Approved Equal.

3.2 EXAMINATION

A. Examine the Bid Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums used for return, or relief air to verify that they meet the leakage class of connected ducts as specified in Division 15 Section "Metal Ducts" and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.

L. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.3 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.

C. Review all Bid Documents existing conditions, and as-built conditions pertaining to the HVAC systems.

D. Mechanical Subcontractor shall provide all equipment, material, parts, supplies, and labor to balance all HVAC equipment to Owner’s satisfaction.

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 NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.

1. Comply with requirements in ASHRAE 62.1-2004, Section 7.2.2, "Air Balancing."

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. After testing and balancing, install test ports and duct access doors that comply with requirements in Division 15 Section "Air Duct Accessories."
3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 15 Sections for Ductwork and Piping Insulation.

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound units.

3.5 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. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Division 15 Section "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 Architect or Construction Manager for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in Section 15725, “Modular Air Handling Units Indoor” for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
7. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur.

Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure airflow of submain and branch ducts.

a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure air outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers 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 Bid 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.

C. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Balance variable-air-volume systems the same as described for constant-volume air systems.
2. Set terminal units and supply fan at full-airflow condition.
3. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
4. Readjust fan airflow for final maximum readings.
5. Measure operating static pressure at the sensor that controls the supply fan if one is installed, and verify operation of the static-pressure controller.
6. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.

7. 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.

8. 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.

D. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.
2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.
3. Set terminal units at full-airflow condition.
4. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
5. Adjust terminal units for minimum airflow.
6. Measure static pressure at the sensor.
7. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow. 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 CONSTANT-FLOW HYDRONIC SYSTEMS

A. Measure water flow at pumps. Use the following procedures except for positive-displacement pumps:

1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.

    a. If impeller sizes must be adjusted to achieve pump performance, obtain approval from Owner and comply with requirements in Division 15 Section "Hydronic Pumps."

2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.

    a. Monitor motor performance during procedures and do not operate motors in overload conditions.

3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
4. Report flow rates that are not within plus or minus 10 percent of design.

B. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.

C. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.

D. Set calibrated balancing valves, if installed, at calculated presettings.

E. Measure flow at all stations and adjust, where necessary, to obtain first balance.

1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

F. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

G. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:

1. Determine the balancing station with the highest percentage over indicated flow.
2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
3. Record settings and mark balancing devices.

H. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

I. Measure the differential-pressure-control-valve settings existing at the conclusion of balancing.

J. Check settings and operation of each safety valve. Record settings.

3.10 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.

3.11 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

A. Balance the primary circuit flow first and then balance the secondary circuits.

3.12 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.13 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record compressor data.

3.14 PROCEDURES FOR BOILERS

A. Hydronic Boilers: Measure and record entering- and leaving-water temperatures and water flow.

B. Steam Boilers: Measure and record entering-water temperature and flow and leaving-steam pressure, temperature, and flow.

3.15 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 steam coil:

1. Dry-bulb temperature of entering and leaving air.
2. Airflow.
3. Air pressure drop.
4. Inlet steam pressure.

D. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.
4. Air pressure drop.
5. Refrigerant suction pressure and temperature.

3.16 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.

1. Measure and record the operating speed, airflow, and static pressure of each fan.
2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
3. Check the refrigerant charge.
4. Check the condition of filters.
5. Check the condition of coils.
6. Check the operation of the drain pan and condensate-drain trap.
7. Check bearings and other lubricated parts for proper lubrication.
8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:

1. New filters are installed.
2. Coils are clean and fins combed.
3. Drain pans are clean.
4. Fans are clean.
5. Bearings and other parts are properly lubricated.
6. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the Renovation Work.

1. Compare the indicated airflow of the Renovated Work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
2. Verify that the indicated airflows of the Renovated Work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
3. If calculations increase or decrease the air flow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
4. Balance each air outlet.

3.17 TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Heating-Water Flow Rate: Plus or minus 10 percent.

3.18 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Bid 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 monthly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.19 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 Subcontractor.
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 Bid Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.

14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:

    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data:

    a. Unit identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.
    f. Unit arrangement and class.
    g. Discharge arrangement.
    h. Sheave make, size in inches, and bore.
    i. Center-to-center dimensions of sheave, and amount of adjustments in inches.
    j. Number, make, and size of belts.
    k. Number, type, and size of filters.

2. Motor Data:

    a. Motor make, and frame type and size.

b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):

a. Total 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.
m. Vortex damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:

a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch o.c.
f. Make and model number.
g. Face area in sq. ft.
h. Tube size in NPS.
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. 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.
o. Inlet steam pressure in psig.

G. Gas-Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Fuel type in input data.
g. Output capacity in Btu/h.
h. Ignition type.
i. Burner-control types.
j. Motor horsepower and rpm.
k. Motor volts, phase, and hertz.
l. Motor full-load amperage and service factor.
m. Sheave make, size in inches, and bore.
n. Center-to-center dimensions of sheave, and amount of adjustments in inches.

2. Test Data (Indicated and Actual Values):

a. Total air flow rate in cfm.
b. Entering-air temperature in deg F.
c. Leaving-air temperature in deg F.
d. Air temperature differential in deg F.
e. Entering-air static pressure in inches wg.
f. Leaving-air static pressure in inches wg.
g. Air static-pressure differential in inches wg.
h. Low-fire fuel input in Btu/h.
i. High-fire fuel input in Btu/h.
j. Manifold pressure in psig.
k. High-temperature-limit setting in deg F.

l. Operating set point in Btu/h.
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btu/h.

H. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Coil identification.
d. Capacity in Btu/h.
e. Number of stages.
f. Connected volts, phase, and hertz.
g. Rated amperage.
h. Air flow rate in cfm.
i. Face area in sq. ft.
j. Minimum face velocity in fpm.

2. Test Data (Indicated and Actual Values):

a. Heat output in Btu/h.
b. Air flow rate in cfm.
c. Air velocity in fpm.
d. Entering-air temperature in deg F.
e. Leaving-air temperature in deg F.
f. Voltage at each connection.
g. Amperage for each phase.

I. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches, and bore.
h. Center-to-center dimensions of sheave, and amount of adjustments in inches.

2. Motor Data:

    a. Motor make, and frame type and size.
    b. Horsepower and rpm.
    c. Volts, phase, and hertz.
    d. Full-load amperage and service factor.
    e. Sheave make, size in inches, and bore.
    f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
    g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

    a. Total airflow rate in cfm.
    b. Total system static pressure in inches wg.
    c. Fan rpm.
    d. Discharge static pressure in inches wg.
    e. Suction static pressure in inches wg.

J. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

    a. System and air-handling-unit number.
    b. Location and zone.
    c. Traverse air temperature in deg F.
    d. Duct static pressure in inches wg.
    e. Duct size in inches.
    f. Duct area in sq. ft.
    g. Indicated 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.

K. Air-Terminal-Device Reports:

1. Unit Data:

    a. System and air-handling unit identification.
    b. Location and zone.
    c. Apparatus used for test.
    d. Area served.
    e. Make.

f. Number from system diagram.
g. Type and model number.
h. Size.
i. Effective area in sq. ft.

2. Test Data (Indicated and Actual Values):

a. 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.

L. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

a. System and air-handling-unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

a. 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.

M. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Service.
d. Make and size.
e. Model number and serial number.
f. Water flow rate in gpm.

g. Water pressure differential in feet of head or psig.
h. Required net positive suction head in feet of head or psig.
i. Pump rpm.
j. Impeller diameter in inches.
k. Motor make and frame size.
l. Motor horsepower and rpm.
m. Voltage at each connection.
n. Amperage for each phase.
o. Full-load amperage and service factor.
p. Seal type.

2. Test Data (Indicated and Actual Values):

a. Static head in feet of head or psig.
b. Pump shutoff pressure in feet of head or psig.
c. Actual impeller size in inches.
d. Full-open flow rate in gpm.
e. Full-open pressure in feet of head or psig.
f. Final discharge pressure in feet of head or psig.
g. Final suction pressure in feet of head or psig.
h. Final total pressure in feet of head or psig.
i. Final water flow rate in gpm.
j. Voltage at each connection.
k. Amperage for each phase.

N. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.20 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 Bid 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 Owner, Construction Manager, or Commissioning Authority.
2. The TAB Subcontractor's test and balance Engineer shall conduct the inspection in the presence of Owner or Construction Manager.
3. Owner or Construction Manager 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 Subcontractor to complete TAB Work according to the Bid Documents and deduct the cost of the services from the original TAB Subcontractor's final payment.

D. Prepare test and inspection reports.

3.21 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 15950

PART 6 - ELECTRICAL

SECTION 13852 - 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 SUMMARY

A. Section Includes:
   1. Existing fire-alarm control panel.
   2. Manual fire-alarm boxes.
   3. System smoke detectors.
   4. System carbon monoxide detectors
   5. Heat detectors.
   6. Notification appliances.
   7. Device guards.
   8. Magnetic door holders.
   9. Remote annunciator.
   10. Addressable interface device.
   11. Digital alarm communicator transmitter.
   12. Radio alarm transmitter.
   13. System printer.

1.3 DEFINITIONS

A. EMT: Electrical Metallic Tubing.

B. FACP: Fire Alarm Control Panel.

C. HLI: High Level Interface.

D. NICET: National Institute for Certification in Engineering Technologies.

E. PC: Personal computer.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including furnished options and accessories.

1. Include construction details, material descriptions, dimensions, profiles, and finishes.
2. Include rated capacities, operating characteristics, and electrical characteristics.

B. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, details, and attachments to other Work.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
4. Detail assembly and support requirements.
5. Include voltage drop calculations for notification-appliance circuits.
6. Include battery-size calculations.
7. Include input/output matrix.
8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
9. Include performance parameters and installation details for each detector.
10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
11. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.

    a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
    b. Show field wiring required for HVAC unit shutdown on alarm.
    c. Locate detectors according to manufacturer's written recommendations.

12. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
13. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.

C. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction.
2. Shop Drawings shall be prepared by persons with the following qualifications:

    a. Trained and certified by manufacturer in fire-alarm system design.

b. NICET-certified, fire-alarm technician; Level IV minimum.
c. Licensed or certified by authorities having jurisdiction.

D. Delegated-Design Submittal: For notification appliances, smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by the qualified Professional Engineer responsible for their preparation.

1. Drawings showing the location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the device.
2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
3. Indicate audible appliances required to produce square wave signal per NFPA 72.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Field quality-control reports.

C. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. Include the following and deliver copies to authorities having jurisdiction:

a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
d. Riser diagram.
e. Device addresses.
f. Record copy of site-specific software.
g. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:

1) Equipment tested.
2) Frequency of testing of installed components.
3) Frequency of inspection of installed components.
4) Requirements and recommendations related to results of maintenance.
5) Manufacturer's user training manuals.

h. Manufacturer's required maintenance related to system warranty requirements.
i. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Smoke Detectors, Fire Detectors: Five of each type installed.
2. Detector Bases: Five of each type installed.
3. Keys and Tools: One extra set for access to locked or tamper proofed components.
4. Audible and Visual Notification Appliances: Five of each type installed.

1.8 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 IV technician.

C. NFPA Certification: Obtain certification according to NFPA 72 by an NRTL (nationally recognized testing laboratory).

1.9 PROJECT CONDITIONS

A. Perform a full test of the existing system prior to starting Work. Document any equipment or components not functioning as designed.

B. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:

1. Notify Owner no fewer than seven days in advance of proposed interruption of fire-alarm service.
2. Do not proceed with interruption of fire-alarm service without Owner's written permission.

C. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

1.10 SEQUENCING AND SCHEDULING

A. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service, and label existing fire-alarm equipment "NOT IN SERVICE" until removed from the building.

B. Existing system shall remain operational until the new system is installed and tested.

C. Provide fire watch as required by local Authority Having Jurisdiction for areas not covered by Fire Alarm system.

D. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

1.11 WARRANTY

A. Warranty: System provider agrees to repair or replace fire-alarm system equipment and components including but not limited to the fire alarm control panel, detection devices, and notification devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

1.12 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include one (1) year full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

1. Include visual inspections according to the "Visual Inspection Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
2. Perform tests in the "Test Methods" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Perform tests per the "Testing Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Provide system manufacturer's certification that all components provided have been tested as, and will operate as, a system.

B. UL-certified addressable system, with multiplexed signal transmission and speaker/strobe evacuation.

C. Automatic sensitivity control of certain smoke detectors.

D. All components provided shall be listed for use with the selected system.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:

1. Manual stations.
2. Heat detectors.
3. Smoke detectors.

4. Duct smoke detectors.
5. Smoke beam detector.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances.
2. Identify alarm and specific initiating device at fire-alarm control unit and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Release fire and smoke doors held open by magnetic door holders.
6. Activate voice/alarm communication system.
7. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
8. Close smoke dampers in air ducts of designated air-conditioning duct systems.
9. Recall elevators to primary or alternate recall floors.
10. Activate elevator power shunt trip.
11. Activate emergency lighting control.
12. Activate emergency shutoffs for gas and fuel supplies.
13. Record events in the system memory.
14. Record events by the system printer.
15. Indicate device in alarm on the graphic annunciator.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Alert and Action signals of air-sampling detector system.
2. Independent fire-detection and -suppression systems.
3. User disabling of zones or individual devices.
4. Loss of communication with any panel on the network.

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
4. Loss of primary power at fire-alarm control unit.
5. Ground or a single break in internal circuits of fire-alarm control unit.
6. Abnormal ac voltage at fire-alarm control unit.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.

10. Voice signal amplifier failure.
11. Hose cabinet door open.

E. System Supervisory Signal Actions:

1. Initiate notification appliances.
2. Identify specific device initiating the event at fire-alarm control unit and remote annunciators.
3. Record the event on system printer.
4. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.
5. Transmit system status to building management system.
6. Display system status on graphic annunciator.

2.3 FIRE-ALARM CONTROL PANEL

A. The fire alarm control panel is an existing Siemens XLS System. The Contractor shall provide new devices, booster panels, and expansion modules as required for a complete and operational installation.

B. All new equipment and devices shall be UL listed and compatible with the existing fire alarm system.

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

B. 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 operated switch.
3. Indoor Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
4. Weatherproof Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.
5. In addition to devices shown on the Bid Drawings, provide additional quantity of devices as specified on the fire alarm riser diagram. Include wiring, testing and programming, location as directed by the Engineer or local fire marshal.

2.5 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be two-wire type.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. 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.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
7. Remote Control: Unless otherwise indicated, detectors shall be digital-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 of combination smoke- and heat-detection units shall be selectable at fire-alarm control unit for 15 or 20 deg F per minute.
    b. Fixed-temperature sensing characteristic of combination smoke- and heat-detection units 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. Multiple levels of detection sensitivity for each sensor.
    d. Sensitivity levels based on time of day.

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.).
3. In addition to devices shown on the Bid Drawings, provide additional quantity of devices as specified on the fire alarm riser diagram. Include wiring, testing and programming, location as directed by the Engineer or local fire marshal.

C. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
4. 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. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.
7. In addition to devices shown on the Bid Drawings, provide additional quantity of devices as specified on the fire alarm riser diagram. Include wiring, testing and programming, location as directed by the Engineer or local fire marshal.

2.6 CARBON MONOXIDE DETECTORS

A. General: Carbon monoxide detector listed for connection to fire-alarm system.

1. Mounting: Adapter plate for outlet box mounting.
2. Testable by introducing test carbon monoxide into the sensing cell.
3. Detector shall provide alarm contacts and trouble contacts.
4. Detector shall send trouble alarm when nearing end-of-life, power supply problems, or internal faults.
5. Comply with UL 2075.
6. Locate, mount, and wire according to manufacturer's written instructions.
7. Provide means for addressable connection to fire-alarm system.
8. Test button simulates an alarm condition.

B. In addition to devices shown on the Bid Drawings, provide additional quantity of devices as specified on the fire alarm riser diagram. Include wiring, testing and programming, location as directed by the Engineer or local fire marshal.

2.7 MULTICRITERIA DETECTORS

A. Mounting: Twist-lock base interchangeable with smoke-detector bases.

B. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

C. Automatically adjusts its sensitivity by means of drift compensation and smoothing algorithms. The detector shall send trouble alarm if it is incapable of compensating for existing conditions.

D. Test button tests all sensors in the detector.

E. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

1. Primary status.
2. Device type.
3. Present sensitivity selected.
4. Sensor range (normal, dirty, etc.).

F. Sensors: The detector shall be comprised of four sensing elements including a smoke sensor, a carbon monoxide sensor, an infrared sensor, and a heat sensor.

1. Smoke sensor shall be photoelectric type as described in "System Smoke Detectors" Article.
2. Carbon monoxide sensor shall be as described in "Carbon Monoxide Detectors" Article.
3. Heat sensor shall be as described in "Heat Detectors" Article.
4. Each sensor shall be separately listed according to requirements for its detector type.

G. In addition to devices shown on the Bid Drawings, provide additional quantity of devices as specified on the fire alarm riser diagram. Include wiring, testing and programming, location as directed by the Engineer or local fire marshal.

2.8 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

1. Temperature sensors shall test for and communicate the sensitivity range of the device.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F or 195 deg F or as indicated on Drawings, 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.

C. In addition to devices shown on the Bid Drawings, provide additional quantity of devices as specified on the fire alarm riser diagram. Include wiring, testing and programming, location as directed by the Engineer or local fire marshal.

2.9 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Connected to notification appliance signal circuits, zoned as indicated, equipped for mounting as indicated and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated and with screw terminals for system connections.

B. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol.

C. Visible Notification Appliances: Xenon strobe lights 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- (25-mm-) high letters on the lens.

1. Rated Light Output:
   a. 15/30/75/110 cd, selectable in the field.
2. Mounting: Wall or ceiling mounted as shown on the plans.
3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
4. Flashing shall be in a temporal pattern, synchronized with other units.
5. Strobe Leads: Factory connected to screw terminals.
6. Mounting Faceplate: Factory finished red for walls, white for ceilings, unless otherwise directed by the Architect.

D. In addition to devices shown on the Bid Drawings, provide additional quantity of devices as specified on the fire alarm riser diagram. Include wiring, testing and programming, location as directed by the Engineer or local fire marshal.

2.10 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

1. Electromagnets: Require no more than 3 W to develop 25-lbf holding force.
2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
3. Rating: 24-V ac or dc.
4. Rating: 120-V ac.

B. Material and Finish: Match door hardware.

2.11 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.

2.12 ADDRESSABLE INTERFACE DEVICE

A. General:

1. Include address-setting means on the module.
2. Store an internal identifying code for control panel use to identify the module type.
3. Listed for controlling HVAC fan motor controllers.

B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.

C. Integral Relay: Capable of providing a direct signal to circuit-breaker shunt trip for power shutdown.

1. Allow the control panel to switch the relay contacts on command.
2. Have a minimum of two normally open and two normally closed contacts available for field wiring.

D. Control Module:

1. Operate notification devices.

E. In addition to devices shown on the Bid Drawings, provide additional quantity of devices as specified on the fire alarm riser diagram. Include wiring, testing and programming, location as directed by the Engineer or local fire marshal.

2.13 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture two telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a

C. local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station ov

D. er the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

E. Local functions and display at the digital alarm communicator transmitter shall include the following:

1. Verification that both telephone 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.

F. Digital data transmission shall include the following:

1. Address of the alarm-initiating device.
2. Address of the supervisory signal.
3. Address of the trouble-initiating device.
4. Loss of ac supply.
5. Loss of power.
6. Low battery.
7. Abnormal test signal.
8. Communication bus failure.

G. Secondary Power: Integral rechargeable battery and automatic charger.

H. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.14 SYSTEM PRINTER

A. Printer shall be listed and labeled as an integral part of fire-alarm system.

2.15 DEVICE GUARDS

A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, audible / visual signals, or other device requiring protection.

1. Factory fabricated and furnished by device manufacturer.
2. Finish: Paint of color to match the protected device.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

1. Devices placed in service before all other trades have completed cleanup shall be replaced.

2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.

B. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.

1. Connect new equipment to existing control panel in existing part of the building.
2. Connect new equipment to existing monitoring equipment at the supervising station.
3. Expand, modify, and supplement existing control and/or monitoring equipment as necessary to extend existing control and/or monitoring functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.

C. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in the normal path of egress within 60 inches of the exit doorway.
2. Mount manual fire-alarm box on a background of a contrasting color.
3. The operable part of manual fire-alarm box shall be between 42 inches and 48 inches above floor level. All devices shall be mounted at the same height unless otherwise indicated.

D. Smoke- or Heat-Detector Spacing:

1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
3. 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 Annex A or Annex B in NFPA 72.
5. HVAC: Locate detectors not closer than 36 inches 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 and not directly above pendant mounted or indirect lighting.

E. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.

F. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches long shall be supported at both ends.

1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

G. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

H. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and audible devices on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

I. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm audible device and at least 6 inches below the ceiling. Install all devices at the same height unless otherwise indicated.

J. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.3 PATHWAYS

A. Pathways shall be installed in EMT.

B. Exposed EMT shall be painted red enamel.

3.4 CONNECTIONS

A. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Smoke dampers in air ducts of designated HVAC duct systems.
2. Magnetically held-open doors.
3. Electronically locked doors and access gates.
4. Alarm-initiating connection to activate emergency lighting control.
5. Data communication circuits for connection to mass notification system.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 16075 "Identification for Electrical Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.

3.6 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.7 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by The Engineer and authorities having jurisdiction.

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. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Visual Inspection: Conduct visual inspection prior to testing.

    a. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
    b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.

2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

F. Fire-alarm system will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

H. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

I. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.8 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system for a minimum of two days of training.

END OF SECTION 13852

SECTION 16051 - 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 this Section.

1.2 SUMMARY

A. Section Includes:

1. Electrical equipment coordination and installation.
2. Sleeves for raceways and cables.
3. Sleeve seals.
4. Grout.
5. Common electrical installation requirements.

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For sleeve seals.

1.5 COORDINATION

A. Coordinate arrangement, mounting, and support of electrical equipment:

1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
3. To allow right of way for piping and conduit installed at required slope.
4. So, connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Through Penetration Firestop Systems".

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Sleeves for Rectangular Openings: Galvanized sheet steel.

1. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter, less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.
b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

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. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Metraflex Co.
d. Pipeline Seal and Insulator, Inc.
e. Or approved equal.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
3. Pressure Plates: Plastic. 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.

2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, or wireways or masonry walls, or fire-rated floor and wall assemblies.

B. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

C. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

D. Cut sleeves to length for mounting flush with both surfaces of walls.

E. Extend sleeves installed in floors 2 inches above finished floor level.

F. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.

G. Seal space outside of sleeves with grout for penetrations of concrete and masonry

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

H. Interior Penetrations of Non-Fire-Rated Walls and Floors: 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."

I. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.3 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use 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.

3.4 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Through Penetration Firestop Systems."

END OF SECTION 16051

SECTION 16055 - 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 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.

B. Provide coordination study only for the new electrical distribution system from the new circuit breaker in existing Main Distribution Switchboard to all new panelboards and equipment provided in the scope of this project.

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. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals may 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 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Coordination Study Specialist.

B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

1.6 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 Division 01 Section "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.

1.7 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. 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

C. Comply with IEEE 242 and IEEE 399.

D. 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.

E. 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. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. 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. 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.

    b. Fuses: Show current rating, voltage, and class.

F. 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. Generator short-circuit decrement curve and generator damage point.
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:

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project for new equipment only. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. Generator Protection: Select protection according to manufacturer's written recommendations and to IEEE 242.

H. 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.

I. 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. Standby generators and automatic transfer switches.
   3. New branch circuit panelboards.

3.3 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the overcurrent protective device study.
   1. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
   2. 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.

3.4 FIELD ADJUSTING

A. Make modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.

END OF SECTION 16055

SECTION 16056 - OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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. Other Action Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals may 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.

    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 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Arc-Flash Study Specialist.

B. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.

B. Operation and Maintenance Procedures: In addition to items specified in Division 01 Section "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.

PART 2 - RODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Comply with IEEE 1584 and NFPA 70E.

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.

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. Panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 16055 "Overcurrent Protective Device Coordination 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. Equivalent impedance.
d. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
e. 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 16075 "Identification for Electrical Systems." Produce a 3.5-by-5-inch thermal transfer label of high-adhesion polyester 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. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 16055 "Overcurrent Protective Device Coordination 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. 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.

F. 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).

G. 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.

H. 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. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.

2. For existing equipment, whether or not relocated, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and Engineers.

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. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
9. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
10. Motor horsepower and NEMA MG 1 code letter designation.
11. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.4 LABELING

A. Apply one arc-flash label for 600-V ac, 480-V ac, and applicable 208-V ac panelboards and disconnects and for each of the following locations:
1. Low-voltage distribution panels.

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.

END OF SECTION 16056

SECTION 16060 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes methods and materials for grounding systems and equipment.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Field quality-control test reports.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch 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. Bare Grounding Conductor and Conductor Protector for Wood Poles:

1. No. 4 AWG minimum, soft-drawn copper.
2. Conductor Protector: Half-round PVC or wood molding; if wood, use pressure-treated fir, cypress, or cedar.

D. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

2.2 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure type with at least two bolts.

1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

D. Bus-bar Connectors: Mechanical type, cast silicon bronze, solderless exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.3 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel, sectional type; 3/4 inch by 10 feet in diameter.

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. 3/0 AWG minimum. Bury at least 24 inches below grade.

C. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down to specified height above floor; connect to horizontal bus.

D. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Armored and metal-clad cable runs.
8. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.

C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

E. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

F. Signal and Communication Equipment: In addition to grounding and bonding required by NFPA 70, provide a separate grounding system complying with requirements in TIA/ATIS J-STD-607-A.

1. For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
2. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-4-by-12-inch grounding bus.
3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

3.3 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Rods: Drive rods until tops are 2 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.
2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.

D. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

E. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

F. Ufer Ground (Concrete-Encased Grounding Electrode): In new addition areas, fabricate according to NFPA 70; use a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.

1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.
2. 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 LABELING

A. Comply with requirements in Division16 Section "Electrical Identification" 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."

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal.
   a. Perform tests by fall-of-potential method according to IEEE 81.

B. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 ohms.
2. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohms.

3. Pad-Mounted Equipment: 5 ohms.

C. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 16060

SECTION 16073 - 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

1.3 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 systems and its contents.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

D. At stage, music and band rooms, all conduit shall be supported using elastomeric hangers and mounts providing 1/10” minimum deflection such as Mason RWHD and BR, or approved equal.

E. At stage, music and band rooms, all panels shall be mounted to walls using isolator as manufactured by Mason PB, or approved equal.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Steel 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. Equipment supports.

1.6 QUALITY ASSURANCE

A. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Allied Tube & Conduit.
b. Cooper B-Line, Inc.; a division of Cooper Industries.
c. ERICO International Corporation.
d. GS Metals Corp.
e. Thomas & Betts Corporation.
f. Unistrut; Tyco International, Ltd.
g. Wesanco, Inc.
h. Or approved equal.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.

5. Channel Dimensions: Selected for applicable load criteria.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

a. 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.
5) Or approved equal.

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.
6) Or approved equal.

3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
5. Toggle Bolts: All-steel springhead type.

6. Hanger Rods: Threaded steel.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as scheduled in NECA 1, where its Table 1 lists maximum spacings less than stated in 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.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for one-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. 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.

2. To Light Steel: Sheet metal screws.
3. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, pull and junction boxes, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.

3.3 PAINTING

A. Touchup: Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

END OF SECTION 16073

SECTION 16075 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Warning labels and signs.
5. Instruction signs.
6. Equipment identification labels.
7. Miscellaneous identification products.

1.3 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

1.4 QUALITY ASSURANCE

A. Comply with ANSI A13.1 and IEEE C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.5 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 POWER RACEWAY IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.

B. Colors for Raceways Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage.

C. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

D. Snap-Around Labels for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

E. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.

2.2 ARMORED AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Colors for Raceways Carrying Circuits at 600 V and Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage.

C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

D. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches wide; compounded for outdoor use.

2.3 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

C. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.

D. Write-On Tags: Polyester tag, 0.015-inch-thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.

1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

E. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

F. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

2.4 CONDUCTOR IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

C. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

D. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

E. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

F. Write-On Tags: Polyester tag, 0.015-inch-thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.

1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.5 FLOOR MARKING TAPE

A. 2-inch- wide, 5-mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

2.6 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Screw Fastened Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

C. Baked-Enamel Warning Signs:

1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.

2. 1/4-inch grommets in corners for mounting.
3. Nominal size, 7 by 10 inches

D. Metal-Backed, Butyrate Warning Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal size, 10 by 14 inches.

E. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES"

2.7 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16-inch-thick for signs up to 20 sq. inches and 1/8 inch thick for larger sizes.

1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.8 EQUIPMENT IDENTIFICATION LABELS

A. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch.

B. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch

2.9 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self extinguishing, one piece, self locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F, According to ASTM D 638: 12,000 psi.

3. Temperature Range: Minus 40 to plus 185 deg F
4. Color: Black except where used for color-coding.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self extinguishing, one piece, self locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F, According to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black.

C. Plenum-Rated Cable Ties: Self extinguishing, UV stabilized, one piece, self locking.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F, According to ASTM D 638: 7000 psi.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F.
5. Color: Black.

2.10 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Select paint system applicable for surface material and location exterior or interior.

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish Work.

D. Attach signs and plastic labels type with mechanical fasteners appropriate to the location and substrate.

E. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color

markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

F. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

G. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.2 IDENTIFICATION SCHEDULE

A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A, and 120 V to ground: Identify with self-adhesive vinyl tape applied in bands. Install labels at 10-foot maximum intervals.

B. Power-Circuit Conductor Identification, 600 V or Less: For conductors in pull and junction boxes use color-coding conductor tape to identify the phase.

1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service feeder and branch-circuit conductors.

a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit .
b. Colors for 208/120-V Circuits:

1) Phase A: Black.
2) Phase B: Red.
3) Phase C: Blue.

c. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

C. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.

D. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source.

E. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
3. Coordinate identification with Bid Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.

F. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

G. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

END OF SECTION 16075

SECTION 16120 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 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.
3. Sleeves and sleeve seals for cables.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Field quality-control test reports.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Copper Conductors: Comply with NEMA WC 70.

B. Conductor Insulation: Comply with NEMA WC 70 for Types THW, THHN-THWN, XHHW, UF, USE, and SO.

C. Multiconductor Cable: Comply with NEMA WC 70 for metal-clad cable, Type MC.

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:

B. Manufacturers: Subject to compliance with requirements, provide products by one of 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. Or approved equal.

C. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Exposed Branch Circuits: Type THHN-THWN, single conductors in raceway.

B. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and 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 cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Support cables according to Division 16 Sections "Hangers and Supports for Electrical Systems."

F. Identify and color-code conductors and cables according to Division 16 Section "Identification for Electrical Systems."

G. 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.

H. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.

I. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (of slack.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. After installing conductors and cables test all light fixtures and occupancy sensors to insure proper operation and compliance with design intent.

C. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. 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 16120

SECTION 16130 - RACEWAY 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 Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. ENT: Electrical nonmetallic tubing.

C. EPDM: Ethylene-propylene-dieneterpolymer rubber.

D. FMC: Flexible metal conduit.

E. IMC: Intermediate metal conduit.

F. LFMC: Liquidtight flexible metal conduit.

G. LFNC: Liquidtight flexible nonmetallic conduit.

H. NBR: Acrylonitrile-butadiene rubber.

I. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other Work.

1. Custom enclosures and cabinets.

C. Coordination Drawings: Conduit routing plans, 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. Structural members in the paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in the paths of conduit groups with common supports.

3. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
4. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Qualification Data: For Professional Engineer and testing agency.

E. Source 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.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

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. Alflex Inc.
3. Allied Tube & Conduit; a Tyco International Ltd. Co.
4. Anamet Electrical, Inc.; Anaconda Metal Hose.
5. Electri-Flex Co.
6. Manhattan/CDT/Cole-Flex.
7. Maverick Tube Corporation.
8. O-Z Gedney; a unit of General Signal.

9. Wheatland Tube Company.
10. Or approved equal.

B. Rigid Steel Conduit: ANSI C80.1.

C. IMC: ANSI C80.6.

D. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch minimum.

E. EMT: ANSI C80.3.

F. FMC: Zinc-coated steel

G. LFMC: Flexible steel conduit with PVC jacket.

H. Fittings for Conduit Including all Types and Flexible and Liquidtight, EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
1. Fittings for EMT: Steel or die-cast, compression set-screw or compression type.
2. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch with overlapping sleeves protecting threaded joints.

I. Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.2 NONMETALLIC CONDUIT AND TUBING

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. Cooper B-Line, Inc.
2. Hoffman.
3. Square D; Schneider Electric.
4. Or approved equal.

C. ENT: NEMA TC 13.

D. RNC: NEMA TC 2, Type EPC-80-PVC, unless otherwise indicated.

E. LFNC: UL 1660.

F. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.

G. Fittings for LFNC: UL 514B.

2.3 METAL WIREWAYS

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.
2. Hoffman.
3. Square D; Schneider Electric.
4. Or approved equal.

B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, 12, 3R, unless otherwise indicated.

C. Fittings and Accessories: Include 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 or as indicated.

E. Finish: Manufacturer's standard enamel finish.

2.4 SURFACE RACEWAYS

A. Surface Metal Raceways: Galvanized steel with snap-on covers. Manufacturer's standard enamel finish in color selected by Architect

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. Thomas & Betts Corporation.
b. Walker Systems, Inc.; Wiremold Company The.
c. Wiremold Company The; Electrical Sales Division.
d. Or approved equal.

B. Surface Nonmetallic Raceways: Two-piece construction, manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard custom colors.

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. Butler Manufacturing Company; Walker Division.
b. Enduro Systems, Inc.; Composite Products Division.
c. Hubbell Incorporated; Wiring Device-Kellems Division.
d. Lamson & Sessions; Carlon Electrical Products.
e. Panduit Corp.
f. Walker Systems, Inc.; The Wiremold Company.
g. The Wiremold Company; Electrical Sales Division.
h. Or approved equal.

2.5 BOXES, ENCLOSURES, AND CABINETS

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 Crouse-Hinds; Div. of Cooper Industries, Inc.
2. EGS/Appleton Electric.
3. Erickson Electrical Equipment Company.
4. Hoffman.
5. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
6. O-Z/Gedney; a unit of General Signal.
7. RACO; a Hubbell Company.
8. Robroy Industries, Inc.; Enclosure Division.
9. Scott Fetzer Co.; Adalet Division.
10. Spring City Electrical Manufacturing Company.
11. Thomas & Betts Corporation.
12. Walker Systems, Inc.; The Wiremold Company.
13. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.
14. Or approved equal.

B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy Type FD, with gasketed cover.

D. Nonmetallic Outlet and Device Boxes: NEMA OS 2.

E. Metal Floor Boxes Cast or sheet metal, fully adjustable rectangular.

F. Nonmetallic Floor Boxes: Nonadjustable, round.

G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

H. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, galvanized, cast iron with gasketed cover.

I. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Nonmetallic Enclosures:

J. Cabinets:

1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.

2.6 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. Description: Comply with SCTE 77.

1. Color of Frame and Cover: Gray or Green, match adjacent surface.
2. Configuration: Units shall be designed for flush burial and have open bottom, unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering, "ELECTRIC."
6. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
7. Handholes 12 inches wide by 24 inches long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel or fiberglass or a combination of the two.

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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Basis-of-Design Product: Subject to compliance with requirements, provide Hubbell or a comparable product by one of the following:

    a. Armorcast Products Company.
    b. Carson Industries LLC.
    c. CDR Systems Corporation.
    d. NewBasis.
    e. Or approved equal.

C. Fiberglass Handholes and Boxes with Polymer-Concrete Frame and Cover: Sheet-molded, fiberglass-reinforced, polyester-resin enclosure joined to polymer-concrete top ring or frame.

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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Basis-of-Design Product: Subject to compliance with requirements, provide Hubbell or a comparable product by one of the following:

    a. Armorcast Products Company.
    b. Carson Industries LLC.
    c. Christy Concrete Products.
    d. Synertech Moulded Products, Inc.; a division of Oldcastle Precast.
    e. Or approved equal.

D. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with covers of polymer concrete.

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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Basis-of-Design Product: Subject to compliance with requirements, provide Hubbell or a comparable product by one of the following:

    a. Carson Industries LLC.
    b. Christy Concrete Products.

c. Nordic Fiberglass, Inc.
d. Or approved equal.

2.7 SLEEVES FOR RACEWAYS

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inchthickness as indicated and of length to suit application.

D. Coordinate sleeve selection and application with selection and application of Firestopping specified in Division 07 Section "Penetration Firestopping."

2.8 SLEEVE SEALS

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. Advance Products & Systems, Inc.
2. Calpico, Inc.
3. Metraflex Co.
4. Pipeline Seal and Insulator, Inc.
5. Or approved equal.

B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.

1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
2. Pressure Plates: Plastic. Include two for each sealing element.
3. 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.

2.9 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by a independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered Professional Engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:

1. Exposed Conduit: Rigid steel conduit or, Type EPC-80-PVC.
2. Concealed Conduit, Aboveground: IMC or, Type EPC-40-PVC.
3. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
4. Underground Conduit: RNC, Type EPC- 80-PVC, direct buried.

5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
6. Application of Handholes and Boxes for Underground Wiring:

    a. Handholes and Pull Boxes 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.
    b. Handholes and Pull Boxes in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Heavy-duty fiberglass units with polymer-concrete frame and cover, SCTE 77, Tier 8 structural load rating.
    c. Handholes and Pull Boxes Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbfvertical loading.

B. Comply with the following indoor applications, unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.

2. Exposed, Not Subject to Severe Physical Damage: EMT.

3. Exposed and Subject to Severe Physical Damage: Rigid steel conduit. Includes raceways in the following locations:
    a. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
    b. Mechanical rooms.

4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.

6. Damp or Wet Locations: Rigid steel conduit

C. Minimum Raceway Size: 3/4-inch trade size.

D. 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.

E. Do not install aluminum conduits in contact with concrete.

3.2 INSTALLATION

A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

B. Keep raceways at least 6 inchaway from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Support raceways as specified in Division 16 Section "Hangers and Supports for Electrical Systems."

E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.

G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.

H. Raceways Embedded in Slabs:

1. Run conduit larger than 1-inchtrade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Change from ENT to RNC, Type EPC-40-PVC, rigid steel conduit, or IMC before rising above the floor.

I. 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.

J. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

K. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lbtensile strength. Leave at least 12 inch of slack at each end of pull wire.

L. Install raceway sealing fittings at suitable, approved, and accessible locations 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 at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where otherwise required by NFPA 70.

M. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F, and that has straight-run length that exceeds 25 feet.

1. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:

    a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
    c. Indoor Spaces: Connected with the Outdoors without Physical Separation: 125 deg F temperature change.

2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg Fof temperature change.

3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.

N. Flexible Conduit Connections: Use maximum of 72 inch of flexible conduit for recessed and semi recessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Provide each flexible connection with enough slack to form an 8” deep U-shaped bend at all motorized/vibrating equipment.

2. Use LFMC in damp or wet locations subject to severe physical damage.

O. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.

P. Set metal floor boxes level and flush with finished floor surface.

Q. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 2 Section "Earthwork" for pipe less than 6 inchesin nominal diameter.
2. Install backfill as specified in Division 2 Section "Earthwork."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 2 Section "Earthwork."
4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.

6. Warning Planks: Bury warning planks approximately 12 inches above direct-buried conduits, placing them 24 inches o.c. Align planks along the width and along the centerline of conduit.

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inchsieve to No. 4sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.

D. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.

E. Field-cut openings for conduits 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.

3.5 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of Firestopping specified in Division 07 Section "Penetration Firestopping."

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Penetrations of conduit through walls/floors/ceilings shall be oversized by ½” to 1”. There shall be no contact between the penetrating element and the partition, and the resultant gap shall be filled with closed cell foam backer rod and acoustical sealant for an airtight seal. Penetrations through fire walls shall be fire rated.

E. Rectangular Sleeve Minimum Metal Thickness:

1. For sleeve cross-section rectangle perimeter, less than 50 inch and no side greater than 16-inch thickness shall be 0.052 inch
2. For sleeve cross-section rectangle perimeter, equal to, or greater than, 50 inch and 1 or more sides equal to, or greater than, 16-inch thickness shall be 0.138 inch

F. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

G. Cut sleeves to length for mounting flush with both surfaces of walls.

H. Extend sleeves installed in floors 2 inch above finished floor level.

I. Size pipe sleeves to provide 1/4-inchannular clear space between sleeve and raceway unless sleeve seal is to be installed or unless seismic criteria require different clearance.

J. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

K. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

L. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials. Comply with Division 07 Section "Penetration Firestopping."

M. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with Roofing Work.

N. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inchannular clear space between pipe and sleeve for installing mechanical sleeve seals.

O. Underground, Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inchannular clear space between raceway and sleeve for installing mechanical sleeve seals.

3.6 SLEEVE-SEAL INSTALLATION

A. Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve

seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.7 FIRESTOPPING

A. Apply Firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.8 PROTECTION

A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 16130

SECTION 16139 - CABLE TRAYS FOR COMMUNICATIONS 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. Ladder cable trays.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of cable tray.

1. Include data indicating dimensions and finishes for each type of cable tray indicated.

B. Shop Drawings: For each type of cable tray.

1. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and sections, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Include scaled cable tray layout and relationships between components and adjacent structural, electrical, and mechanical elements.
2. Vertical and horizontal offsets and transitions.
3. Clearances for access above and to side of cable trays.

4. Vertical elevation of cable trays above the floor or below bottom of ceiling structure.

B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR CABLE TRAYS

A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.

1. Source Limitations: Obtain cable trays and components from single manufacturer.

B. Structural Performance: See articles for individual cable tray types for specific values for the following parameters:

1. Uniform Load Distribution: Capable of supporting a uniformly distributed load on the indicated support span when supported as a simple span and tested according to NEMA VE 1.
2. Concentrated Load: A load applied at midpoint of span and centerline of tray.
3. Load and Safety Factors: Applicable to both side rails and rung capacities.

2.2 LADDER CABLE TRAYS

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. Allied Tube & Conduit; a Tyco International Ltd. Co.
2. Chalfant Manufacturing Company.
3. Cooper B-Line, Inc.
4. Mono-Systems, Inc.
5. MP Husky.
6. Niedax-Kleinhuis USA, Inc.
7. Or approved equal.

B. Description:

1. Configuration: Two I-beam side rails with transverse rungs welded to side rails.
2. Rung Spacing: 6 inches o.c.
3. Radius-Fitting Rung Spacing: 9 inches at center of tray's width.

4. Minimum Cable-Bearing Surface for Rungs: 7/8-inch width with radius edges.
5. No portion of the rungs shall protrude below the bottom plane of side rails.
6. Structural Performance of Each Rung: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb concentrated load, when tested according to NEMA VE 1.
7. Minimum Usable Load Depth: 6 inches.
8. Straight Section Lengths: Refer to Drawings.
9. Width: 24 inches (unless otherwise indicated on Drawings).
10. Fitting Minimum Radius: 24 inches.
11. The maximum uniform load and the support span are indicated by the cable tray class.
12. Class Designation: Comply with NEMA VE 1, Class 12B.
13. Splicing Assemblies: Bolted type using serrated flange locknuts.
14. Hardware and Fasteners: ASTM F 593 and ASTM F 594 stainless steel, Type 316.
15. Splice Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

2.3 MATERIALS AND FINISHES

A. Steel:

1. Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of ASTM A 1011/A 1011M, SS, Grade 33.
2. Steel Tray Splice Plates: ASTM A 1011/A 1011M, HSLAS, Grade 50, Class 1.
3. Fasteners: Steel complies with the minimum mechanical properties of ASTM A 510/A 510M, Grade 1008.
4. Finish: Mill galvanized before fabrication.

    a. Standard: Comply with ASTM A 653/A 653M, G90 (Z275).
    b. Hardware: Chromium-zinc plated, ASTM F 1136.

5. Finish: Electrogalvanized before fabrication.

    a. Standard: Comply with ASTM B 633.
    b. Hardware: Galvanized, ASTM B 633.

6. Finish: Hot-dip galvanized after fabrication.

    a. Standard: Comply with ASTM A 123/A 123M, Class B2.
    b. Hardware: Stainless steel, Type 316, ASTM F 593 and ASTM F 594.

2.4 CABLE TRAY ACCESSORIES

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.

B. Barrier Strips: Same materials and finishes as for cable tray.

C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.5 WARNING SIGNS

A. Lettering: 1-1/2-inch- high, black letters on yellow background with legend "Warning! Not To Be Used as Walkway, Ladder, or Support for Ladders or Personnel."

B. Comply with requirements for fasteners in Section 16075 "Identification for Electrical Systems."

2.6 SOURCE QUALITY CONTROL

A. Testing: Test and inspect cable trays according to NEMA FG 1, NEMA VE 1.

PART 3 - EXECUTION

3.1 CABLE TRAY INSTALLATION

A. 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.

B. Install cable trays so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.

C. Remove burrs and sharp edges from cable trays.

D. Join aluminum cable tray with splice plates; use four square neck-carriage bolts and locknuts.

E. Fasten cable tray supports to building structure.

F. Design fasteners and supports to carry cable tray, the cables, and a concentrated load of 200 lb. Comply with requirements in Division 16 "Hangers and Supports for Electrical Systems."

G. Place supports so that spans do not exceed maximum spans on schedules and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.

H. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.

I. Support bus assembly to prevent twisting from eccentric loading.

J. Install center-hung supports for single-rail trays designed for 60 versus 40 percent eccentric loading condition, with a safety factor of 3.

K. Support wire-basket cable trays with trapeze hangers.

L. Support trapeze hangers for wire-basket trays with 3/8-inch diameter rods.

M. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.

N. Make cable tray connections using manufacturer's recommended fittings.

O. Seal penetrations through fire and smoke barriers. Comply with requirements in Division 07.

P. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.

Q. Install cable trays with enough workspace to permit access for installing cables.

R. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15 000 V.

S. Install warning signs in visible locations on or near cable trays after cable tray installation.

3.2 CABLE TRAY GROUNDING

A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Division 27 "Grounding and Bonding for Electrical Systems."

B. Cable trays with communications cable shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.

C. Cable trays with control conductors shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.

D. Bond cable trays to power source for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."

3.3 CABLE INSTALLATION

A. Install cables only when each cable tray run has been completed and inspected.

B. Fasten cables on horizontal runs with cable clamps or cable ties according to NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.

C. Fasten cables on vertical runs to cable trays every 18 inches.

D. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 72 inches.

E. Tie MI cables down every 36 inches where required to provide a 2-hour fire rating and every 72 inches elsewhere.

3.4 CONNECTIONS

A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.

B. Connect pathways to cable trays according to requirements in NEMA VE 2 and NEMA FG 1.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.
2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.

3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.
4. Verify that there are no intruding items such as pipes, hangers, or other equipment in the cable tray.
5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
7. Check for improperly sized or installed bonding jumpers.
8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.

B. Prepare test and inspection reports.

3.6 PROTECTION

A. Protect installed cable trays and cables.

1. 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.
2. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
3. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION 16139

SECTION 16140 - 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. This Section includes the following:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Twist-locking receptacles.
3. Receptacles with integral surge suppression units.
4. Snap switches and wall-box dimmers.
5. Solid-state fan speed controls.
6. Communications outlets.
7. Floor service outlets, poke-through assemblies, service poles, and multi-outlet assemblies.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

D. RFI: Radio-frequency interference.

E. SPD: Surge protective device.

F. UTP: Unshielded twisted pair.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

C. Samples: One for each type of device and wall plate specified, in each color specified.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.

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 NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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 Wiring Devices; a division of Cooper Industries, Inc. Cooper.
2. Hubbell Incorporated; Wiring Device-Kellems Hubbell.
3. Leviton Mfg. Company Inc. Leviton.
4. Pass & Seymour/Legrand; Wiring Devices & Accessories Pass & Seymour.
5. Or approved equal.

2.2 STRAIGHT BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; 5351 single, 5352 duplex.
b. Hubbell; HBL5351 single, CR5352 duplex.

c. Leviton; 5891 single, 5352 duplex .
d. Pass & Seymour; 5381 single, 5352 duplex.
e. Or approved equal.

B. Tamper-Resistant Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.

1. Description: Labeled to comply with NFPA 70, "Health Care Facilities" Article, "Pediatric Locations" Section.

C. Isolated-Ground, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.

1. Description: Straight blade; equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.3 GFCI RECEPTACLES

A. General Description: Straight blade, feed-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; SGF20.
b. Pass & Seymour; 2095.
c. Leviton; GFNT2
d. Hubbell; GFST20
e. Or approved equal.

2.4 FINISHES

A. Color: Wiring device catalog numbers in Section Text do not designate device color.

1. Wiring Devices Connected to Normal Power System: As selected by Architect, unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Emergency Power System: Red.
3. TVSS Devices: Blue.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.

B. Coordination with Other Trades:

1. Take steps to ensure that devices and their boxes are protected. 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 the 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 just 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 meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:

    a. Cut back and pigtail, or replace all damaged conductors.
    b. Straighten conductors that remain and remove corrosion and foreign matter.
    c. Pigtailing existing conductors is permitted provided the outlet box is large enough.

D. Device Installation:

1. Replace all devices that have been in temporary use during construction or that show signs that they 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, 2/3 to 3/4 of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.

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.

3.2 IDENTIFICATION

A. Comply with Division 16 Section "Identification for Electrical Systems."

1. Receptacles: Identify Panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience 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 not acceptable.
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. The 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.

END OF SECTION 16140

SECTION 16145 - 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. This Section includes the following lighting control devices:

1. Indoor occupancy and vacancy sensors.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings:

1. Show installation details for the following:

a. Occupancy sensors.
b. Vacancy sensors.

C. Field quality-control test reports.

D. Operation and maintenance data.

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.

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

    a. Faulty operation of lighting control software.
    b. Faulty operation of lighting control devices.

2. Warranty Period: Two years from date of Substantial Completion.

1.6 COORDINATION

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 system, and partition assemblies.

PART 2 - PRODUCTS

2.1 INDOOR OCCUPANCY SENSORS

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:

C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawing or a comparable product by one of the following:

1. Sensor Switch, Inc.

2. Or approved equal.

D. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.

1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
3. Relay Unit: 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. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
4. 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.

5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
6. Bypass Switch: Override the on function in case of sensor failure.
7. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc ; keep lighting off when selected lighting level is present.

E. Dual Technology Type: Ceiling mounting; detect occupancy by sensing a combination of heat and movement in area of coverage.

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. and detect a person of average size and weight moving not less than 12in. in either horizontal or vertical manner.
2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 2000 sq. when mounted on a 108-inch high ceiling.

2.2 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawing or a comparable product by one of the following:

1. Sensor Switch, Inc.

2. Or approved equal.

B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox using hardwired connection.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Occupancy Sensor Operation: Unless otherwise indicated, turn lights on manually when coverage area is occupied, and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
3. Switch Rating: Not less than 800-W LED load at 120 V, 1200-W LED load at 277 V.

C. Wall-Switch Sensor Tag Sos or Svs:

1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 900 sq. ft..
2. Sensing Technology: Dual technology - PIR and ultrasonic.
3. Switch Type: 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.
7. Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
8. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
9. Color: White**.**
10. Faceplate: Color matched to switch.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SENSOR INSTALLATION

A. Comply with NECA 1.

B. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, and partition assemblies.

C. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

D. When requested within 12 months of 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.

3.3 WIRING INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Comply with Division 16 Section "Low voltage electrical power conductors and cables" Minimum conduit size shall be 1/2 inch.

C. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 IDENTIFICATION

A. Identify components and power and control wiring according to Division 16 Section " Identification of Electrical Systems."

1. Identify controlled circuits in lighting contactors.
2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.

3.5 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
2. Operational Test: Verify operation of each lighting control device, and adjust time delays.

B. Lighting control devices that fail tests and inspections are defective Work and shall be replaced.

END OF SECTION 16145

SECTION 16231 - PACKAGED ENGINE GENERATOR

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes packaged engine-generator sets for standby power supply with the following features:

1. Natural Gas engine.

2. Unit-mounted cooling system.

3. Unit-mounted control and monitoring.

4. Performance requirements for sensitive loads.

5. Outdoor weatherproof sound attenuating enclosure.

B. Related Sections include the following:

1. Division 16 Section "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

1.3 DEFINITIONS

A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.4 SUBMITTALS

A. Product Data: For each type of packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:

1. Thermal damage curve for generator.

2. Time-current characteristic curves for generator protective device.

B. Submittal packages shall include overcurrent protective device coordination study per section 16055 and Arc Flash study per section 16056.

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.

1. Dimensioned outline plan and elevation Drawings of engine-generator set and other components specified.

2. Design Calculations: Signed and sealed by a qualified Professional Engineer. Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

3. Vibration Isolation Base Details: Signed and sealed by a qualified Professional Engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.

4. Wiring Diagrams: Power, signal, and control wiring.

5. Copies of application for permits and certificate, current forms (R-GP-005), completed and approved by the New Jersey Department of Environmental Protection - General Permit Registration form for Emergency Generator(s).

D. Qualification Data: For manufacturer and testing agency.

E. Source quality-control test reports.

1. Certified summary of prototype-unit test report.

2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.

3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.

4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.

5. Report of sound generation.

6. Report of exhaust emissions showing compliance with applicable regulations.

7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:

1. List of tools and replacement items recommended to be stored at Project for ready access. Include part and Drawing numbers, current unit prices, and source of supply.

H. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

1. Maintenance Proximity: Not more than four hours' normal travel time from Installer's place of business to Project site.

2. Engineering Responsibility: Preparation of data for vibration isolators and seismic restraints of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.

B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 200 miles of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.

C. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.

D. 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.

E. Comply with ASME B15.1.

F. Comply with NFPA 37.

G. Comply with NFPA 70.

H. Comply with NFPA 99.

I. Comply with NFPA 110 requirements for Level 1 emergency power supply system.

J. Comply with UL 2200.

K. Engine Exhaust Emissions: Comply with applicable state and local government requirements.

L. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Architect and Owner no fewer than five days in advance of proposed interruption of electrical service.

2. Do not proceed with interruption of electrical service without Architect's and Owner's written permission.

B. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: 5 to 113 deg F Minus 15 to plus 40 deg C.

2. Relative Humidity: 0 to 95 percent.

3. Altitude: Sea level to 1000 feet

1.7 COORDINATION

A. Coordinate size and location of concrete bases for package engine generators. Cast anchor-bolt inserts into bases.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 3 years from date of Substantial Completion.

1.9 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, provide 24 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Onan/Cummins Power Generation; Industrial Business Group
2. Caterpillar.
3. Kohler Co.; Generator Division.
4. Or approved equal.

2.2 ENGINE-GENERATOR SET

A. Factory-assembled and -tested, engine-generator set. Generator set shall be IBC Seismic Certified by the Generator Manufacturer. A certificate shall be provided prior to shipment from the Factory.

B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.

C. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated on Drawing.

2. Output Connections: Three-phase, four wire.

3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

D. Generator-Set Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.

2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.

3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.

4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.

5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.

6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics.

Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.

7. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.

8. Start Time: Comply with NFPA 110, Type 10, system requirements.

E. Generator-Set Performance for Sensitive Loads:

1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.

   a. Nameplate Data for Oversized Generator: Show ratings required by the Bid Documents rather than ratings that would normally be applied to generator size installed.

2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.

3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.

4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.

5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.

6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.

7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.

8. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-

load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.

9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.

    a. Provide permanent magnet excitation for power source to voltage regulator.

10. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.3 ENGINE

A. Fuel: Natural Gas (where shown on plans).

B. Fuel: Diesel (where shown on plans).

C. Rated Engine Speed: 1800 rpm.

D. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm.

E. Lubrication System: The following items are mounted on engine or skid:

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.

2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.

3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

F. Engine Fuel System:

1. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.

2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

G. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.

H. Governor: Mechanical

I. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.

2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.

3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.

4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.

a. Rating: 50-psig maximum working pressure with coolant at 180 deg F, and non collapsible under vacuum.

b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

J. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 25 dB at 500 Hz.

2. Sound level measured at a distance of 10 feet from exhaust discharge after installation is complete shall be 85 dBA or less.

K. Air-Intake Filter: Standard-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

L. Starting System: 12-V electric, with negative ground.

1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.

2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.

3. Cranking Cycle: As required by NFPA 110 for system level specified.

4. Battery: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least twice without recharging.

5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.

6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in Part 1 "Project Conditions" Article. Include accessories required to support and fasten batteries in place.

7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.

8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:

    a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.

    b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.

    c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.

d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.

e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.

f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.4 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.

B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.

C. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel.

D. Indicating and Protective Devices and Controls: As required by NFPA 110 for Level 1 system, and the following:

1. AC voltmeter.

2. AC ammeter.

3. AC frequency meter.

4. DC voltmeter (alternator battery charging).

5. Engine-coolant temperature gage.
6. Engine lubricating-oil pressure gage.
7. Running-time meter.
8. Ammeter-voltmeter, phase-selector switch(es).
9. Generator-voltage adjusting rheostat.
10. Generator overload.

E. Indicating and Protective Devices and Controls:

1. AC voltmeter.
2. AC ammeter.
3. AC frequency meter.
4. DC voltmeter (alternator battery charging).
5. Engine-coolant temperature gage.
6. Engine lubricating-oil pressure gage.
7. Running-time meter.
8. Ammeter-voltmeter, phase-selector switch(es).
9. Generator-voltage adjusting rheostat.
10. Start-stop switch.
11. Overspeed shutdown device.
12. Coolant high-temperature shutdown device.
13. Coolant low-level shutdown device.
14. Oil low-pressure shutdown device.
15. Fuel tank derangement alarm.
16. Fuel tank high-level shutdown of fuel supply alarm.

17. Generator overload.

F. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

G. Remote Monitoring: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication is reserved for connections for data-link transmission of indications to remote data terminals.

1. Contractor shall furnish and install OmniMetrix #G8500-C wireless monitor with eight (8) inputs and GPS Option. System shall monitor the following, and/or as directed by the Owner:
   a. Engine running and stopped
   b. Accumulated run times
   c. Fuel consumption
   d. Battery voltages
   e. Fault conditions
   f. Exercise intervals.

2. Upon detection of critical events, the monitor shall deliver specific information to an unlimited number of designated recipients via cell phone and email. The Contractor shall include one (1) year of service (minimum of 2 site visits) and one (1) year of system monitoring.

H. Common Remote Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel.

1. Overcrank shutdown.

2. Coolant low-temperature alarm.

3. Control switch not in auto position.

4. Battery-charger malfunction alarm.

5. Battery low-voltage alarm.

I. Common Remote Audible Alarm: Signal the occurrence of any events listed below without differentiating between event types. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset.

1. Engine high-temperature shutdown.

2. Lube-oil, low-pressure shutdown.

3. Overspeed shutdown.

4. Remote emergency-stop shutdown.

5. Engine high-temperature prealarm.

6. Lube-oil, low-pressure prealarm.

7. Fuel tank, low-fuel level.

8. Low coolant level.

J. Remote Alarm Annunciator: Comply with NFPA 99. An LED labeled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated. Field locate as directed by the Architect and/or Owner.

2.5 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.

1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.

2. Trip Settings: Selected to coordinate with generator thermal damage curve.

3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.

4. Mounting: Adjacent to or integrated with control and monitoring panel.

B. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

2.6 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H.

D. Alternator Temperature Rise: Actual temperature rise measured by resistance method at full load shall not exceed 105 degrees C over a 40 degree C ambient.

E. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.

F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

G. Enclosure: Dripproof.

H. Instrument Transformers: Mounted within generator enclosure.

I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.

1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.

J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

L. Subtransient Reactance: 12 percent, maximum.

2.7 OUTDOOR GENERATOR-SET ENCLOSURE

A. Description: Sound attenuating, vandal-resistant, weatherproof steel housing, wind resistant up to 100 mph. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure. Enclosure shall be sound attenuated to a net resulting noise level of no more than 72 dBA at 7 meters.

B. Description: Prefabricated or pre-engineered skin tight enclosure with the following features:

1. Construction: Galvanized-steel, metal-clad, integral structural-steel-framed building erected on concrete foundation.

2. Structural Design and Anchorage: Comply with ASCE 7 for wind loads.

3. Space Heater: Thermostatically controlled and sized to prevent condensation.

4. Louvers: Equipped with bird screen and filter arranged to permit air circulation when engine is not running while excluding exterior dust, birds, and rodents.

5. Hinged Doors: With padlocking provisions.

6. Ventilation: Louvers equipped with bird screen and filter arranged to permit air circulation while excluding exterior dust, birds, and rodents.

7. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine-generator-set components.

8. Muffler Location: Within enclosure.

C. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.

1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.

2. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.

2.8 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.9 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.

B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.

B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

C. Install packaged engine generator with restrained spring isolators having a minimum deflection of 1 inch on 8 inch high concrete base. Secure sets to anchor bolts installed in concrete bases.

D. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.3 CONNECTIONS

A. Ground equipment according to Division 16 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 16 Section "Low Voltage Electrical Power Conductors and Cables."

3.4 IDENTIFICATION

A. Identify system components according to Division 16 Section "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

C. Perform tests and inspections and prepare test reports.

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.

D. Tests and Inspections:

1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.

3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.

a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.

b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.

c. Verify acceptance of charge for each element of the battery after discharge.

d. Verify that measurements are within manufacturer's Specifications.

4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.

5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.

6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg. Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.

7. Exhaust Emissions Test: Comply with applicable government test criteria.

8. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.

9. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.

10. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line and compare measured levels with required values.

E. Coordinate tests with tests for transfer switches and run them concurrently.

F. Test instruments shall have been calibrated within the last 12 months, traceable to standards of NIST, and adequate for making positive observation of test results. Make calibration records available for examination on request.

G. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

H. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

I. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

J. Remove and replace malfunctioning units and retest as specified above.

K. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

L. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

M. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Substantial Completion.

2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

END OF SECTION 16231

SECTION 16410 - 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. Nonfusible switches.
3. Molded-case circuit breakers (MCCBs).
4. Molded-case switches.
5. Enclosures.

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.5 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. Include evidence of NRTL listing for series rating of installed devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

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.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. 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.

D. Manufacturer's field service report.

1.7 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 Div 01 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

1.8 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.

1.9 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. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NFPA 70.

1.10 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify no fewer than seven days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Architect's Construction Manager's Owner's written permission.
4. Comply with NFPA 70E.

1.11 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.

1.12 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.
5. Or approved equal.

B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Type HD, Heavy Duty, Double Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

E. 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. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: Mechanical type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.
9. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

2.2 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.
5. Or approved equal.

B. Type HD, Heavy Duty, Single Throw, 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. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac, 200 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.

D. Type HD, Heavy Duty, Double Throw, 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.

E. 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. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
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.
7. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

2.3 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.
5. Or approved equal.

B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

C. All circuit breakers 1200A or higher shall be provided with Arc Energy Reduction per NEC 240.87.

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. 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. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

H. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.

I. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

J. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

K. 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. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type 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.
4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
5. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
6. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
7. Alarm Switch: One NO contact that operates only when circuit breaker has tripped.
8. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
9. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
10. Electrical Operator: Provide remote control for on, off, and reset operations.
11. Accessory Control Power Voltage: Integrally mounted, self-powered.

2.4 MOLDED-CASE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.
5. Or approved equal.

B. General Requirements: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

C. Features and Accessories:

1. Standard frame sizes and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
3. Ground-Fault Protection: Comply with UL 1053; remote-mounted and powered type 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.
4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
5. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
6. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.
7. Alarm Switch: One NO NC contact that operates only when switch has tripped.
8. Key Interlock Kit: Externally mounted to prohibit switch operation; key shall be removable only when switch is in off position.
9. Zone-Selective Interlocking: Integral with ground-fault shunt trip unit; for interlocking ground-fault protection function.
10. Electrical Operator: Provide remote control for on, off, and reset operations.
11. Accessory Control Power Voltage: Integrally mounted, self-powered;

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.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R.
3. Kitchen Areas: NEMA 250, Type 4X.

4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
6. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7.

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. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Div. 16 "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. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. 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.

D. 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.

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. Perform the following infrared scan tests and inspections and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
    c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

G. 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.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges

END OF SECTION 16410

SECTION 16415 - TRANSFER SWITCHES

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 transfer switches rated 600 V and less, including the following:

1. Open Transition Automatic transfer switches.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.

B. Submittal packages shall include overcurrent protective device coordination study per section 16055 and Arc Flash study per section 16056.

C. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.

1. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.

D. Qualification Data: For manufacturer and testing agency.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1. Features and operating sequences, both automatic and manual.
2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.

B. Testing Agency Qualifications: An independent agency, with the experience and capability 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.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

C. Source Limitations: Obtain automatic transfer switches and through one source from a single manufacturer. Coordinate equipment requirements with Bid Drawings.

D. 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.

E. Comply with NEMA ICS 1.

F. Comply with NFPA 70.

G. Comply with NFPA 99.

H. Comply with NFPA 110.

I. Comply with UL 1008 unless requirements of these Specifications are stricter.

1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of the Automatic Transfer Switch and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 3 years from date of Substantial Completion.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service:

1. Notify Owner and no fewer than five days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Owner's written permission.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following:

a. Kohler Power Systems; Generator Division.
b. Emerson; ASCO Power Technologies, LP.
c. Onan/Cummins Power Generation; Industrial Business Group
d. Or approved equal.

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.

C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to

IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

E. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.

F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.

G. Neutral Switching. Where four-pole switches are indicated on Bid Drawings, provide neutral pole with overlapping neutral contacts.

H. Neutral Terminal: Solid and fully rated, unless otherwise indicated.

I. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for oversize neutral shall be double the nominal rating of circuit in which switch is installed.

J. Battery Charger: For generator starting batteries.

1. Float type rated 10 Amp minimum or as indicated on Bid Drawings.
2. Ammeter to display charging current.
3. Fused ac inputs and dc outputs.

K. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device. Coordinate requirements with Bid Drawings.

L. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Division 16 Section "Identification for Electrical Systems."

1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.

3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.

M. Enclosures: General-purpose NEMA 250, Type 1, 3R, or 12, complying with NEMA ICS 6 and UL 508, unless otherwise indicated. Coordinate enclosure requirement with Bid Drawings.

2.3 AUTOMATIC TRANSFER SWITCHES

A. Comply with Level 1 equipment according to NFPA 110.

B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.

C. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

D. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval shall be adjustable from 1 to 30 seconds.

E. Digital Communication Interface if shown on Bid Drawings: Matched to capability of remote annunciator or annunciator and control panel.

F. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.

G. Motor Disconnect and Timing Relay: Controls designate starters so they disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters is through wiring external to automatic transfer switch. Time delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are as indicated. Relay contacts handling motor-control circuit inrush and seal currents are rated for actual currents to be encountered.

H. Programmed Neutral Switch Position: Switch operator has a programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Pause is adjustable from 0.5 to 30 seconds minimum and factory set for 0.5 second, unless otherwise indicated. Time delay occurs for both transfer directions. Pause is disabled unless both sources are live.

I. Automatic Transfer-Switch Features:

1. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
4. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

    a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Time delay adjustable from zero to thirty minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
12. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
b. Push-button programming control with digital display of settings.
c. Integral battery operation of time switch when normal control power is not available.

2.4 SOURCE QUALITY CONTROL

A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Switch mounting as indicated on Bid Drawings: If pad-mounted, furnish anchors to floor by bolting.

B. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.

C. Identify components according to Division 16 Section "Identification for Electrical Systems."

D. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

B. Ground equipment according to Division 16 Section "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Division 16 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Testing Agency's Tests and Inspections:

1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

    a. Check for electrical continuity of circuits and for short circuits.
    b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
    c. Verify that manual transfer warnings are properly placed.
    d. Perform manual transfer operation.

4. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.

    a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
    b. Simulate loss of phase-to-ground voltage for each phase of normal source.
    c. Verify time-delay settings.
    d. Verify pickup and dropout voltages by data readout or inspection of control settings.
    e. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
    f. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

5. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

    a. Verify grounding connections and locations and ratings of sensors.

C. Coordinate tests with tests of generator and run them concurrently.

D. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

E. Remove and replace malfunctioning units and retest as specified above.

F. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
2. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below.

B. Coordinate this training with that for generator equipment.

END OF SECTION 16415

SECTION 16441 - SWITCHBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Service and distribution switchboards rated 600 V and less.
2. Surge protection devices.
3. Disconnecting and overcurrent protective devices.
4. Instrumentation.
5. Control power.
6. Accessory components and features.
7. Identification.

1.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards.
3. Include schematic and wiring diagrams for power, signal, and control wiring.
4. Detail bus configuration, current, and voltage ratings.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data. For switchboards and components to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NEMA PB 2.

C. Comply with NFPA 70.

D. Comply with UL 891.

1.6 FIELD CONDITIONS

A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Architect, Construction Manager, Owner, and Engineer no fewer than fourteen days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Architect's, Construction Manager's, Owner's, and Engineer’s written permission.
4. Comply with NFPA 70E.

1.7 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 with concrete.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace switchboard enclosures, buswork, overcurrent protection devices, accessories, and installed factory interconnection wiring that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Three years from date of Substantial Completion

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Siemens Energy & Automation, Inc.
2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
3. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
4. Square D; a brand of Schneider Electric.
5. Or approved equal.

B. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Panel mounted.
2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

C. Nominal System Voltage: As indicated on Bid Drawings.

D. Main-Bus Continuous: As indicated on Bid Drawings.

E. Enclosure: Steel, NEMA 250, Type 1 or Type 3R as indicated on Bid Drawings.

1. Enclosure Finish: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
2. Enclosure: Flat roof; bolt-on rear covers for each section, with provisions for padlocking.

F. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

G. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

H. Pull Box on Top of Switchboard:

1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
2. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
3. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
4. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.

I. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from the front of the switchboard.
2. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, silver-plated.
3. Phase- and Neutral-Bus Material: Tin-plated, high-strength, electrical-grade aluminum alloy with tin-plated aluminum circuit-breaker line connections.
4. Copper feeder circuit-breaker line connections.
5. Tin-plated aluminum feeder circuit-breaker line connections.
6. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with mechanical connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.

7. Ground Bus: 1/4-by-2-inch-minimum size, hard-drawn copper of 98 percent conductivity, equipped with pressure connectors for feeder and branch-circuit ground conductors.
8. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections.
9. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with pressure connectors for outgoing circuit neutral cables.

J. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.2 SURGE PROTECTION DEVICES

A. Surge Protection Device Description: IEEE C62.41-compliant, integrally mounted, solid-state, parallel-connected, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the switchboard short-circuit rating, and with the following features and accessories:

1. Fuses, rated at 100-kA interrupting capacity.
2. LED indicator lights for power and protection status.
3. Audible alarm, with silencing switch, to indicate when protection has failed.
4. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device.
5. Transient-event counter set to totalize transient surges.

B. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase.

C. Withstand Capabilities: 5000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.

D. Protection modes and UL 1449 SVR for grounded wye circuits with 208Y/120 V, three-phase, four-wire circuits shall be as follows:

1. Line to Neutral: 800 V for 208Y/120 V.
2. Line to Ground: 1200 V for 208Y/120 V.
3. Line to Line: 1000 V for 208Y/120 V.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. All circuit breakers 1200A or higher shall be provided with Arc Energy Reduction per NEC 240.87.
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. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
4. Electronic trip circuit breakers 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.

5. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
6. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.
b. Lugs: Compression style, suitable for number, size, trip ratings, and conductor material.
c. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
d. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
e. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
f. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
g. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

B. hinges, and for conductors for interconnections between shipping units.

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.

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 INSTALLATION

A. Receive, inspect, handle, store and install switchboards and accessories according to NECA 400.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Div 03 "Miscellaneous 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 switchboards.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

D. Install filler plates in unused spaces of panel-mounted sections.

E. Install overcurrent protective devices, surge protection devices, and instrumentation.

1. Set field-adjustable switches and circuit-breaker trip ranges.

F. Comply with NECA 1.

3.2 CONNECTIONS

A. Bond conduits entering underneath the switchboard to the equipment ground bus with a bonding conductor sized per NFPA 70.

B. Support and secure conductors within the switchboard according to NFPA 70.

C. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 16075 "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Div 16 "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 Div 16 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:

1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. 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.

C. Switchboard will be considered defective if it does not pass tests and inspections.

D. 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.

END OF SECTION 16441

SECTION 16442 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Lighting and appliance branch-circuit panelboards.
   2. Distribution Panel

1.3 DEFINITIONS

A. SVR: Suppressed voltage rating.

B. SPD: Surge Protective Device

C. GFCI: Ground-fault circuit interrupter

D. MCCB: Molded-case circuit breaker

1.4 SUBMITTALS

A. Product Data: For each type of Panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each Panelboard and related equipment.

   1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and 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. Include evidence of NRTL listing for series rating of installed devices.

6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Include wiring diagrams for power, signal, and control wiring.
8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

C. Qualification Data: For qualified testing agency.

D. 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.

E. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

F. 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.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member Company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Source Limitations: Obtain panelboards, 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 1.

E. Comply with NFPA 70.

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.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Handle and prepare panelboards for installation according to NECA 407.

1.7 PROJECT CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet Work in spaces is complete and dry, Work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

    a. Ambient Temperature: Not exceeding 23 deg F to plus 104 deg F
    b. Altitude: Not exceeding 6600 feet

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Owner no fewer than five days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without Owner's written permission.
3. Comply with NFPA 70E.

1.8 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.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace devices that fails in materials or workmanship within specified warranty period.

1. Warranty Period: three years from date of Substantial Completion.

1.10 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Keys: Two spares for each type of Panelboard cabinet lock.
2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection GFEP Types: Two spares for each Panelboard.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Enclosures: Flush- and surface-mounted cabinets as requested.

1. Rated for environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250, Type 1
b. Outdoor Locations: NEMA 250, Type 3R
c. Kitchen Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
d. 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.
3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
4. Skirt for Surface-Mounted Panelboards: Same gage and finish as Panelboard front with flanges for attachment to Panelboard, wall, and ceiling or floor.
5. Gutter Extension and Barrier: Same gage and finish as Panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
6. Finishes:

a. Panels and Trim: Steel and galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
b. Back Boxes: Galvanized steel same finish as panels and trim.

7. Directory Card: Inside Panelboard door, mounted in metal frame with transparent protective cover.

B. Incoming Mains Location: Top and bottom as requested.

C. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
3. Neutral Bus: Neutral bus rated 100 percent of phase bus and UL listed.

D. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
3. Main and Neutral Lugs: Mechanical type.
4. Ground Lugs and Bus-Configured Terminators: Mechanical type.
5. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
6. Subfeed Double Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
7. Gutter-Tap Lugs: Compression 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.

2.2 POWER PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.

3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.
5. Or approved equal.

B. Panelboards: NEMA PB 1, distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors, more than 36 inches high, provide two latches, keyed alike.

D. Mains: Circuit breaker or lugs only as indicated on Bid Drawings.

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

G. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.
5. Or approved equal.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or lugs only as indicated on Bid Drawings.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held, general-purpose controller, with same short-circuit interrupting rating as Panelboard.

1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
2. External Control-Power Source: 120-V branch circuit.

F. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

G. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.
5. ABB (Asea Brown Boveri)
6. Or approved equal.

B. All circuit breakers 1200A or higher shall be provided with Arc Energy Reduction per NEC 240.87.

C. Molded-Case Circuit Breaker MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic trip circuit breakers 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.

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. Arc-Fault Circuit Interrupter AFCI Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
7. Molded-Case Circuit-Breaker MCCB Features and Accessories:

    a. Standard frame sizes, trip ratings, and number of poles.
    b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
    c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge HID lighting circuits.
    d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
    e. Shunt Trip: 120 V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
    f. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
    g. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in ON or OFF position.
    h. Handle Clamp: Loose attachment, for holding circuit-breaker handle in ON position.

2.5 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from Panelboard. Include relay and meter test plugs suitable for testing Panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store panelboards according to NECA 407.

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 NECA 407.

B. Mount panel board 6 feet above finished floor to highest operating handle unless otherwise indicated.

C. Mount Panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

D. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.

E. Install filler plates in unused spaces.

F. Stub four 1-inchempty conduits from Panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inchempty conduits into raised floor space or below slab not on grade.

G. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

H. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 16 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.

C. Panelboard Nameplates: Label each Panelboard with a nameplate complying with requirements for identification specified in Division 16 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 16 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. 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.

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 scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as indicated.

C. 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 20 percent between phase loads, within a Panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

END OF SECTION 16442

SECTION 16461 - LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 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.

1.2 SUBMITTALS

A. Product Data: For each product indicated.

B. Shop Drawings: Indicate dimensions and weights.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Operation and maintenance data.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Products.
2. Hammond Power Solutions.
3. Powersmiths.
4. General Electric.

5. Siemens Energy & Automation, Inc.
6. Square D; Schneider Electric.
7. Or approved equal.

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: Copper.

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,

1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

D. Transformer Enclosure Finish: Comply with NEMA 250.

1. Finish Color: Gray.

E. 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.

H. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

2.4 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate. Nameplates are specified in Division 16 Section "Electrical Identification."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install trapeze mounted transformers level and plumb with hangers and supports as specified on the plans.

B. Mount transformers on elastomeric vibration isolation pads or mounts providing a minimum static deflection of 0.3”.

C. Conduit connections to shall employ sufficient slack to create an 8” deep U-shaped bend.

3.2 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

3.3 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 recording and tap settings as test results.

END OF SECTION 16461

SECTION 16491 - 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, panelboards, switchboards and enclosed controllers.

1.3 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. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
3. Current-limitation curves for fuses with current-limiting characteristics.
4. Time-current coordination curves average melt and current-limitation curves instantaneous peak let-through current for each type and rating of fuse. Submit on translucent log-log graph paper.
5. Coordination charts and tables and related data.

B. Operation and Maintenance Data: For fuses 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. Ambient temperature adjustment information.
2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves average melt and current-limitation curves instantaneous peak let-through current for each type and rating of fuse. Submit on translucent log-log graph paper.
4. Coordination charts and tables and related data.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

1.5 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

1.6 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. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three 3 of each size and type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Cooper Bussmann, Inc.

2. Edison Fuse, Inc.
3. Ferraz Shawmut, Inc.
4. Or approved equal.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:
1. Motor Branch Circuits: Class RK5, time delay.
2. Other Branch Circuits: Class RK1, time delay.
3. Control Circuits: Class CC, fast acting.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Division 16 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 16491

SECTION 16511 - LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Suspended, linear.
2. Luminaire supports.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color-rendering index.

C. LER: Luminaire efficacy rating.

D. Lumen: Measured output of LED.

E. Luminaire: Complete lighting fixture, including driver.

F. LED: Light-emitting diode.

1.4 SUBMITTALS

A. Product Data: For each type of luminaire, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:

1. Physical description of luminaire including dimensions.
2. Energy-efficiency data.
3. Life, output (lumens, CCT, and CRI), and energy-efficiency data for LED.
4. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing & Calculation Guides, of each luminaire type. The adjustment factors shall be for LED and accessories identical to those indicated for the luminaire as applied in this Project.

a. 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. Installation instructions.

C. Qualification Data: For qualified agencies providing photometric data for luminaires.

D. Operation and Maintenance Data: For lighting equipment and luminaires to include in emergency, operation, and maintenance manuals.

1. Provide a list of all LED and driver types used on Project; use ANSI and manufacturers' codes.

E. Warranty: Sample of special warranty.

1.5 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

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.

1.6 COORDINATION

A. Coordinate layout and installation of luminaires and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.7 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide product indicated on Drawings.

2.2 GENERAL REQUIREMENTS FOR LUMINAIRES

A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

B. Metal Parts: Free of burrs and sharp corners and edges.

C. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit maintenance without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during maintenance and when secured in operating position.

E. Factory-Applied Labels: Comply with UL 1598. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when LED's are in place.

1. Label shall include the following characteristics:
    a. LED wattage.
    b. CCT and CRI for all luminaires.

F. Internal driver.

2.3 LED LUMINAIRES

A. Driver: shall deliver full range dimming from 0-10V control signal.

B. Nominal lumens as indicated on Drawings, CRI equivalent to fixtures indicated on Drawings, color temperature as indicated on Drawings, and average rated life 50,000 hours unless otherwise indicated.

2.4 LUMINAIRE SUPPORT

A. Comply with Division 16 Section "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single luminaire. Finish same as luminaire.

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 luminaire and line voltage and equipped with threaded attachment, cord, and locking-type plug.

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.

B. Internally Lighted Signs:

1. Lamps for AC Operation: LEDs, 50,000 hours minimum rated lamp life.
2. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.

    a. Battery: Sealed, maintenance-free, nickel-cadmium type.
    b. Charger: Fully automatic, solid-state type with sealed transfer relay.
    c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
    d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
    e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
    f. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.

g. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires:

1. Level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Temporary Lighting: If it is necessary, and approved by Architect, 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.

D. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and maintenance.
3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire mounting devices be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.

E. Lay-in Ceiling Lighting Fixtures Supports: Use grid as a support element.

F. Flush-Mounted Luminaire Support:

1. Secured to outlet box.

2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

G. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

H. Ceiling-Grid-Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

I. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and wire support for suspension for each unit length of luminaire chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

J. Install ceiling support system rods or wires, independent of the ceiling suspension devices for each luminaire. Locate not more than 6 inches from luminaire corners.

K. Support Clips: Fasten to luminaires and to ceiling grid members at or near each luminaire corner with clips that are UL listed for the application.

L. Luminaires of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support luminaires independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.

M. Connect wiring according to Division 16 Section "Low-Voltage Power Conductors and Cables."

3.3 IDENTIFICATION

A. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Division 16 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. 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 16511

SECTION 16526 –LIGHTING CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes manually operated, PC-based, digital lighting controls with external signal source and control module.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other Work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
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 and other devices to be used. Describe characteristics of network and other data communication lines.

C. 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.

D. Field quality-control reports.

E. Software licenses and upgrades required by and installed for operation and programming of digital and analog devices.

F. Operation and maintenance data.

1.3 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.

1.4 COORDINATION

A. Coordinate lighting control components to form an integrated interconnection of compatible components.

1.5 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.

1. 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.

2. Warranty Period: Five (5) years from date of Substantial Completion.
3. Extended Warranty Period Failure Due to Transient Voltage Surges: Eight years.

1.6 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for two years.

B. Upgrade Service: 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 the software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide basis of design product indicated on Drawings:
1. Current Lighting, Inc.
2. Or approved equal.

2.2 SYSTEM EQUIPMENT

A. Lighting Control Panels: Lighting control system shall consist of a master and remote panel(s) controlled by a 32-channel digital time clock (DTC) that controls and programs the entire lighting control system. The DTC shall supply all time functions and accept external inputs. The DTC shall accept local control and display prompts to the user on an 8 line 21-letter display. The DTC shall accept user input from keypad pushbuttons, connected computer, modem, Ethernet or internet devices. All commands shall be in plain English. User help information shall display on the DTC screen.

B. Digital Switches: All digital switches shall communicate via RS485, CAT5 patch cable with RJ45 connectors. Contact closure style switches are not acceptable. Any digital switch button function shall be able to be changed locally (at the DTC or a PC) or remotely, via modem, Ethernet or internet device. Refer to single line diagram for wiring details. Switches which cannot be programmed remotely shall not be acceptable.

C. Photocells: Exterior (PCO) or interior (PCI) photocells shall provide numeric readout on the DTC display in numerical values corresponding to foot-candles values. Each photocell shall provide a minimum of 14 trigger points. Each trigger point can be programmed to control any field configurable relay or zone. Each trigger point shall be set through DTC, locally or remotely. Photocells that require the use of set screws or manual adjustments at the photocell control card shall not be acceptable.

D. Accessory Devices: Accessory lighting control system interfaces to include a dry contact input interface, BMS interface, dimming system interface, Ethernet/internet interface and an interface to Smartbreaker panel boards. Verify and install only those interfaces indicated on the plans.

E. Lighting Control Software: Unity™ lighting control software shall provide via local or remote PC a visual representation of each device on the bus, show real time status and the ability to change the status of any individual device, relay or zone. System shall be capable of running optional Unity GX2 lighting control software. Unity GX2 shall provide for importing vector based graphics and a simple interface that allows users or a factory programmer to overlay color “controls” that are associated with relays or collections of relays.

2.3 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG, complying with Division 16 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Structured Network Digital and Multiplexed Signal Cables: Outdoor rated UTP cable with copper conductors, complying with TIA/EIA-568-B.2, Category 5e or 6 for horizontal copper cable.

PART 3 - EXECUTION

3.1 WIRING INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Install wiring in raceways. Minimum conduit size shall be 1/2 inch.

1. For power wiring comply with Division 16 Section " Low-Voltage Electrical Power Conductors and Cables."

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. 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 terminal cabinets, equipment enclosures, and in junction, pull, and outlet boxes.

F. Identify components and power and control wiring according to Division 16 Section "Electrical Identification."

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.
4. Test system diagnostics by simulating improper operation of several components selected by Architect.

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.

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.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting controls and software training for PC-based control systems.

END OF SECTION 16526

SECTION 16721 – NATURAL GAS & CO GAS DETECTION AND ALARM

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 CO and Methane monitors, notification appliances.

1.3 ACTION SUBMITTALS

A. Product Data:

1. For each type of monitor, include sensing range in ppm, temperature and humidity range, alarm outputs, display range, furnished specialties, installation requirements, and electric power requirement.

B. Shop Drawings:

1. Wiring Diagrams: Power, signal, and control wiring.
2. Locations of the specific sensors and alarm panel location.

C. Coordination Drawings: Include machinery-room layout showing location of monitoring devices and air-sampling tubing with filter/inlet locations in relation to refrigerant equipment.

D. Product Certificates: For monitoring devices, signed by product manufacturer.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant monitoring equipment and SCBA 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. One calibration kit including clean air calibration gas bottle for zero calibration and specific refrigerant calibration gas for span calibration, minimum 58-L capacity, pressure regulator, and tubing.

PART 2 - PRODUCTS

2.1 MANUFACTURERS: Subject to compliance with requirements, provide products by the following:

A. Mine Safety Appliances Company Z Gard

B. Macurco TracXP Gas Detector
C. Or engineer approved equal.

2.2 NATURAL GAS AND CO GAS DETECTION SYSTEM Z GARD CONTROLLER

A. Provide a standalone CO/LEL controller as shown on the plans. The controller shall be housed in a Nema 1 Painted steel enclosure. Operating range shall be from –20 degrees F to 122 degrees F. Units that are not capable of these temperature limits shall be provided with a method of auxiliary heat and fans as required to maintain the required ambient conditions.

B. Controller shall accept 110 Vac, direct to the controller, internal step down transformers shall be provided to power up to the field mounted CO and LEL sensors. System shall be UL and or CSA listed to accommodate controller and step down transformer in one panel. If alternate system requires mounting of more than 1 panel the mfg shall include all costs required for additional field wiring to accommodate this task.

C. The Controller shall be connected via a 4 wire field bus to remotely mounted Z Gard sensors that are automatically recognized and establishes the sensors range and gas type. The sensors shall be linked by a RS485 network communication system. The controller shall continuously monitor the sensors for excessive levels of the Specified target gases and provide the necessary notification controls in the event that the gas levels rise above the preset limits.

D. The controller shall manage the Z Gard S sensor inputs on the RS485 Serial communications network. The controller shall provide minimum of 8 relays that can be used to start fans and open OA Louvers. Upon sensing the concentration of target gas at levels equivalent to the warning or alarm set point the relay contact(s) shall energize signaling the event.

E. The controller shall have a programmable Off time delay function that is adjustable from 0 – 600 seconds. The warning and alarm relay shall deactivate from 0-600 seconds after the warning or alarm occurance has abated.

F. The controller shall have the capability of providing a full scale, 2 wire 4 to 20 ma sourcing analog output that is representative of the highest concentration level of any zone of sensors on the network. This output shall be able to communicate with the BAS system.

G. The Controller shall have a local Readout display indicating the active Sensor Point number, the corresponding gas concentration level and gas type, Warning and Alarm indication, Zone number, number of Sensors, Voting and Diagnostic status of the system. The display will scan through all active channels in 5 second intervals. The readout display will visible from a minimum of 5 feet and will be present always, and will not require being turned on or off.

H. The Controller shall have a LCD Readout for the purpose of displaying the Diagnostic Status of the system and associated Sensors. The User Interface Keypad of 16 items to access the menu driven operating parameters located inside the front door of the enclosure. All setup parameters shall be accessed using the keypad.

I. The controller shall include 4 Common LEDs to indicate Sensor Okay, Warning, Alarm and Sensor Fail status.

J. This Controller shall include a local mounted Audible Alarm rated @ 90 dB with push-button reset switch. The pushbutton reset switch shall silence and reset the Audible Alarm when alarm points are exceeded. The Common LED visual alarms will remain on as long as any Warning or Alarm levels are exceeded. This push-button will reset latched alarms if normal gas conditions exist. A horn relay shall be included to facilitate control of a remote alarm reset pushbutton.

K. Warning and Alarm Set Point Levels - The controller shall provide 4 relays for control of the wall mounted exhaust fans and outdoor intake louvers. Provide manual 3-hour override timers for each relay. Timers shall be labelled to the system served.

L. The controller shall provide a normally energized Sensor Fail Relay. If a loss of communication occurs between the Controller and remote Sensor Transmitter the Sensor Fail Relay will be activated and the Sensor Okay LED located on the Controller door will turn off.

M. All Warning, Alarm and Sensor Fail Relays shall be Form C, single pole, double throw. Contacts shall be rated for 10 Amps 1/8 HP @ 125VAC, 5 amps resistive at 250VAC or 30VDC.

N. The contacts shall be capable of being selected normally open or normally closed.

O. The control panel must be a MSA Z Gard CX or approved equal controller.

P. Optional remote relay panel shall be available for remote fans operation

Q. Bacnet interface shall be included for communications to the BMS system

2.3 Z-GARD CO AND LEL SENSORS

A. Provide as shown on the plans Carbon monoxide and LEL sensors. Sensors have been located for radius coverage and points of egress. Locations as shown on the plans shall not be modified by the manufacturer.

B. Sensors housing shall be Nema 4 enclosure with plastic cover. Sensors shall utilize electro chemical technology. Accuracy of the sensors shall not be less than ±2% of Full Scale with no requirement of periodic addition of reagents. Solid State Sensors shall not be acceptable

C. When used with the Z Gard C Controller: The RS 485 Network communication wiring from the Sensor to the Z Gard C Controller shall be a shielded 4-wire cable of sufficient gage to meet distance requirements of the Z Gard RS 485 Network Communication. The Sensor Transmitter terminal strips shall be removable for ease of wiring and accept up to 10 GA AWG wire.

D. The Sensor electronics shall consist of dual PCB that is microprocessor-based computer-aided and factory-calibrated for the target gas compounds with compensation for ambient humidity and temperature and linearized signal output. The PCB includes all the components required to power, operate the sensor, make calibration adjustments and set the network address jumpers when used in the Z Gard Communication network. The single PCB shall be mounted to the enclosure using industry standard hardware.

E. CO sensors shall be located at 5’ AFF

F. LEL sensors shall be located 12“ Below the Roof Line

2.4 MONITOR ALARM SEQUENCE

A. The MSA Control panel will constantly Poll the CO and LEL sensors located in the Boiler Room Upon increase in CO levels above 25 PPM or LEL levels above 10% LEL the alarm shall sound.

B. If the CO increase above 35 PPM or the LEL increase above 35% LEL the 2nd alarm contact shall close and the boilers shall be checked to ensure they are working properly.

2.5 NOTIFICATION APPLIANCES

A. Horns: Comply with UL 464; electric-vibrating-polarized type, listed by a qualified testing agency with provision for housing the operating mechanism behind a grille. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn.

B. Visible Alarm Devices: Comply with UL 1971; three color xenon strobe lights, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The words "CO - GAS DETECTION" printed in minimum 1/2-inch-high letters on the lens. Rated light output is 75 candela.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Mount sensors in accordance with manufacturer’s recommendations.

B. Wall mount monitor panels with top of unit 60 inches above finished floor.

C. Audible Alarm-Indicating Devices: Install at each entry door to, mechanical equipment room, and position not less than 6 inches below the ceiling. Install horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.

D. Visible Alarm-Indicating Devices: Install adjacent to each alarm horn at each entry door to mechanical equipment room. Install in accordance with manufacturers recommendations.

3.2 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

C. Perform tests and inspections and prepare test reports.

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.

D. Tests and Inspections:

1. Inspect field-assembled components, equipment installation, and electrical connections for compliance with requirements.
2. Test and adjust controls and safeties.
3. 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.

E. Repair or replace malfunctioning units and retest as specified above.

3.3 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain refrigerant detection devices and equipment. Refer to requirements in Division 01.

END OF SECTION 16721

SECTION 16800 – EMERGENCY RESPONDER RADIO 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 SUMMARY – PERFORMANCE SPECIFICATION

A. Pre-installation Testing - Contractor shall perform pre-installation testing for percent coverage and signal strength in accordance with all applicable codes. Testing shall not be performed until after the building is fully enclosed (roof, exterior skin, doors and windows are installed), and interior ceilings and walls are in place.

B. Performance specification for an Emergency Responder Radio Coverage (ERRC) System and related equipment as required by Section 510 of the International Fire Code (IFC).
   1. In compliance with Section 510 of the IFC, the building is to support adequate radio coverage for various emergency services workers, including but not limited to firefighters and police officers.

C. Design, furnish, install, and test a complete and operating ERRC System. The system will support the radio systems for various emergency services workers, including but not limited to the Local Fire Department and Local Police Department.

D. This Section includes the requirements for an ERRC for the purposes of amplifying Emergency Responder radio signals to achieve minimum signal strength of -95 dbm in 95% of all areas of the high school building and 99% in elevators (measured at the primary recall floor), stair shafts, and fire command centers.

E. Provide two-way ERRC to enable communications between emergency responders at the exterior perimeter of the buildings and emergency responders within the buildings. All areas of the buildings shall have code compliant radio coverage.

F. Final acceptance and approval is required from the local Fire Department and Police Department in writing prior to contract closeout.

1.3 REGULATIONS

A. Codes, regulations and standards.
   1. NFPA 70 – The National Electrical Code

2. NFPA 72 - National Fire Alarm Code
3. NEC – National Electric Code
4. New Jersey IBC
5. FCC 47 CFR Private Land Mobile Radio
6. NFPA 101, Life Safety Code and Local Code and Building Authority requirements.
7. ADA “Americans with Disabilities Act”
8. FCC's OET 65 Standards "Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields".
9. FCC Rules Part 22, Part 90 and Part 101.

1.4 DEFINITIONS

A. Bi-Directional Amplifier (BDA): Device used to amplify band-selective or multi-band RF signals in the uplink, to the base station for enhanced signals and improved coverage.

B. Emergency Responder Radio Coverage System: A two-way radio communication system installed to assure the effective operation of radio communications systems for fire, emergency medical services or law enforcement agencies within a building or structure. A system used by firefighters, police, and other emergency services personnel.

C. Delivered Audio Quality Definitions (DAQ): This is a universal standard often cited in system designs and specifications.
1. DAQ 1: Unusable, speech present but unreadable.
2. DAQ 2: Understandable with considerable effort. Frequent repetition due to noise/distortion.
3. DAQ 3: Speech understandable with slight effort. Occasional repetition required due to noise/distortion.
4. DAQ 3.5: Speech understandable with repetition only rarely required. Some noise/distortion
5. DAQ 4: Speech easily understood. Occasional noise/distortion.
6. DAQ 4.5: Speech easily understood. Infrequent noise/distortion.
7. DAQ 5: Speech easily understood. Coupled Bonding Conductor (CBC) – The term "Coupled Bonding Conductor" shall mean a bonding conductor placed, e.g. strapped, on the outside of any technology cable, used to suppress transient noise.

D. FCC: Federal Communications Commission

E. OET 65 Standards: FCC's Bulletin 65 provides Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields.

F. Public Safety/First Responder: Public Safety or First Responder agencies which are charged with the responsibility of responding to emergency situations. These include,

but are not limited to: law enforcement departments, fire departments, and emergency medical companies.

1.5 DELEGATED DESIGN SUBMITTALS

A. Submit product data for each type of proposed system component specified, including dimensioned drawings showing minimum clearances and installed features.

B. Layout Drawings:
   1. Component specification sheets shall be 8.5-inch x 11 inch or greater, scaled or dimensioned, with dimensions or scale clearly noted.
   2. Floor plan drawings scaled to legible size.
   3. Floor plan drawings may include elevation detail names for each elevation view. Sheet title shall include site name, address, sheet number, floor plan number and north arrow. Include site plan view of the subject buildings and surrounding property to clearly indicate the location and orientation of roof mounted outdoor antennas associated with the proposed system.
   4. Include a minimum of (1) building elevation depicting the location of any outdoor antennas associated with the proposed system. Include height of antenna centerline above building, orientation, and location of all external grounding connections.
   5. Include a detail plan view of all Telecommunications Spaces housing head-end and/or other consolidated equipment, showing the location of the rack(s) and/or enclosure(s) of the Emergency Responder Radio Antenna/Repeater System equipment.
   6. Include a separate plan view of each interior floor where indoor antenna systems are proposed. Include antenna numbers, coaxial cable routes, and the locations of any other system components including splitters, couplers, filters, amplifiers, etc. All components shall be named or labeled for reference in power budget calculations tables. Overlay approximated coverage radii indicating –95 dbm downlink (base to mobile) signal strength around each proposed indoor coverage antenna. Include results of any previous coverage testing per grid, if available.
   7. Include a minimum of one (1) detail elevation view(s) of all rack(s) and/or enclosure(s) housing the Emergency Responder Radio Antenna/Repeater System equipment. Identify each piece of equipment by brand, model number and equipment type.
   8. Specify antenna grounding and surge protection in accordance with NEC Article 810.
   9. Specify the backup power source (Life Safety), and include calculations to ensure the backup power requirements as specified in this standard are met.

C. Equipment Specification Sheets.

1. Provide copies of manufacturer specification sheets of all system components, including:
    a. Amplifiers
    b. Antennas
    c. Coaxial cable, couplers, splitters, combiners, or other passive components
2. Operation and maintenance data.
3. Pass band curves in for the uplink and downlink portions of the NPSPAC band for any amplifiers, if not included in #1. Amplifiers may NOT amplify portions of other licensed services, including Nextel and Specialized Mobile Radio Licensee band, or Cellular A or B bands.
4. Backup battery and charging system.

D. Submit wiring diagrams from manufacturer differentiating clearly between factory and field-installed wiring. Include diagrams for each component of the system with all terminals and interconnections identified. Make all diagrams specific to this Project.

E. Submit product certificates signed by the manufacturer of radio system components certifying that their products comply with specified requirements.

F. Submit agenda for training class and copies of all handouts for the class.

G. Maintenance data for radio system shall be included in the operation and maintenance manual. Include data for each type of product, including all features and operating sequences, both automatic and manual. Provide the names, addresses, and telephone numbers of service organizations that carry stock of repair parts for the system to be furnished.

H. Record of field tests of the radio system shall be included in the operation and maintenance manuals.

I. Design Approval: Plans shall be submitted and approved prior to installation. The following information shall be provided to the local Fire Department unit representative by the system designer/Contractor.
1. A minimum of three (3) copies of detailed drawings showing the location of the amplification equipment and associated antenna systems which includes a view showing building access to the equipment; and
2. A minimum of three (3) copies of schematic drawings of the electrical system, backup power, antenna system and any other associated equipment relative to the amplification equipment including panel locations and labeling.
3. A minimum of one (1) copy of the Manufacturer's data sheets on all equipment to be installed.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Single-Source Responsibility: Obtain radio system components from a single source who assumes responsibility for compatibility of system components.

C. All equipment shall be UL listed and labeled, and in accordance with applicable NEMA and ANSI Standards. Where copper cabling is routed to an area, either in another building, or with a separate electrical service, the Technology Contractor shall provide primary protective equipment.

D. All ERRC equipment shall be FCC certified.

E. The contractor shall be FCC licensed as required by code.

F. Components of the ERRC shall industry standard and readily available.

G. All racks and enclosures shall be either welded or assembled with paint piercing ground washers, grounding strip and bonding jumper shall be provided.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace ERRC system equipment and components that fail in materials or workmanship within specified warranty period.
   1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
   2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. The detailed technical design of the ERRC shall be the responsibility of the contractor.
   1. Contractors must obtain approvals from the State of New Jersey Department of Community Affairs (DCA), as well as coordinate and obtain approvals from the local Fire Department, local Police Department, the FCC, and any other emergency responders, in order to define the system and frequencies to be used.
      a. Trunk System Frequencies
      b. Conventional Frequencies

1) 700 & 800 MHz bands allocated for fire and police

2.2 MANUFACTURERS:

A. Subject to compliance with requirements, available Integrators offering products that may be incorporated into the Work include the following:
   1. CommScope/Andrew
   2. Westell
   3. Times Microwave
   4. Tessco Technologies
   5. CCI (Communication Components Inc.)
   6. Solid Technologies
   7. Or engineer approved equal.

2.3 GENERAL PERFORMANCE REQUIREMENTS

A. Compatibility: The equipment, including but not limited to repeaters, transmitters, receivers, signal boosters, cabling, fiber distributed antenna system, etc., shall not interfere with the existing communication systems utilized by the Public Safety and First Responder agencies.

B. Power Supplies: At least two (2) independent and reliable power supplies shall be provided, one primary and one secondary. The primary power source shall be supplied from a dedicated 20 ampere branch circuit and comply with 4.4.1.4 of NFPA 72. The secondary power source shall be a dedicated battery, capable of operating the in-building radio system for at least 12 hours of 100% system operation. The battery system shall automatically charge in the presence of external power input. The battery system shall be contained in one NEMA 4 or 4X type enclosures. Monitoring the integrity of power supplies shall be in accordance with 4.4.7.3 of NFPA 72.

C. Provide a UPS sized to provide emergency power to ERRC headend and node equipment for a minimum of 24 hours. Connect the UPS to the emergency generator power circuit.
   1. UPS shall be enclosed in a NEMA Type 4 enclosure.
   2. UPS batteries shall be of the sealed maintenance-free type.
   3. Provide battery ventilation in accordance with code, if required.

D. Provide supervision of the ERRC antennas, signal boosters, power supplies and UPS.
   1. Provide supervisory and trouble alarm output contacts indicating an impairment. Connect the supervisory and trouble alarm contacts to the building fire alarm system.

2. Program the fire alarm system to relay ERRC supervisory and trouble alarm signals to the appropriate supervising station. Instruct supervising station personnel to notify the local fire and police departments of an impairment.

E. Survivability
1. Physical Protection: All wiring and fiber optics shall be installed in conduit. Refer to Division 16 Section, "Raceways and Boxes for Electrical Systems" for type, sizing and installation standards.
2. Fire Performance: All main risers or trunks of the antenna system shall be installed with resistance to attack from a fire using one of the following methods:
   a. A 2-hour fire rated cable or cable system.
   b. Routing the cable through a 2-hour fire rated enclosure(s) or shaft(s).
   c. A system configured in a looped design, routed through 1-hour fire rated enclosure(s) or shaft(s). The circuit shall be capable of transmitting and receiving a signal during a single open or non-simultaneous single ground fault on a circuit conductor.
   d. Performance alternative approved by the authority having jurisdiction.
3. Cabinet: The signal booster and all associated RF filters shall be housed in a single, NEMA 4 certified, painted steel weather tight box. The cabinet shall be large enough to dissipate internal heat without venting the inside of the cabinet to the outside atmosphere. Operating temperatures: –22 degrees F to +120 degrees F (–30 degrees C to +50 degrees C) minimum temperature range, including microprocessors. Equipment installed on the roof of structures shall be rated for the expected extreme temperatures associated with rooftop installations.
4. Passive Equipment: Passband shall be 700-900 MHz, IP rating of 2 GHz.
5. Cable: Passband shall be 700-900 MHz. Cable shall be rated for fire plenum and riser rating.

2.4 SYSTEM COMPONENTS

A. Signal Strength
1. Downlink: A minimum signal strength of -95 dBm shall be provided throughout the coverage area.
2. Uplink: Minimum signal strength of -95 dBm received at the local Fire Department Radio System from the coverage area.
3. A donor antenna must maintain isolation from the distributed antenna system. The donor antenna signal level shall be a minimum of 15 dB above the distributed antenna system under all operating conditions.

B. Permissible Systems
1. Buildings and structures shall be equipped with an FCC Certificated Class B Bi-Directional UHF Amplifier(s) as needed.

2. The distributed antenna system may utilize a radiating cable, fixed antennas or a combination of both.

C. Supported Frequencies: The radio system shall support frequencies in the 700 and 800 MHz public safety bands as utilized by the local Fire Department.

D. Reject Filters: Notch filter sections shall be incorporated to minimize adjacent channel cellular and SMR (Nextel) degradation of the signal booster performance. The minimum downlink band adjacent band rejection shall be 35 dB or greater at 865 MHz and 870 MH.

E. Band Migration Capability: The signal booster shall include re-tunable or replaceable filters to accommodate rapid and economic passband changes in the event of mandatory FCC changes within the NPSPAC band. The use of non-adjustable and non-replaceable RF input and output filters is prohibited.

F. Output Level Control: An automatic output leveling circuit shall be included for both passbands with a minimum dynamic range of 60 dB, less any gain reduction setting, to maintain FCC out of band and spurious emission compliance.

G. Degraded Performance in Emergencies: The system shall be designed to allow degraded performance in adverse conditions, such as abnormally high temperatures resulting from nearby fires, extreme voltage fluctuations or other abnormal conditions that may occur during an emergency. Circuits that intentionally disable the signal booster in such situations (i.e. under/over voltage, over/under current, over/under temperature, etc.) will not be implemented as the standard mode for public safety applications.

H. Mode of Operation: The system shall be normally powered on and shall continuously provide passing of frequencies within the Public Safety and First Responder bands.

I. All in-building radio systems shall be compatible with both analog and digital communications simultaneously at the time of installation.

2.5 SYSTEM MONITORING

A. The distributed antenna system shall include a connection to the fire alarm system to monitor the integrity of the circuit of the signal booster(s) and power supplies and annunciate this malfunction on the fire alarm system shall comply with 4.4.7.1 of NFPA 72.

B. A sign shall be located at the fire alarm panel with the name and telephone number of the local Fire Department indicating that they shall be notified of any failures that extend past the 2 hour time limit.

PART 3 - EXECUTION

3.1 PRE-INSTALLATION TESTING

A. Contractor shall perform pre-installation testing for percent coverage and signal strength in accordance with all applicable codes. Testing shall not be performed until after the building is fully enclosed (roof, exterior skin, doors and windows are installed), and interior ceilings and walls are in place.
   1. Measure the percent coverage and signal strength in both the critical and general areas on each floor. Measure the signal strength receivable within the building and the signal strength received when transmitting from within the building.
   2. Install amplification only on the floors which fail to have the required percent coverage and signal strength in accordance with all applicable codes.
   3. Provide spare capacity to install amplification later on floors that pass pre-installation testing but may drop below the required percent coverage or signal strength when construction and furniture move-in are completed.

3.2 INSTALLATION

A. Distribution System Signal Wires and Cables
   1. Wires and cables shall enter each equipment enclosure, console, cabinet or rack in such a manner that all doors or access panels can be opened and closed without removal or disruption of the cables.
   2. Routing and Interconnection
      a. Wires or cables routed between consoles, cabinets, racks, and other equipment shall be installed in an approved conduit or cable tray that is secured to building structure.
      b. Completely test all of the cables after installation and replace any that are found to be defective.
   3. Install cables without damaging conductors, shield, or jacket.
   4. Do not bend cables, while handling or installing, to radii smaller than as recommended by manufacturer.
   5. Pull cables without exceeding cable manufacturer's recommended pulling tensions.

B. Product Delivery, Storage, and Handling
   1. Delivery: Deliver materials to the job site in OEM's original unopened containers, clearly labeled with the OEM's name and equipment model and serial identification numbers.
   2. Store and protect equipment in a conditioned space until installation.

C. System Installation

1. Coaxial antenna cabling shall not be installed in the same conduit, raceway, or cable trays used for other systems.
2. All equipment shall be connected according to the OEM's specifications to insure correct installation and system performance.
3. Coordinate all roof penetrations with Owner and/or roofing contractor.

3.3 LICENSING

A. All fees associated with the licensing shall be paid by the Contractor.

B. All testing must be done on frequencies authorized by the FCC.

3.4 GROUNDING

A. Ground cable shields and equipment per Manufacturer's requirements.

B. Antenna mast shall be grounded per NFPA 70 NEC requirements, Division 16 Section, "Grounding and Bonding" and antenna manufacturer's requirements. Provide grounding blocks and surge protection for outside coaxial cabling. Bond the antenna mast to the existing lightning protection system.

3.5 APPROVAL TESTING

A. The Architect/Engineer shall review plans and specifications prior to any installation of ERRC. Any field changes that occur during construction shall be incorporated into new As-Built plans, including any manufacturer's data sheets for any equipment changes not submitted in the original submittal. As-Built plans, if required due to system changes, shall be submitted to the architect/engineer.

B. Tests shall be made using frequencies close to the frequencies used by the Fire Department and appropriate emergency services. If testing is done on the actual frequencies, then this testing must be coordinated with the local Fire Department unit. All testing must be done on frequencies authorized by the FCC. A valid FCC license will be required if testing is done on frequencies different from the police, fire or emergency medical frequencies.

C. Testing Procedures
1. Minimum Signal Strength: For testing system signal strength and quality, the testing shall be based on the delivered audio quality (DAQ) system. A DAQ level below 3.0 shall be considered a failed test for a given grid cell.
2. Measurements shall be made with the antenna held in a vertical position at 3 to 4 feet above the floor to simulate a typical portable radio worn on the belt or turnout coat pocket.

D. Final Acceptance Testing
   1. All acceptance testing shall be done in the presence of a local Fire Department representative or by the local Fire Department unit at no expense to the City.
   2. Small scale drawings (11-inch x 17-inch maximum) of the structure shall be provided by the Contractor to the architect/engineer. The plans shall show each floor divided into the grids as described above, and the results of the pre-testing. Each grid shall be labeled to indicate the DAQ result from the final acceptance testing.
   3. The Contractor shall provide the latest approved plans for the system, including any manufacture's data sheets for any equipment changes not submitted in the original submittal to the architect/engineer.
   4. Include testing results of the repeater (output wattage, gain level, etc) and connection to the fire alarm.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

END OF SECTION 16800