SPECIFICATIONS

for
ADDITIONS AND RENOVATIONS TO
WEST WINDSOR-PLAINSBORO HIGH SCHOOL SOUTH
346 Clarksville Rd., West Windsor, NJ 08550

for the
WEST WINDSOR-PLAINSBORO REGIONAL SCHOOL DISTRICT
WEST WINDSOR TOWNSHIP, MERCER COUNTY, NEW JERSEY

FVHD PROJECT #5063L / NJDOE# 5715-020-18-3000

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SECTION 05120 - STRUCTURAL STEEL FRAMING

PART 1 - GENERAL

1.01 SUMMARY

A. Extent of structural steel work is shown on drawings, including schedules, notes and details to show size and location of members, typical connections and type of steel required.

B. Structural steel is that work defined in American Institute of Steel Construction (AISC) "Code of Standard Practice" as modified here and as otherwise shown on drawings.

1. Section 2.1 to include “Lintels shown or otherwise enumerated or scheduled.”
2. Section 4.4, The first two sentences of this section are to be replaced with the following, “Shop drawings are to be made by the fabricator, prints thereof are to be submitted to the structural engineer and architect for their examination and approval. These shop drawings are to be submitted in minimum of the following three phases: Anchor bolt plans and advanced shipment pieces; Erection plans and thirdly; Piece details (maximum of 100 sheets per submission). The fabricator is to await the receipt of the previous phase prior to submission of the next phase. The fabricator is to include an allowance of fourteen (14) calendar days in his schedule for the review of these drawings by the structural engineer for the return of shop drawings. These calendar days start from the time the drawings are received by the engineer.”

C. Miscellaneous Metal Fabricators are specified elsewhere in Division 5.

D. Refer to Division 3 for anchor bolt installation in concrete; Division 4 for masonry.

E. Source Quality Control: Materials and fabrication procedures are subject to inspection and tests in mill, shop and field, conducted by a qualified inspection agency. Such inspections and tests will not relieve Contractor of responsibility for providing materials and fabrication procedures in compliance with specified requirements.

1. Promptly remove and replace materials or fabricated components which do not comply.

F. Design of Members and Connections: Details shown are typical; similar details apply to similar conditions, unless otherwise indicated. Verify dimensions at site whenever possible without causing delay in the work.

1. Promptly notify Architect whenever design of members and connections for any portion of structure are not clearly indicated.
1.02 SUBMITTALS

A. Product Data: Submit producer's or manufacturer's specifications and installation instructions for following products. Include laboratory test reports and other data to show compliance with specifications (including specified standards).

1. Structural steel (each type), including certified copies of mill reports covering chemical and physical properties.
2. High-strength bolts (each type), including nuts and washers.
3. Structural steel primer paint.

B. Shop Drawings: Submit shop drawings, including complete details and schedules for fabrication and assembly of structural steel members, procedures and diagrams.

C. Include details of cuts, connections, camber, holes and other pertinent data. Indicate welds by standard AWS A2.1 and A2.4 symbols; and show size, length and type of each weld.

1. Provide setting drawings, templates and directions for installation of anchor bolts and other anchorages to be installed as work of other sections.

D. Test Reports: Submit copies of tests conducted on shop and field bolted and welded connections. Include data on type (s) of tests conducted and test results.

E. LEED Submittals:

1. Product Data for Credit MR 4.1: For products having recycled content documentation indicating percentages by weight of postconsumer and preconsumer recycled content.

1.03 QUALITY ASSURANCE

A. Codes and Standards: Comply with provisions of following, except as otherwise indicated:

B. AISC "Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings", including "Commentary" and Supplements thereto as issued.

C. AISC "Specifications for Architecturally Exposed Structural Steel".

D. AISC "Specifications for Structural Joints using ASTM A 325 or A 490 Bolts" approved by the Research Council on Riveted and Bolted Structural Joints of the Engineering Foundation.

E. American Welding Society (AWS) D1.1 "Structural Welding Code - Steel".

F. Qualifications for Welding Work: Qualify welding processes and welding operators in accordance with AWS "Standard Qualification Procedure".
G. Provide certification that welders to be employed in work have satisfactorily passed AWS qualification tests.

1. If recertification of welders is required, retesting will be Contractor's responsibility.

1.04 DELIVERY, STORAGE AND HANDLING

A. Deliver materials to site at such intervals to insure uninterrupted progress of work.

B. Deliver anchor bolts and anchorage devices, which are to be embedded in cast-in-place concrete or masonry, in ample time to not delay work.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Metal Surfaces, General: For fabrication of work which will be exposed to view, use only materials which are smooth and free of surface blemishes including pitting, rust and scale seam marks, roller marks, rolled trade names and roughness. Remove such blemishes by grinding, or by welding and grinding, prior to cleaning, treating and application of surface finishes.

B. Structural Steel Wide Flange Shapes: ASTM A 992/A572, Grade 50

C. Other Structural Steel Shapes, Plates and Bars: ASTM A 36.

D. Cold-Formed Steel Tubing: ASTM A 500, Grade B.

E. Anchor Bolts: ASTM F 1554, Grade 36, nonheaded type unless otherwise indicated.

F. High-Strength Threaded Fasteners: Heavy hexagon structural bolts, heavy hexagon nuts and hardened washers, as follows:

1. Quenched and tempered medium-carbon steel bolts, nuts and washers, complying with ASTM A 325.

2. Direct tension indicator washers may be used at Contractor's option.


H. Structural Steel Primer Paint: SSPC-PS Guide 7.00

2.02 FABRICATION

A. Shop Fabrication and Assembly: Fabricate and assemble structural assemblies in shop to greatest extent possible. Fabricate items of structural steel in accordance with AISC Specifications and as indicated on final shop drawings. Provide camber in structural members where indicated.
B. Properly mark and match-mark materials for field assembly. Fabricate for delivery sequence which will expedite erection and minimize field handling of materials.

C. Where finishing is required, complete assembly, including welding of units, before start of finishing operations. Provide finish surfaces of members exposed in final structure free of markings, burrs and other defects.

D. Connections: Weld or bolt shop connections, as indicated.

E. Bolt field connections, except where welded connections or other connections are indicated.
   1. Provide high-strength threaded fasteners for all bolted connections, except where unfinished bolts are indicated.

F. High-Strength Bolted Construction: Install high-strength threaded fasteners in accordance with AISC "Specifications for Structural Joints using ASTM A 325 or A 490 Bolts" (RCRBSJ).

G. Welded Construction: Comply with AWS Code for procedures, appearance and quality of welds and methods used in correcting welding work.

H. Holes for Other Work: Provide holes required for securing other work to structural steel framing, and for passage of other work through steel framing members, as shown on final shop drawings.

I. Provide threaded nuts welded to framing, and other specialty items as indicated to receive other work.

J. Cut, drill or punch holes perpendicular to metal surfaces. Do not flame cut holes or enlarge holes by burning. Drill holes in bearing plates.

K. Field drill holes in existing steel members for connection of new steel as noted on the drawings.

2.03 SHOP PAINTING

A. General: Shop paint structural steel, except those members or portions of members to be embedded in concrete or mortar or to receive fire-proofing. Paint embedded steel which is partially exposed on exposed portions and initial 2" of embedded areas only.

B. Surface Preparation: After inspection and before shipping, clean steelwork to be painted. Remove loose rust, loose mill scale and spatter, slag or flux deposits. Clean steel in accordance with Steel Structures Painting Council (SSPC) as follows:
   1. SP-1 "Solvent Cleaning".
   2. SP-3 "Power Tool Cleaning".
C. Painting: Immediately after surface preparation, apply structural steel primer paint in accordance with Manufacturer's instructions and at a rate to provide dry film thickness of not less than 1.5 mils. Use painting methods which result in full coverage of joints, corners, edges and exposed surfaces.

PART 3 - EXECUTION

3.01 ERECTION

A. Surveys: Employ a registered professional engineer or land surveyor for accurate erection of structural steel. Check elevations of concrete and masonry bearing surfaces, and locations of anchor bolts and similar devices, before erection work proceeds, and report discrepancies to Architect. Do not proceed with erection until corrections have been made, or until compensating adjustment to structural steel work have been agreed upon with Architect.

B. Temporary Shoring and Bracing: Provide temporary shoring and bracing members with connections of sufficient strength to bear imposed loads. Remove temporary members and connections when permanent members are in place and final connections are made. Provide temporary guy lines to achieve proper alignment of structures as erection proceeds.

C. Temporary Planking: Provide temporary planking and working platforms as necessary to effectively complete work.

D. Field Assembly: Set structural frames accurately to lines and elevations indicated. Align and adjust various members forming part of complete frame or structure before permanently fastening. Clean bearing surfaces and other surfaces which will be in permanent contact before assembly. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.

E. Level and plumb individual members of structure within specified AISC tolerances.

F. Splice members only where indicated and accepted on shop drawings.

G. Erection Bolts: On exposed welded construction, remove erection bolts, fill holes with plug welds and grind smooth at exposed surfaces.

H. Comply with AISC Specifications for bearing, adequacy of temporary connections, alignment and removal of paint on surfaces adjacent to field welds.

I. Do not enlarge unfair holes in members by burning or by use of drift pins, except in secondary bracing members. Ream holes that must be enlarged to admit bolts.

J. Gas Cutting: Do not use gas cutting torches in field for correcting fabrication errors in primary structural framing. Cutting will be permitted only as acceptable to Architect.

K. Touch-Up Painting: Immediately after erection, clean field welds, bolted connections and abraded areas of shop paint. Apply paint to exposed areas using
same material as used for shop painting.

L. Apply by brush or spray to provide minimum dry film thickness of 1.5 mils.

### 3.02 QUALITY CONTROL

A. Owner to engage an independent testing and inspection agency to inspect high-strength bolted connections and welded connections and to perform tests and prepare test reports.

B. Testing agency shall conduct and interpret tests and state in each report whether test specimens comply with requirements, and specifically state any deviations therefrom.

C. Provide access for testing agency to places where structural steel work is being fabricated or produced so that required inspection and testing can be accomplished.

D. Testing agency may inspect structural steel at plant before shipment; however, Architect reserves right, at any time before final acceptance, to reject material not complying with specified requirements.

E. Correct deficiencies in structural steel work which inspections and laboratory test reports have indicated to be not in compliance with requirements. Perform additional tests, at Contractor's expense, as may be necessary to reconfirm any noncompliance of original work, and as may be necessary to show compliance of corrected work.

F. Shop Bolted Connections: Inspect or test in accordance with AISC specifications.

G. Shop Welding: Inspect and test during fabrication of structural steel assemblies, as follows:
   1. Certify welders and conduct inspections and tests as required. Record types and locations of defects found in work. Record work required and performed to correct deficiencies.
   2. Perform visual inspection of all welds.

H. Field Bolted Connections: Inspect in accordance with AISC specifications.

I. Field Welding: Inspect and test during erection of structural steel as follows:
   1. Certify welders and conduct inspections and tests as required. Record types and locations of defects found in work. Record work required and performed to correct deficiencies.
   2. Perform visual inspection of all welds.

J. Testing agency shall confirm that the structure is square, plumb and level in accordance with AISC tolerances.
K. In addition to visual inspection, field-welded connections will be inspected and tested according to AWS D1.1 and the inspection procedures listed below, at testing agency’s option.

1. Liquid Penetration Inspection: ASTM E 165.
2. Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration will not be accepted.
3. Radiographic Inspection: ASTM E 94 and ASTM E 142; minimum quality level “2-2T.”

3.03 STEEL ALLOWANCE

A. Provide and include in this bid a lump sum of $20,000 (4 tons of steel @ $5,000.00 per ton) of fabricated and erected steel. This steel shall be provided at any time until final acceptance of this contract by the Architect. This steel may consist of W. F. Sections, angles, frames or various miscellaneous steel. Include shop drawings, fabrication and erection in this item.

1. Upon completion of the project, any of the allowance work not used, shall be credited to the Owner against the contract price at the rate of two dollars and fifty cents ($2.50) per pound.

END OF SECTION 05120
SECTION 05210 - STEEL JOIST FRAMING

PART 1 - GENERAL

1.01 SCOPE

A. The general provisions of the Contract, including General and Supplementary Conditions and General Requirements, apply to the work specified in this section.

B. The extent of steel joists is shown on the drawings, including basic layout and type of joists required.

1.02 QUALITY ASSURANCE

A. Provide joists fabricated in compliance with the following, and as herein specified.

   1. AISC-SJI "Standard Specifications and Load Tables" for:
      a. K-Series Open Web Steel Joists
      b. LH-Series Steel Joists

B. Steel joist manufacturer shall be an approved member of the Steel Joist Institute for the types of joists supplied.

C. Qualification of Welding Work:

   1. Qualify welding processes and welding operators in accordance with the AWS "Standard Qualification Procedure".

   2. Joists welded in place are subject to inspection and testing. Expense of removing and replacing any portion of the steel joists for testing purposes will be borne by the Owner if welds are found to be satisfactory. Remove and replace any work found to be defective and provide new acceptable work.

D. Workmanship:

   1. Steel Inspection and Testing Service: Employ, at Contractor's expense, a testing laboratory acceptable to the Architect to inspect welded connections and to perform tests and submit inspection and test reports to the Architect.

1.03 SUBMITTALS

A. Manufacturer's Data, Steel Joists:

   1. Submit two (2) copies of manufacturer's specifications and installation instructions for each type of joist and its accessories. Include manufacturer's certification that joists comply with AISC-SJI "Specifications".

B. Shop Drawings, Steel Joists:
1. Submit detailed drawings showing layout of joist units, special connections, jointing and accessories. Include the mark, number, type, location and spacing of joists and bridging.

Provide templates or location drawings for installation of anchor bolts.

C. Delivery, Storage and Handling:

1. Deliver, store and handle steel joists as recommended in AISC-SJI "Specifications". Handle and store joists in a manner to avoid deforming members and to avoid excessive stresses.

D. LEED Submittals:

1. Product Data for Credit MR 4.1: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content.

   a. Include statement indicating costs for each product having recycled content.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Steel: Comply with AISC-SJI "Specifications".

B. Steel Prime Paint: Comply with SJI "Specifications".

2.02 FABRICATION

A. General: Fabricate steel joists in accordance with AISC-SJI "Specifications".

B. Extended Ends: Provide extended ends on joists where shown, complying with the manufacturer's standards and requirements of applicable AISC-SJI "Specifications" and load tables.

C. Ceiling Extension: Provide ceiling extensions in areas having ceilings attached directly to joist bottom chord. Provide either an extended bottom chord element or a separate unit, to suit manufacturer's standards, of sufficient strength to support the ceiling construction. Extend ends to within 1/2" of the finished wall surface unless otherwise indicated.

D. Bridging: Provide horizontal or diagonal type bridging for "open web" joists, complying with AISC-SJI "Specifications". Provide bridging anchors for ends of all bridging lines terminating at walls or beams.

E. End Anchorage: Provide end anchorages to secure joists to adjacent construction, complying with AISC-SJI "Specifications", unless otherwise indicated.
F. Header Units: Provide header units to support tail joists at openings not framed with steel shapes.

G. Shop Painting: Shop paint all steel joist work, except contact surfaces which are to be welded or high-strength bolted.

H. Surface Preparation: After inspection and before shipping, clean steelwork to be painted complying with SJI "Specifications" unless otherwise indicated.

I. Application: Immediately after surface preparation, apply structural steel primer paint in accordance with manufacturer's instructions and at a rate to provide a uniform dry film thickness of 1.5 mils. Use painting methods which will result in full coverage of joints, corners, edges and all exposed surfaces.

PART 3 - EXECUTION

3.01 ERECTION

A. Place and secure steel joists in accordance with AISC-SJI "Specifications", final shop drawings and as herein specified.

B. Furnish anchor bolts and other devices to be built into the concrete and masonry construction. Furnish templates for the accurate location of anchors in other work.
   1. Furnish unfinished threaded fasteners for anchor bolts, unless otherwise indicated.
   2. Refer to Division 3 sections for installation of anchors set in concrete.
   3. Refer to Division 4 sections for installation of anchors set in masonry.

C. Placing Joists:
   1. Do not start placement of steel joists until supporting work is in place and secured. Place joists on supporting work, adjust and align in accurate locations and spacing before permanently fastening.
   2. Provide temporary bridging, connections and anchors to ensure lateral stability during construction. Where "open web" joist lengths are 40 feet and longer, install a center row of bolted bridging to provide lateral stability before slackening of hoisting lines.

D. Bridging: Install bridging simultaneously with joist erection, before any construction loads are applied. Anchor ends of bridging lines at top and bottom chords where terminating at walls or beams.

E. Fastening Joists: Field weld or high-strength bolt joists to supporting steel framework in accordance with AISC-SJI "Specifications" and as shown on drawings for the type of joists used. Coordinate welding sequence and procedure with the placing of joists.

F. Touch-Up Painting: After joist installation, paint all field bolt heads and nuts, and welded areas, abraded or rusty surfaces on joists and steel supporting members.
Wire brush surfaces and clean with solvent before painting. Use the same type of paint as used for shop painting.

3.02 FIELD QUALITY CONTROLS

A. The testing agency shall conduct and interpret the tests and state in each report whether the test specimens comply with the requirements, and specifically state any deviations therefrom.

1. Provide access for the testing agency to places where steel joist work is being fabricated or produced so that required inspection and testing can be accomplished.

2. The testing agency may inspect steel joist work at the plant before shipment; however, the Architect reserves the right, at any time before final acceptance, to reject material not complying with specified requirements.

B. Inspection of Shop Painting:

1. Visually evaluate surface preparation by comparison with pictorial standards in accordance with SSPC-Vis 1.

2. Measure dry film thickness with a magnetic film thickness gage in accordance with SSPC-PA 2.

3. Visually inspect dried film for runs, sags, dry spray, overspray and missed areas.

C. Correct deficiencies in steel joist work which inspections and laboratory test reports have indicated to be not in compliance with requirements. Perform additional tests, at Contractor's expense, as may be necessary to reconfirm any non-compliance of the original work, and as may be necessary to show compliance of corrected work.

END OF SECTION 05210
SECTION 05310 - STEEL DECKING

PART 1 - GENERAL

1.01 SUMMARY

A. Extent of metal decking is indicated on drawings, including basic layout and type of deck units required.

1.02 SUBMITTALS

A. Product Data: Submit manufacturer's specifications and installation instructions for each type of decking and accessories. Include manufacturer's certification as may be required to show compliance with these specifications.

B. Shop Drawings: Submit detailed drawings showing layout and types of deck panels, anchorage details and conditions requiring closure panels, supplementary framing, sump pans, cant strips, cut openings, special jointing or other accessories.

C. Provide acoustical inserts for metal deck for installation by others.

D. LEED Submittals:

1. Product Data for Credit MR 4.1: For products having recycled content documentation indicating percentages by weight of postconsumer and preconsumer recycled content.

   a. Include statement indicating costs for each product having recycled content.

1.03 QUALITY ASSURANCE

A. Code and Standards: Comply with provisions of the following codes and standards, except as otherwise indicated or specified:

   1. AISI "Specification for the Design of Cold-Formed Steel Structural Members".
   2. AWS D1.3 "Structural Welding Code - Sheet Steel".
   3. SDI "Design Manual for Floor Decks and Roof Decks"

B. Qualification of Field Welding: Qualify welding processes and welding operators in accordance with "Welder Qualification" procedures of AWS D1.1.

C. Welded decking in place is subject to inspection and testing. Expense of removing and replacing portions of decking for testing purposes will be borne by Owner if welds are found to be satisfactory. Remove work found to be defective and replace with new acceptable work.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include, but are not limited to, the following.
1. Metal Roof Deck Units:
   a. Roof Deck, Inc.
   b. Canam-United Steel Deck
   c. New Millennium Building Systems
   d. Nucor-Vulcraft Group
   e. Epic Metal Inc.
   f. Or approved equal.

2. Composite Metal Floor Deck Units:
   a. Canam-United Steel Deck
   b. New Millennium Building Systems
   c. Nucor-Vulcraft Group
   d. Or approved equal.

2.02 MATERIALS

A. Steel for Galvanized Metal Deck Units: ASTM A 653, Grade 33 or higher – Roof Decking; ASTM A 652, Grade 40 or higher – Floor Decking.

B. Steel for Painted Metal Deck Units: ASTM A 1008, Grade 33 or higher – Roof Decking; ASTM A 652, Grade 40 or higher – Floor Decking.

C. Sheet Metal Accessories: ASTM A 526, commercial quality, galvanized.

D. Galvanizing: ASTM A 653, G60.

E. Galvanizing Repair Paint: High zinc-dust content paint for repair of damaged galvanized surfaces complying with Military Specifications MIL-P-21035 (Ships).

F. Flexible Closure Strips: Manufacturer's standard vulcanized, closed-cell, synthetic rubber.

2.03 FABRICATION

A. General: Form deck units in lengths to be continuous over three (3) or more spans, with flush, telescoped or nested 2" laps at ends and interlocking or nested side laps, unless otherwise indicated.

B. Roof Deck Units: Provide deck configurations complying with SDI "Roof Deck Specifications" of metal thickness, depth and width as shown.

C. Open-Beam Composite Units: Fabricate deck units with integral embossing or raised pattern to furnish mechanical bond with concrete slabs. Fabricate open-beam units with fluted section having interlocking side laps: of metal thickness, depth and width as shown.

D. Metal Closure Strips: Fabricate metal closure strips, for cell raceways and openings between decking and other construction, of not less than 0.045" min. (18 gage) sheet steel. Form to provide tight-fitting closures at open ends of cells or flutes and sides of decking.
E. Roof Sump Pans: Fabricate from single pieces of .071" min. (14 gage) galvanized sheet steel with level bottoms and sloping sides to direct water flow to drain, unless otherwise shown. Provide sump pans of adequate size to receive roof drains and with bearing flanges not less than 3" wide. Recess pans not less than 1-1/2" below roof deck surface, unless otherwise shown or required by deck configuration. Holes for drains will be cut in the field.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General: Install deck units and accessories in accordance with manufacturer's recommendations and final shop drawings, and as specified herein.

B. Place deck units on supporting steel framework and adjust to final position with ends accurately aligned and bearing on supporting members before being permanently fastened. Do not stretch or contract side lap interlocks.

C. Place deck units in straight alignment for entire length of run of cells and with close alignment between cells at ends of abutting units.

D. Place deck units flat and square, secured to adjacent framing without warp or excessive deflection.

E. Do not place deck units on concrete supporting structure until concrete has cured and is dry.

F. Coordinate and cooperate with structural steel erector in locating decking bundles to prevent overloading of structural members.

G. Fastening Deck Units:

   1. Fasten roof deck units to steel supporting members by not less than 5/8" diameter fusion welds or elongated welds of equal strength, spaced not more than 12" o.c. In addition, secure deck to each supporting member in ribs where side laps occur.

H. Comply with AWS requirements and procedures for manual shielded metal arc welding, appearance and quality of welds and methods used in correcting welding work.

I. Cutting and Fitting: Cut and neatly fit deck units and accessories around other work projecting through or adjacent to the decking, as shown.

J. Mechanically fasten side laps of adjacent deck units between supports, at intervals not exceeding 36" o.c. using self-tapping No. 10 or larger machine screws, unless a closer spacing or a larger screw is called for on the drawing.

K. Uplift Loading: Install and anchor roof deck units to resist gross uplift of 45 lbs. per sq. ft. at eave overhang, building corners and perimeter, and 30 lbs. per sq. ft. for other roof areas.

L. Reinforcement at Openings: Provide additional metal reinforcement and closure pieces as required for strength, continuity of decking and support of other work.
shown.

M. Joint Covers: Provide metal joint covers at abutting ends and changes in direction of floor deck units, except where taped joints are required.

N. Shear Connectors: Weld shear connectors to supports through decking units in accordance with manufacturer's instructions. Do not weld shear connectors through two layers (lapped ends) of decking units. Weld only on clean, dry deck surfaces.

O. Pour Stops: Weld continuous pour stops to supporting decking units or structural steel supports with a minimum 1" long weld at 12" on center. Install pour stop with a minimum of 2" bearing on supports.

1. Provide pour stops at edge of all slabs, all openings and as indicated on drawings.

P. Roof Sump Pans: Place over openings provided in roof decking and weld to top decking surface. Space welds not more than 12" o.c. with at least one weld at each corner. Cut opening in roof sump bottom to accommodate drain size indicated.

Q. Edge Finish Strips: Provide metal finish strips at edges of roof decking, parallel to flutes. Weld into position to provide a complete deck installation.

R. Touch-Up Painting: After deck installation, wire brush, clean and paint scarred areas, welds and rust spots on top and bottom surfaces of decking units and supporting steel members.

1. Touch-up galvanized surfaces with galvanizing repair paint applied in accordance with manufacturer's instructions.
2. Touch-up painted surface with same type of shop paint used on adjacent surfaces.

S. In areas where shop-painted surfaces are to be exposed, apply touch-up paint to blend into adjacent surfaces.

T. Touch-Up Painting: Cleaning and touch-up painting of field welds, abraded areas and rust spots, as required after erection and before proceeding with field painting, is included in Division 9 under Painting.

3.02 QUALITY CONTROL

A. The owner shall employ a testing laboratory satisfactory to the Architect to perform the following tests and to submit testing and inspection reports.

1. Welding: Inspect welding to determine if welds are at proper locations, are proper size and material, and meet AWS standards.
2. Sidelap Connections: Inspect sidelap connections to determine if the connections are in accordance with contract documents.
3. Shear Connectors: All shear connectors shall be visually inspected and tapped with a hammer. All/any studs which do not appear to have a sound weld or which produce a dull sound rather than a ringing sound when tapped shall be further tested as follows:
a. The stud shall be struck with a hammer and bent approximately 15 degrees off perpendicular towards the nearest end of the beam. Studs meeting this test without coming loose shall remain on the beam. Studs failing this test shall be replaced.

END OF SECTION 05310
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 DESCRIPTION OF WORK

A. Definition: Miscellaneous structural steel include items made from iron and steel shapes, plates, bars, strips, tubes, pipes and castings which are not a part of Structural Steel or other metal fabrication systems specified elsewhere.

B. Extent of miscellaneous structural steel fabrications is indicated on drawings and schedules.

1. Work of this section shall include miscellaneous structural steel framing and supports for floor, wall and roof openings whether or not shown on structural drawings.

a. Refer to architectural, mechanical and electrical drawings for the following:

   1) Locations and sizes of roof penetrations, roof top supported mechanical and electrical equipment, roof drains, ducts, piping, raceways, etc.
   2) Locations and sizes of wall penetrations, wall chases, louvers, duct penetrations, etc.
   3) Locations and sizes of floor penetrations; ducts, piping, raceways, etc.
   4) Locations of all steel handrails, railings and guardrails.

b. All miscellaneous structural steel supports shall be in accordance with typical structural steel details and schedules shown on structural steel drawings and/or as directed by the Architect.

c. All miscellaneous structural steel supports shall meet indicated load requirements and/or as directed by the Architect.

d. In existing building(s) where alteration and/or renovation work is/are indicated, refer to Division 1 Sections for miscellaneous structural steel framing and supports which may be assigned to be provided and installed by other Trades.

C. Types of work in this section include metal fabrications for:

1. Loose Steel lintels, bearing and leveling plates and miscellaneous steel framing and supports

2. Steel Framed Stairs:
   a. Metal Stairs
   b. Steel wire mesh guardrails

3. Steel railings, handrails, and guardrails at all stairs and ramps.
D. Related Sections:

1. Section 01400 - Testing Laboratory Service
2. Section 03300 - Concrete Work
3. Section 04200 - Unit Masonry
4. Section 05120 - Structural Steel
5. Section 05210 - Steel Joists
6. Section 05300 - Metal Decking
7. Section 05500 - Metal Fabrications
8. Section 09900 - Painting
9. Division 15 - Mechanical Work

1.3 QUALITY ASSURANCE

A. Field Measurements: Take field measurements prior to preparation of shop drawings and fabrication, where possible. Do not delay job progress; allow for trimming and fitting where taking field measurements before fabrications might delay work.

B. Shop Assembly: Preassemble items in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

C. Delegated Design:

1. Performance and Design Criteria: Where professional design services or certifications by a design professional are specifically required of Contractor by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated. Designated Design includes, but is not limited to:

   a. Miscellaneous steel framing, stair stringers, tread pans, platforms, landings and supplemental framing for landings, metal framing, hangers, columns, struts, clips, brackets, bearing plates and other components.

   b. Handrails, guardrails, balusters, newel posts, clips struts, brackets, bearing plates and other components.

2. Professional Engineer Qualifications: A professional engineer legally authorized to practice in the jurisdiction where Project is located, (State of New Jersey), and experienced in providing engineering services of the kind indicated that have resulted in the installation of structural assemblies, similar to this Project in material, design, and extent and that has a record of successful in-service performance. Provide analysis data and signed & sealed documents.

3. Conform to all applicable State and Local Codes for design loads and all other requirements.

4. Refer to paragraph 1.4 - SUBMITTALS (below).

E. NAAMM Stair Standard: Comply with "Recommended Voluntary Minimum Standards for Fixed Metal Stairs" in NAAMM AMP 510, "Metal Stairs Manual," for class of stair designated, unless more stringent requirements are indicated.

1. Architectural Class.
   a. Fabricator Qualifications: A firm experienced in producing metal stairs similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.


1.4 SUBMITTALS

A. Product Data: Submit manufacturer's specifications, anchor details and installation instructions for products used in miscellaneous metal fabrications, including paint products and grout.

B. Shop Drawings: Submit shop drawings for fabrication and erection of miscellaneous steel fabrications. Include plans, elevations and details of sections and connections. Show anchorage and accessory items. Provide templates for anchor and bolt installation by others.

   1. Submit shop drawings for miscellaneous steel framing and supports, steel stairs and railings. Signed and sealed shop drawings shall be submitted by a qualified professional Structural Engineer, licenced in the state where project is located.

C. Where materials or fabrications are indicated to comply with certain requirements for design loadings, include structural computations, material properties and other information needed for structural analysis.

D. Samples: Submit 2 sets of representative samples of materials and finished products as may be requested by Architect.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Metal Surfaces, General: For fabrication of miscellaneous structural steel work which will be exposed to view, use only materials which are smooth and free of surface blemishes including pitting, seam marks, roller marks, rolled trade names and roughness.

B. Steel

   1. Steel Plates, Shapes and Bars: ASTM A 36.
   2. Steel Tubing: Cold-formed, ASTM A 500; or hot-rolled, ASTM A 501.
   3. Structural Steel Sheet: Hot-rolled, ASTM A 570; or cold-rolled ASTM A 611, Class 1; of grade required for design loading.
4. Galvanized Structural Steel Sheet: ASTM A 446, of grade required for design loading. Coating designation as indicated, or if not indicated, G90.

5. Steel Pipe: ASTM A 53; Type and grade (if applicable) as selected by fabricator and as required for design loading; black finish unless galvanizing is indicated; standard weight (schedule 40), unless otherwise indicated.


7. Malleable Iron Castings: ASTM A 47, grade as selected by fabricator.

C. Brackets, Flanges and Anchors: Cast or formed metal of the same type material and finish as supported rails, unless otherwise indicated.

D. Concrete Inserts: Threaded or wedge type; galvanized ferrous castings, either malleable iron, ASTM A 47, or cast steel, ASTM A 27. Provide bolts, washers and shims as required, hot-dip galvanized, ASTM A 153.

E. Grout:
   1. Metallic Non-Shrink Grout: Pre-mixed, factory-packaged, ferrous aggregate grout complying with CE CRD-C588, Type M.
   2. Non-Shrink Non-Metallic Grout: Pre-mixed, factory-packaged, non-staining, non-corrosive, non-gaseous grout complying with CE CRD-C621. Provide grout specifically recommended by manufacturer for interior and exterior applications of type specified in this section.

F. Fasteners:
   1. General: Provide zinc-coated fasteners for exterior use or where built into exterior walls. Select fasteners for the type, grade and class required.
   2. Bolts and Nuts: Regular hexagon head type, ASTM A 307, Grade A.
   3. Lag Bolts: Square head type, FS FF-B-561.

G. Toggle Bolts: Tumble-wing type, FS FF-B-588, type, class and style as required.
   1. Lock Washers: Helical spring type carbon steel, FS FF-W-84.

H. Paint:
   2. Primer: Tnemec Series 90-97 Tneme-Zinc, or equal, @ 2.5 - 3.5 mils (dry)
   3. Primer selected must be compatible with finish coats of paint. Coordinate selection of metal primer with finish paint requirements specified in Section 09900.
2.2 FABRICATION, GENERAL

A. Workmanship: Use materials of size and thickness indicated, or if not indicated, as required to produce strength and durability in finished product for use intended. Work to dimensions indicated or accepted on shop drawings, using proven details of fabrication and support. Use type of materials indicated or specified for various components of work.

B. Form exposed work true to line and level with accurate angles and surfaces and straight sharp edges. Ease exposed edges to a radius of approximately 1/32” unless otherwise indicated. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.

C. Weld corners and seams continuously, complying with AWS recommendations. At exposed connections, grind exposed welds smooth and flush to match and blend with adjoining surfaces.

D. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners wherever possible. Use exposed fasteners of type indicated or, if not indicated, Phillips flat-head (countersunk) screws or bolts.

E. Provide for anchorage of type indicated, coordinated with supporting structure. Fabricate and space anchoring devices to provide adequate support for intended use.

F. Galvanizing:
   1. Provide a zinc coating for exterior items and those items indicated or specified to be galvanized, as follows:
      a. ASTM A 153 for galvanizing iron and steel hardware.
      b. ASTM A 123 for galvanized rolled, pressed and forged steel shapes, plates, bars and strip 1/8” thick and heavier.
      c. ASTM A 386 for galvanizing assembled steel products.

G. Fabricate joints which will be exposed to weather in a manner to exclude water or provide weep holes where water may accumulate.

H. Shop Painting
   1. Shop paint miscellaneous structural steel, except members or portions of members to be embedded in concrete or masonry, surfaces and edges to be field welded, and galvanized surfaces, unless otherwise indicated.
   2. Remove scale, rust and other deleterious materials before applying shop coat. Clean off heavy rust and loose mill scale in accordance with SSPC SP-6.
   3. Immediately after surface preparation, brush or spray on primer in accordance with manufacturer’s instructions. Use painting methods which will result in full coverage of joints, corners, edges and exposed surfaces.
4. Apply one shop coat to fabricated metal items, except apply two coats of paint to surfaces inaccessible after assembly or erection. Change color of second coat to distinguish it from the first.

2.3 MISCELLANEOUS STRUCTURAL STEEL


1. Structural Performances: Provide railing and handrail assemblies which, when installed, shall comply ASCE standards for minimum design loads for handrail assemblies and guardrail systems and capable of withstanding the following loads applied as indicated:

   a. To resist a load of 50 pound per linear foot applied in any direction at the top and to transfer this load through the supports to the structure.

   b. To resist a single concentrated load of 200 pounds applied in any direction at any point along the top, and have attachment devices and supporting structure to transfer this loading to the building structural assemblies, walls, floors or slabs. This load shall act concurrently with loads indicated in Paragraph “a” above.

   c. Intermediate rails (all those except the handrail), balusters and panel fillers shall withstand a horizontally applied normal load of 50 lbs. On an area not to exceed one square foot area including openings and space between rails. Reactions due to this loading are not required to be superimposed with those of paragraphs “a” and “b” above.

   d. Guards: Intermediate rails and balusters capable of withstanding a horizontal concentrated load of 200 lbs. applied on a one square foot area at any point in system of gross area of guard, including any open areas, of which they are a part. Load need not be assumed to be acting concurrently with uniform horizontal loads on toprails of railing assembly in determining stress on guard supporting members.

   e. Guards shall be designated and constructed for a uniform load of 50 pounds per foot applied horizontally at required guardrail height and a simultaneous uniform load of 100 pounds applied vertically downwards at top of guardrail.

   f. In-fill Area:

      1) Concentrated Load: 200 pounds, horizontal load, applied on a 1-square-foot area at any point in the system, including intermediate rail or other elements serving this purpose.

      2) This loading condition shall not be applied simultaneously with loading conditions indicated above, (a, b, and c).

B. Fabricate pipe railings and handrails to design, dimensions, and details indicated. Provide railings and handrails members formed of pipe of sizes and wall thickness indicated, or if not
shown, as required to support indicated design loading. Unless otherwise indicated all shown dimensions for pipes, rails and other round shapes are outside diameter.

1. Interconnect railing and handrail members by butt-welding or welding with internal connectors, at fabricator’s option, unless otherwise indicated.
   a. At tee and cross intersections provide coped joints.
   b. At bends interconnect pipe by means of prefabricated elbow fittings or flush radius bends, as applicable, of radii as indicated.
   c. Perform welding to comply with applicable AWS specifications, using method appropriate for metal and finish indicated. Grind exposed welds smooth and flush to match and blend with adjoining surfaces.

2. Form simple and compound curves by bending pipe in jigs to produce uniform curvature for each repetitive configuration required; maintain cylindrical cross-section of pipe throughout entire bend without buckling, twisting or otherwise deforming exposed surfaces of pipe.

3. Provide wall returns at ends of wall-mounted handrails, except where otherwise indicated.

4. Close exposed ends of pipe by welding 3/16" thick steel plate in place or by use of prefabricated fittings.

5. Brackets, Flanges, Fittings and Anchors: Provide wall brackets, end closures, flanges, miscellaneous fittings and anchors for interconnections of pipe and attachment of railings and handrails to other work. Furnish inserts and other anchorage devices for connecting railings and handrails to concrete or masonry work.

2.4 STEEL FRAMED STAIRS

1. General: Construct stairs to conform to sizes and arrangements indicated; join pieces together by welding unless otherwise indicated.
   a. Provide complete stair assemblies including metal framing, hangers, columns, railings, newels, balusters, struts, clips, brackets, bearing plates and other components necessary for the support of stairs and platforms and as required to anchor and contain the stairs on the supporting structure.

2. Stair Framing: Fabricate stringers of structural steel channels, plates, or a combination of both as indicated.
   a. Provide closures for exposed ends of stringers.
   b. Construct platforms of structural steel channel headers and miscellaneous framing members as indicated.
c. Bolt or weld headers to strings, newels and framing members to strings and headers; fabricate and join so that bolts, if used, do not appear on exposed finish surfaces.

d. Provide continuous steel scriber plates at masonry walls. Match stringer width.

3. Where masonry walls support steel stairs, provide temporary supporting struts designed for erection of steel stair components before installation of masonry.

4. Metal Pan Risers, Subtreads, and Subplatforms: Shape metal pans for risers and subtreads to conform to configuration shown. Provide structural steel sheet for metal pans of minimum thickness of 0.0677 inch, unless otherwise indicated, but not less than that required to support total design loading.

5. Form metal pans of cold-rolled carbon steel sheet unless otherwise indicated.

6. Attach risers and subtreads to stringers by means of brackets made of steel angles or bars. Weld brackets to strings and attach metal pans to brackets by welding, riveting or bolting.

7. Coordinate steel stair work with concrete work specified in Section 03300.

2.5 STEEL STAIRS AND RAILINGS:

1. Basis of Design: Subject to compliance with indicated requirements, provide metal stair and railings as manufactured by American Stair Corp. Inc.; Pacific Stair Corp., EeStairs; or approved equal.

2. Provide subplatforms of configuration and construction indicated, or if not indicated, of same metal as risers and subtreads and in thicknesses required to support design loading. Attach subplatform to platform framing members with welds.

3. Steel Floor Plate Treads and Platforms: Provide raised pattern steel floor plate complying with FS QQ-F-461, Class I. Provide pattern indicated or, if not indicated, as selected from manufacturer's standard patterns.

4. Form treads of 1/4" thick steel floor plate with integral nosing and back edge stiffener. Weld steel supporting brackets to strings and treads to brackets.

   a. Provide stairs capable of supporting a minimum live load of 100 psi and a concentrated load of 300 psi.

5. Provide steel railings, handrails and guardrails as indicated or selected from manufacturer's available full range of types.

   a. Perforated Steel Infill Grille at Stairs:

      1) Fabricate to comply with requirements indicated for design, dimensions, details, finish, and member sizes, including thickness of material, spacings, and anchorage, but not less than that needed to withstand indicated loads.

6. Finishes and Colors: As indicated in Section 09900.
PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate and furnish anchorages, setting drawings, diagrams, templates, instructions, and directions for installation of anchorages, such as concrete inserts, sleeves, anchor bolts and miscellaneous items having integral anchors, which are to be embedded in concrete or masonry construction. Coordinate delivery of such items to project site.

1. Coordinate work of this section with other work affected by other Trades.

2. Obtain locations, opening sizes, weighs and other required information from affected trades.

3. Comply with coordination requirements indicated in Division 1 Sections.

3.2 INSTALLATION

A. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing miscellaneous metal fabrications to in-place construction; including, threaded fasteners for concrete and masonry inserts, toggle bolts, through-bolts, lag bolts, wood screws and other connectors as required.

B. Cutting, Fitting and Placement: Perform cutting, drilling and fitting required for installation of miscellaneous metal fabrications. Set work accurately in location, alignment and elevation, plus, level, true and free of rack, measured from established lines and levels. Provide temporary bracing or anchors in formwork for items which are to be built into concrete masonry or similar construction.

C. Fit exposed connections accurately together to form tight hairline joints. Weld connections which are not to be left as exposed joints, but cannot be shop welded because of shipping size limitations. Grind exposed joints smooth and touch-up shop paint coat. Do not weld, cut or abrade the surfaces of exterior units which have been hot-dip galvanized after fabrication, and are intended for bolted or screwed field connections.

D. Field Welding: Comply with AWS Code for procedures of manual shielded metal-arc welding, appearance and quality of welds made, and methods used in correcting welding work.

E. Set loose lintels weighing more than 200 pounds, leveling and grouting as for plates. Deliver loose lintels weighing less than 200 pounds to the General Construction Contractor, allow sufficient time for scheduling his installations.

3.3 PIPE RAILINGS AND HANDRAILS

A. Adjust railing prior to anchoring to ensure matching alignment at abutting joints. Space posts at spacing indicated, or if not indicated, as required by design loadings. Plumb posts in each direction. Secure posts and railing ends to building construction as follows:

1. Anchor posts in concrete by means of sleeves preset and anchored into concrete. After posts have been inserted into sleeves, fill annular space between post and sleeve
solid with non-shrink, non-metallic grout, mixed and placed to comply with grout manufacturer's directions.

2. Leave anchorage joint exposed; wipe off excess grout and leave 1/8 inch build-up, sloped away from post. For installation exposed on exterior or to flow of water, seal grout to comply with grout manufacturer's directions.

3. Anchor rail ends into concrete and masonry with steel round flanges welded to rail ends and anchored into wall construction with lead expansion shields and bolts.

B. Anchor rail ends to steel with steel oval or round flanges welded to rail ends and bolted to structural steel members, unless otherwise indicated.

C. Secure handrails to wall with wall brackets and end fittings. Provide bracket with not less than 1-1/2" clearance from inside face of handrail and finished wall surface. Locate brackets as indicated, or if not indicated, at spacing required for design loading. Secure wall brackets and wall return fittings to building construction as follows:

1. Use type of bracket with flange tapped for concealed anchorage to threaded hanger bolt.

2. For concrete and solid masonry anchorage, use drilled-in expansion shield and either concealed hanger bolt or exposed lag bolt, as applicable.

3. For hollow masonry anchorage, use toggle bolts having square heads.

3.4 ADJUST AND CLEAN

A. Touch-Up Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with same material as used for shop painting.

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

C. For galvanize surfaces: Clean field welds, bolted connections and abraded areas and apply galvanizing repair paint to comply with ASTM A 780.

END OF SECTION 05400
PART 4 - PLUMBING, DRAINAGE & SPRINKLER SYSTEM WORK
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.
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.


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


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


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 engineer approved equal.
   2. Pressure Rating: 175 psig minimum.
   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.

B. Ball Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Anvil International, Inc.
   b. Victaulic Company.
   c. Or engineer 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 engineer approved equal
2. Standard: UL 1091.
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 engineer approved equal

2. Standard: UL 1091.
4. Body Material: Cast or ductile iron.
5. Style: Lug or wafer.

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 engineer approved equal

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 engineer approved equal

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 engineer approved equal

2. Standard: UL 1091.
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.


2.5 TRIM AND DRAIN VALVES

A. General Requirements:

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 engineer 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. Flowserv.
   h. FNW.
   i. Jomar International, Ltd.
   j. Kennedy Valve; a division of McWane, Inc.
   k. Kitz Corporation.
   l. Legend Valve.
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 engineer approved equal

E. Plug Valves:

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

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

2.6 SPECIALTY VALVES

A. General Requirements:

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 engineer approved equal

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 engineer approved equal

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:
   b. Fire-End & Croker Corporation.
c. Potter Roemer.
d. Or engineer approved equal

2. Standard: UL 199.
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 engineer approved equal

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 engineer approved equal

5. Size: Same as connected piping.
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 engineer approved equal

3. Type: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid.
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.
3. Reliable Automatic Sprinkler Co., Inc.
4. Tyco Fire & Building Products LP.
5. Venus Fire Protection Ltd.
8. Or engineer approved equal

B. General Requirements:

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 engineer 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.
4. WIKA Instrument Corporation.
5. Or engineer 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 Architect 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.
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. Trapezoid 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.


2.2 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.
3. ERICO International 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 engineer 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.
   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.
   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.


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-PA1 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

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.
4. Isolation Technology, Inc.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.
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.
7. Mason Industries.
8. TOLCO Incorporated; a brand of NIBCO INC.
9. Unistrut; Tyco International, Ltd.
10. Or engineer 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:
   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.
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.


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."

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.

C. Pipe Label Color Schedule:

1. Domestic Water Piping:
   a. Background Color: Green.

2. Sanitary Waste Piping:
   a. Background Color: Green.

3. Storm Drainage Piping:
   a. Background Color: Green.

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:

2. Valve-Tag Color:
   a. Cold Water: Green.
   b. Hot Water: Green.
3. Letter Color:

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 engineer approved equal

2. Material and Thickness: Brass, 0.032-inch-thick, with predrilled holes for attachment hardware.
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.
5. Craftmark.
6. emedco.
7. LEM Products Inc.
8. Marking Services Inc.
10. Seton Identification Products.
11. Stranco, Inc.
12. Or engineer 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.
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 engineer 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.

2.4 VALVE TAGS

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

   1. ActionCraft Products, Inc.
   2. Brady Corporation.
   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 engineer 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.
5. Craftmark.
6. emedco.
8. LEM Products Inc.
9. Marking Services Inc.
10. Seton Identification Products.
11. Or engineer 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."
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.

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.

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:


1.5 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


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 engineer 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 engineer 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 engineer 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


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

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

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.
   b. Or engineer 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.
   d. K-Flex USA; R-373 Contact Adhesive.
   e. Or engineer 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:
   b. Eagle Bridges - Marathon Industries; 225.
   d. Mon-Eco Industries, Inc.; 22-25.
e. Or engineer 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).


1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   b. Eagle Bridges - Marathon Industries; 225.
   d. Mon-Eco Industries, Inc.; 22-25.
   e. Or engineer 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.
   d. Speedline Corporation; Polyco VP Adhesive.
   e. Or engineer 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:
   b. Vimasco Corporation; 749.
   c. Or engineer 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.

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:
   c. Vimasco Corporation; 713 and 714.
   d. Or engineer 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.

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:
   b. Or engineer 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.


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.
      c. Proto Corporation; LoSmoke.
      d. Speedline Corporation; SmokeSafe.
      e. Or engineer approved equal

   2. Adhesive: As recommended by jacket material manufacturer.
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 engineer approved equal
   2. Width: 3 inches.
   3. Thickness: 11.5 mils.
   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 engineer approved equal
   2. Width: 2 inches.
   3. Thickness: 6 mils.
   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 engineer 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:

   b. Or engineer 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 engineer 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.

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:

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: 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 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**


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

3. Interior Partitions:

END OF SECTION 15091
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.
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.
   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 engineer approved equal

   2. Description:
      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:

   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 engineer approved equal

2. Description:

   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 engineer approved equal

2. Description:

b. CWP Rating: 200 psig.
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 engineer approved equal

2. Description:

a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 200 psig.
c. Body Design: Horizontal flow.
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 engineer 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 engineer approved equal

2. Description:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 200 psig.
   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 engineer 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:

   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.
f. Or engineer approved equal

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 \hspace{1em} **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 \hspace{1em} **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 \hspace{1em} **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.
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.

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.

   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 Engineer 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.
   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.

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.
4. Or engineer approved equal.

B. Description:

1. Standard: UL 1091 and FM Global standard for indicating valves, (butterfly or ball type), Class Number 1112.
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.

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.
4. Kennedy Valve; a division of McWane, Inc.
5. NIBCO INC.
6. Tyco Fire & Building Products LP.
7. Victaulic Company.
8. Or engineer approved equal.

B. Description:

1. Standard: UL 1091 and FM Global standard for indicating valves, (butterfly or ball type), Class Number 112.
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.
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.
14. Or engineer approved equal.

B. Description:

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.

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 engineer approved equal.

B. Description:

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.

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 engineer approved equal.
B. Description:

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.

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.
5. NIBCO INC.
6. Victaulic Company
7. Or engineer approved equal.

B. Description:

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.

2.9 TRIM AND DRAIN VALVES

A. Ball Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   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 engineer approved equal.

2. Description:
   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 engineer approved equal.

2. Description:
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 engineer approved equal.

2. Description:
   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 or engineer approved equal.
   b. Or engineer 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 engineer 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 engineer 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.
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.

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:
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.


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

F. Copper Unions:
   1. MSS SP-123.
   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 engineer 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 engineer 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.
   d. Jomar International.
   e. Matco-Norca.
   g. Watts; a division of Watts Water Technologies, Inc.
   h. Wilkins; a Zurn company.
   i. Or engineer approved equal

3. Pressure Rating: 125 psig minimum at 180 deg F.
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 engineer approved equal

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.

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 2 and 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

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.
   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 engineer approved equal

3. Size: NPS 1/4 to NPS 3, as required to match connected piping.
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 engineer approved equal

5. Finish: Chrome or nickel plated.

2.4 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:
1. Manufacturers: Subject to compliance with requirements, provide products by 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 engineer approved equal

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.

2.5 HOSE BIBBS

A. Hose Bibbs:

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.
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.
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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. MIFAB, Inc.
   c. Prier Products, 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 engineer approved equal

2. Standard: ASME A112.21.3M for concealed or exposed-outlet, self-draining wall hydrants.
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.
12. Operating Keys(s): Two with each wall hydrant.

2.7 DRAIN VALVES

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

2. Pressure Rating: 400-psig minimum CWP.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
8. Inlet: Threaded or solder joint.

2.8 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters:

1. Manufacturers: Subject to compliance with requirements, provide products 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.
   g. Tyler Pipe; Wade Div.
   h. Watts Drainage Products.
   i. Zurn Industries, LLC; Plumbing Products Group; Specification Drainage Products.
   j. Or engineer approved equal

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.
   e. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
   f. Or engineer approved equal

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.
7. Metraflex, Inc.
8. Proco Products, Inc.
9. TOZEN Corporation.
10. Unaflex. Universal Metal Hose; a Hyspan company.
11. Or engineer approved equal

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

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:

1.4 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.
      d. MIFAB, Inc.
      e. Mission Rubber Company; a division of MCP Industries, Inc.
      f. Stant.
      g. Tyler Pipe.
      h. Or engineer approved equal
   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:
   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:
         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 engineer approved equal
      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:
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:
      2) Mission Rubber Company; a division of MCP Industries, Inc.
      3) Or engineer approved equal
   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.
         7) Watts Regulator Co.; a division of Watts Water Technologies, Inc.
         8) Wilkins; a Zurn company.
         9) Or engineer 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 engineer 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 engineer 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.
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


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-inch rod.
2. NPS 3: 48 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.

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.

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.

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.

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.

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.

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.
      4) Tyler Pipe.
      5) Watts Drainage Products.
      6) Zurn Plumbing Products Group.
      7) Or engineer 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.

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.
5) Tyler Pipe.
6) Watts Drainage Products.
7) Zurn Plumbing Products Group.
8) Or engineer 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.
7. Outlet Connection: Inside calk.
8. Closure: Brass plug with tapered threads.
9. Adjustable Housing Material: Cast iron with threads.
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.
15. Size: Same as connected branch.
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:
   b. MIFAB, Inc.
   d. Tyler Pipe; Wade Div.
   e. Watts Drainage Products.
   f. Zurn Plumbing Products Group; Specification Drainage Operation.
   g. Or engineer 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.

2.2 FLOOR DRAINS

A. Cast-Iron Floor Drains (FD):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Commercial Enameling Co.
   b. Josam Company; Josam Div.
   c. MIFAB, Inc.
   d. Prier Products, Inc.
   f. Tyler Pipe; Wade Div.
   g. Watts Drainage Products.
   h. Zurn Plumbing Products Group; Specification Drainage Operation.
   i. Or engineer approved equal

2. Standard: ASME A112.6.3.
5. Seepage Flange: Required.
6. Anchor Flange: Required.
7. Clamping Device: Required.
8. Outlet: Bottom.
11. Sediment Bucket: Not required.
12. Top or Strainer Material: Nickel bronze.
14. Top Shape: Square.
15. Dimensions of Top or Strainer: 5" or 6".
17. Funnel: Not required.
18. Inlet Fitting: Not required.
21. Trap Features: Not required.

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 engineer 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.

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 engineer 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.


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: Counterflushing-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 counterflushing.

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.

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.

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. Grease Interceptors: Connect inlet and outlet to unit, and connect flow-control fitting and vent to unit inlet piping.

D. Ground equipment according to Section 16 "Grounding and Bonding for Electrical Systems."

E. 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.

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.
   d. MIFAB, Inc.
   e. Mission Rubber Company; a division of MCP Industries, Inc.
   f. Stant.
g. Tyler Pipe.
h. Or engineer approved equal.

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:

   2) Mission Rubber Company; a division of MCP Industries, Inc.
   3) Or engineer approved equal

   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:

   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 engineer approved equal.

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.
7) Watts Regulator Co.; a division of Watts Water Technologies, Inc.
8) Wilkins; a Zurn company.
9) Or engineer 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 engineer 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 engineer 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. 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 engineer 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


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.
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.
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.
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.
END OF SECTION 15160
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. Manufacturers: Subject to compliance with requirements, provide products by the following:

   b. Or engineer approved equal

2. Standard: ASME A112.6.4, for general-purpose roof drains.
5. Combination Flashing Ring and Gravel Stop: Required.
7. Outlet: Bottom and side outlet. See schedule on drawings.
8. Extension Collars: Required.
10. Expansion Joint: Not required.
11. Sump Receiver Plate: Required.
15. Water dam: 2 inches high-overflow drains only.

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

   b. Oatey.
   d. Watts Water Technologies, Inc.
   e. Zurn Plumbing Products Group; Light Commercial Products Operation.
   f. Zurn Plumbing Products Group; Specification Drainage Operation.
   g. Or engineer 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.
7. Outlet Connection: Inside calk.
8. Closure: Brass plug with tapered threads.
9. Adjustable Housing Material: Cast iron with threads.
11. Frame and Cover Shape: Square.
13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.

B. Wall Cleanouts COWP:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   b. MIFAB, Inc.
   d. Tyler Pipe.
   e. Watts Water Technologies, Inc.
   f. Zurn Plumbing Products Group; Specification Drainage Operation.
   g. Or engineer approved equal

2. Standard: ASME A112.36.2M, for cleanouts. Include wall access.
3. Size: Same as connected drainage piping.
5. Closure: Countersunk, brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

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.


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:
   2. Piping specialties.

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

A. PP Drainage Pipe and Fittings: ASTM F 1412, pipe extruded and drainage-pattern fittings molded, with Schedule 40 dimensions, from PP resin with fire-retardant additive complying with ASTM D 4101; with fusion- and mechanical-joint ends.

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. Town & Country Plastics, Inc.
   b. Or engineer 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. Town & Country Plastics, Inc.
   b. Orion Fittings, Inc.; a division of Watts Water Technologies, Inc
   c. Or engineer 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 engineer 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, standard, wheelchair accessible.
      1. Manufacturers: Subject to compliance with requirements, provide products by the following:
a. Elkay Manufacturing Co.
b. Or engineer approved equal

2. Cabinet: Bi-level level with bottle filling station, vinyl-covered steel with stainless-steel top.
3. Bubbler: One, with adjustable stream regulator.
5. Bottle filling station.
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.


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

   a. Kohler.
   b. Or Engineer approved Equal.

1. Bowl:

   b. Material: Vitreous china.
   c. Type: Siphon jet.
   d. Style: Flushometer valve.
   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.

2.2 FLUSHOMETER VALVES

A. Hard Wired, Solenoid-Actuator, Piston Flushometer Valves:

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

   a. Sloan Valve Company.
   b. Or Engineer approved equal.

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.

2.3 TOILET SEATS

A. Toilet Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Church Seats.
   b. Or engineer approved equal

4. Type: Commercial (Heavy duty).
5. Shape: Elongated rim, open front.
8. Seat Cover: Not required.

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. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Kohler
   b. Or engineer approved equal

2. Fixture:
   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.


4. Waste Fitting:
   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. Hard Wired, Solenoid-Actuator Flushometer Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Sloan Valve Company.
   b. Or Engineer approved equal.

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.

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 STAINLESS STEEL, COUNTER MOUNTED LAVATORIES

A. Lavatory: Stainless Steel, counter mounted.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Just Co.
   b. Or engineer approved equal

2. Fixture:
   b. Type: For wall hanging. Basis of design, refer to Schedule on drawing. Or engineer approved equal
   c. Nominal Size:
   d. Faucet-Hole Punching: Basis of design, refer to Schedule on drawing. Or engineer approved equal
   e. Mounting Material: Sealant.

3. Faucet: See "Solid-Brass, Automatically Operated Hard Wired Faucets".

2.2 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 engineer 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.

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. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Fiat.
   b. Or engineer approved equal.

2. Fixture:
   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:
   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:
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


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

1. Bell & Gossett's
2. Taco Pump
3. Or Engineer 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.
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.
   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, Power-Burner, Gas-Fired, Storage, Domestic-Water Heaters:

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

   a. Smith, A. O. Water Products Co.; a division of A. O. Smith Corporation.
   b. Or engineer approved equal


   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.
   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.


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. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Amtrol, Inc.
   b. Or engineer 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."


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.

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


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 safety systems. 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
PART 5 - HEATING, VENTILATING, AIR CONDITIONING & REFRIGERATION WORK
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 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.

2.2 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.
3. ERICO International 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-psig or 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.
   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.


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. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.

4. Pipes NPS 8 and Larger: Include 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 24 if 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 24 if longer ends are required for riser clamps.

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

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

2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.

3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.

4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.

5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

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

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.

2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.

3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.

4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
   a. Light (MSS Type 31): 750 lb.
   b. Medium (MSS Type 32): 1500 lb.
   c. Heavy (MSS Type 33): 3000 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
   2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
   3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

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

6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.

7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.

8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

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

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

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

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

END OF SECTION 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-2015. 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.
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.
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-2015)

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-2015 or Occupancy Category IV, IBC-2003-2015 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-2015), 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-2015: 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-2015).

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-2015).

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. 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-2015, 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.


   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-2015, 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-2015, 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 contractor, 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-2015 as reference code standard unless otherwise designated.

SECTION 2 – PRODUCTS

2.1 MANUFACTURERS

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. 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 or approved equal.
3. Products from other specified manufacturers are acceptable provided their systems strictly comply with these specifications. Manufacturer shall be a regular member of VISCMA (Vibration Isolation and Seismic Controls Manufacturers Association).

2.2 VIBRATION ISOLATION TYPES

A. Type A: Spring Isolator – Free Standing

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
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 \( \frac{1}{4}'' \) 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)

1. Hangers shall consist of rigid steel frames containing minimum 1 \( \frac{3}{4}'' \) 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

1. Molded (minimum 1 \( \frac{3}{4}'' \) 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

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

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)

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)

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

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

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

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

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

1. Refer to vibration isolation Type B.

B. Type II: Seismically Restrained Elastomer Floor Isolator

1. Refer to vibration isolation Type F.

C. Type III: All-Directional Seismic Snubby

1. All-directional seismic snubbers shall consist of interlocking steel members restrained by an elastomeric bushing. Bushing shall be replaceable and a minimum of 1/4” 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

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

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

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

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
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

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

Option: Sound Package 1 & 2 VMC group model VMC/AB-RPFMA/SRPFMA or Approved equal

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 $\frac{3}{4}"$ thick. Steel springs shall be laterally stable and rest on $\frac{3}{4}"$ 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

Option: Sound Package VMC group model VMC-RPFMA/SRPFMA System or
Approved equal

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

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

a. This shall have the same provisions as Type B-5 without the spring isolation.

7. Type B-7: Computer Room Unit Base

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
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 manufactured by The VMC Group or Approved equal.

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 manufactured by The VMC Group or Approved equal.

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 manufactured by The VMC Group or Approved Equal.

2.5 FLEXIBLE CONNECTORS

A. Type FC-2: Flexible Stainless Steel Hose

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:

<table>
<thead>
<tr>
<th>Flanged</th>
<th>Male Nipples</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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 contract 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 1 ¼” 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. EQUIPMENT:
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 resilently mounted, where the Importance Factor, \( I_p = 1.0 \) 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 \( I_p = 1.0 \) 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 \( I_p = 1.0 \) 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 \( I_p = 1.0 \).
2. High deformability pipe or conduit in Seismic Design Category C, 2” or less in diameter suspended by individual hanger rods where \( I_p = 1.5 \).
3. High deformability pipe in Seismic Design Category D, E or F, 1” or less in diameter suspended by individual hanger rods where \( I_p = 1.5 \).
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-2015 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

<table>
<thead>
<tr>
<th>EQUIPMENT (See Notes)</th>
<th>ON GRADE, BASEMENT OR SLAB ON GRADE</th>
<th>ABOVE GRADE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Size/Type</td>
<td>Mitg Isol Nom Defl* Base Restr Isol Nom Defl* Base Restr</td>
</tr>
<tr>
<td><strong>Outdoor Condensing Units/Condensers</strong></td>
<td>Roof</td>
<td>--- --- --- IV B 2.50 Minimum B-5 IV</td>
</tr>
<tr>
<td><strong>Axial Fans (Inline Type)</strong></td>
<td>Floor</td>
<td>B 0.75 --- IV B See Guide --- IV</td>
</tr>
<tr>
<td></td>
<td>Ceiling</td>
<td>--- --- --- --- E See Guide --- V</td>
</tr>
<tr>
<td><strong>Centrifugal Fans Arr. 1 &amp; 3</strong></td>
<td>Class 1 Floor</td>
<td>B 0.75 B-1 IV B See Guide B-1 IV</td>
</tr>
<tr>
<td></td>
<td>Class 2 &amp; 3 Floor</td>
<td>B 0.75 B-2 IV B See Guide B-2 IV</td>
</tr>
<tr>
<td><strong>Class 2 &amp; 3 Ceiling</strong></td>
<td>Ceiling</td>
<td>--- --- --- --- E See Guide B-2 V</td>
</tr>
<tr>
<td><strong>Centrif. Fans (Vent Sets) Arr. 9 &amp; 10</strong></td>
<td>Class 1 Floor</td>
<td>B 0.75 --- IV B See Guide See Note 4 IV</td>
</tr>
<tr>
<td></td>
<td>Class 2 &amp; 3 Ceiling</td>
<td>--- --- --- --- E See Guide B-2 V</td>
</tr>
<tr>
<td><strong>Condensate Pumps</strong></td>
<td>Floor</td>
<td>F 0.20 If req. IV F 0.20 If req. IV</td>
</tr>
<tr>
<td><strong>Curb Mtd. Equip. (Non-Isol.)</strong></td>
<td>Roof</td>
<td>--- --- --- --- --- --- B-6 ---</td>
</tr>
<tr>
<td><strong>Fan Coil Units</strong></td>
<td>Floor</td>
<td>F 0.20 --- IV B 0.75 --- IV</td>
</tr>
<tr>
<td></td>
<td>Ceiling</td>
<td>--- --- --- --- E 0.75 --- V</td>
</tr>
<tr>
<td><strong>Rooftop AHU/AC (curb mounted)</strong></td>
<td>&lt; 10 Ton Roof</td>
<td>--- --- --- --- IV B 1.50 B-3 See Notes 5,6 ---</td>
</tr>
<tr>
<td></td>
<td>&gt; 10 Ton Roof</td>
<td>--- --- --- --- IV B 2.50 B-3 See Notes 5,6 ---</td>
</tr>
<tr>
<td><strong>Rooftop AHU/AC (dunnage mounted)</strong></td>
<td>&lt; 10 Ton Roof</td>
<td>--- --- --- --- IV B 1.50 B-8 ---</td>
</tr>
<tr>
<td></td>
<td>&gt; 10 Ton Roof</td>
<td>--- --- --- --- IV B 2.50 B-8 ---</td>
</tr>
</tbody>
</table>

*See Minimum Deflection Guide for Equipment with Low RPM

**Minimum Deflection Guide for Equipment with Low RPM**

<table>
<thead>
<tr>
<th>Lowest RPM of Rotating Equipment</th>
<th>Minimum Actual Deflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less Than 400</td>
<td>3.5”</td>
</tr>
<tr>
<td>401 thru 600</td>
<td>2.5”</td>
</tr>
<tr>
<td>601 thru 900</td>
<td>1.5”</td>
</tr>
<tr>
<td>Greater than 900</td>
<td>0.75”</td>
</tr>
</tbody>
</table>
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)

<table>
<thead>
<tr>
<th>Equipment</th>
<th>On Center Transverse</th>
<th>On Center Longitudinal</th>
<th>Change of Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duct</td>
<td>30 Feet</td>
<td>60 Feet</td>
<td>4 Feet</td>
</tr>
</tbody>
</table>

**Pipe Threaded, Welded, Soldered Or Grooved; Conduit and Conduit Racks**

<table>
<thead>
<tr>
<th></th>
<th>On Center Transverse</th>
<th>On Center Longitudinal</th>
<th>Change of Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>To 16”</td>
<td>40 Feet</td>
<td>80 Feet</td>
<td>4 Feet</td>
</tr>
<tr>
<td>18” – 28”</td>
<td>30 Feet</td>
<td>60 Feet</td>
<td>4 Feet</td>
</tr>
<tr>
<td>30” – 40”</td>
<td>20 Feet</td>
<td>60 Feet</td>
<td>4 Feet</td>
</tr>
<tr>
<td>42” &amp; Larger</td>
<td>10 Feet</td>
<td>30 Feet</td>
<td>4 Feet</td>
</tr>
</tbody>
</table>

### 4.3 VERTICAL HANGER ROD BRACING SCHEDULE

**Table “E” Hanger Rod Bracing Schedule**  
(Stiffener to be maximum 6” from end of rod)

<table>
<thead>
<tr>
<th>Rod Dia.</th>
<th>Clamp Size</th>
<th>Maximum Un-braced Rod Length</th>
<th>Steel Angle Size</th>
<th>Clamp Spacing</th>
<th>Min # of Clamps per Stiffener</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8”</td>
<td>SRBC-1-1/4</td>
<td>19”</td>
<td>1 x 1 x ¼”</td>
<td>16”</td>
<td>2</td>
</tr>
<tr>
<td>1/2”</td>
<td>SRBC-1-1/4</td>
<td>25”</td>
<td>1 x 1 x ¼”</td>
<td>20”</td>
<td>2</td>
</tr>
<tr>
<td>5/8”</td>
<td>SRBC-1-1/4</td>
<td>31”</td>
<td>1 x 1 x ¼”</td>
<td>24”</td>
<td>2</td>
</tr>
<tr>
<td>3/4”</td>
<td>SRBC-1-1/2</td>
<td>37”</td>
<td>1 ½ x 1 ½ x ¼”</td>
<td>28”</td>
<td>2</td>
</tr>
<tr>
<td>7/8”</td>
<td>SRBC-1-1/2</td>
<td>43”</td>
<td>1 ½ x 1 ½ x ¼”</td>
<td>33”</td>
<td>2</td>
</tr>
<tr>
<td>1”</td>
<td>SRBC-1-1/2</td>
<td>50”</td>
<td>1 ½ x 1 ½ x ¼”</td>
<td>40”</td>
<td>2</td>
</tr>
<tr>
<td>1 1/8”</td>
<td>SRBC-1-1/2</td>
<td>62”</td>
<td>1 ½ x 1 ½ x ¼”</td>
<td>50”</td>
<td>2</td>
</tr>
</tbody>
</table>
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 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, 1/8 inch thick, and having predrilled holes for attachment hardware.
   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.

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.

C. Pipe Label Color Schedule:

1. Heating Water Piping (HWS & HWR):
   b. Letter Color: Red.
2. Refrigerant Piping:
   a. Background Color: Blue.
3. Gas Piping
   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:
   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 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 in 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


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:
   b. Eagle Bridges - Marathon Industries; 225.
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.


1. Products: Subject to compliance with requirements, provide one of the following:
   b. Eagle Bridges - Marathon Industries; 225.
   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:
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.

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:
   b. Eagle Bridges - Marathon Industries; 501.
   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.

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:
   b. Eagle Bridges - Marathon Industries; 570.
   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.

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:

   b. Eagle Bridges - Marathon Industries; 550.
   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.

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:

   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.

2.5 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

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


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:

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.
5. Flexible connectors.
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.

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.

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.

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.

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. Aluminum, Smooth: 0.040 inch thick.
   2. 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. Aluminum, Smooth with 1-1/4-Inch-Deep Corrugations: 0.040 inch thick.
   2. 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.
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:
2.2 INSULATING CEMENTS


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.


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.

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.

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.

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.

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.

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.

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.

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.

   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:
   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.
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.


   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.
   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. Option 1: 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.
   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.

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.
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.
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.
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.
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.

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.
      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.
      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.
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: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

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.
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:

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.
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.

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.

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.

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.

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 15084 – FIRE BARRIER DUCT & PLENUM WRAP

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 Fire-rated insulation for the following applications:

1. Chemical exhaust ducts.
2. Hazardous exhaust ducts.
3. Construction requiring fire-rated enclosure assembly construction.
4. Plenum rated insulation to cover non-plenum rated plastic pipe and plastic jacketed electric cables.

B. Related Sections:

1. Division 15 Section "HVAC Equipment Insulation."
2. Division 15 Section "HVAC Piping Insulation."
3. Division 15 Section "Metal Ducts" for duct liners.

1.3 REFERENCES

A. Ventilation Air Duct Enclosure System Test Standards:

1. ISO 6944-1985; 'Fire Resistive Tests - Ventilation Ducts'.
2. ISO 834; 'Fire Resistive Tests - Elements of Building Construction'.
3. ASTM E 814 (UL1479); 'Standard Test Method for Fire Tests of Through-Penetration Fire Stops'.
4. ASTM E 84; 'Standard Test Method for Surface Burning Characteristics of Building Materials'.
5. ASTM C 1338; 'Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings'.
6. NFPA 90A; 'Standard for the Installation of Air-Conditioning and Ventilating Systems'.

B. Plenum Rated Enclosure System Test Standards:
1. ASTM E 84; 'Standard Test Method for Surface Burning Characteristics of Building Materials'.
2. UL 1887; 'Fire Test of Plastic Sprinkler Pipe for Visible Flame and Smoke Characteristics'.
3. NFPA 252 (UL 910); 'Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces'.

C. Independent Listing Agency References:
   1. Underwriters Laboratories (UL).
   3. Intertek Testing Service (ITS) - Label Mark is OPL.

D. Building Code References:
   1. International Mechanical Code (IMC).
   2. International Association of Plumbing and Mechanical Officials - Uniform Mechanical Code (IAPMO UMC).

E. Health Studies on Bio-solubility of Ceramic and Mineral Fibers:
   1. Long Fiber Fraction Half Life Solubility Study - Performed in accordance with Guideline 97/69/EC dated 5 December 1997 Appendix Q.

1.4 SUBMITTALS

A. Product Data: Manufacturer’s data sheets on each product to be used, including:
   1. For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).
   3. Submit UL and/or Intertek Testing Service (ITS) Listings.
   5. Preparation instructions and recommendations.
   6. Storage and handling requirements and recommendations.
   7. Installation methods.

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.
6. Submit UL and/or Intertek Testing Service (ITS) Listings.
8. Preparation instructions and recommendations.
9. Storage and handling requirements and recommendations.
10. Installation methods

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.

1.5 QUALITY ASSURANCE

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

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

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

C. HVAC Ducts Requiring Fire-Rated Enclosures: Fire-rated assemblies using FireMaster or Pyroscat by Thermal Ceramics are an acceptable equivalent to gypsum board shaft wall and masonry fire assemblies specified in Division 9. At the Contractor's option, submit FireMaster or Pyroscat products for fire-rated enclosures for HVAC ductwork, including manufacturer's UL Listings and acceptance by local authority or code having jurisdiction.
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.

B. Store products in manufacturer's unopened packaging until ready for installation.

C. Deliver materials in original sealed packages, clearly labeled with manufacturing information, including product identification and manufacturing lot numbers.

D. Store material out of weather and away from incidental damage.

1.7 PROJECT CONDITIONS

A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.

1.8 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Division 23 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.

C. Coordinate installation and testing of heat tracing.

D. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.

1.9 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 Manufacturers: Subject to compliance with requirements, provide products by the following:
   A. 3M Company
   B. Or Approved Equal.

2.2 APPLICATIONS/SCOPE
   A. 2 Hour Applied Fire Protection when tested in accordance with UL 1978; Compliant per Intertek Listing TC/BI 120-01.
   B. 2 Hour F- and T-Rated Through Penetration Firestop when tested in accordance with ASTM E 814 (UL 1479): UL Through Penetration listings; C-AJ-7012; C-AJ-7014; C-AJ-7035; C-AJ-7047; C-AJ-7095; C-AJ-7098; F-C-7036; F-C-7037; F-C-7055; W-L-7041; W-L-7099; W-L-7121; W-L-7145; W-L-7158; W-J-7086. See UL Online Fire Resistance Directory at www.ul.com for current listings.
   C. 2 Hour Applied Fire Protection for Ventilation Air Duct when tested in accordance with ISO 6944-1985 - Reference UL Listings HNLJ V2 (for 3-hour); HNLJ V19 (for 2-hour).

2.3 INSULATION MATERIALS
   A. Thermal Material: 2192 F degree rated core blanket, manufactured from patented bio-soluble Superwool chemistry (Calcium Magnesium Silicate).
      1. Product: 3M Fire Barrier Duct Wrap 15 A or 3M Fire Barrier Duct Wrap 615+ as manufactured by 3M or Approved equal.
      2. Fully encapsulated thermal material in fiberglass reinforced aluminum/polypropylene scrim (FSP).
         a. Encapsulation FSP marked with UL Classification Mark.
         b. Encapsulation FSP marked with ICC-ES report number ESR 2213 or ESR 2832.
         c. Collars supplied in 6 inch wide by 25 feet long rolls.
   B. Product Characteristics:
       1. Thickness: 1-1/2 inch.
3. R-Value: 6.3 per layer of 3M Fire Barrier Duct Wrap 15 A or 3M Fire Barrier Duct Wrap 615+ or Approved equal when tested in accordance with ASTM C 518 at ambient temperature.
4. Flame Spread: <25 when tested in accordance with ASTM E 84.
5. Smoke Development: <50 when tested in accordance with ASTM E 84

2.4 ACCESSORY MATERIALS:

A. Glass Filament Tape: Minimum 3/4 inch wide - used to temporarily secure blanket until permanent attachment using steel banding and/or steel insulation pins.

B. Aluminum Foil Tape: Minimum 3 inches used to seal cut edges.

C. Carbon Steel or Stainless Strapping Material Minimum: 1/2 inch wide and 0.015 inch thick

D. Steel Insulation Pins: Minimum 12 gage, length sufficient to penetrate through duct wrap insulation.

E. Insulation Clips: Galvanized steel, minimum 1-1/2 inches round or square.

F. Through Penetration Firestop Sealants:

1. Protect the annular space around the duct passing through a fire-rated wall assembly with an Intertek-certified, compatible, 3M penetration firestop system having the same fire rating as the wall or floor assembly.
2. Firestop sealants per applicable building code report and/or laboratory design listings.

G. Support: Support the chemical fume exhaust duct with insulation using a “trapeze” system composed of a minimum 2x2x1/4-inch steel angle as the trapeze cross-number and minimum 3/8-inch diameter roads. Connect all-thread steel rods to the trapeze cross-member using nuts and washers. Connect the all-thread steel rods to the bottom of the floor assembly equivalent to ASTM E 119 time-temperature curve. Place one all-thread steel rod 2 inches from each end of trapeze cross-member. Central chemical fume exhaust duct with insulation on trapeze cross-member. Space all-thread steel rods a maximum 6 inch from surface of the insulated chemical fume exhaust duct. Extend trapeze cross-member at least 2 inches past each all-thread steel rod. Space trapeze supports a maximum 60 inches O.C.

H. Access Doors:

1. 3M fire barrier Access doors; Supplied in standard door sizes of 6 by 10 inches, 8 by 12 inches, 12 by 12 inches, 12 by16 inches, and 20 by 20 inches.
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. Do not begin installation until substrates have been properly prepared.

C. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

D. Coordinate installation of the 3M fire barrier access door between sheet metal and insulation trades.

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

3.2 PREPARATION

A. Remove dirt and dust from surfaces of openings and items penetrating rated floors and rated walls.

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

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install 3M Fire Barrier Duct Wrap 15A or 3M fire barrier Duct Wrap 615+ or Approved equal in direct contact with the chemical fume exhaust ductwork for 2 hour fire rating in accordance with manufacturer's instructions, applicable laboratory listings and building code reports, and referenced standards. For additional complex duct design installation recommendations, see the 3M’ complete installation guide or approved equal.

B. Mechanical Fastening of Enclosure Material to Ductwork:

1. Banding - Carbon steel or stainless steel banding is used to hold the outer layer of the blanket enclosure in place. Banding is minimum 1/2 inch wide, and is placed around the entire perimeter of the duct on maximum 10-1/2 inches centers and 1-1/2 inches from each blanket or collar edge.
2. Pinning - To prevent blanket sag on duct spans wider than 24 inches, minimum 12-gauge steel insulation pins are welded to the duct along bottom horizontal and outside vertical runs in columns spaced 12 inches apart, 6 to 12 inch from each edge, and on 10-1/2 inches centers. Pins are locked in place with 1-1/2 inch diameter or 1-1/2 inch square galvanized steel speed clips or cup head pins. Pins are turned down or the excess cut off to eliminate sharp edges.

C. Access Door Installation:
   1. Install 3M fire barrier or approved equal access door per manufacturers' instructions, and applicable building code reports and laboratory design listings.

D. Through-Penetration Firestop System:
   1. When the duct penetrates a concrete or dry wall fire rated floor, ceiling, or wall an approved firestop system shall be employed. 3M penetration firestop system insulation shall be installed directly to the duct through the penetration or terminated on both sides of the penetration depending on the annular space allowance between the duct and the duct opening. When the 3M penetration firestop system insulation enclosure system is terminated on both sides of the through penetration, the duct wrap material is mechanically attached to the duct at the termination points using either steel banding or steel pins.
   2. To fire stop the through penetration void area, fill the annular space between the wrapped duct or bare duct and the periphery of the opening with scrap 3M penetration firestop insulation firmly packed into the opening. Compress scrap blanket to percentage stated in the firestop listing for a minimum depth as specified in the firestop listing. Recess packing material below surface on both sides of walls or top side only for floors to the depth stated in the firestop listing. Seal over the packing material using an approved firestop sealant to a depth as stated in the firestop listing, flush with top side of a floor assembly and both sides of a wall assembly.

3.4 FIRE-RATED INSULATION SYSTEM INSTALLATION
   A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.
   B. Insulate duct access panels and doors to achieve same fire rating as duct.
   C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Division 07 Section "Penetration Firestopping."
3.5 REPAIR PROCEDURES

A. Repair damaged 3M Fire Barrier Duct Wrap 15 A or 3M Fire Barrier Duct Wrap 615+ in accordance with manufacturer's instructions.

B. Remove damaged section by cutting the bands and removing the anchor clips holding it in place. Apply a new section of the same dimension ensuring the same overlap and installation method that existed previously. Cut edges and tears in the foil must be taped with aluminum tape to prevent the insulation from wicking moisture or grease.

3.6 PROTECTION

A. Protect installed products until completion of project.

B. Touch-up, repair or replace damaged products before Substantial Completion.

3.7 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.

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

END OF SECTION 15084
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


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


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:

   b. Eagle Bridges - Marathon Industries; 225.
   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.


1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include the following:
   
   b. Eagle Bridges - Marathon Industries; 225.
   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.
   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:
      b. Vimasco Corporation; 749.
      c. Or Approved Equal

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:
      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

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:
      b. Eagle Bridges - Marathon Industries; 405.
      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:
      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
   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.
   c. Proto Corporation; LoSmoke.
   d. Speedline Corporation; SmokeSafe.
   e. Or Approved Equal

2. Adhesive: As recommended by jacket material manufacturer.


4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

   a. Shapes: 45- and 90-degree 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.
   c. Or Approved equal.

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.
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 90.1-2016 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.


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


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


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.
   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 15124 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

   a. Adsco Manufacturing LLC.
   b. Flex-Weld, Inc.
   c. Hyspan Precision Products, Inc.
   d. Metraflex, Inc.
   e. Senior Flexonics Pathway.
   f. Unaflex.
   g. 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. Flex-Hose Co., Inc.
   b. Flex Pression Ltd.
   c. Metraflex, Inc.
   d. Unisource Manufacturing, Inc.
   e. 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.

6. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6: Carbon-steel fittings with flanged or weld end connections.
   a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F and 145 psig at 600 deg F ratings.

7. Expansion Joints for Steel Piping NPS 8 to NPS 12: Carbon-steel fittings with flanged or weld end connections.
   a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 125 psig at 70 deg F and 90 psig at 600 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. Adsco Manufacturing LLC.
   b. Advanced Thermal Systems, Inc.
   c. Flex-Hose Co., Inc.
   d. Flex-Weld, Inc.
   e. Hyspan Precision Products, Inc.
   f. Metraflex, Inc.
   g. Senior Flexonics Pathway.
   h. Unisource Manufacturing, Inc.
   i. 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.
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.

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.

C. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
D. Install rubber packless expansion joints according to FSA-NMEJ-702.

E. Install grooved-joint expansion joints to grooved-end steel piping

3.2 PIPE LOOP AND SWING CONNECTION INSTALLATION

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

B. Connect risers and branch connections to mains with at least 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(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.

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

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

E. Anchor Attachments:


2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24, U-bolts bolted to anchor.

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

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

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

END OF SECTION 15124
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. Or Approved Equal

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.
   b. Design for Thermowell Installation: Bare stem.
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
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.
   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:

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

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.
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:

B. Thermometers at inlet and outlet of each hydronic boiler shall be the following:

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:

D. Thermometers at inlets and outlets of each hydronic heat exchanger shall be the following:

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. Condenser 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.

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.
   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. Grooved, Mechanical-Joint, Wrought-Copper Fittings: ASME B16.22.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Victaulic Company.
      b. Or Approved Equal
   2. Grooved-End Copper Fittings: ASTM B 75, copper tube or ASTM B 584, bronze casting.
   3. Grooved-End-Tube Couplings: Rigid pattern, unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves, prelubricated EPDM gasket rated for minimum 230 deg F for use with housing, and steel bolts and nuts.

D. 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.


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:
   2. End Connections: Butt welding.
   3. Facings: Raised face.

H. Grooved Mechanical-Joint Fittings and Couplings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Victaulic Company.
      b. Or Approved Equal
   2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106/A 106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
   3. Couplings: Ductile- or malleable-iron housing and Grade “E” EPDM synthetic rubber gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

I. 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:

   b. Central Plastics Company.
   d. Jomar International Ltd.
   e. Matco-Norca, Inc.
   g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   h. Wilkins; a Zurn company.
   i. Or Approved Equal

2. Description:

   b. Pressure Rating: 125 psig minimum at 250 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:

   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:

   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 psig at 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.
8. Handle Style: Lever, with memory stop to retain set position.
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.
5. Disc: Glass and carbon-filled PTFE.
6. Seat: PTFE.
7. End Connections: Flanged or grooved.
9. Handle Style: Lever, with memory stop to retain set position.
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.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Low inlet-pressure check valve.
8. Inlet Strainer: stainless steel, removable without system shutdown.
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.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
8. Inlet Strainer: stainless steel, removable without system shutdown.
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 bronze or brass-alloy ball valve.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.
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.
7. Maximum Operating Temperature: 225 deg F.

C. Automatic Air Vents:
1. Body: Bronze or cast iron.
2. Internal Parts: Nonferrous.
4. Inlet Connection: NPS 1/2.
7. Maximum Operating Temperature: 240 deg F.

2.6 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:
1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.

B. Basket Strainers:
1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.

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:

2. End Connections: Threaded or flanged to match equipment connected.
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, or pressure-seal joints.
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.
4. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
5. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

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. Condensate-Drain Piping: Type M, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
E. 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 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install valves according to Division 15 Section "General-Duty Valves for HVAC Piping."

P. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

Q. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

R. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and 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, 9 feet; minimum rod size, 3/8 inch.
6. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.

F. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

A. 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.


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.

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. Tolyvirazole Copper and Yellow Metal Corrosion Inhibitor: Minimum 10 ppm.
8. Total Suspended Solids: Maximum 10 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:

2. Suction Lines for Heat-Pump Applications: 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."


C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

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:
   2. End Connections: Socket ends.
   3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
   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.
   3. Operator: Rising stem and hand wheel.
   5. End Connections: Socket, union, or flanged.
   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.
   5. Seal Cap: Forged-brass or valox hex cap.
   6. End Connections: Socket, union, threaded, or flanged.
   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.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 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.
4. End Connections: Copper spring.

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.
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.
7. Maximum Operating Temperature: 240 deg F.

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.
4. End Connections: Threaded.
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.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: 42 deg F.
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.
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.
5. Seat: Polytetrafluoroethylene.
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.
9. Set Pressure: as required
10. Throttling Range: Maximum 5 psig.
12. Maximum Operating Temperature: 240 deg F.

I. Straight-Type Strainers:

2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
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.
6. Maximum Operating Temperature: 275 deg F.

K. Moisture/Liquid Indicators:

2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
5. End Connections: Socket or flare.
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.
5. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
9. Maximum Operating Temperature: 240 deg F.

M. Mufflers:
2. End Connections: Socket or flare.
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.
4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
5. End Connections: Socket or threaded.
7. Maximum Operating Temperature: 275 deg F.

O. Liquid Accumulators: Comply with ARI 495.
2. End Connections: Socket or threaded.
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.

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 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, crawlspace, 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.

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:
   b. End Connections: Threaded or butt welding to match pipe.
   c. Lapped Face: Not permitted underground.
   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.
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.
   3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
   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.
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.
   c. Lyall, R. W. & Company, Inc.
   e. Perfection Corporation; a subsidiary of American Meter Company.
   f. Or Approved Equal

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.
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.
   c. Lyall, R. W. & Company, Inc.
   e. Perfection Corporation; a subsidiary of American Meter Company.
   f. Or Approved Equal
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.
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.
   c. Or Approved Equal
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.
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.
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


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.
5. Springs and Valve Trim: Stainless steel.
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.
7. 120-V ac, 60 Hz, Class B, continuous-duty molded coil, and replaceable.
8. NEMA ICS 6, Type 4, coil enclosure.

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.


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.
6. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
7. Orifice: Aluminum; interchangeable.
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.
12. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.

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:

   b. Central Plastics Company.
   d. Jomar International Ltd.
   e. Matco-Norca, Inc.
2. Description:
   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:
      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:
      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


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


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:
   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.
   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.
   d. Color: Yellow.
2. Alkyd System: MPI INT 5.1E.
   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.

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.

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.

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 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.


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. Product similar to Heatfab Saf-T Vent CI Plus.

C. 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.

D. Construction: Inner shell and outer jacket separated by at least a 1-inch airspace with 1” fiber insulation.

E. Inner Shell: ASTM A 959, Type AL29-4C stainless steel.

F. 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. Product similar to Selkirk model IPS.

C. 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.
D. 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.

E. 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.

F. Ceramic fiber insulation between the inner liner and outer jacket shall be a nominal two-inch thick.

G. This stack system shall be designed and installed to be gas tight and thus prevent leakage of combustion products into a building.

H. 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.

I. 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 15562 - PACKAGED, DIRECT-FIRED, OUTDOOR, HEATING-ONLY MAKEUP-AIR UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes direct-fired heating and ventilating units.

1.3 DEFINITIONS

A. DDC: Direct digital control.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design MAU supports to comply with wind performance requirements, including comprehensive engineering analysis by a qualified NJ professional engineer, using performance requirements and design criteria indicated.

B. Wind-Restraint Performance:
   1. Basic Wind Speed: Refer to structural drawings.
   2. Building Classification Category: Refer to structural drawings.
   3. Minimum 10 lb/sq. ft multiplied by the maximum area of the mechanical component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

C. Sound Ratings shall be equal or better than basis of design. Any sound rating deviation shall be approved by owner.

1.5 ACTION SUBMITTALS

A. Product Data: For each type and configuration of outdoor, direct-fired heating and ventilating unit.
1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each type and configuration of outdoor, direct-fired heating and ventilating unit.
   1. Include plans, elevations, sections, and mounting/attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   4. Sound ratings: Provide sound data measurements/ratings measured at same distance as basis of design specified equipment.
   5. Detail fabrication and assembly of gas-fired heating and ventilating units, as well as procedures and diagrams.
   6. Design Calculations: Calculate requirements for selecting vibration isolators and wind/seismic restraints and for designing vibration isolation bases.
   7. Equipment anchorage detail for securing to wind/seismic roof curb.
   8. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

C. Delegated-Design Submittal: For MUA supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified NJ professional engineer responsible for their preparation.
   1. Design Calculations: Calculate requirements for selecting vibration isolators and wind/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 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 MUA will be attached.
2. Roof openings
3. Roof curbs and flashing

1.6 INFORMATIONAL SUBMITTALS

A. Startup service reports.

B. Sample Warranty: For manufacturer's special warranty.

C. Wind/Seismic Qualification Certificates: For outdoor, direct-fired heating and ventilating units, 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.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For direct-fired heating and ventilating units to include in emergency, operation, and maintenance manuals.

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. Filters: One set(s) for each unit.
   2. Fan Belts: One set(s) for each unit.

1.9 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of direct-fired heating and ventilating units that fail in materials or workmanship within specified warranty period.
   1. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

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

A. CaptiveAire

B. Or engineer approved equal.

2.2 DESCRIPTION

A. Direct-fired gas heating and ventilating unit(s), as indicated on the drawings shall be furnished. Unit(s) shall be tested in accordance with ANSI Standard Z83.4 and CSA 3.7 and shall bear the ETL label. Orientation shall be horizontal, down or side discharge. Unit(s) shall be factory assembled, tested and shipped as a complete packaged assembly, for indoor or outdoor mounting, consisting of the following:
   1. Gas burner
   3. Centrifugal blower (forward-curved double width/double inlet)
   4. Motor starter with thermal overload protection
   5. Motor and drive assembly
   6. Fuel burning and safety equipment
   7. Temperature control system
   8. Gas piping

2.3 HOUSING

A. Unit housing shall be constructed of 20 Gauge G-90 galvanized steel. The wall panels and roof panels shall be fabricated by forming double-standing, self-locking seams that require no additional support. The floor and wall panels shall be caulked air tight with a silicone caulk. All casing panels shall be attached with sheet metal screws or rivets, which can be removed to field service large components. The unit base shall be suitable for curb or flat mount. Housing construction should be suitable for outdoor or indoor installation.
B. An observation port shall be located on the exterior of the unit for observation of the main flame and pilot flame. All controls, gas valves, modulating controls and electrical components shall be mounted within the burner vestibule. The burner vestibule shall be an integral part of the unit and not extend outside the exterior casing of the unit and not exposed to the main air stream.

C. The vestibule full-size door shall provide easy access to controls and gas-train components. Blower door shall provide easy access to blower, motor and drives. Access doors shall be provided on both front and backside of unit providing full access to every part of the unit.

D. Internal ridged board 1" x 1.5" foil face insulation shall be installed on roof, walls and base of casing.

2.4 BASE

A. The base shall be constructed of galvanized steel for improved rigidity. Base shall be structurally reinforced to accommodate the blower assembly and burner.

2.5 BLOWER

A. Blower(s) shall be forward-curved, centrifugal, Class I or II (depending on application requirements), double width, double inlet, constructed G-90 galvanized steel. Unit shall have a heavy-duty, solid-steel shaft. Wheels shall be balanced in two planes and done in accordance with AMCA standard 204-96, Balance Quality and Vibration Levels for Fans. The wheel blades shall be aerodynamically designed to minimize turbulence, increase efficiency and reduce noise. The wheel blades shall be securely attached to the wheel inlet ring. The wheel shall be firmly attached to the fan shaft with setscrews and keys. The blower assembly shall be isolated from the fan structure with vibration isolators.

B. External Static is the sum of duct loss, plus duct component static. All blowers shall be tested and set at rated speed after being installed in the factory-assembled unit.

2.6 MOTOR & MOTOR COMPARTMENT

A. Motors shall be heavy-duty ball bearing type and furnished at the specified voltage, phase and enclosure. Motor mounting plate shall be constructed of heavy gauge galvanized steel and shall be designed to provide easy adjustment of the belt tension. Blower motor shall be an Open Drip Proof.
2.7 SHAFT & BEARINGS

A. Shafts shall be precision ground and polished. Heavy duty, pre-lubricated bearings shall be selected for a minimum (L50) life in excess of 200,000 hours of operation at maximum cataloged operating speed. They shall be designed for, and individually tested, specifically for use in air handling applications.

2.8 BELTS & DRIVES

A. Belts shall be oil and heat resistant, non-static, grip-notch type. Drives shall be cast type, precision machined and keyed, and secured attached to the fan and motor shafts. Fan operating speed shall be factory set using adjustable pitch motor pulleys. All drives shall be a minimum of 2 grooves above 2 HP.

2.9 BURNER

A. The gas burner shall be direct-fired, draw-through type, using natural gas at an inlet-supply pressure to the unit of 7" w.c. minimum.

B. The burner shall burn over its entire length at all times when the system is in operation.

C. The burner shall have non-clogging, 4302B stainless-steel combustion baffles attached to a ductile aluminum gas-supply section with no moving parts to wear out or fail. The burner shall be capable of 92% combustion efficiency with a maximum turndown ratio of up to 30 to 1.

D. The gas burner shall be furnished with a pilot package arranged so that the pilot flame lights the burner with instantaneous ignition. Pilot assembly includes a flame rod, spark rod and pilot, which is automatically ignited by ignition transformer. A flame-rod rectification system shall be used to prove pilot and main flame.

E. Rear access doors will provide complete access to burner and pilot assembly.

F. Burner profile plates shall be self-adjusting to operate across the complete CFM range of each model heater. Every unit shall be designed for Variable Air Volume capabilities.

2.10 GAS EQUIPMENT

A. All gas equipment should conform to local code requirements. All gas manifold components shall be piped and wired at the factory.
B. Standard components Include:
1. Pilot-gas shut-off valve
2. Pilot-gas regulator
3. Pilot-gas valve
4. Main-gas shut-off valve
5. Main-gas regulator
6. Two solenoid valves
7. Modulating-gas valve
8. Burner

C. Additional components Include:
1. High-gas pressure regulator

2.11 SAFETY CONTROLS

A. Standard:
1. Motor starter with adjustable overloads
2. Air-flow safety switch
3. Electronic flame-safety relay
4. High-temperature limit switch
5. Main-gas regulator
6. Two safety shutoff valves
7. Modulating-gas valve
8. Burner
9. Adjustable burner ON/OFF inlet air duct-stat to shut off burner when inlet air is sufficiently warm to maintain space temperature.
10. Non-Fused Disconnect.
11. Casing insulation shall be 1" x 1.5" density with a foil face.

B. Additional:
1. High-gas pressure switches to open circuit to electronic flame-safety relay, if gas pressure is too high.
2. Low gas-pressure switch to open circuit to electronic flame safety relay, if gas pressure is too low.
3. Adjustable low temperature blower-safety control with bypass timer to shut down unit, if discharge temperature drops below setting.
4. Proof-of-closure switch to energize the main-burner circuit only if the motorized gas valve is in a closed position.
2.12 ACCESSORIES

A. Inlet Dampers: Manufacturer shall provide and install on unit, when possible, a two-position, motor-operated damper with internal end switch to energize the blower-starter circuit, when damper is 80% open. Blades shall be a maximum of 6” wide 16-gauge G-90 galvanized steel and shall be made to guarantee the absence of noticeable vibration at design air velocities. Damper blades are to be mounted on friction-free synthetic bearings. Damper edges shall have PVC coated polyester fabric mechanically locked into blade edge. Jamb seals used are flexible metal, compression type.

B. Filters: The filters shall be (2”) thick, aluminum mesh coated with super-filter adhesive, aluminum mesh with polyester foam or pleated throw away. Aluminum-mesh filters shall have aluminum frames with media to be layers of slit and expanded aluminum, varying in pattern to obtain maximum depth loading. Washable 2” filters shall be enclosed in two-piece, die-cut frame with diagonal supports. Frame shall be constructed of heavy-duty beverage board. Filter media is supported on the air leaving side by a metal grid.

C. Filter Section: Shall be either insulated or non-insulated constructed of G-90 galvanized steel with filters supported by internal slides and with removable access panels.

D. Fresh-Air Inlet Hood: Shall be constructed of G-90 galvanized steel with bird screen.

E. Fresh-Air Inlet Hood/Filter Combination: Shall be constructed of G-90 galvanized steel with bird screen and (2”) cleanable filters supported by internal slides mounted in the inlet face of the hood.

F. Discharge Diffusers: Shall be constructed of G-90 galvanized steel with horizontal and vertical blades capable of four-way diffusion.

G. Curb: 20” curb shall be constructed of 18-gauge aluminized steel as a completed welded assembly.

H. Cooling Coil Section: Cooling coil section shall be field bolted directly to discharge of blower section. Coil section to be designed to fit onto common curb with main unit. Base of coil section to be constructed same as main unit with double pitch stainless steel drain pan for coil. Casing and roof to be 20-gauge G-90 galvanized construction. Inside of section to be fully insulated with foil back insulation. DX or chilled water coil to meet scheduled requirements.
2.13 TEMPERATURE CONTROL SYSTEMS

A. Control equipment and sequence of operation are specified in Division 15 Section "Instrumentation and Control for HVAC."

B. Discharge Temperature Control: Use for building exhaust-air replacement to maintain a constant discharge temperature of supply air. The burner flame modulates to compensate for outdoor temperatures. The optional manual SUMMER-OFF/WINTER selector switch and exhaust system interlock controls the heater-blower operation. Supplied with optional remote-control panel with temperature selector dial and SUMMER-OFF/WINTER selector.

C. Discharge Temperature Control with room override: For building-exhaust air replacement and auxiliary-space heating to maintain a constant supply-air discharge temperature. A room override thermostat raises discharge set point for more heat to maintain room temperature. Discharge temperature probe and room-override thermostat modulate burner flame. Optional SUMMER-OFF/WINTER selector switch and exhaust-system interlock control heater-blower operation. Supplied with optional remote-control panel with temperature-selection dial, SUMMER-OFF/WINTER selector switch and room-override thermostat.

D. Space Temperature Control: For building exhaust-air replacement with modulated space-temperature control. A modulating space thermostat adjusts burner flame to maintain discharge-air temperature to compensate for changing building heat losses or gains. High- and low-discharge air sensor probes limit maximum and minimum discharge-air temperatures. The optional SUMMER-OFF/WINTER selector switch and exhaust-system interlocks control heater-blower operation. Supplied with optional remote-control panel with SUMMER-OFF/WINTER selector switch and a modulating-room thermostat.

E. VAV (Static Pressure Control): A factory-supplied field wired VFD is provided which varies the speed of the blower wheel. The VFD is controlled by a field wired Static Pressure Controller which measures building pressure and closes and opens contacts on the VFD to accelerate or decelerate the blower speed to maintain the building pressure set on the Static Pressure Controller. Factory supplied automatic profiles maintain the burner profile pressure drop as the blower speed is varied.

F. VAV (Manual Speed Control): A factory-supplied field wired VFD is provided which varies the speed of the blower wheel. The VFD is controlled manually to set the speed of the blower. Factory supplied automatic profiles maintain the burner profile pressure drop as the blower speed is varied.

G. VAV (Speed Switch): A factory-supplied field wired VFD is provided which varies the speed of the blower wheel. The VFD is controlled by a field wired speed switch, which manually switches the VFD between pre-set blower speeds. Factory
supplied automatic profiles maintain the burner profile pressure drop as the blower speed is varied.

2.14 WIRING & ELECTRICAL

A. A single point electrical connection shall be supplied. The control circuit voltage shall be 115 volts. A control transformer shall be provided, when required. Wiring in control enclosures shall be in accordance with the National Electrical Code and the local code, as it may affect the installation. Motor starter shall be provided. Starter shall be line voltage, definite purpose type.

B. Unit(s) shall be complete with all items such as relays, starters, switches, safety controls, conduit and wire as previously mentioned, and as required for proper operation. All factory-mounted controls shall be factory pre-wired to the unit control panel. A safety disconnect switch shall be standard on all units and shall be sized according to the unit.

2.15 FACTORY TESTED

A. Unit(s) shall be operated, tested and set at the factory using job-site conditions for electrical and gas input. All operating and safety controls shall be tested and set at the factory. Adjustable or fixed sheaves shall be set for proper RPM at specified conditions. Gas-pressure regulator shall be set for specified burning rate at specified inlet pressure.

2.16 SERVICE & PARTS

A. The supplier shall furnish as built wiring connection and control-circuit diagrams, dimension sheets and a full description of the unit(s). Service manuals, showing service and maintenance requirements, shall be provided with each unit.

2.17 ROOF CURBS

A. Roof curbs with vibration isolators and wind or seismic restraints are specified in Section 15071 "Vibration and Seismic Controls for HVAC."

B. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match unit, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Section 15071 "Vibration and Seismic Controls for HVAC" for wind-load requirements.
2.18 CONTROLS

A. Comply with requirements in Section 15900 "Instrumentation and Controls for HVAC" and Section 15993 "Sequence of Operations for HVAC" for control equipment and sequence of operation.

B. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display status and alarms of heating and ventilating unit.
   1. ASHRAE 135.1 (BACnet) or Industry-accepted, open-protocol communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor the heating and ventilating unit from an operator workstation. Control features and monitoring points displayed locally at heating and ventilating unit control panel shall be available through the DDC system for HVAC.

2.19 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 15058 "Common Motor Requirements for HVAC Equipment."
   1. Efficiency: NEMA Premium efficient.

2.20 CAPACITIES AND CHARACTERISTICS

A. See drawing equipment schedule for details.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of piping and electrical connections before equipment installation.

C. Verify cleanliness of airflow path to include inner-casing surfaces, filters, coils, turning vanes, fan wheels, and other components.

D. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 INSTALLATION

A. Equipment Mounting:
1. Comply with requirements for vibration isolation and seismic control devices specified in Section 15071 "Vibration and Seismic Controls for HVAC."
2. Comply with requirements for vibration isolation devices specified in Section 15071 "Vibration Controls for HVAC."

B. Unit Support: Install heating and ventilating unit level on structural curbs. Coordinate roof and wall penetrations and flashing with roof and wall construction. Secure units to structural support.

C. Install gas-fired units according to IFGC and NFPA 54, "National Fuel Gas Code."

D. Install controls and equipment shipped by manufacturer for field installation with direct-fired heating and ventilating units.

E. 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." and AHRI Guideline B. Install units on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure units to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.

F. Unit Support: Install unit level on structural curbs. Coordinate roof and wall penetrations and flashing with roof and wall construction. Secure units to structural support.

3.3 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.
1. Gas Piping: Comply with requirements in Section 15195 "Facility Natural-Gas Piping." Connect gas piping with shutoff valve and union, and with sufficient clearance for burner removal and service.

B. Drain: Comply with requirements in Section 15150 "Sanitary Waste and Vent Piping" for traps and accessories on piping connections to condensate drain pans under condensing heat exchangers. Where installing piping adjacent to heating and ventilating units, allow space for service and maintenance.

C. Duct Connections: Connect supply ducts to direct-fired heating and ventilating units with flexible duct connectors. Comply with requirements in Section 15820 "Air Duct Accessories" for flexible duct connectors.
D. Ground equipment according to Section 16060 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 16120 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

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

D. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
   1. Inspect for visible damage to burner combustion chamber.
   2. Inspect casing insulation for integrity, moisture content, and adhesion.
   3. Verify that clearances have been provided for servicing.
   4. Verify that controls are connected and operable.
   5. Verify that filters are installed.
   6. Purge gas line.
   7. Inspect and adjust vibration isolators and seismic restraints.
   8. Verify bearing lubrication.
   9. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
   10. Adjust fan belts to proper alignment and tension.

C. Start unit according to manufacturer's written instructions.
   1. Complete startup sheets and attach copy with Contractor's startup report.
   2. Inspect and record performance of interlocks and protective devices; verify sequences.
   3. Operate unit for run-in period recommended by manufacturer.
   4. Perform the following operations for both minimum and maximum firing, and adjust burner for peak efficiency:
      a. Measure gas pressure at manifold.
b. Measure combustion-air temperature at inlet to combustion chamber.
c. Measure supply-air temperature and volume when burner is at
maximum firing rate and when burner is off. Calculate useful heat to
supply air.
5. Calibrate thermostats.
6. Adjust and inspect high-temperature limits.
7. Inspect dampers, if any, for proper stroke and interlock with return-air
dampers.
8. Inspect controls for correct sequencing of heating, mixing dampers,
refrigeration, and normal and emergency shutdown.
9. Measure and record airflow. Plot fan volumes on fan curve.
10. Verify operation of remote panel, including pilot-operation and failure
modes. Inspect the following:
a. High-limit heat.
b. Alarms.
11. After startup and performance testing, change filters, verify bearing
lubrication, and adjust belt tension.
13. Verify outdoor-air damper operation.

3.6 ADJUSTING
A. Adjust initial temperature set points.
B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
C. Occupancy Adjustments: When requested within 12 months from date of
Substantial Completion, provide on-site assistance in adjusting system to suit
actual occupied conditions. Provide up to two visits to Project during other-than-
normal occupancy hours for this purpose.

3.7 DEMONSTRATION
A. Engage a factory-authorized service representative to train Owner's maintenance
personnel to adjust, operate, and maintain heating and ventilating units.

END OF SECTION 15562
SECTION 15732 - PACKAGED, OUTDOOR, ROOFTOP & 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.
4. Economizer outdoor- and return-air damper section.
5. Integral, space temperature controls.
6. Roof curbs.
7. See Drawings for units with energy recovery wheel.

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.
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 that fail 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. Daikin
2. Lennox Industries Inc.
3. Trane.
4. Or Approved Equal

2.2 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.
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.
2.3 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.

2.4 GENERAL DESCRIPTION

A. Furnish as shown on plans, Daikin Applied Rebel Single Zone Heating and Cooling Unit(s) model DPS. 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 where scheduled on the drawings.

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-410 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.
2.5 CABINET, CASING, AND FRAME

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 7.0, 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 750-hour salt spray test in accordance with ASTM B117 standard for salt spray resistance.

C. Service doors shall be provided on the fan section, filter section, control panel section, and heating vestibule in order to provide user access to unit components. All service access doors shall be mounted on multiple, stainless steel hinges and shall be secured by a latch system. Removable service panels secured by multiple mechanical fasteners are not acceptable.

D. The unit base shall overhang the roof curb for positive water runoff and shall seat on the roof curb gasket to provide a positive, weathertight seal. Lifting brackets shall be provided on the unit base to accept cable or chain hooks for rigging the equipment.

2.6 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.

2.7 ENERGY RECOVERY

A. The rooftop unit shall be provided with an AHRI certified rotary wheel air-to-air heat exchanger in a cassette frame complete with seals, drive motor and drive belt. The energy recovery wheel shall be an integral part of the rooftop unit with unitary construction and does not require field assembly. Bolt-on energy recovery units that require field assembly and section to section gasketing and sealing are not acceptable.


C. The rooftop unit shall be designed with a track so the entire energy recovery wheel cassette can slide out from the rooftop unit to facilitate cleaning.

D. The unit shall have 2” Merv 8 filters for the outdoor air before the wheel to help keep the wheel clean and reduce maintenance. Filter access shall be by a hinged access door with ¼ turn latches.

E. The matrix design shall have channels to reduce cross contamination between the outdoor air and the exhaust air. The layers shall be effectively captured in aluminum and stainless steel segment frames that provide a rigid and self-supporting matrix. All diameter and perimeter seals shall be provided as part of the cassette assembly and shall be factory set. Drive belt(s) of stretch urethane shall be provided for wheel rim drive without the need for external tensioners or adjustment.

F. The total energy recovery wheel shall be coated with silica gel desiccant permanently bonded without the use of binders or adhesives, which may degrade desiccant performance. The substrate shall be lightweight polymer and shall not degrade nor require additional coatings for application in marine or coastal environments. Coated segments shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity.

G. Wheels shall be provided with removable energy transfer matrix. Wheel frame construction shall be a welded hub, spoke and rim assembly of stainless, plated and/or coated steel and shall be self-supporting without matrix segments in place.
Segments shall be removable without the use of tools to facilitate maintenance and cleaning.

H. Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours. Rim shall be continuous rolled stainless steel. Wheels shall be connected to the shaft by means of taper lock hubs.

I. The exhaust air fan shall be a direct drive SWSI plenum fan. The exhaust fan shall be sized for the airflow requirements per the construction schedule. The unit controller shall control the exhaust fan to maintain building pressure. A VFD shall be provided for the exhaust fan motor or the exhaust fan motor shall be an ECM motor. The rooftop unit shall have single point electrical power connection and shall be ETL listed.

J. The control of the energy recovery wheel shall be an integral part of the rooftop unit’s DDC controller. The DDC controller shall have visibility of the outdoor air temperature, leaving wheel temperature, return air temperature, and exhaust air temperature. These temperatures shall be displayed at the rooftop units DDC controller LCD display. All of these temperatures shall be made available through the BACnet interface.

K. The rooftop unit with the energy recovery wheel shall incorporate the economizer operation. The energy recovery wheel shall have a bypass damper. When the unit is in the economizer mode of operation the energy recovery wheel shall stop and the bypass dampers shall be opened. The outdoor air shall be drawn through the bypass dampers to reduce the pressure drop of the outdoor airstream.

L. The rooftop unit DDC controller shall provide frost control for the energy recovery wheel. When a frost condition is encountered the unit, controller shall stop the wheel. When in the frost control mode, the wheel shall be jogged periodically and not be allowed to stay in the stationary position.

2.8 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.

2.9 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 contract documents.

2.10 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.

2.11 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.

2.12 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.

2.13 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.

2.14 HEATING SECTION

A. The rooftop unit shall include a natural gas heating section. The gas furnace design shall be one natural gas fired heating module factory installed downstream of the supply air fan in the heat section. The heating module shall be a tubular design with in-shot gas burners.

B. Each module shall have two stages of heating control. The module shall be complete with furnace controller and control valve capable of 5:1 modulating operation.

C. The heat exchanger tubes shall be constructed of stainless steel.

D. The module shall have an induced draft fan that will maintain a negative pressure in the heat exchanger tubes for the removal of the flue gases.

E. Each burner module shall have two flame roll-out safety protection switches and a high temperature limit switch that will shut the gas valve off upon detection of improper burner manifold operation. The induced draft fan shall have an airflow safety switch that will prevent the heating module from turning on in the event of no airflow in the flue chamber.

F. The factory-installed DDC unit control system shall control the gas heat module. Field installed heating modules shall require a field ETL certification. The manufacturer’s rooftop unit ETL certification shall cover the complete unit including the gas heating modules.

2.15 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 25°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.

2.16 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.

2.17 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.
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  

2.18 ACCESSORIES (See Plan Schedule Notes)  

2.19 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.

2.20 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.

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:
   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 15734 - COMPUTER-ROOM AIR-CONDITIONERS, FLOOR-MOUNTED UNITS (5 TONS OR SMALLER)

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes floor-mounted, computer-room air conditioners of 5 tons or smaller.
   1. This specification describes requirements for a precision environmental control system. The CyberONE-EC “COS” vertical floor-mounted air conditioning system or Approved equal shall provide precision temperature and/or humidity control for computer rooms or rooms containing telecommunications or other highly-sensitive heat load equipment where continuous 24 hour a day, 365 days a year air conditioning is required. Designed for front-only access, “COS” systems require minimum floor space. The units are designed with a wide range of options to handle both precision and comfort cooling applications. The system model number shall be Air-Cooled - Remote Condenser - (AR)-(EC) or Approved equal.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For computer-room air conditioners.
   1. Include plans, elevations, sections, and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.

C. Color Samples: For unit cabinet, discharge grille, and exterior louver and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, using input from installers of the items involved.

B. Field quality-control reports.

C. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.
1.5 QUALITY ASSURANCE

A. The specified system shall be factory-tested before shipment. Testing shall include, but shall not be limited to: Quality Control Checks, “Hi-Pot.” The system shall be designed and manufactured according to world-class quality standards. The manufacturer shall be ISO 9001 certified.

B. The Thermal Management system shall be a Liebert self-contained, factory-assembled unit. Units shall be CSA-certified to the harmonized U.S. and Canadian product safety standard, "CSA C22.2 No 236/UL 1995 for Heating and Cooling Equipment" and are marked with the CSA c-us logo.

C. The system shall be AHRI Certified the trusted mark of performance assurance for heating, ventilation, air conditioning and commercial refrigeration equipment, using AHRI Standard 1360.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of computer-room air conditioners that fail in materials or workmanship within specified warranty period.
   1. Warranty Period for Compressors: Manufacturer's standard, but not less than 10 years from date of Substantial Completion.
   2. Warranty Period for Humidifiers: Manufacturer's standard, but not less than three years from date of Substantial Completion.
   3. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Trane/STULZ
   2. Liebert; a brand of Vertiv.
   3. Or approved equal

2.2 CABINET

A. The cabinet and access panels shall be fabricated from 16 gauge galvanized steel and painted with a 2-ply epoxy finish to match and provide corrosion protection. The panels shall be lined with 1/2" (13 mm), 2 lb (.90 kg), high-density sound and thermal insulation and sealed with self-extinguishing gasketing conforming to NFPA 90A and 90B. The main unit color shall be White.
2.3 FILTERS

A. For Upflow units, the filter chamber shall be located within the cabinet, and filters shall be removable from the front of the unit. Filters shall be arranged in a horizontal bank configuration.

B. Filters, 4 in. MERV8 - Filters shall be deep pleated 4 in. filters with an ASHRAE 52.2 MERV8 rating (45% ASHRAE 52.1).

C. Extra Filter Set - 1 extra set(s) of filters shall be provided per system.

2.4 LOCKING DISCONNECT SWITCH

A. The manual disconnect switch shall be mounted in the high-voltage section of the electrical panel. The switch shall be accessible from the outside of the unit with the door closed, and shall prevent access to the high voltage electrical components until switched to the Off position.

2.5 ELECTRIC SYSTEM

A. Modular Motor Controllers
   1. The systems shall incorporate modular motor controllers utilizing motor start protectors and circuit breakers to eliminate the need for fuses. All wiring shall be in accordance with the National Electric Code (NEC) and shall include: * Motor branch circuit short circuit protection; * Motor load switching controllers (contactors) and * Motor overload protection. The control circuit shall be a 24 VAC Class II low voltage circuit, including primary and secondary circuit protection. Low voltage, high voltage, and common wires shall be color-coded and shall be individually numbered at each end for ease of service tracing. All wiring shall be in accordance with the National Electric Code (NEC). .

B. Main Power-Electric Non-fused Disconnect Switch
   1. The unit mounted main power disconnect switch factory provided, is as standard. The disconnect switch shall be dust-proof, non-fused type with a lockable handle.

2.6 DIRECT EXPANSION SYSTEM

A. Coils
   1. The system shall be configured for a draw-thru air pattern to provide uniform air distribution over the coil face. The coils shall be designed to provide maximum coil surface area and minimum depth to provide a high sensible cooling capacity. The coils shall be seamless drawn copper tubes, mechanically bonded to tempered aluminum fins with a raised lanced fin design for maximum heat transfer. Coil end plates shall be hot dipped galvanized steel. The evaporator coil shall be mounted in an insulated stainless steel condensate drain. The evaporator coil shall have a 5.5 ft² face area and be 4 rows deep. It shall be constructed of copper tubes and
aluminum fins and has a maximum face velocity of 364 ft/min at 2000 CFM CFM. Refrigerant flow shall be controlled by an externally equalized thermostatic expansion valve.

B. Refrigeration System
1. All refrigerant piping shall be refrigerant grade tubing. Each refrigeration circuit shall include, as a minimum a refrigerant drier/strainer sight glass with moisture detector, a thermal expansion valve with rapid bleed port feature and external equalizer, an evaporator coil, a compressor, a high pressure switch with manual reset, and a low pressure switch with automatic reset. Split/Remote systems shall have a liquid line solenoid for refrigerant isolation to prevent liquid slugging. All high-pressure joints shall be brazed, and the entire system shall be pressure tested at the factory with dry nitrogen, evacuated to at least 50 microns and fully charged with refrigerant.

C. Scroll Compressor
1. The compressor shall be high efficiency, high reliability and low noise scroll compressor(s). The compressor shall be complete with charging and service shraeder ports, internal vibration isolation, internal thermal overloads, an internal pressure relief valve, an internal discharge gas vibration eliminator, and external vibration mounting isolation.

2.7 Backward Inclined, Plenum Style Fan, With an EC Motor

A. The blower(s) shall be direct driven, single inlet, two-fold backward curved radial fan with an electronically commutated motor for maintenance free operation. The motor shall include: integrated electronic control board and direct microprocessor control signaling for fan speed control, soft-starting capabilities, RS-485 BUS connection, and integrated current limitations. Each fan shall be low noise, low vibration manufactured with an anti-corrosive aluminum impeller. Each fan impeller shall be dynamically and statically balanced in two planes to minimize vibration during operation.

2.8 SERIES MICROPROCESSOR CONTROLLER

A. The floor mounted A/C shall be provided with STULZ E² Series or approved equal Microprocessor based Temperature and Humidity controller with Alarms or approved equal unit controller. The controller shall incorporate a "user-friendly", menu driven, operating environment, to allow easy system setup and operation. The E² Series or approved equal is a complete microprocessor-based control system designed for operating, controlling and monitoring the CyberONE precision air conditioning unit or approved equal.

B. Easy to Read LCD Graphic Display
1. The E² Series or approved equal control system is a microprocessor-based control system with a backlit LCD alphanumeric display for visual indication of unit operating conditions.
C. User Interface
1. The E² Series or approved equal Interface features an easy to read, liquid-crystal alpha-numerical display. The attractive unit mounted interface allows the operator to visually monitor and customize unit functions and settings. The controller is operated via a 6-key menu-driven Windows type structure, in five different modes; Information, Alarm Log, Control, Service and Factory.

D. System Information
1. The E² Series or approved equal LCD Graphic Display shall indicate current unit functions via symbol identification:
   - Cooling
   - Heating
   - Humidifying
   - Dehumidifying

E. Run Times
1. The E² Series or approved equal maintains actual running hours of all the motor devices and operational cool times. These hours are displayed on demand. This feature assists in maintaining the control equipment in peak condition to minimize down time.

F. Security
1. The flexibility, reliability and control offered by the E² Series or approved equal microprocessor are extensive. However, these benefits need to be reserved for operators that understand their proper use. The E² SERIES or approved equal provides three levels of restricted entry into the configuration options to ensure that the operating parameters are not changed by unauthorized operators. Level 1 – Basic user operating set points Level 2 – Operating offsets Level 3 - Factory settings

G. Alarm Control
1. Alarm conditions activate an audible and visual indicator. The alarms are acknowledged through a dedicated alarm key located on the user interface. The E² Series or approved equal alerts to the following alarm conditions (if applicable):
   - High Temperature
   - Dirty Filter
   - Low Temperature
   - Smoke Detection
   - High Humidity
   - Firestat
   - Low Humidity
   - Leak Detection
   - High Head Press
   - Sensor Failure
   - Low Suction Press
   - Comm. Failure
• Loss of Air Flow  Upon the receipt of any alarm, the alarm condition is displayed along with suggested operator actions to be taken. An audible tone and red LED is presented at time of the alarm occurrence.

H. Alarm History
1. The E² Series or approved equal controller provides users with a recorded history of the last 50 alarms, including the time and date of the alarm.

I. Set Points
1. User adjustable set points are available for temperature, humidity; control deadbands, high temperature alarm, low temperature alarm, high humidity alarm and low humidity alarms, EC fan speed, and economizing control are made through the Control menu.

J. Power Loss - Restart
1. The E² Series or approved equal controller can be configured for Automatic or Manual Restart after a power failure event. The E non-volatile memory enables the system to restart when power is restored, without the loss of any stored set points or other system configuration settings.

K. Sequential Activation
1. To minimize the total in rush current loads during system startup/restart, the E² Series or approved equal controller is configured for time-delay sequence startup. The user can designate electric heater, EC fans and/or humidifier restart delays. The unit restart delay can be adjusted from 0 to 999 seconds.

L. Recovery Delay
1. After a power loss, the E² Series or approved equal Recovery Delay feature allows the Precision A/C to operate without initiating any high or low temperature or humidity alarms for a delayed period. This feature allows the time (15 to 60 minutes adj.) to "pull-down" the conditioned space's load without nuisance alarms during startup or power loss restart.

M. Cooling Inhibit Feature
1. All cooling functions are inhibited in the event that the temperature drops 4 °F below the setpoint during dehumidification. This temperature can be adjusted by the user. Cooling functions are automatically restored once the temperature returns to the set point.

N. Nonvolatile Memory
1. The E² Series or approved equal controller is equipped with a nonvolatile memory that retains the current configuration and alarm status in the event of a power loss. The operating program and control parameters are saved to FLASH-MEMORY and E² SERIES or approved equal Prom ensuring they are stored in the event of power failures.

O. Internal Clock / Date
1. The E² Series or approved equal controller is equipped with an internal clock and date function with battery back-up.

P. Field Programmable
1. The E² Series or approved equal microprocessor can be field programmed for all control configurations to match the unique needs of any data center, telecommunications or other critically defined areas.

Q. System of Units (I-P)
1. The controller allows for the display of intermixed Metric and I-P properties.

R. Common Alarm Output
1. The controller has one (1) available non-powered dry contact that will activate if an alarm was configured to activate the common contact. The contact closes upon the receipt of the alarm and opens when the alarm condition has been cleared.

S. Assignable Common Alarm Output
1. The controller has one (1) available non-powered dry contact that will activate if a user configured alarm was programmed to activate. The contact closes upon the receipt of the alarm and opens when the alarm has been cleared.

T. Inherent Fail Safe Mode
1. The E² Series or approved equal controller software is equipped with an operational fail safe mode. Upon a return air or supply air sensor failure, all EC fans will increase to the maximum fan speed setting and the chilled water valve will default to 100% open. In the event of a BAS monitoring/control signal failure, the E² Series or approved equal controllers will default to local operation at present set points for the fan, external economizer damper and chilled water valve control. The local sensors have priority over the BAS system.

U. Cooling Control Sequences
1. The E² Series or approved equal controller includes two control methods for maintaining desired air conditions. Return air temperature, humidity and dew point control are included with each controller package as a standard control method. All control and alarm conditions are based on the return air mounted sensor. Supply air temperature and humidity sensing is available as an option to allow the E² SERIES or approved equal controller to control operating modes and alarms from a supply air sensor.

V. Psychrometric Control
1. The E² Series or approved equal controller includes a user configurable temperature and humidity (relative humidity) or dew point control for dehumidification and humidification functions. When enabled for traditional relative humidity control, the controller continuously monitors the selected control sensors humidity (outdoor air or return air) to determine the activation of the humidifier or dehumidification functions. When enabled for dew point control, the controller continuously monitors the selected control sensors to compute the actual dew point conditions. The calculated dew point property is used to enable the humidifier or
dehumidification functions which results in higher operational efficiency and shorter component usage.

W. Technical Data
1. The data listed are specifically assigned to the E² SERIES or approved equal controller. Supply Air Control Temperature Range: 50 °F to 95.0 °F Return Air Control Temperature Range: 68 °F to 95.0 °F Control Temperature Resolution: 0.2 °F Control Temperature Tolerance: +/-1 °F Control Humidity Range: 20.0% to 70.0% RH Control Humidity Resolution: 0.1% Control Humidity Tolerance: +/-3% Control Humidity Input: 4-20ma Analog Inputs Max.10, NTC, 0-20ma, 4-20ma Digital Inputs Max.18, optically isolated Analog Outputs Max.6, 0-10 Vdc optically isolated Digital Outputs Max.18 Proportional Cool Valve Output: 0-10 Vdc EC Fan Control Output 0-10 Vdc Operating Temperature Range: -25 °C to 70.0 °C, 90% RH non-condensing Storage Temperature: -40 °C to 70.0 °C, 90% RH non-condensing Power Consumption: 40 VA Input Power: 24 VAC, +10% / -15% 50-60 Hz Certification: UL 873 and C22.2 No. 24-93

2.9 HUMIDITY CONTROL

A. Dehumidification Cycle
1. The floor A/C shall provide refrigeration-based dehumidification mode. Moisture is condensed on the cooling coil and discharged through the condensate drain. Reheat (electric, hot gas, steam, or hot water) shall be provided to offset sensible cooling during the dehumidification cycle.

2.10 AIR COOLED SYSTEMS

A. Air Cooled Remote Evaporator
1. The system shall be a remote (split) air cooled, floor mounted precision air conditioner evaporator. The evaporator section shall house, as a minimum, the evaporator coil, expansion valve, compressor, evaporator blower/motor and associated electrical and refrigeration components.
2. The evaporator section shall be located at some distance from its corresponding STULZ-ATS model air cooled condenser or approved equal.
3. The evaporator system shall require only a single point main power supply connection; and the system shall ship from the STULZ-ATS or approved equal factory with a dry nitrogen holding charge ready for field refrigerant charging.

2.11 CAPACITIES AND CHARACTERISTICS

A. See drawing schedules for details.
PART 3 - EXECUTION

3.1 INSTALLATION

A. Layout and install computer-room air conditioners and suspension system coordinated with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

B. Install computer-room air conditioners level and plumb, maintaining manufacturer's recommended clearances. Install according to AHRI Guideline B.

C. Retain one or more of three paragraphs below. Coordinate with Drawings and Sections specifying vibration and seismic controls. Retain or insert amount of required deflection.

D. Computer-Room Air-Conditioner Mounting: Install using elastomeric pads or elastomeric mounts or restrained spring isolators. Comply with requirements for vibration isolation devices specified in Section 15 "Vibration Controls for HVAC."
   1. Minimum Deflection: 1 inch.

E. Air-Cooled Refrigerant Condenser Mounting: Install using spring isolators on concrete base. Comply with requirements for vibration isolation devices specified in Section 15 "Vibration Controls for HVAC."
   1. Minimum Deflection: 1 inch.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other heating, ventilating, and air-conditioning Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to computer-room air conditioners, allow space for service and maintenance.

C. Drainage Connections: Comply with applicable requirements in Section 15 "Domestic Water Piping." Provide adequate connections for water-cooled units, condensate drain, and humidifier flushing system.

D. Refrigerant Piping: Comply with applicable requirements in Section 15 "Refrigerant Piping." Provide shutoff valves and piping.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
   2. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

D. After startup service and performance test, change filters and flush humidifier.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain computer-room air conditioners.

END OF SECTION 15734
SECTION 15738 – VARIABLE REFRIGERANT FLOW SYSTEM

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 split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

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

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

C. Samples for Initial Selection: For units with factory-applied color finishes.

D. Field quality-control reports.

E. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

F. Warranty: Sample of special warranty.
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 Compliance:
   1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
   2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Procedures," and Section 7 - "Construction and System Start-Up."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

1.5 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

   1. Warranty Period:
      a. For Compressor: Six year(s) from date of Substantial Completion.
      b. For Parts: Two year(s) from date of Substantial Completion.
      c. For Labor: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

   1. Daikin
   2. Mitsubishi Electric
   3. LG.
4. Or Approved Equal

B. The variable capacity, heat recovery air conditioning system shall be a Variable Refrigerant Volume (heat and cool model) split system as specified. The system shall consist of multiple evaporators, branch selector boxes, joints and headers, a three pipe refrigeration distribution system using PID control and condenser unit. The condenser shall be a direct expansion (DX), air-cooled heat recovery, multi-zone air-conditioning system with variable speed inverter driven compressors using R-410A refrigerant. All zones are each capable of operating separately with individual temperature control. A dedicated hot gas pipe shall be required to ensure optimum heating operation performance. Two-pipe, heat recovery systems utilizing a lower temperature mixed liquid/gas refrigerant to perform heat recovery are not acceptable due to reduced heating capabilities.

C. The condensing unit shall be interconnected to indoor units in accordance with manufacturer’s engineering data book detailing each available indoor unit. The indoor units shall be connected to the condensing unit utilizing manufacturer’s specified piping joints and headers to ensure correct refrigerant flow and balancing. T style joints are not acceptable for a variable refrigerant system.

D. Operation of the system shall permit either individual cooling or heating of each indoor unit simultaneously or all of the indoor units associated with each branch of the cool/heat selector box. Each indoor unit or group of indoor units shall be able to provide set temperature independently via a local remote controller and a BMS interface.

E. Branch selector boxes shall be located as shown on the shop drawing submittals. The branch selector boxes shall have the capacity to control up to 290 MBH (cooling) downstream of the branch selector box. Each branch of the branch selector box shall consist of three electronic expansion valves, refrigerant control piping and electronics to facilitate communications between the box and main processor and between the box and indoor units. The branch selector box shall control the operational mode of the subordinate indoor units. The use of three EEV’s ensures continuous heating during defrost (multiple condenser systems), no heating impact during changeover and reduced sound levels. The use of solenoid valves for changeover and pressure equalization shall not be acceptable due to refrigerant noise.

F. Autocharging – Each system shall have a refrigerant auto-charging function.

G. Defrost Heating – Multiple condenser VRV systems shall maintain continuous heating during defrost operation. Reverse cycle (cooling mode) defrost operation shall not be permitted due to the potential reduction in space temperature.

H. Oil Return Heating – Multiple condenser VRV systems shall maintain continuous heating during oil return operation. Reverse cycle (cooling mode) oil return during heating operation shall not be permitted due to the potential reduction in space temperature.

I. The operating range in cooling or cooling dominant simultaneous cooling/heating will be -4°F DB ~ 122°F DB.
J. Each system as standard shall be capable of onsite reprogramming to allow low ambient cooling operation down to -4°F DB.
K. The operating range in heating or heating dominant simultaneous cooling/heating will be -13°F WB – 60°F WB.
L. The units shall be compatible with interfacing with a BMS system via optional LonWorks or BACnet gateways.

2.2 INDOOR UNITS Heat Pump Heat Recovery

A. 4-Way Ceiling Cassette Unit:

1. General: Indoor unit shall be a ceiling cassette fan coil unit, operable with R-410A refrigerant, equipped with an electronic expansion valve, for installation into the ceiling cavity equipped with an air panel grill. It shall be a four-way air distribution type, impact resistant with a washable decoration panel. The supply air is distributed via motorized louvers which can be horizontally and vertically adjusted from 0° to 90°. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition. The unit shall be equipped with a programmed drying mechanism that dehumidifies while limiting changes in room temperature. The indoor units sound pressure shall range from 29 dB(A) to 34 dB(A) at low speed measured at 5 feet below the unit.
2. Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.
3. Both refrigerant lines shall be insulated from the outdoor unit.
4. The 4-way supply air flow can be field modified to 3-way and 2-way airflow to accommodate various installation configurations including corner installations.
5. Return air shall be through the concentric panel, which includes a resin net mold resistant filter.
6. The indoor units shall be equipped with a condensate pan and condensate pump. The condensate pump provides up to 21” of lift and has a built in safety shutoff and alarm.
7. The indoor units shall be equipped with a return air thermistor.
8. All electrical components are reached through the decoration panel, which reduces the required side service access.
9. The indoor unit will be separately powered with 208~230V/1-phase/60Hz.

B. Concealed Ducted FCU:

1. General: Indoor unit shall be a fan coil unit, operable with R-410A refrigerant, equipped with an electronic expansion valve. It shall be a ducted supply and return. Provide field fabricated mixing plenum. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition. The unit shall be equipped with a
programmed drying mechanism that dehumidifies while limiting changes in room temperature.

2. Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.

3. Both refrigerant lines shall be insulated from the outdoor unit.

4. The indoor units shall be equipped with a condensate pan and condensate pump. The condensate pump provides up to 21” of lift and has a built in safety shutoff and alarm.

5. The indoor units shall be equipped with a return air thermistor.

6. All electrical components are reached through the decoration panel, which reduces the required side service access.

7. Unit Cabinet:
   a. Cabinet: Enameled steel or plastic with removable panels on front and ends in standard color selected by discharge drain pans with drain connection and integral condensate pump.
      1) The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.
   b. Refrigerant Coil:
      1) Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 210/240.
      2) The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.
      3) The coil shall be a 2-row cross fin copper evaporator coil with 17 FPI design completely factory tested.
      4) The refrigerant connections shall be flare connections and the condensate will be 1 -1/32 inch outside diameter PVC.
      5) A condensate pan shall be located under the coil.
      6) A condensate pump with a 21 inch lift shall be located below the coil in the condensate pan with a built in safety alarm.
      7) A thermistor will be located on the liquid and gas line
   c. Fan: Direct drive, centrifugal.
   d. Fan Motors:
      1) Multitapped, multispeed with internal thermal protection and permanent lubrication.
      2) Retain first subparagraph below if enclosure is not open-dripproof type. Retain second subparagraph for premium efficiency.
      3) Enclosure Type: Totally enclosed, fan cooled.
      4) NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
      5) Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Electrical Division Sections.
      6) Retain first subparagraph below to require that disconnect switches be supplied with unit.
      7) Mount unit-mounted disconnect switches on interior of unit.
e. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

2.3 OUTDOOR UNITS Heat Pump Heat Recovery

A. Air-Cooled, Inverter Compressor-Condenser Components:

1. The condensing unit shall be factory assembled in the USA and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit of the condensing unit shall consist of Daikin inverter scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports, liquid receiver and suction accumulator. High/low pressure gas line, liquid and suction lines must be individually insulated between the condensing and indoor units.
   a. The condensing unit can be wired and piped with access from the left, right, rear or bottom.
   b. The connection ratio of indoor units to condensing unit shall be permitted up to 200%.
   c. Each condensing system shall be able to support the connection of up to 64 indoor units dependent on the model of the condensing unit.
   d. The sound pressure level standard shall be that value as listed in the Daikin engineering manual for the specified models at 3 feet from the front of the unit. The condensing unit shall be capable of operating automatically at further reduced noise during night time or via an external input.
   e. The system will automatically restart operation after a power failure and will not cause any settings to be lost, thus eliminating the need for reprogramming.
   f. The unit shall incorporate an auto-charging feature. Manual changing should be support with a minimum of 2 hours of system operation data to ensure correct operation.
   g. The condensing unit shall be modular in design and should allow for side-by-side installation with minimum spacing.
   h. The following safety devices shall be included on the condensing unit; high pressure sensor and switch, low pressure sensor, control circuit fuses, crankcase heaters, fusible plug, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.
   i. To ensure the liquid refrigerant does not flash when supplying to the various indoor units, the circuit shall be provided with a sub-cooling feature.
j. Oil recovery cycle shall be automatic occurring 2 hours after start of operation and then every 8 hours of operation. Each system shall maintain continuous heating during oil return operation.

k. The condensing unit shall be capable of heating operation at -13°F wet bulb ambient temperature without additional low ambient controls or an auxiliary heat source.

2. The multiple condenser VRV systems shall continue to provide heat to the indoor units in heating operation while in the defrost mode.

3. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.

4. VFD Inverter Control and Variable Refrigerant Temperature – Each condensing unit shall use high efficiency, variable speed all “inverter” compressor(s) coupled with inverter fan motors to optimize part load performance. The system capacity and refrigerant temperatures shall be modulated automatically to set suction and condensing pressures while varying the refrigerant volume for the needs of the cooling or heating loads. The control will be automatic and customizable depending on load and weather conditions.

5. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

a. Compressor Type: Scroll. (Inverter)

b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.

c. Refrigerant Charge: R-410A.

d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 210/240.

e. The capacity control range shall be as low as 3% to 100%.

f. The inverter scroll compressors shall be variable speed (PVM inverter) controlled which is capable of changing the speed to follow the variations in total cooling and heating load as determined by the suction gas pressure as measured in the condensing unit. In addition, samplings of evaporator and condenser temperatures shall be made so that the high/low pressures detected are read every 20 seconds and calculated. With each reading, the compressor capacity (INV frequency) shall be controlled to eliminate deviation from target value. Non inverter-driven compressors, which may cause starting motor current to exceed the nominal motor current (RLA) and require larger wire sizing, shall not be allowed.
g. The inverter driven compressor in each condensing unit shall be of highly efficient reluctance DC (digitally commutating), hermetically sealed scroll “G-type” or “J-type”.

h. Neodymium magnets shall be adopted in the rotor construction to yield a higher torque and efficiency in the compressor instead of the normal ferrite magnet type. At complete stop of the compressor, the neodymium magnets will position the rotor into the optimum position for a low torque start.

i. The capacity control range shall be as low as 3% to 100%.

j. The compressors’ motors shall have a cooling system using discharge gas, to avoid sudden changes in temperature resulting in significant stresses on winding and bearings.

k. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.

l. Oil separators shall be standard with the equipment together with an intelligent oil management system.

m. The compressor shall be spring mounted to avoid the transmission of vibration eliminating the standard need for spring insolation.

n. In the event of compressor failure the remaining compressors shall continue to operate and provide heating or cooling as required at a proportionally reduced capacity. The microprocessor and associated controls shall be designed to specifically address this condition.

o. In the case of multiple condenser modules, conjoined operation hours of the compressors shall be balanced by means of the Duty Cycling Function, ensuring sequential starting of each module at each start/stop cycle, completion of oil return, completion of defrost or every 8 hours and extending the operating life of the system.


7. Fan: The condensing unit shall consist of one or more propeller type, direct-drive fan motors that have multiple speed operation via a DC (digitally commutating) inverter.


9. Condenser Coil:
   a. The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond.
   b. The heat exchanger coil shall be of a waffle louver fin and rifled bore tube design to ensure high efficiency performance.
   c. The heat exchanger on the condensing units shall be manufactured from Hi-X seamless copper tube with N-shape internal grooves mechanically bonded on to aluminum fins to an e-Pass Design.
   d. The fins are to be covered with an anti-corrosion Ulta Gold coating as standard with a salt spray test rating of 1000hr (ASTM B117 & Blister
e. The pipe plates shall be treated with powdered polyester resin for corrosion prevention. The thickness of the coating must be between 2.0 to 3.0 microns.

f. The outdoor coil shall have three-circuit heat exchanger design eliminating the need for bottom plate heater. The lower part of the coil shall be used for inverter cooling and be on or off during heating operation enhancing the defrost operation.

10. Low Ambient Kit: Permits operation down to 23 degree F.

11. Mounting Base: refer to plans.

2.4 BRANCH SELECTOR BOX FOR HEAT RECOVERY SYSTEM

A. General: The branch selector boxes are designed specifically for use with VRV heat recovery system components.

1. These selector boxes shall be factory assembled, wired, and piped.
2. Branch controllers must be run tested at the factory.
3. These selector boxes must be mounted indoors.
4. When simultaneously heating and cooling, the units in heating mode shall energize their subcooling electronic expansion valve.

B. Unit Cabinet:

1. These units shall have a galvanized steel plate casing.
2. Each cabinet shall house 3 electronic expansion valves for refrigerant control per branch.
3. The cabinet shall contain one subcooling heat exchanger per branch.
4. The unit shall have sound absorption thermal insulation material made of flame and heat resistant foamed polyethylene.

C. Condensate Removal:

1. The unit shall not require provisions for condensate removal.

2.5 REFRIGERANT PIPING

A. The system shall be capable of refrigerant piping up to 540 actual feet or 623 equivalent feet from the condensing unit to the furthest indoor unit, a total combined liquid line length of 3,280 feet of piping between the condensing and indoor units with 295 feet maximum vertical difference, without any oil traps.

B. Piping joints and headers shall be used to ensure proper refrigerant balance and flow for optimum system capacity and performance. T style joints shall not be
acceptable as this will negatively impact proper refrigerant balance and flow for optimum system capacity and performance.

2.6 ACCESSORIES

A. Control equipment and sequence of operation are specified in Mechanical Division Sections "HVAC Instrumentation and Controls" and "Sequence of Operation."

B. Thermostat: Low voltage with subbase to control compressor and evaporator fan.

C. Automatic-reset timer to prevent rapid cycling of compressor.

D. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

E. Drain Hose: For condensate.

F. Additional Monitoring: Via Local Panel.
   1. Monitor constant and variable motor loads.
   3. Monitor economizer cycle.
   4. Monitor cooling and heating load.
   5. Monitor air distribution static pressure and ventilation air volumes.

2.7 CAPACITIES AND CHARACTERISTICS: SEE PLAN SCHEDULES

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install ground-mounted, compressor-condenser components on 4-inch-thick, reinforced concrete base that is 4 inches larger, on each side, than unit.

D. Install seismic restraints.
E. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit, in accordance with manufacturer 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.

B. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

F. With Integral Condensate Pump.

3.3 STARTUP SERVICE

A. Perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Work shall be performed by Factory Authorized service technicians.

3.4 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 15738
SECTION 15739 - SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section includes split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.3 ACTION SUBMITTALS
A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: For power, signal, and control wiring.
C. Samples for Initial Selection: For units with factory-applied color finishes.

1.4 INFORMATIONAL SUBMITTALS
A. Field quality-control reports.
B. Warranty: Sample of special warranty.
1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Filters: One set(s) for each air-handling unit.
2. Gaskets: One set(s) for each access door.
3. Fan Belts: One set(s) for each air-handling unit fan.

1.7 QUALITY ASSURANCE

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

B. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Procedures," and Section 7 - "Construction and System Start-up."

C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

1.8 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Section 03300 "Cast-in-Place Concrete."

B. Coordinate sizes and locations of equipment supports, and vibration isolators with actual equipment provided.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.
1. Warranty Period:
   a. For Compressor: Five year(s) from date of Substantial Completion.
   b. For Parts: One year(s) from date of Substantial Completion.
   c. For Labor: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Basis of Design Product Subject to compliance with requirements, provide products indicated on the drawing; Daikin or a comparable approved by one of the following:
   1. Carrier.
   2. Trane.
   3. Or approved equal.

2.2 INDOOR UNITS (5 TONS OR LESS)

A. Wall-Mounted, Evaporator-Fan Components:
   1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
   2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
   5. Fan Motors:
      a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 15058 "Common Motor Requirements for HVAC Equipment."
      b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
      c. Enclosure Type: Totally enclosed, fan cooled.
      d. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
      e. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
      f. Mount unit-mounted disconnect switches on interior of unit.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

7. Condensate Drain Pans:
   a. Fabricated with two percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
      1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
      2) Depth: A minimum of 1 inch deep.
   c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
      1) Minimum Connection Size: NPS 1.
   d. Pan-Top Surface Coating: Asphaltic waterproofing compound.

8. Air Filtration Section:
   a. General Requirements for Air Filtration Section:
      1) Comply with NFPA 90A.
      2) Minimum MERV according to ASHRAE 52.2.
      3) Filter-Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.
   b. Extended-Surface, Disposable Panel Filters:
      1) Factory-fabricated, dry, extended-surface type.
      2) Thickness: 1 inch.
      3) Initial Resistance: 0.05 inches wg.
      4) Recommended Final Resistance: 0.25 inches wg.
      5) MERV according to ASHRAE 52.2: 7.
      6) Media: Fibrous material formed into deep-V-shaped pleats with antimicrobial agent and held by self-supporting wire grid.
      7) Media-Grid Frame: Nonflammable cardboard.
      8) Mounting Frames: Welded, galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.
2.3 OUTDOOR UNITS (5 TONS OR LESS)

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.

2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
   
   a. Compressor Type: Scroll.
   b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
   c. Refrigerant: R-410A.
   d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.


4. Fan: Aluminum-propeller type, directly connected to motor.

5. Motor: Permanently lubricated, with integral thermal-overload protection.

6. Low Ambient Kit: Permits operation down to 45 deg F.


2.4 ACCESSORIES

A. Control equipment and sequence of operation are specified in Section 15900 "Instrumentation and controls" and Section 15993 "Sequence of Operations for HVAC."

B. Thermostat: Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:

1. Compressor time delay.
2. 24-hour time control of system stop and start.
3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
4. Fan-speed selection including auto setting.

C. Automatic-reset timer to prevent rapid cycling of compressor.

D. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.
E. Drain Hose: For condensate.

2.5 CAPACITIES AND CHARACTERISTICS: As Scheduled on drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Equipment Mounting:

1. Install ground-mounted, compressor-condenser components on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 03300 "Cast-in-Place Concrete."
2. Install ground-mounted, compressor-condenser components on polyethylene mounting base.
3. Comply with requirements for vibration isolation devices specified in Section 15071 "Vibration Controls for HVAC."

D. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

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

1. Water Coil Connections: Comply with requirements specified in Section 15181 "Hydronic Piping and specialties". Connect hydronic piping to supply and return coil connections with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

C. Duct Connections: Duct installation requirements are specified in Section 15815 "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply and return ducts to split-system air-conditioning units with flexible duct
connectors. Flexible duct connectors are specified in Section 15820 "Air Duct Accessories."

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

   1. Complete installation and startup checks according to manufacturer's written instructions.

3.5 DEMONSTRATION

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

END OF SECTION 15739
SECTION 15761 - HYDRONIC AIR COILS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes hydronic heating air coils.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
2. Include rated capacities, operating characteristics, and pressure drops for each air coil.

B. Sustainable Design Submittals: Detail hydronic coil location and adjacent equipment. Show support locations, type of supports, weight on each support, required clearances 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. Structure members to which coils will be attached.
2. Size and location of initial access modules for acoustical tile.

C. Field quality-control test reports.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which coil location and ceiling-mounted access panels are shown and coordinated with each other.
1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air coils to include in operation and maintenance manuals.

1.6 COORDINATION

A. Coordinate location and installation of humidifiers with manifolds in ducts and air-handling units or occupied space. Revise locations and elevations to suit field conditions and to ensure proper humidifier operation.

PART 2 - PRODUCTS

2.1 DESCRIPTION

A. ASHRAE Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

2.2 COILS

A. Manufacturer
   1. Daikin
   2. Trane
   3. Or approved equal

B. Performance Ratings: Tested and rated according to AHRI 410 and ASHRAE 33.

C. Minimum Working-Pressure/Temperature Ratings: 200 psig, 325 deg F.

D. Source Quality Control: Factory tested to 300 psig

E. Tubes: ASTM B 743 copper, minimum 0.049 inch (1.245 mm) thick.

F. Fins: Aluminum, minimum 0.0075 inch thick.

G. Headers: Seamless copper tube with brazed joints, prime coated.

H. Frames: Galvanized-steel channel frame, minimum 0.079 inch (2.0 mm) thick for flanged mounting.

I. Hot-Water Coil: Alternating arrangement of coil segments and dampers.
   1. Coil Configuration: Horizontal tubes.
J. Hot-Water Coil Capacities and Characteristics:

1. Coil Face Dimensions:
   a. Finned Length: as indicated in schedule.
   b. Finned Width: as indicated in schedule

2. Minimum Fin Spacing: as indicated on schedule.
3. Tube Diameter: 0.375 inch (9.5 mm).
4. Number of Rows: as indicated on schedule
6. Coating: Baked phenolic.

7. Air Side:
   a. Flow Rate: as indicated on schedule.
   b. Finned Area Face Velocity: as indicated on schedule.
   c. Static Pressure Drop: as indicated on schedule
   d. Total Capacity: as indicated on schedule.
   e. Entering Temperature: as indicated on schedule.
   f. Leaving Temperature: as indicated on schedule

8. Water Side:
   a. Flow Rate: as indicated on schedule
   b. Tube Velocity: as indicated on schedule
   c. Pressure Drop: as indicated on schedule
   d. Entering Temperature as indicated on schedule.
   e. Leaving Temperature: as indicated on schedule.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.

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

A. Install coils level and plumb.

B. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

C. Install stainless-steel drain pan under each cooling coil.
   1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
   2. Construct drain pans to extend beyond coil length and width and to connect to condensate trap and drainage.
   3. Extend drain pan upstream and downstream from coil face.
   4. Extend drain pan under coil headers and exposed supply piping.

D. Install moisture eliminators for cooling coils. Extend drain pan under moisture eliminator.

E. Straighten bent fins on air coils.

F. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.3 CONNECTIONS

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

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

C. Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping. Control valves are specified in Section 15110 "General duty valves for HVAC piping," and other piping specialties are specified in Section 15181 "Hydronic Piping and Specialties."

END OF SECTION 15761
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.
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. 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 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.
2. Wiring Terminations: Match conductor materials and sizes indicated.

2.5 FAN
   A. Propeller with aluminum blades directly connected to motor.

2.6 FAN MOTORS
   A. Multispeed motor with integral thermal-overload protection.

2.7 ACCESSORIES
   A. Horizontal Configuration: Louver fin diffuser.
   B. Vertical Configuration: Louver cone diffuser.

2.8 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.

2.9 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 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.
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.
9. Hazardous exhaust ducts
12. Access door

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:


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.
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.
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.

2. Type: S.
3. Grade: NS.
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:
   3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.9 HAZARDOUS EXHAUST SYSTEMS

A. Codes: Hazardous exhaust systems shall comply with the International Mechanical Code, Section 510.
B. Hazardous exhaust systems are systems designed to capture and control hazardous emissions generated from product handling or processes, and convey those emissions to the outdoors. Hazardous emissions include flammable vapors,
gases, fumes, mists, or dusts, and volatile or airborne materials posing a health hazard, such as toxic or corrosive materials.

C. Duct Construction: Ducts utilized to convey hazardous exhaust shall be constructed of approved G90 galvanized sheet steel, with a minimum nominal thickness as specified in Table 510.8. Where the products being exhausted are detrimental to the duct material, the duct shall be constructed of alternate materials that are compatible with the exhaust. Note: Acid-resistant, fume-handling, exhaust ducts (serving a Science Lab fume hood) shall be stainless steel in lieu of G90 galvanized sheet steel.

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<thead>
<tr>
<th>Minimum Duct Thickness</th>
<th>Minimum Nominal Thickness</th>
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<tbody>
<tr>
<td>Diameter of Duct or Maximum Side Dimension</td>
<td>Nonabrasive Materials</td>
</tr>
<tr>
<td>0-8 inches</td>
<td>0.028 inch (No. 24 gage)</td>
</tr>
<tr>
<td>9-19 inches</td>
<td>0.034 inch (No. 22 gage)</td>
</tr>
<tr>
<td>19-30 inches</td>
<td>0.040 inch (No. 20 gage)</td>
</tr>
<tr>
<td>Over 30 inches</td>
<td>0.052 inch (No. 18 gage)</td>
</tr>
</tbody>
</table>

D. Duct joints shall be made tight with lap joints having a minimum lap of 1 inch.

E. Ducts shall have a clearance to combustibles in accordance with Table 510.8.2.

<table>
<thead>
<tr>
<th>Type of Exhaust or Temperature of Exhaust (degrees F)</th>
<th>Clearance to Combustibles (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 100</td>
<td>1</td>
</tr>
<tr>
<td>100-600</td>
<td>12</td>
</tr>
<tr>
<td>Flammable vapors</td>
<td>6</td>
</tr>
</tbody>
</table>

F. Ducts shall be supported at intervals not exceeding 10 feet. Supports shall be constructed of noncombustible material.
### 2.10 CLOTHES DRYER EXHAUST DUCTS

A. Codes: Clothes dryer exhaust ducts shall comply with the International Mechanical Code, Section 504, Clothes Dryer Exhaust.

B. Material: All ducts shall be constructed of rigid metal (either rigid aluminum or rigid galvanized steel) of thickness required by code.

C. Installation: Clothes dryers shall be exhausted in accordance with the manufacturer’s instructions. Dryer exhaust systems shall be independent of all other systems and shall convey the moisture and any other products of combustion to the outside of the building.

D. Exhaust Penetrations: Ducts that exhaust clothes dryers shall not penetrate or be located within fire blocking, draftstopping or any wall, floor/ceiling, or other assembly required by the International Building Code to be fire-resistance rated, unless such duct is constructed of galvanized steel or aluminum of thickness specified in Section 603.4 Metallic Ducts (of the International Mechanical Code) and the fire-resistance rating is maintained in accordance with the International Building Code.

| Table 603.4 Duct Construction Minimum Sheet Metal Thickness for Single Dwelling Unit |
|------------------------------------------|-----------------|-----------------|
| Duct Size                                | Galvanized      | Aluminum        |
| Round ducts and enclosed rectangular ducts | Minimum thickness (inches) | Equivalent gage no. | Minimum thickness (inches) |
| 14" or less                              | 0.0157          | 28              | 0.0175          |
| 16" & 18"                                | 0.0187          | 26              | 0.0180          |
| 20" & over                               | 0.0236          | 24              | 0.0230          |

E. Cleanouts: Each vertical riser shall be provided with a means for cleanout.
F. Exhaust Installation: Dryer exhaust ducts for clothes dryers shall terminate on the outside of the building and shall be equipped with a backdraft damper. Screens shall not be installed at the duct termination. Ducts shall not be connected or installed with metal screws or fasteners that will obstruct the exhaust flow. Clothes dryer exhaust ducts shall not be connected to a vent connector, vent, or chimney. Clothes dryer exhaust ducts shall not extend into or through ducts or plenums.

G. Makeup Air: Installation exhausting more than 200 cfm shall be provided with makeup air. Where a closet is designed for installation of a clothes dryer, an opening having an area of not less than 100 square inches shall be provided in the closet enclosure or makeup air shall be provided by other approved means.

H. Domestic Clothes Dryer Ducts: Exhaust ducts for domestic clothes dryers shall be constructed of metal and shall have a smooth interior finish. The exhaust duct shall be a minimum nominal size of 4 inches in diameter. The entire exhaust system shall be supported and secured in place. The male end of the duct at overlapped duct joints shall extend in the direction of airflow. Clothes dryer transition ducts used to connect the appliance to the exhaust duct system shall be limited to single lengths not to exceed 8 feet and shall be listed and labeled for the application. Transition ducts shall not be concealed within construction.

1. Domestic Clothes Dryer Duct Maximum Length: The maximum length of a clothes dryer exhaust shall not exceed 25 feet from the dryer location to the outlet terminal. The maximum length of the duct shall be reduced 2.5 feet for each 45-degree bend and 5 feet for each 90-degree bend. The maximum length of the exhaust duct does not include the transition duct.

   a. Exception: Where the make and model of the clothes dryer to be installed is known and the manufacturer’s installation instructions for such a dryer are provided to the code official, the maximum length of the exhaust duct, including any transition duct, shall be permitted to be in accordance with the dryer’s manufacturer’s installation instructions.

I. Commercial Clothes Dryers: The installation of dryer exhaust ducts serving Type 2 clothes dryers shall comply with the appliance manufacturer’s installation instructions. Exhaust fan motors installed in exhaust systems shall be located outside of the airstream. In multiple installations, the fan shall operate continuously or be interlocked to operate when any individual unit is operating. Ducts shall have a minimum clearance of 6 inches to combustible materials. Clothes dryer transition ducts used to connect the appliance to the exhaust duct system shall be limited to single lengths not to exceed 8 feet in length and shall be listed and labeled for the application. Transition ducts shall not be concealed within construction.
2.11  KITCHEN EXHAUST DUCTWORK

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

1. McGill AirFlow LLC.
2. Metal-Fab, Inc.
4. Van-Packer Company, Inc.
5. Or approved equal

B. Description: Factory-fabricated, -listed, and -labeled, double-wall ducts tested according to UL 1978 and rated for 500 deg F continuously, or 2000 deg F for 30 minutes; with positive or negative duct pressure and complying with NFPA 211.

C. Codes and Standards:

1. Provide factory built grease duct that is tested and listed by the Underwriters’ Laboratories, Inc. (UL 1978) for use with commercial cooking equipment, as described in NFPA-96.
2. The U.L. listed insulated grease duct shall be certified for zero clearance to combustible material per UL 2221 with a 2-hour fire rating and have a 1-hour fire rating per ASTM-E2336. Hourly ratings are met with use of factory fire stop at necessary floor/wall penetrations.
3. International Mechanical Code (IMC 506.3.1.1): Factory-built commercial kitchen grease ducts shall be listed and labeled in accordance with UL 1978 and installed in accordance by the terms of their approval, the conditions of the listing, the manufacturer’s installation instructions, and the IMC (Section 304.1).

D. Construction: Inner shell and outer jacket separated by at least a 3-inch annular space filled with high-temperature, ceramic-fiber insulation. Insulation thickness shall be as required for 2-hour fire rating.

1. Inner Shell: ASTM A 666, Type 304 (minimum 20 gauge) stainless steel.

E. Gaskets and Flanges: Ensure that gaskets and sealing materials are rated at 1500 deg F minimum.

F. Hood Connectors: Constructed from same material as grease duct with internal or external continuously welded or brazed joints.

G. Accessories: Tees, elbows, increasers, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all
listed for same assembly. Include unique components required to comply with NFPA 96 including cleanouts, transitions, adapters, and drain fittings.

H. Grease Duct Supports: Construct duct bracing and supports from non-combustible material.

1. Design bracing and supports to carry static and seismic loads within stress limitations of the International Building Code.
2. Ensure that bolts, screws, rivets and other mechanical fasteners do not penetrate duct walls.

I. Comply with ASTM E 2336.

J. Factory Tests: Test and inspect fire resistance of grease duct system according to ASTM E 2336.

2.12 ACCESS DOOR

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

1. 3M.
2. Acudor Products, Inc.
3. Ductmate Industries, Inc.
4. Sachwin Products, Inc.
5. Or approved equal

B. Description: Factory-fabricated, -listed, and -labeled, double-wall personnel & maintenance access doors tested according to UL 1978 and rated for 500 deg F continuously, or 2000 deg F for 30 minutes; with positive or negative duct pressure and complying with NFPA 211.

1. Construction: 0.0625-inch ASTM A 666, Type 304 stainless-steel inner shell and aluminized-steel (for indoors) and stainless-steel (for outdoors) outer cover with two handles.
2. Fasteners: Stainless-steel bolts and wing nuts.
   a. Ensure that bolts do not penetrate interior of duct space.
4. Personnel Access Door Dimensions: 22 x 20 inches or 24 x 24 inches (coordinate with duct sizes on the design drawings).
5. Door Label: Mark door with uppercase lettering as follows: "ACCESS PANEL. DO NOT OBSTRUCT."
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. All ductwork subject to moisture shall be constructed of aluminum i.e. locker room exhaust, dryer exhaust etc.

D. Install round and flat-oval ducts in maximum practical lengths.

E. Install ducts with fewest possible joints.

F. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

G. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

H. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

I. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

J. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

K. 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.

L. 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.

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.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
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:


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.
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.
4. Control dampers.
5. Fire dampers.
6. Ceiling dampers.
7. Smoke dampers.
8. Combination fire and smoke dampers.
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.
   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


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 inches or less; 3/8-inch minimum 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.
   4. Nailor Industries Inc.
   5. Ruskin Company.
   6. SEMCO Incorporated.
   7. Or Approved Equal

B. Description: Gravity balanced.

D. Maximum System Pressure: 1-inch wg

E. Frame: 0.052-inch-thick, 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.
4. Nailor Industries Inc.
5. Ruskin Company.
6. SEMCO Incorporated.
7. Or Approved Equal

B. Suitable for horizontal or vertical mounting.


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.
   3. Action: Parallel.
   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:
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-inch minimum 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 inch thick.
7. Bearings:
   a. Molded synthetic.
   b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
8. Tie Bars and Brackets: Galvanized steel.

### 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.
5. McGill AirFlow LLC.
6. METALAIRE, Inc.
7. Nailor Industries Inc.
8. Ruskin 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.
   4. 0.064 inch thick.

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.
   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-fpm velocity.

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.


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.
   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.


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.


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.
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.


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. Ventfabs, Inc.
7. Or Approved Equal


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:

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 inch thick 18 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.


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.


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.


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.
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.

   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.

   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.
   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 wg positive and 1.0-inch wgnegative.
   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 wgp positive and 1.0-inch wgnegative.
3. Temperature Range: Minus 10 to plus 160 deg F.

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.

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 wg and 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-inch lengths 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 15821 - DUCT SILENCERS

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. Duct Silencers.

1.3 SUBMITTALS

A. Performance Data:

1. Silencer manufacturer to provide submittal drawings detailing all duct silencer data specified in the mechanical drawing schedule.
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 25-30 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.

B. Shop Drawings: For duct silencers. 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.

C. Coordination Drawings: Roof plans, drawn to scale, showing ductwork and duct silencer installation.

D. Source quality-control reports.

1. Silencer manufacturer to provide a copy of their laboratory NVLAP accreditation certificate for the ASTM E477-13 test standard with the submittals. Data from non-NVLAP accredited test facilities will not be accepted.

E. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.4 QUALITY ASSURANCE

B. Silencer performance must have been substantiated by laboratory testing in a duct-to-reverberant room test facility according to ASTM E477-13. The test facility must provide for airflow in both directions through the test silencer. The test setup, procedure and facility shall eliminate all effects due to flanking, directivity, end reflection, standing waves and reverberation room absorption. The aero-acoustic laboratory must be currently NVLAP accredited for the ASTM E477-13 test standard.

C. Silencer manufacturer shall provide a written test report by a third-party organization showing silencer assemblies have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84, or UL 723.

PART 2 - PRODUCTS

2.1 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:

2. McGill AirFlow LLC.
3. Ruskin Company.
4. Pottorff.
5. Or Approved equal

B. GENERAL REQUIREMENTS

1. Silencers shall be of the size, configuration, capacity and acoustic performance as scheduled on the drawings. All silencers shall be factory fabricated and supplied by the same manufacturer.
2. Silencer inlet and outlet connection dimensions must be equal to the duct sizes shown on the drawings. Duct transitions at silencers are not permitted unless shown on the contract drawings.
3. Silencers shall be constructed in accordance with ASHRAE and SMACNA standards for the pressure and velocity classification specified for the air distribution system in which it is installed. Material gauges noted in other sections are minimums. Material gauges shall be increased as required for the system pressure and velocity classification. The silencers shall not fail structurally when subjected to a differential air pressure of 8 inches water gauge.
4. All casing seams and joints shall be lock-formed and sealed or stitch welded and sealed, to provide leakage-resistant construction. Airtight construction
shall be achieved by use of a duct-sealing compound supplied and installed by the contractor at the jobsite.

5. All perforated steel shall be adequately stiffened to insure flatness and form. All spot welds shall be painted.

6. Fire-Performance Characteristics: Silencer assemblies, including acoustic media fill, film liner, sealants, and acoustical spacer, shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84, or UL 723.

7. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2016.

C. Rectangular Elbow Silencers: Outer casing shall be ASTM A 653/A 653M, G90 galvanized sheet steel, 18 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.


1. Rectangular Elbow Silencers: 22 gauge.

E. Principal Sound-Absorbing Mechanism:

1. Dissipative silencers:
   a. Acoustic media. Media shall be of acoustic quality, shot-free glass fiber insulation with long, resilient fibers bonded with a thermosetting resin. Glass fiber density and compression shall be as required to insure conformance with laboratory test data. Glass fiber shall be packed with a minimum of 15% compression during silencer assembly. Media shall be resilient such that it will not crumble or break, and conform to irregular surfaces. Media shall not cause or accelerate corrosion of aluminum or steel. Mineral wool will not be permitted as a substitute for glass fiber.

2. Media Protection:
   a. Dissipative silencers: Media shall be encapsulated in glass fiber cloth to help prevent shedding, erosion and impregnation of the glass fiber.

3. Accessories:
   a. Shipping Protection: Silencers shall be shipped with factory-installed end caps to prevent contamination during shipping.

4. Source Quality Control: Test according to ASTM E 477-13
5. Capacities and Characteristics:

a. See duct silencer performance schedule on mechanical drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel ducts.

C. Connect ducts to duct silencers rigidly.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Ensure duct silencers are installed with airflow arrows in direction of airflow.

END OF SECTION 15821
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:

   2. Ceiling-mounted ventilators.
   3. Commercial kitchen (grease) exhaust fans.

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:
B.
   1. Carnes Company.
   2. Greenheck Fan Corporation
   3. Penn-Barry.
   4. Loren Cook Company.
   5. Or Approved equal.
C. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.
D. Belt Drives:
   1. Resiliently mounted to housing.
   2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
   5. Fan and motor isolated from exhaust airstream.
E. Accessories:
1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted 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.

F. 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.
5. Metal Liner: Galvanized steel.

G. 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:

B.
1. Carnes Company.
2. Greenheck Fan Corporation.
3. Penn-Barry.
4. Loren Cook Company.
5. Or Approved Equal

C. Housing: Steel, lined with acoustical insulation.

D. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.

E. Grille (where fan is not inline model): Plastic, Aluminum, or Painted aluminum, louvered grille with flange on intake and thumbscrew attachment to fan housing.

F. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

G. 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.
5. Manufacturer's standard wall cap, and transition fittings.

H. Capacities and Characteristics (See Plan Schedule):

2.3 COMMERCIAL KITCHEN (GREASE) EXHAUST FANS

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

1. CaptiveAire or approved equal.

B. Model: NCA-HPFA

C. Description: Fan shall be a spun aluminum and G90 Galvanized, roof mounted, belt driven, upblast centrifugal exhaust ventilator. Fans up to and including models with a 24" nominal wheel and a 2HP (Single Phase) or 3 HP (Three Phase) motor are suitable for wall mounting.

D. Application: Centrifugal roof exhausters are engineered to discharge grease laden vapors, fumes and other contaminants vertically away from the building.

E. Certifications: All models shall be ETL Listed and comply with UL705 (electrical) and UL762 Standards and CSA Std C22.2, No 113. Fan shall bear the AMCA certified ratings seal for sound and air performance.

F. Construction:

G. Housing: The fan windband shall be constructed of heavy gauge aluminum or G90 Galvanized and shall be spun on an automatic lathe to provide consistent dimensions. Horizontal and vertical internal supports shall be used to securely fasten the windband to the discharge apron to provide rigidity for hinging and added strength to reduce shipping damage. The discharge apron shall have a rolled bead for added strength.

H. Base: The base shall be constructed of galvanized steel for improved rigidity. Base corners shall be welded to provide strength and support for hinging and cleaning and to prevent leakage into the building.

I. Wheel: The fan wheel shall be centrifugal backward inclined and non-overloading. Wheels shall be balanced in two planes and done in accordance
with AMCA standard 204-96, Balance Quality and Vibration Levels for Fans. The wheel blades shall be aerodynamically designed to minimize turbulence, increase efficiency and reduce noise. The wheel blades shall be welded to the wheel inlet cone. In the event that balancing weights are required they shall be riveted to the blades or wheel. The wheel inlet shall overlap the fan base inlet for maximum performance and efficiency. The wheel shall be firmly attached to the motor shaft with two set screws.

J. Motor & Motor Compartment: Motors shall be heavy duty ball bearing type, mounted out of the airstream and furnished at the specified voltage, phase and enclosure. Motor mounting plate shall be constructed of heavy gauge galvanized steel and isolated from the fan structure with vibration isolators. The motor compartment shall be cooled by outside air drawn through an extruded aluminum conduit tube. To seal the conduit tube passage and prevent noise silicone rubber grommets shall isolate the conduit tube from the fan housing. The motor compartment shall be of a two-piece construction with the top cap having quick release clips to provide quick and easy access to the motor compartment.

K. Shaft & Bearings: Shafts shall be precision ground and polished. Heavy duty, pre-lubricated bearings shall be selected for a minimum (L10) life in excess of 200,000 hours of operation at maximum cataloged operating speed. They shall be designed for and individually tested specifically for use in air handling applications.

L. Belts & Drives: Belts shall be oil and heat resistant, non-static type. Drives shall be cast type, precision machined and keyed and secured attached to the fan and motor shafts. Drives shall be sized for a minimum of 150% of the installed motor horsepower. Fan operating speed shall be factory set using adjustable pitch motor pulleys; motors over 2 HP will come standard with double groove pulleys.

M. Grease Spout: A grease spout made of aluminum tubing shall be welded to the fan housing. The weld shall be factory tested to ensure it will not leak.

N. Nylon Washers: To provide a tight seal all fasteners in the fan housing shall be backed with nylon washers.

O. Safety Disconnect Switch: A safety disconnect switch shall be standard on all NCA-HPFA units with open drip proof motors. Switches shall be installed in a NEMA3R enclosure and mounted to exterior of windband for easy access.

P. Capacities, Characteristics, and Accessories (See Plan Schedules).
2.4 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.

2.5 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 15839 – LABORATORY EXHAUST 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: For each product.

1.3 REFERENCES

B. ANSI/AMCA Standard 204-05, "Balance Quality and Vibration Levels for Fans"
C. ANSI/AMCA Standard 210-07, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating"
D. AMCA Publication 211-05, "Certified Ratings Program – Product Rating Manual for Fan Air Performance"
E. ANSI/AMCA Standard 300-08, "Reverberant Room Method for Sound Testing of Fans"
F. AMCA Publication 311-05, "Certified Ratings Program – Product Rating Manual for Fan Sound Performance"
G. AMBA Method of Evaluating Load Ratings of Bearings ANSI-11 (r1999)
H. ANSI/AMCA Standard 500-D-12, "Laboratory Methods of Testing Dampers for Rating"
I. ANSI/AMCA Standard 500-L-12, "Laboratory Methods of Testing Louvers for Rating"
J. SMACNA - Medium Pressure Plenum Construction Standard
K. ANSI/AIHA Z9.5-2012 – Laboratory Ventilation
1.4 ACTION SUBMITTALS

A. Product Data:
   1. Include rated capacities, furnished specialties, and accessories for each fan.
   2. Certified fan performance curves with system operating conditions indicated.
   3. Certified fan sound-power ratings.
   4. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   5. Material thickness and finishes, including color charts.
   6. Dampers, including housings, linkages, and operators.

B. Shop Drawings:
   1. Include plans, elevations, sections, and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.
   4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

1.5 QUALITY ASSURANCE

A. Performance ratings: Conform to ANSI/AMCA Standards 210 and 300. Fans must be tested in accordance with AMCA Publications 211 and 311 in an AMCA accredited laboratory and certified for air and sound performance. Fan shall be licensed to bear the AMCA ratings seal for air performance (AMCA 210) and sound performance (AMCA 300). Manufacturers that are not licensed to bear the AMCA 210 ratings seal must provide performance witness testing (at the manufacturer’s expense), per paragraph 1.4.D.

B. Classification for Spark Resistant Construction shall conform to ANSI/AMCA Standard 99.

C. Each fan shall be vibration tested before shipping, as an assembly, in accordance with ANSI/AMCA Standard 204. Each assembled fan shall be test run at the factory at the specified fan RPM and vibration signatures shall be taken on each bearing in three planes - horizontal, vertical, and axial. The maximum allowable fan vibration shall be less than 0.15 in. /sec peak velocity; filter-in reading as measured at the fan RPM. This report shall be provided at no charge to the customer upon request.

D. Manufacturer’s that do not comply with paragraph 1.4.A must also provide, at the owner and engineer’s option and manufacturer’s expense, witness testing of fan discharge airflow, performed at an AMCA accredited laboratory, in accordance with AMCA 210. This test shall verify the critical and safety related performance of the high plume blower, as stated by the manufacturer.

E. Seismic certification requires each fan shall be shake table tested at an independent test facility, shall meet an Importance Factor of 1.5, an SDS Value of 2.28, all Site Classes, all Occupancy Categories and all Seismic Design Categories (A-F)

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

B. Field quality-control reports.
1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For centrifugal fans to include in emergency, operation, and maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Belts: One set for each belt-driven unit.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to site in manufacturer’s original, unopened containers and packaging, with labels clearly indicating manufacturer, material, products included, and location of installation.

B. Store materials in a dry area indoor, protected from damage, and in accordance with manufacturer’s instructions. For long term storage, follow manufacturer’s Installation, Operation and Maintenance manual.

C. Handle and lift fans in accordance with the manufacturer’s instructions. Protect materials and finishes during handling and installation to prevent damage. Follow all safety warnings posted by the manufacturer.

1.10 WARRANTY

A. Submit, for Owner's acceptance, manufacturer's standard warranty document executed by authorized company official. Manufacturer's warranty is in addition to, and not a limitation of, other rights Owner may have under Contract Documents.

1. The warranty of this equipment is to be free from defects in material and workmanship for a period of 24 months from the purchase date. Any units or parts which prove defective during the warranty period will be replaced at the manufacturers’ option when returned to the manufacturer, transportation prepaid.

2. Motor Warranty is warranted by the motor manufacturer for a period of two year. Should motors furnished prove defective during this period, they should be returned to the nearest authorized motor service station.
PART 2 - PRODUCTS

2.1 LABORATORY EXHAUST SYSTEM

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

1. Greenheck.
2. Or Approved Equal.

2.2 GENERAL

A. Base fan performance at standard conditions (density 0.075 Lb. /ft³).

B. Fans selected shall be capable of accommodating static pressure and flow variations of +/-15% of scheduled values.

C. Each fan shall be belt driven in AMCA arrangement 10 according to drawings.

D. Fans are to be equipped with lifting lugs.

E. Fasteners exposed to corrosive exhaust shall be stainless steel.

F. Fan assembly shall be designed for a minimum of 92 MPH wind speed, without the use of guy wires or additional structural support.

2.3 FAN HOUSING AND OUTLET

A. Fan housing to be aerodynamically designed with high-efficiency inlet, engineered to reduce incoming air turbulence.

B. Fan shall be of airtight PermaLock™ construction with the scroll panel material formed and embedded into the side panels. All interior and exterior surface steel shall be coated with a minimum of 2-4 mils of Permatector (Polyester Urethane), electrostatically applied and baked. Finish color shall be RAL-7023, concrete grey. No uncoated metal fan parts will be allowed.

C. Housing and bearing support shall be constructed of welded structural steel members to prevent vibration and rigidly support the shaft and bearings.

D. Housing shall include discharge stack of same material as fan housing to increase the overall discharge height of the unit. Minimum overall unit height with stack to be 10 feet (3 m) from the roof deck.
E. Stack material to be a minimum of 18 gauge. Stack to match outlet dimensions of
the fan and shall not add additional static pressure drop to the exhaust fan. Stack
discharge shall have tapered design increasing exit velocity and not adding
additional static pressure drop to the exhaust fan

F. No discharge rain caps or flapper caps are permitted as to interfere with exhaust
airflow.

G. Drain port shall be located at lowest part of scroll housing to prevent moisture
build-up in the interior of fan.

H. An OSHA compliant weatherhood shall be included to completely cover the motor
pulley and belt(s).

2.4 FAN IMPELLER

A. The fan wheel shall be of the non-overloading single width backward inclined
centrifugal type. Wheels shall be statically and dynamically balanced to balance
grade G6.3 per ANSI S2.19.

B. Fan wheel shall be manufactured of single thickness blades securely riveted or
welded to a heavy gauge back plate and wheel cone.

C. The wheel and fan inlet shall be carefully matched and shall have precise running
tolerances for maximum performance and operating efficiency

2.5 FAN MOTORS AND DRIVE

A. Motors shall meet or exceed EISA (Energy Independence and Security Act)
efficiencies. Motors to be NEMA T-frame, 1800 or 3600 RPM, Totally Enclosed
Fan Cooled (TEFC) with a 1.15 service factor.

B. Drive belts and sheaves shall be sized for 150% of the fan operating brake
horsepower, and shall be readily and easily accessible for service, if required.

C. Fan shaft to be turned and polished steel that is sized so the first critical speed is at
least 25% over the maximum operating speed for each pressure class.

D. Fan shaft bearings shall be Air Handling Quality, bearings shall be heavy-duty
grease lubricated, self-aligning or roller pillow block type.

E. Air Handling Quality bearings to be designed with low swivel torque to allow the
outer race of the bearing to pivot or swivel within the cast pillow block. Bearings
shall be 100% tested for noise and vibration by the manufacturer. Bearings shall be
100% tested to insure the inner race diameter is within tolerance to prevent vibration.

F. Bearings shall be selected for a basic rating fatigue life (L-10) of 80,000 hours at maximum operating speed for each pressure class

G. Bearings shall have Zerk fittings to allow for lubrication.

2.6 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 15 "Common Motor Requirements for HVAC Equipment."

2.7 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210/ASHRAE 51, "Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine areas to receive fans. Notify the Engineer of conditions that would adversely affect installation or subsequent utilization and maintenance of fans. Do not proceed with installation until unsatisfactory conditions are corrected.

B. Install fans in accordance with manufacturer’s Installation, Operation and Maintenance manual.

C. Install centrifugal fans level and plumb.

D. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

E. Lift and support units with manufacturer's designated lifting or supporting points.
F. Equipment Mounting:

1. Comply with requirements for vibration isolation devices specified in Section 15 "Vibration Isolation, Seismic, Wind Restraints for HVAC."

G. Curb Support: Install roof curb on roof structure, level and secure, according to "The NRCA Roofing and Waterproofing Manual," Low-Slope Membrane Roofing Construction Details Section, Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." Install and secure centrifugal fans on curbs, and coordinate roof penetrations and flashing with roof construction. Secure units to curb support with anchor bolts.

H. Unit Support: Install centrifugal fans level on structural curbs. Coordinate wall penetrations and flashing with wall construction.

I. Install units with clearances for service and maintenance.

J. Label fans according to requirements specified in Section 15 "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 15 "Air Duct Accessories."

B. Install fans as indicated, with flexible electrical leads.

C. Install ducts adjacent to fans to allow service and maintenance.

D. Install piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain with pipe sizes matching the drain connection.

3.3 FIELD QUALITY CONTROL

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

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

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

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.

3. Verify that cleaning and adjusting are complete.

4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.

5. Adjust belt tension.

6. Adjust damper linkages for proper damper operation.

7. Verify lubrication for bearings and other moving parts.

8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

9. See Section 15 "Testing, Adjusting, and Balancing For HVAC" for testing, adjusting, and balancing procedures.

10. Remove and replace malfunctioning units and retest as specified above.

D. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.4 DEMONSTRATION

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

END OF SECTION 15839
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.
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.

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.
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.

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.

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.
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.


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.
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.
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.
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

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

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 contractor: 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 contractor: 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 15860 - LOUVERS

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. Fixed, extruded-aluminum louvers.

1.3 DEFINITIONS

A. Louver Terminology: Definitions of terms for metal louvers contained in AMCA 501 apply to this Section unless otherwise defined in this Section or in referenced standards.

B. Drainable-Blade Louver: Louver with blades having gutters that collect water and drain it to channels in jambs and mullions, which carry it to bottom of unit and away from opening.

1.4 PERFORMANCE REQUIREMENTS

A. Structural Performance: Provide louvers capable of withstanding the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of louver components, noise or metal fatigue caused by louver blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act on vertical projection of louvers.

1. Wind Loads: Determine loads based on a uniform pressure of 30-lbf/sq. ft., acting inward or outward.

B. Thermal Movements: Provide louvers that allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, failure of
connections, and other detrimental effects. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.

C. Air-Performance, Water-Penetration, Air-Leakage, and Wind-Driven Rain Ratings: Provide louvers complying with performance requirements indicated, as demonstrated by testing manufacturer's stock units identical to those provided, except for length and width according to AMCA 500-L.

D. Airborne Sound Transmission Loss: Provide acoustical louvers complying with airborne sound transmission loss ratings indicated, as demonstrated by testing manufacturer's stock units identical to those specified, except for length and width according to ASTM E 90.

1.5 SUBMITTALS

A. Product Data: For each type of product indicated. For louvers specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.

B. Shop Drawings: For louvers and accessories. Include plans, elevations, sections, details, and attachments to other Work. Show blade profiles, angles, and spacing.

1. For installed louvers and vents indicated to comply with design loads, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Wiring Diagrams: Power, signal, and control wiring for motorized adjustable louvers.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain louvers and vents through one source from a single manufacturer where indicated to be of same type, design, or factory-applied color finish.

B. Welding: Qualify procedures and personnel according to the following:

2. AWS D1.3, "Structural Welding Code--Sheet Steel."

D. UL and NEMA Compliance: Provide motors and related components for motor-operated adjustable louvers that are listed and labeled by UL and comply with applicable NEMA standards.

1.7 PROJECT CONDITIONS

A. Field Measurements: Verify louver openings by field measurements before fabrication and indicate measurements on Shop Drawings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Louvers:
   a. Arrow United Industries.
   b. Carnes Company, Inc.
   c. Construction Specialties, Inc.
   d. Greenheck.
   e. Ruskin Company; Tomkins PLC.
   f. Safe Air/Dowco.
   g. United Enertech.
   h. Or approved equal

2.2 MATERIALS

A. Aluminium Extrusions: ASTM B 221, alloy 6063-T5 or T-52.

B. Fasteners: Of 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-head or hex-head or Phillips pan-head screws for exposed fasteners, unless otherwise indicated.
C. Postinstalled 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.

D. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.3 FABRICATION, GENERAL

A. Assemble louvers in factory to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

B. Maintain equal louver blade spacing to produce uniform appearance.

C. Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.

1. Frame Type: Channel or Exterior flange or Interior flange, unless otherwise indicated.

D. Include supports, anchorages, and accessories required for complete assembly.

E. Provide vertical mullions of type and at spacings indicated, but not more than recommended by manufacturer, or 72 inches o.c., whichever is less.

1. Fully Recessed Mullions: Where indicated, provide mullions fully recessed behind louver blades. Where length of louver exceeds fabrication and handling limitations, fabricate with close-fitting blade splices designed to permit expansion and contraction.

2. Semirecessed Mullions: Where indicated, provide mullions partly recessed behind louver blades so louver blades appear continuous. Where length of louver exceeds fabrication and handling limitations, fabricate with interlocking split mullions and close-fitting blade splices designed to permit expansion and contraction.

3. Exposed Mullions: Where indicated, provide units with exposed mullions of same width and depth as louver frame. Where length of louver exceeds fabrication and handling limitations, provide interlocking split mullions designed to permit expansion and contraction.

4. Exterior Corners: Prefabricated corner units with mitered and welded blades or mitered blades with concealed close-fitting splices and with fully recessed or semirecessed mullions at corners.
F. Join frame members to each other and to fixed louver blades with fillet welds concealed from view, unless otherwise indicated or size of louver assembly makes bolted connections between frame members necessary.

G. Join frame members to each other and to fixed louver blades with fillet welds, threaded fasteners, or both, as standard with louver manufacturer, concealed from view, unless otherwise indicated or size of louver assembly makes bolted connections between frame members necessary.

2.4 FIXED, EXTRUDED-ALUMINUM LOUVERS

A. Horizontal, Drainable-Blade Louver:
   1. Louver Depth: 4 inches or 6 inches as scheduled on the drawings.
   2. Frame and Blade Nominal Thickness: As required to comply with structural performance requirements, but not less than 0.080 inch for blades and 0.080 inch for frames.
   3. Mullion Type: Exposed.
   4. Performance Requirements:
      a. Free Area: Not less than 8.0 sq. ft. for 48-inch wide by 48-inch high louver.
      b. Point of Beginning Water Penetration: Not less than 1000 fpm.
      c. Air Performance: Not more than 0.10-inch wg static pressure drop at 750-fpm free-area velocity.
   5. AMCA Seal: Mark units with AMCA Certified Ratings Seal.

2.5 LOUVER SCREENS

A. General: Provide screen at each exterior louver.
   1. Screen Location for Fixed Louvers: Interior face.
   2. Screen Location for Adjustable Louvers: Interior face, unless otherwise indicated.
   3. Screening Type: Bird screening.

B. Secure screens to louver frames with stainless-steel machine screws, spaced a maximum of 6 inches from each corner and at 12 inches O.C.

C. Louver Screen Frames: Fabricate with mitered corners to louver sizes indicated.
   1. Metal: Same kind and form of metal as indicated for louver to which screens are attached. Reinforce extruded-aluminum screen frames at corners with clips.
2. Finish: Same finish as louver frames to which louver screens are attached.
3. Type: Non-rewirable, U-shaped frames for permanently securing screen mesh.

D. Louver Screening for Aluminum Louvers:
   1. Bird Screening: Aluminum, 1/2-inch square mesh, 0.063-inch wire.

2.6 BLANK-OFF PANELS

A. Insulated, Blank-off Panels: Laminted metal-faced panels consisting of insulating core surfaced on back and front with metal sheets.
   1. Thickness: 1 inch or 2 inches as indicated on the drawings.
   2. Metal Facing Sheets: Aluminum sheet, not less than 0.032-inch nominal thickness.
   3. Insulating Core: Unfaced mineral-fiber rigid insulation board.
   4. Edge Treatment: Trim perimeter edges of blank-off panels with louver manufacturer's standard extruded-aluminum-channel frames, not less than 0.080-inch nominal thickness, with corners mitered and with same finish as panels.
   5. Seal perimeter joints between panel faces and louver frames with 1/8-by-1-inch PVC compression gaskets.
   7. Attach blank-off panels to back of louver frames with clips or stainless-steel, sheet metal screws.

2.7 FINISHES, GENERAL

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Finish louvers after assembly.

2.8 ALUMINUM FINISHES

A. Finish designations prefixed by AA comply with system established by the Aluminum Association for designating aluminum finishes. Architect to select finish below:
   1. Fluoropolymer Three-Coat Coating System: Manufacturer's standard three-coat, thermocured system consisting of specially formulated inhibitive primer, fluoropolymer color coat, and clear fluoropolymer topcoat, with
both color coat and clear topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight; complying with AAMA 2605.

2. Color and Gloss: As selected by Architect from manufacturer's full range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and openings, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

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

3.2 PREPARATION

A. Coordinate setting drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

3.3 INSTALLATION

A. Locate and place louvers and vents level, plumb, and at indicated alignment with adjacent work.

B. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weather-tight connection.

C. Form closely fitted joints with exposed connections accurately located and secured.

D. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
E. 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.

F. 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.

G. Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weathertight louver joints are required. Comply with Division 7 Section "Joint Sealants" for sealants applied during louver installation.

3.4 CLEANING

A. Clean exposed surfaces of louvers and vents that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate until final cleaning.

B. Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.

C. Restore louvers and vents damaged during installation and construction so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.

1. Touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory-applied finish coating.

END OF SECTION 15860
SECTION 15875 – DUST COLLECTION 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. Provide a wood shop dust collection system as required by this section and as indicated on the drawings and schedules.

B. Section Includes:

1. Self-Cleaning Cabinet Type Dust Collector.
2. Dust Collection Exhaust ductwork.
3. Back Pressure Flap
4. Safety After Filter For Dust Collector Return Air.
5. Auto Start System.
7. Free-Hanging Air Cleaners for General Filtration.
9. Extraction Arms for Drill Press Tables

C. Description of Work

1. Supply and Install complete dust collection system for West Windsor South High School. The contractor shall be responsible for supplying all necessary labor and material to provide a turnkey dust collection system for the school in accordance with NFPA 664, International Building code and any State and local codes. The system will be ducted to (15) wood working machines and (1) floor/table sweeps. The contractor will be responsible for supplying effective source capture hoods where needed.

D. The wood shop dust collection system shall source capture wood dust from the following machines:
1. Band saws (2)
2. Drill Press (2)
3. Multi Sander (2)
4. Planer (1)
5. Table Saw (1)
6. Oscillating Sander (1)
7. Tabletop disc sanders (2)
8. Scroll saw (4)
10. Other wood working equipment.

E. Related Requirements:
1. Section 05500 "Misc Metal Framing" for reinforcements in metal-framed partitions for anchoring dust collection systems.
2. Section 15950 "Testing, Adjusting, and Balancing for HVAC" for field quality-control testing of fume hoods.
3. Section 15900 "Instrumentation and Control System for HVAC" for Dust Collection System.

1.3 QUALITY ASSURANCE

A. Manufacturer’s Qualifications: Firms regularly engaged in manufacture of air cleaning equipment of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. NFPA 664: Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities
2. NFPA Compliance: Comply with applicable portions of NFPA 90A and 90B, and NEC pertaining to installation of air filters and associated electric wiring and equipment.
3. UL Compliance: Comply with UL Standards pertaining to safety performance of air filter units.
5. International Mechanical Code Compliance, Chapter 5 Exhaust Systems.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.5 COORDINATION

A. Coordinate layout and installation of framing and reinforcements for lateral support of dust collection system.
B. Coordinate installation of dust collection system with laboratory casework and other laboratory equipment.

1.6 ACTION SUBMITTALS

A. Product Data: Include manufacturer's technical data, 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. Include plans, elevations, sections, and attachment details.
2. Wiring Diagrams: Power, signal, and control wiring.
3. Sound ratings: Provide sound data measurements/ratings measured at same distance as basis of design specified equipment.
4. Indicate details for anchoring Dust Collection System to permanent building construction including locations of blocking and other supports.
5. Indicate locations and types of service fittings together with associated service supply connection required.
6. Indicate duct connections, electrical connections, and locations of access panels.
7. Include roughing-in information for mechanical, plumbing, and electrical connections.
8. Show adjacent walls, doors, windows, other building components, laboratory casework, and other laboratory equipment. Indicate clearances from the above items.
9. Include layout of dust collection system in relation to lighting fixtures, ductwork, and air-conditioning registers and grilles.

C. 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 Dust Collection System will be attached.
2. Roof and/or wall openings
3. Equipment mounting curbs

1.7 INFORMATIONAL SUBMITTALS

A. Product Test Reports: Showing compliance with specified performance requirements for as-manufactured containment and static pressure loss, based on
evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified testing agency.

B. Operation and Maintenance Data: For Dust Collection System to include in emergency, operation, and maintenance manuals.

C. Source quality-control reports.

D. Field quality-control reports.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of dust collection system that fail in materials or workmanship within manufacturer specified warranty period of two (2) year.

1.9 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish complete touchup kit for each type and color of dust collection system finish provided. Include fillers, primers, paints, and other materials necessary to perform permanent repairs to damaged dust collection system finish.

B. 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. Return Filters: One set of filters
2. Filters: for downdraft table

1.10 DELIVERY, STORAGE, AND HANDLING

A. Protect finished surfaces during handling and installation with protective covering of polyethylene film or another suitable material.

1.11 FIELD CONDITIONS

A. Locate concealed framing, blocking, and reinforcements that support dust collection system by field measurements before being enclosed, and indicate measurements on Shop Drawings.
PART 2 - PRODUCTS

2.1 DUST COLLECTOR

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

1. Arrestall Model AR2-10
2. or Approved Equal.

B. Source Limitations: Obtain Dust Collector from single manufacturer.

C. Furnish and install, where shown on the plans, a high efficiency filter type dust collector with integral blower sized for design air flow of 3300 CFM @ 11.00 " TSP.

D. The dust collector shall be a completely self-contained fabric type unit consisting of a collector housing, fan, motor, filter cartridges, and automatic shaker. The unit shall also include a funnel bottom for dust disposal. Overall construction shall be of Hot Rolled Steel with polyester powder coat paint on the interior and exterior for maximum corrosion resistance. Air inlets shall be on the back of the funnel section opposite the doors and the air outlet shall be on top of the unit with horizontal flow through the fan outlet. Cartridge access shall be through full height doors with quick opening, flush latches for speed and security. Integral lifting lugs shall be included for placement of the equipment.

E. The fan shall be backwardly inclined for non-overloading operation. The fan shall be fitted with a scroll for maximum efficiency and quiet operation. It shall be direct driven by a 10hp 3600-rpm TEFC motor and both fan and motor shall be dynamically balanced for smooth vibration free operation. A fan outlet silencer and transition piece shall be provided for sound attenuation. Silencer and transition are shipped separate for field installation. They are designed to be structurally supported by others. The transition is painted to match the ArrestAll. The silencer will be galvanized material and will not be painted.

F. The filter cartridge shall consist of individual pockets sewn from one piece of 8.2-ounce Cotton sateen Flame retardant designed to deliver in excess of 99% efficiency by weight on fine industrial dusts. The cartridge shall be available in Standard Wide (264 square feet) spacing with 16 pockets respectively for maximum application flexibility. The filter cartridges shall have rigid corrugated separators to prevent pocket collapse and to channel the cleaned air in a laminar flow profile into the fan inlet cone. Adjacent pockets shall be positioned by steel bars at the top and a shaker comb at the bottom to keep the pockets open and separated. Dust shall be collected on the outside of the filter media. The cartridge fabric shall be fitted over a galvanized steel locking frame and all
separators securely positioned by a galvanized steel retainer resulting in a tight pocket assembly to minimize pressure drop and maximize dust release. Each cartridge assembly shall be locked in place by two lever actuated over-center cam assemblies which force the steel header frame securely against a \( \frac{3}{4} \times 1 \frac{1}{4} \) neoprene gasket surface.

G. Shaking action shall be delivered by a horizontal contact system that distributes shaking force throughout the entire surface of each individual filter pocket. Pockets shall be held tightly by the shaker comb which imparts acceleration equal to a minimum of 7 G's from a motorized eccentric driven shaker assembly. Operation of the automatic shaker shall be controlled by a UL-508 labeled control panel with built in starter, transformer, and shaker control. The control shall include a fan delay cycle adjustable from 10 to 20 seconds and an automatic shaker cycle adjustable from 6 to 60 seconds. A hand-off auto switch shall be included for maximum operator flexibility. The shaker control panel, mounted transformer and starter shall match the fan motor voltage. Panel shall be factory installed in a NEMA 4 enclosure with all wiring to be done at the factory except the wiring to the fan. Fan mounting and wiring shall be done in the field.

H. Funnel Bottom Units shall be designed with a steep 45-degree funnel terminating in a 12" diameter drum connection device without gates or doors to permit immediate downflow of dislodged dust into the dust disposal container. The unit shall be designed to accommodate two standard 55 gallon drums with quick opening, positive locking barrel top adaptors to prevent air or dust leakage.

I. Integral Final Filter Housing shall be factory mounted between the cartridges section and the fan section. Filters shall be VariCel I 90-95% efficient filters and are shipped separate for field installation. The after filter housing is a side loading housing with positive locking arms for high efficiency.

J. Silencer Weather Hood shall be shipped loose for field installation by others. The weather hood is only required when the ArrestAll is located outdoors and the air is not going to be sent back to the work space.

K. Explosion Vent shall consist of one factory installed rear door panel with Brixon spring latches and guards. The latches are factory set and field adjustable.

L. Magnehelic Gage – A Dwyer 2010 Magnehelic gage shall be factory installed to read the pressure across the main filter cartridge.

M. Magnehelic Gage – A Dwyer 2010 Magnehelic gage shall be factory installed to read the pressure across the final filter housing.

N. Remote Start/Stop – A remote start/stop pushbutton station shall ship separate for field installation. NEMA 4 Pushbutton station with indicating light.
2.2 DUCTWORK

A. Ductwork Type - To be UMC Class C or SMACNA Class II product conveying.

B. Material of construction: Materials of construction shall be in minimum G-90 galvanized sheet metal in accordance with ASTM-A525 and A527.

C. Duct Size - All duct work shall be round Snap Lock (refer to drawing for sizing).

D. Duct gauge- Duct gauge shall depend on diameter with a minimum operating pressure of -16” w.g. in accordance with SMACNA round industrial duct standards.

E. Duct length - duct shall be provided in continuous 5’ sections whenever possible. Except when interrupted by fittings.

F. Exhaust fittings - branch entrances shall be constructed so that air streams converge at 45 degree angles. All branch entries where main trunk line reduces in diameter, the branch must be made on a tapered branch from larger to smaller diameter.

G. Exhaust Joint construction: All joint connections shall have a factory clamp with nitrile gasket and galvanized bridge pin to hold clamp handle in position. Cleanouts shall include a piano hinged door with spring clamps, locking latches, and edge felting to prevent air leaks.

H. Duct conveying velocity: Duct conveying velocity shall be a minimum 3500 - 4000 fpm in main truck line and 4000 fpm in branches.

I. Duct Support- Duct shall be supported by band strapping around entire diameter of duct using minimum 1” wide strap with minimum 22ga. The strap shall be connected to hanger strap the same size and material via ¼ nut and bolt grade 5 galvanized type.

2.3 FLEXIBLE DUCTWORK

A. Provide flexible duct between the end of spiral ductwork terminal and respective wood working piece of equipment.

B. Provide metallic transition from spiral ductwork to flexible ducting. Minimum 30-degree transition.

   1. Material of construction: Materials of construction shall be in minimum G-90 galvanized sheet metal in accordance with ASTM-A525 and A527.
2. Duct gauge- Duct gauge shall depend on diameter with a minimum operating pressure of -16” w.g. in accordance with SMACNA round industrial duct standards.

C. General Purpose Hose:

1. Hose wall: Thermoplastic polyurethane reinforced with high strength woven polyester fabric
2. Spiral: polyurethane coated spring steel wire, permanently bonded to hose wall.
3. Hose clamp with round pins.
4. Refer to drawings for flexible duct size.
5. Basis of Design by Masterduct, Inc. Master-PUR Gold; www.masterduct.com; 800-318-3300

2.4 BACK BLAST DAMPER

A. The Back Blast Damper shall be an ATEX certified (en16447 & en15089) and NFPA compliant passive explosion isolation system designed to isolate and protect the suction side ducting in the event of a dust explosion in a filtration device.

B. The damper shall be constructed using heavy duty welded steel with safety red epoxy powder coat finish and be delivered complete with a flanged inlet/outlet, co-flanges, inspection/access door, grounding lug, counter-weight, locking mechanism, and metal name plate placard identifying manufacturing information, Kst max rating, Pmax rating, Pred rating, and ATEX standard. Additionally, Microswitch for automatic system shutdown to be connected to dust collector control panel.

2.5 SPARK DETECTION/EXTINGUISHMENT SYSTEM

A. Provide spark detection and extinguishment system to National Fire Protection Standards (NFPA) 69,664 and 72 guidelines. The System shall be a model AN100 single zone control panel as supplied by Air Purifiers Inc. (800) 219-8772. All components shall be new and Factory Mutual (FM) Approved. The system shall comprise of the following components:

B. The AN104 programmable microprocessor panel complete with programmable shutdown, built-in automatic and manual sensitivity checking. The system to provide supervision on all input and output circuits. Shutdown and abort damper relays are included as are alarm and trouble relays for notification to fire alarm or PLC panels. The system shall have battery backup power supply.
1. (2)- Model 100-1W NEMA 4 addressable infrared direct optics spark detectors with built-in calibrated through lens sensitivity checking and quick release brackets.
2. Model 910-1 24v dc alarm horn
3. Model 901-1 spray assembly
4. Model 922-1 supervisory ball valve

C. Abort Gate- Model 2 to meet National Fire Protection Association Standards (NFPA) 664. The gate will be constructed of welded and/or bolted galvanized steel with a 14ga, body and 16ga. cowl. The structure should be reinforced with angle iron for stability. The control box shall be weather tight with removable cover.

D. The 120vac signal from the spark detection panel actuates gate to abort position. After alarm condition is corrected reset the latch by lifting the arm into the latching mechanism. The abort gate shall be equipped with a bird screen on the cowl and factory painted gray. Contractor shall supply support stand to handle weight and size of abort gate.

E. System must be installed in accordance with all of the manufacturer installation requirements, tested and commissioned by factory trained technician before placing the system in operation.

F. Sequence of Operation:
   1. The two optical detectors are located in the main trunk line mounted horizontal to the floor directly across from each other. Distance from dust collector to be determined in the field by factory representative.
   2. The spray assembly will be located downstream from the optical detectors. Location determined by design velocity in ductwork of system.
   3. If the system detects a spark a signal is sent from the optical detectors to the central control panel which will activate the spray assembly to extinguish the spark. The panel will activate the alarm to indicate a spark was detected. If several sparks are detected (number to be set in field) during operation, the panel will then set off abort damper to redirect return air outside. This condition must be reset manually after an inspection of dust collector.
   4. System must be installed in accordance with all of the manufacturer installation requirements, tested and commissioned by factory trained technician before placing the system in operation.

2.6 AUTO START SYSTEM

A. Auto-Start System interlocked with wood working machines:
1. Electrically interlock each woodworking machine with the dust collector so that, when a machine is turned on, the dust collector comes on automatically.

2. All wiring shall be centralized at the circuit breaker panel, for ease of installation and expansion for future machines. The interlock shall not require hard wiring at the machines, modification of the motor starters or special auxiliary contacts. Include an adjustable delay timer that will keep the dust collector on for 15-120 seconds after the last machine is switched off, to minimize dust collector cycling and allow the dust in the duct system to be evacuated. Provide the ComiaUSA Dust Switch or an engineered approved equal; The Dust Switch shall be UL approved.

2.7 CONCRETE PAD FOR DUST COLLECTOR

A. The contract shall be responsible for supplying concrete pad with a minimum dimension of 10’ wide by 8’ deep with 6” thickness. The pad shall be made with 3500 lb. concrete. A base of gravel 2” in depth shall be machine compacted before any concrete is poured. The concrete shall have wire mesh reinforcement and expansion form against school wall. All debris, dirt and macadam must be removed by the contractor. The concrete shall be finished in a professional manner with brush finish.

2.8 FREE HANGING AIR CLEANERS

A. The unit shall self contained filtration system constructed of 18 ga. steel with powder coat finish. The unit shall contain a blower section and 2 stage filtration. The unit shall be powered by a ¾ TEFC 115v 1ph direct drive two speed motor/blower that will deliver 2500 cfm. The unit will have a 4 way airfoil adjustable exhaust grille. The filtration shall consist of a 10 sq.ft. reduced maintenance polyester prefilter and 95% 66 sq.ft. bag filter. The unit shall have access through the front of the unit is hinged prefilter plenum. The unit has eyebolts for ease of mounting and a 6’ power cord with plug. Basis of designed by Airflow Systems Inc. F-70R – Phone 800-219-8772

B. OVERHEAD MANUAL PULL-UP EXHAUST SYSTEM FOR WORK TABLES

2.9 PERFORMANCE REQUIREMENTS

A. Refer to drawing for performance requirements.
PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of dust collection system.

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

3.2 INSTALLATION
A. General: Install dust collection system according to manufacturer's written instructions. Install level, plumb, and true; shim as required, using concealed shims, and securely anchor to building and adjacent laboratory casework. Securely attach access panels but provide for easy removal and secure reattachment.

B. Install units of types indicated, and where shown; in accordance with unit manufacturer's written instructions and with recognized industry practices; to ensure that filters and units comply with requirements and serve intended purposes.

C. Locate each unit accurately in position indicated (refer to architectural drawings), in relation to other work. Position unit with sufficient clearance for normal service and maintenance. Anchor unit securely to substrate.

D. Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.

1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Electrical sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment Installer.

E. Comply with requirements for installing water and electrical devices.

F. Secure all duct and elbow joints with self-tapping screws and caulk or hardcast type sealer. Duct tape is not acceptable.

G. Position cleanouts with hinged side at bottom center of ductwork.

H. Blast gates shall be positioned within easy reach of equipment operator.
I. Install filters in proper position to prevent passage of unfiltered air.

### 3.3 FIELD QUALITY CONTROL

A. Field test installed dust collection system according to manufacturer’s recommendations.

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. Operate installed air filter units to demonstrate compliance with requirements. Test for air leakage of system while system is operating. Correct malfunctioning units at site, then retest to demonstrate compliance; otherwise remove and replace with new units and proceed with retesting.

1. Adjust dust collection system or replace dust collection system and make other corrections until tested dust collection system perform as specified.
2. After making corrections, retest dust collection system that failed to perform as specified.

### 3.4 ADJUSTING AND CLEANING

A. Clean finished surfaces; touch up as required; and remove or refinish damaged or soiled areas to match original factory finish, as approved by Architect.

B. After completing system installation and testing, adjusting, and balancing dust collection system and air-distribution systems and clean filters.

### 3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain RTUs. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 15875
SECTION 15900 - INSTRUMENTATION AND CONTROL FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS AND SECTIONS:

A. This Section Includes:

1. This Section details the requirements of the projects Building Management System (BMS), utilizing Direct Digital Controls (DDC) based control equipment for HVAC systems and components, including control components for units not supplied with factory-provided controls.

B. Related Work Specified Elsewhere

1. Division 1 Section “General and Special Requirements.”
2. Section Basic Mechanical Materials and Methods:
3. Section "Sequence of Operation for HVAC Equipment”
4. BMS Diagrammatic Details, as shown on the project drawings.
5. Division 16 “Electrical”

C. Products Not Supplied, but Installed Under This Section:

1. Unit Manufacturer wall mounted field sensors
2. Unit Manufacturer network communications wiring

D. Products Not Supplied or Installed, but Integrated with the Work of This Section:

1. Unit Manufacturer VRF components (VRV/CU)

E. Project Drawings and Specifications

1. The project drawings and the General Provisions of the Contract, including General, Supplementary, and Special Conditions, and Division 1 - General Requirements, apply to work specified in this section.
2. The BMS Contractor (BMSC) shall familiarize himself with the terms of the above documents and any sections hereinafter referred to that affect this work.
3. The work of the single BMS Contractor (BMSC) shall be as defined individually and collectively in all Sections of these Division specifications together with the associated Point Sheets and Drawings and the associated interfacing work as referenced in the related documents.
4. If the BMS Contractor (BMSC) believes there are conflicts or missing information in the project documents, the BMS Contractor (BMSC) shall promptly request clarification and instruction from the design team.
1.2 SECTION DEFINITIONS AND ABBREVIATIONS

A. Definitions used in this specification are as follows:

1. Analog:
   a. A continuously variable system or value not having discrete levels.

2. Binary:
   a. A two-state condition, i.e. “ON” or “OFF”.

   a. The single Contractor responsible to provide the work of this Section of this Division. This Contractor shall be the primary manufacturer, installer, commissioner and ongoing service provider for the HVAC Instrumentation and Controls (ATC) and integration Building Management System (BMS) work.

4. Building Management System (BMS) Integration:
   a. The complete functional and operational interconnection and interfacing of all building systems work elements and nodes in compliance with all applicable codes, standards and ordinances so as to provide a single coherent BMS as required by this Division.

5. Building Management System (BMS)
   a. The total integration of the various building’s control systems of fully operational and functional elements, including equipment, software, programming, and associated materials, to be provided by this Division’s BMS Contractor (BMSC) and to be interfaced to the associated work of other related trades.
   b. When used without additional integrations, synonymous with Automatic Temperature Control (ATC) System.

6. Building Management System (BMS) Network:
   a. The total digital on-line real-time interconnected configuration of the building’s system of independent manufacturer digital processing units,
workstations, panels, sub-panels, controllers, devices and associated elements individually known as network nodes.
b. This may take the form of one or more fully interfaced and integrated sub-networks, LAN, WAN or the like.

7. Control Sequence:
   a. A pre-programmed arrangement of software algorithms, logical computation, target values and limits as required attaining the defined operational control objectives.

8. Direct Digital Control (DDC):
   a. The digital algorithms and pre-defined arrangements included in the BMS 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.

9. Furnish:
   a. The term “Furnish” and its derivatives when used in this Division shall mean supply at the BMS Contractor (BMSC)’s cost to the designated third party trade contractor for installation. BMS Contractor (BMSC) shall connect furnished items to the BMS, calibrate, test, commission, warrant and document.

10. Input:
    a. The term used to describe a variable providing data to the BMS. This can be either a physical point or networked variable.

11. Install:
    a. The term “Install” and its derivatives when used in this Division shall mean receive at the jobsite and mount.

12. Output:
    a. The term used to describe a variable controlled by the BMS. This can be either a physical point or networked variable.

13. Parameter:
a. A control variable that is used within an algorithm. The BMS parameters are adjustable without the requirement for additional programming.

14. Provide:
   a. 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.

15. Protocol:
   a. 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 BMS network nodes.

16. Software:
   a. 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 BMS industry for real-time, on-line, integrated BMS configurations.

17. Singular usage:
   a. 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.

18. Wiring:
   a. The term “Wiring” and its derivatives when used in this Division shall mean provide the BMS wiring and terminations.

B. Abbreviations:
1. The following abbreviations and acronyms may be used in describing the work of this Division, Additional acronyms shall be declared throughout the specifications:
2. Organization and project entities
3. ATC - Division 15 Automatic Temperature Controls Contractor
   IEEE - Institute of Electrical and Electronics Engineers
   BMS - Division 15 Building Management System Contractor
BMS - Building Management System
EC - Division 16 Electrical Contractor
GC - General Contractor
MC - Division 15 Mechanical Contractor (Div 15)
SM - Division 15 Sheet Metal Contractor
UM - Unit Manufacturer, Equipment

4. Direct Digital Controls Abbreviations
ANALOG - A variable signal (4-20 mA, 2-10 VDC etc.)
BINARY - A 2 state signal (On/Off, Open/Closed etc.)
FLOATING - A timed digital signal, not analog
AI / AO - Analog Input / Analog Output
CI / CO - Configurable Input / Configurable Output
DI / DO - Digital Input / Digital Output
DDC - Direct Digital Control
I/O - Input/Output point
LOOP - A control algorithm, with an analog input/output
NO / NC - Normally Open / Normally Closed
PID - Proportional, Integral, Derivative

5. Computer or Electronics
PC/OWS - Personal Computer/Operator Workstation
UPS - Uninterruptible Power Supply
GUI - Graphical User Interface
RAM / ROM - Random Access Memory / Read Only Memory
CPU - Central Processing Unit
EEPROM - Electronic Erasable Prog. Read Only Memory
TCP/IP - Transmission Control Protocol/Internet Protocol
LAN/WAN - Local Area Network/Wide Area Network

6. Heating Plant Abbreviations
HWP - Hot Water Pump, Primary (P-), Secondary (S-)
HWS/R - Hot Water Supply/Return

7. Major HVAC Equipment Abbreviations
RTU - Roof Top Unit
HP - Heat Pump Unit
ERU - Energy Recovery Unit

8. Ancillary HVAC Equipment Abbreviations
ACCU - Air Cooled Condenser Unit

9. Field Devices Abbreviations
AQ - Thermostat, pipe mounted SPDT
CT/CS - Current transducer/ Current Switch
F/SD - Fire/Smoke Damper
A. Building Management System:

1. All new BMS controllers shall be compatible with and be based on the Schneider Electric EcoStruxure Building Operation (EBO) System or approved equal.
2. The new BMS control system shall be integrated into the school district’s campus wide BMS system (EBO).
3. All new DDC controllers must communicate over the BACnet Communication Network.
4. Software for the owner interface into the BMS.
1.4 DESCRIPTION OF WORK:

A. It is the intent of this contract to provide the West Windsor-Plainsboro Regional School District with an integrated and updated DDC control system utilizing the existing District Wide Schneider Electric EBO BMS 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 for full integration with owner's existing Schneider Electric EBO platform. Contractor shall provide all required interface devices as required and shall engage existing Building control vendor as necessary to allow for proper integration. New graphics shall match existing to provide a seamless interface and appearance.

B. Building Management System:

1. The Building Management Systems Contractor shall furnish and install a complete Building Management System (BMS) based on the Schneider Electric EcoStruxure Building Operation (EBO) System or approved equal:
   a. All necessary BMS hardware and all operating and applications software necessary as described in This Section to perform the control sequences of operation.
   b. Section “Sequence of Operation for HVAC Controls”,
   c. Project drawings including
      1) BMS Diagrammatic Details
      2) Sheet Notations
      3) Equipment Schedules

2. The Building Management System (BMS) is based on and shall be in compliance with the BACnet standard, ANSI/ASHRAE 135.
   a. Non-BACnet compliant, exclusive rates, protocols (ARCnet 156k) or propriety equipment or systems (including gateways) shall not be acceptable and are specifically prohibited.

3. All Building Management System components shall be integrated into a distributed network system communicating over a Tiered Hierarchical BACnet networks.
4. The Building Management System (BMS) shall consist of:
   a. Supervisory Network and Graphical User Interfaces
   b. Supervisory Network Controllers (SNC)s
   c. Direct Digital Controllers (DDC)s
   d. A distributed network connecting the BMS manufacturer’s DDC controllers and the subsequent control system devices.
e. A distributed network connecting various Building equipment unit manufacturers (UM) Open protocol systems and the subsequent control system devices.

5. The BMS shall incorporate the following integrated features, functions and services:
   a. EBO Graphic Software
   b. Operator information, alarm management and control functions.
   c. Enterprise-level information and control access.
   d. Information management including monitoring, transmission, archiving, retrieval, and reporting functions.
   e. Diagnostic monitoring
   f. Reporting of BMS functions.
   g. Offsite monitoring and management access.
   h. Energy management
   i. Standard applications for terminal HVAC systems.

6. The Building Management Systems (BMS) System architecture shall consist of the products of a manufacturer regularly engaged in the production of DDC Control Systems, and shall be the manufacturer’s latest standard of design at the time of bid.

7. All controls, other than relays, transformers and panels shall be the product of the same manufacturer.

8. All new controllers furnished in this section shall communicate on a peer-to-peer bus over a BACnet Open MS/TP or TCP/IP protocol network.

C. Building Management System Contractor Responsibilities:

1. The BMS Contractor (BMSC)’s work shall consist of the provision of 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 these Division documents which are required for the complete, fully functional and commissioned BMS.

2. The BMS Contractor (BMSC) shall only use only employees who are skilled, experienced, trained, and familiar with the specific equipment, software, standards and configurations to be provided for this Project.

3. The BMS Contractor (BMSC) shall manage and coordinate the BMS work in a timely manner in consideration of the Project schedules. Coordinate with the associated work of other trades so as to not impede or delay the work of associated trades.
4. Provide sequence of operations as specified in Section “Sequence of Operations for HVAC Controls
5. Furnish and install a complete BACnet DDC Control System consisting of a Building Management System and an Automatic Temperature Control System. The system shall be complete in all respects including labor, materials, equipment, and services necessary, and shall be installed by personnel regularly employed by the personnel contractor.
6. Provide new DDC controls, valves, sensors and all necessary equipment for all new and existing equipment’s shown on drawings and this section of the specifications.
7. Provide Building wide communications between all DDC controllers.
8. Provide remote alarm indication and monitoring.

D. Graphical User Interface (GUI)

1. The system shall allow the BMS DDC controlled equipment to be monitored, controlled and scheduled from the computer onsite and remote sites.
2. All Graphics, scheduling, alarming and reporting, including the graphical programming shall be viewable through an Operator Workstation.
3. The BMS Contractor (BMSC) shall provide customized color graphics of all new systems including:
   a. Energy Recovery Units
   b. Rooftop Units
   c. Fan Powered Variable Air Volume Boxes
   d. Variable Air Volume Boxes
   e. VRV Heat Pump System
   f. Exhaust Fans
   g. Kiln Exhaust Fans
   h. Dust Collector
   i. Split AC Units/Associated Condensing Units
   j. Hot Water Unit Heaters
   k. Hot Water System
   l. Unit Ventilators
   m. Exhaust Ventilator
   n. Remote Exhaust Air Dampers
   o. Duct Humidifier

4. Graphic which depicts the system configuration, fans, coils, valve piping, locations of sensors and all controlled elements. The BMS I/O points shall be displayed in real-time, and shall be dynamically updated without requiring a manual refresh of the graphics page. The graphics shall also provide for operator control parameter interface and adjustment.
5. All control points, parameters of the Graphical User Interface shall be on standard web-browser and shall not require the purchase of any special software from the BMS manufacturer for use as a building operations terminal.

6. All graphics and navigation schemes for this project shall match the existing.

E. Owners Access Rights and Licensure:

1. The Owner shall receive all Administrator level login and passwords for engineering toolset at first training session.

2. 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.

3. All software will be licensed to the owner with full password capability and access.

4. Under no circumstances will any part of the BMS software be licensed or controlled by the BMS Contractor (BMSC). The entire system including original software discs will be turned over to the owner.

1.5 QUALITY ASSURANCE

A. Classifications, Qualifications and Certifications:

1. The Building Management System Contractor must be qualified by the State of New Jersey, Department of Property Management and Construction (DPMC) and Schools Development Authority (NJSDA) under classification C043 Control Systems and C098 Energy Management Systems.

2. Each of these qualifications shall not be less than $35 million in aggregate. The qualification requirement shall be held by the BMS Contractor (BMSC) solely. The Division 15 Mechanical contractor’s qualifications shall not be acceptable.

3. This requirement ensures that the Owner will contract with a BMS Contractor (BMSC) that has good financial standing, experience, capacity and necessary resources to install, maintain and provide future service to the installed Building Management System.

4. A copy of this certification shall be part of the bid and/or submitted upon request by the owner or their representatives.

B. Complexity and Project Magnitude

1. The BMS Contractor (BMSC) shall be responsible for the complete installation and proper operation of the control system. The BMS Contractor (BMSC) shall exclusively be in the regular and customary business of design, installation and service of computerized building management systems similar in size and complexity to the system specified.
2. As evidence and assurance of the Building Management System Contractor’s ability to support the Owner's system installation, the Building Management System contractor must have successfully completed at least ten (10) total projects utilizing similar technology of at least 5 times the value of this contract in each of the preceding five years. Contractors or Manufacturer's representatives who have not been representing their present product lines for as previously noted, shall not be acceptable.

C. Experience & Longevity

1. The Building Management System Contractor shall be representative for BMS manufacturer for at least three years and shall have a proven track record of successful installations with the manufacturer of BMS Control equipment proposed for the project.

2. As evidence and assurance of the Building Management Systems Contractor’s ability to support the Owner's system with service and parts, the contractor must have been in the BMS/BMS business, and a manufacturer licensed provider for at least the last ten (10) years and have successfully completed at least ten (10) total projects of at least five (5) times the value of this contract in each of the preceding five (5) years. Contractors or Manufacturer's representatives who have not been representing their present BMS product lines as previously noted, shall not be acceptable.

3. The BMS Contractor (BMSC) shall have a proven record of various manufacturer control system integrations. As requested by the A-E, a listing of Ten (10) projects of comparable scope, detailing the Building Managements System communications integrations involved in this project.

D. Building Management Systems and Integrations Expertise:

1. The BMS Contractor (BMSC)’s primary business shall regularly engage in the engineering, programming, installation and service of total integrated Building Management Systems.

2. The Building Management Systems contractor’s sole business shall be that of designing, installing and maintaining HVAC BMS & BMS systems. BMS Contractor (BMSC)s whose sole business is NOT “Automation Temperature Controls & Building Management Systems” shall not be acceptable.

3. The BMS and BMS DDC Equipment and materials shall be cataloged products of manufacturers regularly engaged in the production and installation of HVAC control systems. Products shall be manufacturer’s latest standard design and have been tested and proven in actual use.

E. Local Office Location:

1. The Building Management Systems Contractor shall have an established full service local office staffed with trained engineers, technicians and service mechanics within 50 miles of project site.
F. Building Automation System Support

1. The BMS Contractor (BMSC) shall have an established 24-hour emergency service organization.

2. The BMS Contractor (BMSC) shall have a minimum of ten, directly employed (not subcontracted) on staff full time system certified personnel within a 50-mile radius of the project location.

3. 24-hour Emergency contact information shall be provided to the owner for requesting emergency service, live person coverage as a minimum, voice mail shall not be acceptable. A maximum of eight hours, electronic service technician on site response time shall be guaranteed by the BMS Contractor (BMSC). Three of the ten full time electronic service personnel must work within a 50-mile radius of the project location.

G. Ready Source Stock Spare and Repair Parts Availability:

1. The BMS Contractor (BMSC) shall maintain readily available spare parts inventory and shall have all testing and diagnostic equipment necessary to support this work, as well as staff trained in the use of this equipment.

2. The BMS Contractor (BMSC) shall have an independently verifiable on-hand inventory of Direct Digital Controllers and electronic service parts. This inventory value must have a worth of at least $25,000 per year over each of the preceding five years.


1. All Building Management System controls devices shall be manufactured in the USA.

2. Title 52 of N.J.S.A. refers to State owned buildings or State contracts. N.J.S.A. 52:33-2 provides that only domestic materials are to be used on public works. N.J.S.A. 18A:18A-1 et seq. is the Public School Contracts law.

3. This applies to all public schools in the State of New Jersey. N.J.S.A. 18A:18A-20 also requires American goods and products to be used.

1.6 BMS CONTRACTOR (BMSC) QUALIFICATIONS

A. Qualified BMS Manufacturers:

1. The Building Management System shall be subject to compliance with requirements, provide comparable product by one of the following:

   a. Schneider Electric EcoStruxure Building Operation (EBO) System
   b. Johnson Metasys
   c. Siemens Talon
   d. Or Approved Equal

2. BMS systems shall not be acceptable by:
a. Dealers and Wholesalers:

1) Unauthorized BMS Contractor (BMSC)s buying controls from a wholesale distributors are not acceptable.
2) Bids by wholesalers, service companies or any other firm that cannot document a (minimum) three-year direct Authorized relationship with the Building Management System’s (BMS) manufacturer shall not be acceptable.

1.7 RESPONSIBILITY OF INSTALLATION TRADES

A. Trade Responsibilities Matrix

1. The demarcation of work and responsibilities between the BMS Contractor (BMSC) and other related installation trades shall be as outlined in the Table A below:

<table>
<thead>
<tr>
<th>Work Description</th>
<th>Furnish</th>
<th>Install</th>
<th>Low Voltage</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMS Low Voltage wiring</td>
<td>BMS</td>
<td>BMS</td>
<td>BMS</td>
<td>-</td>
</tr>
<tr>
<td>BMS Enclosures</td>
<td>BMS</td>
<td>BMS</td>
<td>BMS</td>
<td>26</td>
</tr>
<tr>
<td>BMS conduits and raceway</td>
<td>BMS</td>
<td>BMS</td>
<td>BMS</td>
<td>BMS</td>
</tr>
<tr>
<td>Equipment BACnet Interface</td>
<td>UM</td>
<td>BMS</td>
<td>BMS</td>
<td>-</td>
</tr>
<tr>
<td>Heat Pump Unit DDC controls</td>
<td>UM</td>
<td>BMS</td>
<td>BMS</td>
<td>26</td>
</tr>
<tr>
<td>Roof Top Unit DDC controls</td>
<td>UM</td>
<td>BMS</td>
<td>BMS</td>
<td>26</td>
</tr>
<tr>
<td>Motorized Control Valves</td>
<td>BMS</td>
<td>23</td>
<td>BMS</td>
<td>-</td>
</tr>
<tr>
<td>Motorized Control Dampers Actuator</td>
<td>BMS</td>
<td>BMS</td>
<td>BMS</td>
<td>26</td>
</tr>
<tr>
<td>Motorized Control Dampers</td>
<td>23</td>
<td>23</td>
<td>BMS</td>
<td>26</td>
</tr>
<tr>
<td>Manual Valves</td>
<td>23</td>
<td>23</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Seismic bracing</td>
<td>23</td>
<td>23</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>VFDs, Motor Starters &amp; HOA switch</td>
<td>23</td>
<td>26</td>
<td>BMS</td>
<td>26</td>
</tr>
<tr>
<td>Smoke &amp; Heat Detectors</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Fire Dampers</td>
<td>23</td>
<td>23</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fire/Smoke Dampers</td>
<td>23</td>
<td>23</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Fire Alarm Shutdown wiring</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Fire Alarm Control wiring</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Fire Alarm Control Panel (FACP)</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Reference Equipment Unit Schedule, BMS Diagrams and Specification Section 230993</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Responsibility to be further specified under separate subsection of division

BMS Building Management System Contractor
23 Project Mechanical Contractor
B. Electrical Work for Controls

1. Complying with the principle of “unit responsibility” all electrical work for building management system, automatic controls, except as otherwise specified, or shown on the electrical drawings shall be included in mechanical sections.

2. Electrical work shall, in general, comply with the following:
   
   a. Low voltage plenum rated wiring can be run exposed above accessible ceiling. Wiring shall be supported in accordance with Part 3 of this Section.
   b. All control wiring in mechanical spaces shall be installed in EMT.
   c. All low voltage wiring in finished rooms shall be concealed. If any wiring must be exposed in rooms, it shall be installed in wiremold raceway.

3. Electrical work may include both line voltage and low voltage wiring, as required.
   
   a. All electrical work shall comply with the NEC and local electrical codes.
   b. All safety devices shall be wired through both hand and auto positions of motor starting device to insure 100% safety shut-off.
   c. All motor starters furnished by Mechanical Contractor shall have:
      
      1) Control transformers, sized to handle the additional VA needed for the controls – pilots, EP valves, etc.
      2) One (1) set of Auxiliary contacts as required for interlock by BMS Contractor (BMSC) (BMSC)

   d. All interlock and control wiring shown on the electrical prints or in the electrical specifications is by the Division 16 Electrical contractor.

1.8 BUILDING MANAGEMENT SYSTEM PERFORMANCE STANDARDS

A. BMS Open Protocol Communications:

1. The Building Management System shall utilize the BACnet Open protocol throughout the BMS Network communication Tiers.

2. The BMS shall conform to the industry network standards utilizing TCP/IP connections.
3. The BMS manufactures product line shall be tested using manufacturer's recommended hardware and software for operator workstation, client and server for Web-Based systems.

B. BMS Operator Interface

1. Customized Color Graphics:
   a. The web-browser shall view the BMS equipment animated graphics, scheduler graphics, alarm screens, point and click set-point adjustments, point and click alarm acknowledgements and resets and other graphics displays required by end user.

2. Graphic Display.
   a. A graphic with 20 dynamic points shall display with current data within 10 sec.
   b. Graphics screens may have up to 20 dynamic points with current data updating every 8 seconds or less and shall automatically refresh every 15 sec.

C. BMS Response:

1. Program Execution Frequency.
   a. BACnet DDC controllers shall be able to completely execute control loops at a frequency adjustable down to once per second, consistent with the mechanical process under control.

2. Object Command:
   a. Reaction time of less than two seconds between operator command of a binary object and device reaction.

3. Object Scanning:
   a. Transmit change of state and change of analog values to control units or workstation within six seconds.

   a. An object that goes into alarm shall be annunciated at the workstation within 15 sec.

5. Configuration and Tuning Screens.
a. Screens used for configuring, calibrating, or tuning points, control loops, and similar control logic shall automatically refresh within 6 sec.

6. BMS Panels

a. BMS Panels shall restart/reboot within 180 seconds after power is applied.

7. Reporting Accuracy and Stability of Control:

a. Report values and maintain measured variables within tolerances as follows:

<table>
<thead>
<tr>
<th>Measured Variable</th>
<th>Reported Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space Temperature</td>
<td>±1 ºF</td>
</tr>
<tr>
<td>Ducted Air Temperature</td>
<td>±1 ºF</td>
</tr>
<tr>
<td>Outside Air Temperature</td>
<td>±2 ºF</td>
</tr>
<tr>
<td>Dew Point Temperature</td>
<td>±3 ºF</td>
</tr>
<tr>
<td>Water Temperature</td>
<td>±1 ºF</td>
</tr>
<tr>
<td>Water Flow</td>
<td>±2% of full scale</td>
</tr>
<tr>
<td>Water Pressure</td>
<td>±2% of full scale (see Note 2)</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>±5% RH</td>
</tr>
<tr>
<td>Airflow (terminal)</td>
<td>± 10% of full scale (see Note 1)</td>
</tr>
<tr>
<td>Airflow (measuring stations)</td>
<td>±5% of full scale</td>
</tr>
<tr>
<td>Airflow (pressurized spaces)</td>
<td>±3% of full scale</td>
</tr>
<tr>
<td>Air Pressure (ducts)</td>
<td>±0.1 in. w.c.</td>
</tr>
<tr>
<td>Air Pressure (space)</td>
<td>±0.01 in. w.c.</td>
</tr>
<tr>
<td>Electrical (A, V, W, Power Factor)</td>
<td>1% of reading (see Note 3)</td>
</tr>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>±5% of reading</td>
</tr>
<tr>
<td>Carbon Dioxide (CO2)</td>
<td>±50 ppm</td>
</tr>
</tbody>
</table>

Note 1: Accuracy applies to 10%-100% of scale
Note 2: For both absolute and differential pressure
Note 3: Not including utility-supplied meters

<table>
<thead>
<tr>
<th>Controlled Variable</th>
<th>Control Accuracy</th>
<th>Range of Medium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Pressure</td>
<td>±0.2 in. w.c.</td>
<td>0-6 in. w.c.</td>
</tr>
<tr>
<td></td>
<td>±0.01 in. w.c.</td>
<td>-0.1 to 0.1 in. w.c.</td>
</tr>
<tr>
<td>Airflow</td>
<td>±10% of full scale</td>
<td></td>
</tr>
<tr>
<td>Space Temperature</td>
<td>±2.0 ºF</td>
<td></td>
</tr>
<tr>
<td>Duct Temperature</td>
<td>±3 ºF</td>
<td></td>
</tr>
</tbody>
</table>
1.9 SUBMITTALS

A. Submittals shall be provided under provisions of Section 00800

1. Submit documentation of BMS manufacturer’s and contractor’s qualifications, including those indicated in This Section’s "Quality Assurance" if so requested by the A-E.

2. Allow 15 working days for the review of each package by the Architect and Engineer in the scheduling of the total BMS design work.

3. Submittals shall be in defined packages. Each package shall be complete and shall only reference itself and previously submitted packages. The packages shall be as approved and reviewed by the Architect and Engineer for Contract compliance.

4. The BMS Contractor (BMSC) shall submit a list of all shop drawings with submittals dates within 30 days of contract award. Eight (8) copies of shop drawings of the entire control system shall be submitted. Submit the required Copies of submittal data and shop drawings for review prior to ordering or fabrication of the equipment.

B. Building Management System Software Submittals:

1. Software submittals shall contain narrative descriptions of program listings and a complete description of the graphics, reports, alarms and configuration to be furnished with the workstation software.

C. Color Graphics Submittal:

1. Provide a list of the standard and custom color graphic screens for all mechanical systems and floor plans of the building(s). For each screen, provide a conceptual layout of pictures and data.

D. Building Management System Hardware Submittal:

1. 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.

2. Examples of written Unit Controller Checkout Sheets and Performance Verification Procedures for applications similar in scope shall be included for approval.

E. 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 Microsoft Visio Software. In addition to the drawings, the BMS Contractor (BMSC) shall furnish an electronic copy containing the identical information.

3. Building Management System 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. Typical drawings will be allowed where appropriate. 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 will properly function as a system. Specific Terminal identification for all control wiring shall be shown on the shop drawings (i.e. point-to-point diagram).

5. System Product Data:
   a. Device Manufacturer's data sheets shall be provided for each device to be used.
   b. The data sheets shall contain each of the manufacturer's data on the hardware and software products required by the specification including:
      1) Preparation instructions and recommendations.
      2) Storage and handling requirements and recommendations.
      3) Proper Installation instructions and methods.
   c. Operator Work Station, Display data, CPU, Processor speed, HD etc....
   e. Sequence of Operation for each system.

F. Correction – Resubmission:

1. The BMS Contractor (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 BMS Contractor (BMSC) (BMSC).

G. Operation and Maintenance (O&M) Manual Submittal:

1. Upon completion of the work, six (6) copies of the Operation and Maintenance Manuals shall be provided to the Owner's Representative. These shall be as-built versions of the shop drawing submittal product data
The Entire Operation and Maintenance Manual shall be furnished on Compact Disc media, and include the following for the BMS provided:

2. Names, address and 24-hour telephone numbers of Contractors installing equipment, and the control systems and service representative of each.
3. Maintenance instructions and lists of spare parts for each type of control device.
4. Interconnection wiring diagrams with identified and numbered system components and devices.
6. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
7. Calibration records and list of set points.
8. Licenses, Guarantee, and Warrantee documents for all equipment and systems.
9. Recommended preventive maintenance procedures for all system components including a schedule of tasks (inspection, cleaning, calibration, etc.), time between tasks, and task descriptions.
10. The Operation and Maintenance 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.

H. Testing and Commissioning Reports and Checklists.

1. Software and Firmware Operational Documentation:
2. Include the following:
   a. Software operating and upgrade manuals.
   b. Program Software Backup:
   c. Device address list.
   d. Printout of software application and graphic screens.
   e. Software license required by and installed for DDC workstations and control systems.

I. Program Software Backup:

1. On compact disc, provide program software backup complete with data files.
2. Any deviations from these specifications or the work indicated on the drawings shall be clearly identified in the Submittals.

J. Permitting:
1. Equipment and BMS systems requiring approval of local authorities shall comply with such regulations shall be approved by such prior to installation.
2. Where filing is necessary, unless stated otherwise in the project documentations, the expense shall be by the BMS Contractor (BMSC) (BMSC).
3. Provide a copy of all related correspondence and permits/approvals to the Owner.

1.10 BMS PROJECT MANAGEMENT

A. Oversite:
   1. A designate and competent and experienced employee shall be provided to manage the BMS installation and commissioning.
   2. The designated BMS Project Manager shall be empowered to make technical, scheduling and related decisions on behalf of the BMS Contractor (BMSC) minimum, the BMS Project Manager shall:
      a. Manage the scheduling of the work to ensure that adequate materials, labor and other resources are available as needed.
      b. Manage the financial aspects of the BMS Contract.
      c. Coordinate as necessary with other trades.
      d. Be responsible for the work and actions of the BMS workforce on site.

B. Pre-Installation Meetings
   1. Initial Meeting:
      a. A Project Coordination meeting shall convene a minimum two weeks prior to starting work of this section.

C. Workplace Safety and Hazardous Materials
   1. Provide a safety program in compliance with the Contract Documents.
   2. The BMS Contractor (BMSC) shall have a corporately certified comprehensive Safety Certification Manual and a designated Safety Supervisor for the Project.
   3. The BMS Contractor (BMSC) and its employees and sub trades comply with federal, state and local safety regulations.
   4. The BMS Contractor (BMSC) shall ensure that all subcontractors and employees have written safety programs in place that covers their scope of work, and that their employees receive the training required by the OSHA have jurisdiction for at least each topic listed in the Safety Certification Manual.
5. The BMS Contractor (BMSC) shall sign and date a safety certification form prior to any work being performed, stating that the Contractors’ company is in full compliance with the Project safety requirements.

D. Hazardous Material Handling

1. The BMS Contractor (BMSC)’s safety program shall include written policy and arrangements for the handling, storage and management of all hazardous materials to be used in the work in compliance with the requirements at the Project site.

2. The BMS Contractor (BMSC)’s employees and subcontractor’s staff shall have received training as applicable in the use of hazardous materials and shall govern their actions accordingly.

1.11 MATERIAL DELIVERY, STORAGE AND HANDLING

A. Damage Prevention

1. Maintain integrity of shipping cartons for each piece of equipment and control device through shipping, storage and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather.

B. Factory-Mounted Components:

1. Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

C. System Software:

1. Update to latest version of software at Project completion.

1.12 PROJECT SITE CONDITIONS

A. Cooperation with Other Trades:

1. Coordinate the Work of this section with that of other sections to insure that the Work will be carried out in an orderly fashion. It shall be the BMS Contractor (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.

B. System Installation:
1. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

C. Panel Power:

1. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation, Power, Wiring, Conduit, Fire Alarm, Motor-Control Centers, etc. to achieve compliance, compatibility, and interfaces.

D. Third Party Building Management Systems Interface:

1. Coordinate equipment with the appropriate Divisions of the Mechanical Specifications for Motor Controllers, Manufacturer Supplied Controls, etc. to achieve compliance, compatibility, and interfaces.

1.13 WARRANTY AND MATERIAL LABOR

A. Material and Labor:

1. Provide a two-year labor and material warranty on the BMS.
2. 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 BMS Contractor (BMSC) at the cost of the BMS Contractor (BMSC).
3. 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 BMS Contractor (BMSC)’s normal business hours.

PART 2 - PRODUCTS

2.1 BUILDING MANAGEMENT SYSTEMS – ACCEPTABLE MANUFACTURERS

A. The Building Management System shall be subject to compliance with requirements, provide comparable product by one of the following:

   a. Schneider Electric EcoStruxure Building Operation (EBO) System
   b. Johnson Metasys
   c. Siemens Talon
   d. Or approved equal

B. Non-Approved BMS systems include:
1. HVAC Equipment Unit manufacturer supplied Graphical user Interface control systems
   a. i.e. York, McQuay, Trane, etc...

2.2 BUILDING MANAGEMENT SYSTEM – GENERAL DESCRIPTION

A. Overview:
   1. The Building Management System (BMS) shall be comprised of a network of interoperable, direct digital controllers, EBO Graphic Software, a Supervisory Network Controllers, graphics and programming and other control devices for a complete system as specified herein.
   2. The installed Building Management System shall provide secure password access to all features, functions and data contained in the overall BMS.
   3. The Building Management System (BMS) shall use a Schneider Electric EBO BACnet architecture or approved equal and shall integrate a wide variety of third-party devices and applications.
   4. The BMS shall be designed for use on the Internet, or intranets using off the shelf, Open industry standard technology compatible with other manufacturer Open networks.
   5. The Equipment Manufacturer’s BACnet devices shall be integrated to the Schneider Electric EBO Platform or approved equal. Equipment graphics shall be generated and included on the Web-based Graphical user Interface.

B. Components Included
   1. The Building Management System shall consist of the following:
      a. Supervisory Network Controllers(s)(SNC)
      b. Local Display Device(s)(LCD)
      c. Programmable Equipment Controller(s)(PEC)
      d. Input/Output Module(s)(IOM)
      e. Network communications equipment
      f. Other components required for a complete and working BMS

C. BMS expansion capability:
   1. The Building Management System shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices, while re-using existing DDC control equipment.
   2. The Building Management System’s architectural 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.

2.3 BUILDING MANAGEMENT SYSTEM (BMS) NETWORK (BACNET)

A. Installation:

1. Supervisory Network Controllers (SNC)s shall provide control over the BMS network and shall support the Open BACnet TCP/IP, BACnet MS/TP, Modbus, and LonWorks TP/FT. The use of ARCnet156K communications or other proprietary protocols shall not be acceptable.
2. BACnet Protocol Implementation Conformance Statement shall be provided for each DDC controller that will communicate on the BACnet networks.
3. The Building Management System networks shall provide either “Peer-to-Peer” or “Master-Slave” communications.

2.4 THIRD PARTY BUILDING SYSTEMS EQUIPMENT INTEGRATION

A. Open Communications Protocol:

1. BACnet Protocol Integration - BACnet
   
   a. The common protocol used between systems will be BACnet over Ethernet or BACnet over MS/TP. The protocols shall comply with the ASHRAE BACnet standard 135.
   
   b. A complete Protocol Implementation Conformance Statement (PICS) shall be provided for all BMS BACnet system controllers.

B. BACnet Integration Performance:

1. The ability to command, share point object data, change of state (COS) data and schedules between the host and BACnet systems shall be provided.
2. The BMS Contractor (BMSC) shall integrate real-time data from building systems by other trades and databases originating from other trades as specified and required by the Contract Documents. The third party supplier of the integration shall provide assistance to the BMS Contractor (BMSC) in terms of technical information, integration cards, and programming.
3. The Building Management Systems shall include necessary hardware, equipment and software to allow data communications between the existing controls systems and building systems supplied by other trades.
4. The other trade contractors supplying other associated systems and equipment will provide their necessary hardware and software at their cost and will cooperate fully with the BMS Contractor (BMSC) in a timely manner and at their cost to ensure complete functional integration.

C. Proprietary Systems - Hardwired Interface
1. Analog and digital signal values shall be passed from one system to another via hardwired connections.
2. Points required by the BMS shall be provided by the BMS Contractor (BMSC), as required, to meet the sequence of Operations.
3. There will be one separate physical point on each system for each point to be integrated between the systems.

2.5 BUILDING MANAGEMENT SYSTEM - OPEN, INTEGRATED, AND INTEROPERABLE

A. Design Intent:

1. The intent of this Section is to provide a peer-to-peer networked, stand-alone, distributed direct digital controls utilizing the BACnet Open protocol into one seamless open interoperable Building Management System (BMS).

B. BMS Open Protocol Communications:

1. The physical connection of any BACnet controlled equipment, such as chillers, boilers, shall be via BACnet MS/TP, BACnet TCP/IP.
2. BACnet communications over ARCnet 156K is prohibited and shall not be acceptable.

C. BMS Integrated Protocol Communications:

1. The BMS shall provide for connections to third party protocols, utilizing devices that breach the proprietary framework previously inherent in legacy BMS systems. The physical connection shall be spanned utilizing vendor specific software driver to communicate with third party controlled equipment, such as competitive BMS systems, legacy chillers, boilers, and other antiquated systems.

D. Peer-to-Peer DDC controllers:

1. All DDC controllers supplied under this contract shall be true "peer-to-peer" communicating devices.
2. DDC controllers requiring "polling" by a host to pass data shall not be acceptable

E. Open Graphical Objects

1. The BMS Graphical User Interface software provided by the BMS Contractor (BMSC) shall employ object-oriented technology (OOT) for representation of all data and control devices within the system.

F. Interoperable Open Database Connectivity:
1. The supplied BMS system shall incorporate the ability to access all data using HTML5 enabled browsers without requiring proprietary operator interface and configuration programs or browser plug-ins. An Open Database Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on the Operating System Server located in the Facilities Office on the LAN.

2. BMS systems requiring proprietary database and user interface programs shall not be acceptable.

G. BMS Hierarchical Network Topology

1. 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 customer's internal Intranet network.

2. Systems employing a "flat" single tiered architecture shall not be acceptable.

3. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for TCP/IP network connected user interfaces or 60 seconds for remote or dial-up connected user interfaces.

2.6 EMBEDDED WEB-BASED GRAPHICAL USER INTERFACE (GUI)

A. Web-browser Graphical User Interface:

1. The BMS Contractor (BMSC) shall provide a GUI designed around the open standards of web technology. The GUI shall provide graphics via the BMS Tier 1 Ethernet and shall be accessed using a web browser over the Owner's intranet and/or remotely over the Internet.

2. The web browser Graphical User Interface (GUI) shall be browser and operating system agnostic, meaning it will support HTML5 enabled browsers without requiring proprietary operator interface and configuration programs or browser plug-ins. Microsoft, Explorer browsers (current released versions), and Windows as well as non-Window operating systems.

B. Web Browser Graphical User Interface Criteria:

1. The GUI shall be browser based and shall meet the following criteria:
   a. Only the current released browser (Explorer) will be required as the GUI and a valid connection to the server network.
   b. No installation of any custom software shall be required on the operator's GUI workstation/client. Connection shall be over an intranet or the Internet.
   c. Secure Socket Layers:
1) Communication between the Web Browser GUI and BMS server shall offer encryption using 128-bit encryption technology within Secure Socket Layers (SSL).
2) Communication protocol shall be Hyper-Text Transfer Protocol (HTTP).

C. Web-Browser Features:

1. A web-browser GUI shall provide a completely interactive user interface and shall provide a HTML5 experience that supports the following features as a minimum:

   a. Trending.
   b. Scheduling.
   c. Electrical demand limiting.
   d. Duty Cycling.
   e. Downloading Memory to field devices.
   f. Real time 'live' Graphic Programs.
   g. Tree Navigation.
   h. Parameter change of properties.
   i. Set point adjustments.
   j. Alarm / event information.
   k. Configuration of operators.
   l. Execution of global commands.
   m. Add, delete, and modify graphics and displayed data.

D. Web-Software Components:

1. All software shall be the most current version.
2. All software components of the BMS system software shall be provided and installed as part of this project.
3. BMS software components shall include:

   b. Embedded System Configuration Utilities for future modifications
   c. Embedded Graphical Programming Tools.
   d. Embedded Direct Digital Control software.
   e. Embedded Application Software.

E. Web Browser Navigation:

1. The web browser GUI shall provide a comprehensive user interface. Using a collection of web pages, it shall be constructed to "feel" like a single application, and provide a complete and intuitive mouse/menu driven operator interface.
2. The Web Browser GUI shall provide for navigation, and for display of animated graphics, schedules, alarms/events, live graphic programs, active graphic set point controls, configuration menus for operator access, reports and reporting actions for events.

3. User Login:
   a. On launching the web browser and selecting the appropriate domain name or IP address, the operator shall be presented with a login page that will require a login name and strong password.
   b. Both the Navigation tree and Action Pane shall be displayed simultaneously, enabling the Operator to select a specific system or equipment and view the corresponding graphic.
   c. Navigation in the system shall be dependent on the operator's Role-Based application control privileges.

4. Navigation Tree:
   a. Navigation through the GUI shall be accomplished by clicking on the appropriate level of a navigation tree (consisting of an expandable and collapsible tree control like Microsoft's Explorer program) and/or by selecting dynamic links to other system graphics.
   b. The Navigation tree shall as a minimum provide the following views:
      1) Geographic:
         a) Display a logical geographic hierarchy of the system including: cities, sites, buildings, building systems, floors, equipment and objects.
      2) Network:
         a) Display a logical Network hierarchy of the BMS including: SNCs, PECs, AUCs, AVAVs.
      3) Groups
         a) Display Scheduled Groups and custom reports.
   c. Configuration:
      1) Display all the configuration categories:
         a) Operators
         b) Schedule
         c) Event
         d) Reporting
         e) Roles
5. Action Pane:
   a. The Action Pane shall provide several functional views for each subsystem specified. A functional view shall be accessed by clicking on the corresponding button:

F. Customized System Graphics:

1. Using graphical format suitable for display in a web browser, graphics shall include:
   a. aerial building/campus views
   b. color building floor-plans
   c. equipment drawings
   d. active graphic set point controls
   e. web content and other valid HTML elements

2. The data on each graphic page shall automatically refresh.

G. Energy Usage Dashboards:

1. User customizable data using drag and drop HTML5 elements, shall include:
   a. Customized Web Charts
   b. Energy Gauges
   c. Additional Energy Calculation and usage widgets

2. User shall have ability to save custom dashboards.

H. Search:

1. User shall have multiple options for searching data Based upon Tags. Associated equipment, real time data, Properties, and Trends shall be available in result.

I. Properties:

1. Shall include graphic controls and text for the following: 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.

J. Schedules:

1. Shall be used to create, modify/edit and view schedules Based on the systems hierarchy (using the navigation tree).
K. Alarms:

1. Shall be used to view alarm information geographically (using the navigation tree), acknowledge alarms, sort alarms by category, actions and verify reporting actions.

L. Charting:

1. Shall be used to display associated trend and historical data, modify colors, date range, axis and scaling. User shall have ability to create HTML charts through web browser without utilizing chart builder. User shall be able to drag and drop single or multiple data points, including schedules, and apply status colors for analysis.

M. System Graphics Requirements:

1. Color graphics shall be selected and displayed via a web browser for the following:
2. General Overview Graphic:

a. General area maps shall show locations of controlled buildings in relation to local landmarks.
   
   1) Unique Mechanical Systems:

   a) Mechanical system graphics shall show the type of mechanical system components serving any zone through the use of a pictorial representation of components.
   
   b) Selected I/O points being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units.
   
   c) Animation shall be used for rotation or moving mechanical components to enhance usability.

3. Color Graphics:

   a. The Web Browser GUI shall make extensive use of color in the Graphic pane to communicate information related to the system setpoints and controls parameters.
   
   b. Animated gifs or jpg, vector scalable, active set point graphic controls shall be used to enhance usability.
   
   c. Graphics tools used to create Web Browser graphics shall be non-proprietary and conform to the following basic criteria, as a minimum:

4. Display Size:
a. The GUI workstation software shall graphically display in a minimum of 1024 by 768 pixels, 24-bit True Color.

N. Graphical Programming Logic - Dynamic Programs:

1. The GUI will display 'live' graphic programs of the control algorithm, (micro block programming) for the mechanical/electrical system selected in the navigation tree.
2. Other actions such as Print, Help, Command, and Logout shall be available via a drop-down window.

O. BMS Security Access:

1. Systems that Security access from the web browser GUI to BMS server shall require a Login Name and Strong Password.
2. Access to different areas of the BMS system shall be defined in terms of Role-Based Access Control privileges as specified:

P. BMS Operator Roles:

1. Roles shall reflect the actual roles of different types of operators.
2. Each role shall comprise a set of 'easily understood English language' privileges.
3. Roles shall be defined in terms of:
   a. View Privileges.
   b. Edit Privileges.
   c. Function Privileges.
   d. Operator Privileges
4. View Privileges shall comprise:
5. Edit Privileges shall comprise:
   a. Set point, Tuning and Logic, Manual Override, and Point Assignment Parameters.
6. Function Privileges shall comprise:

Q. Geographic Assignment of Roles:
1. Roles shall be geographically assigned using a similar expandable/collapsible navigation tree.
2. For example, it shall be possible to assign two HVAC Technicians with similar competencies (and the same operator defined HVAC Role) to different areas of the system.

2.7 SCHEDULES

A. Hierarchical Schedules:

1. 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.
2. For example, 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.

B. Schedules Types & Standards:

1. Schedules shall comply with the BACnet 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 (1-12, any), Week of Month (1-5, last, any), Day of Week (M-Sun, Any).
   d. Wildcard (i.e. allow combinations like second Tuesday of every month).

C. Schedule Categories:

1. 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.

D. Schedule Groups:

1. In addition to hierarchical scheduling, operators shall be able to define functional Schedule Groups, comprised of an arbitrary group of
areas/rooms/equipment scattered throughout the facility and site. For example, the operator shall be able to define an 'individual tenant' group - who may occupy different areas within a building or buildings. Schedules applied to the 'tenant group' shall automatically be downloaded to control modules affecting spaces occupied by the 'tenant group'.

E. Intelligent Scheduling:

1. The control system shall be intelligent enough to automatically turn on any supporting equipment needed to control the environment in an occupied space. If the operator schedules an individual room in a VAV system for occupancy, for example, the control logic shall automatically turn on the VAV air handling unit, chiller, boiler and/or any other equipment required to maintain the specified comfort and environmental conditions within the room.

F. Partial Day Exceptions:

1. Schedule events shall be able to accommodate a time range specified by the operator (ex: board meeting from 6 pm to 9 pm overrides Normal schedule for conference room).

G. Schedule Summary Graph:

1. The schedule summary graph shall clearly show Normal versus Holiday versus Override Schedules and the net operating schedule that results from all contributing schedules. Note: In case of priority conflict between schedules at the different geographic hierarchy, the schedule for the more detailed geographic level shall apply.

2.8 ALARMS:

A. 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. Alarms View:

   a. Each Alarm shall display an Alarms Category (using a different icon for each alarm category), date/time of occurrence, current status, alarm report and a bold 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 as specified in this section.
2. Alarm Categories:
   a. The operator shall be able to create, edit or delete alarm categories such as HVAC, Maintenance, Fire, or Generator. An icon shall be associated with each alarm category, enabling the operator to easily sort through multiple events displayed.

3. Alarm Templates:
   a. Alarm template shall define different types of alarms and their associated properties. As a minimum, properties shall include a reference name, verbose description, severity of alarm, acknowledgement requirements, and high/low limit and out of range information.

4. Alarm Areas:
   a. Alarm Areas enable an operator to assign specific Alarm Categories to specific Alarm Reporting Actions. For example, it shall be possible for an operator to assign all HVAC Maintenance Alarm on the 1st floor of a building to email the technician responsible for maintenance. The Navigation Tree shall be used to setup Alarm Areas in the Graphic Pane.

5. Alarm Time/Date Stamp:
   a. All events shall be generated at the DDC control module level and comprise the Time/Date Stamp using the standalone control module time and date.

6. Alarm Configuration:
   a. Operators shall be able to define the type of Alarm generated per object. A 'network' view of the Navigation Tree shall expose all objects and their respective Alarm Configuration. Configuration shall include assignment of Alarm, type of Acknowledgement and notification for return to normal or fault status.

7. Alarm Summary Counter:
   a. The view of Alarm in the Graphic Pane shall provide a numeric counter, indicating how many Alarms are active (in alarm), require acknowledgement and total number of Alarms in the BMS Server database.

8. Alarm Auto-Deletion:
a. Alarms that are acknowledged and closed shall be auto-deleted from the database and archived to a text file after an operator defined period.

9. Alarm Reporting Actions:

a. Alarm Reporting Actions specified shall be automatically launched (under certain conditions) after an Alarm is received by the BMS server software. Operators shall be able to easily define these Reporting Actions using the Navigation Tree and Graphic Pane through the web browser GUI. Reporting Actions shall be as follows:

10. Print:

a. Alarm information shall be printed to the BMS server's PC or a networked printer.

11. Email:

a. Email shall be sent via any POP3-compatible e-mail server (most Internet Service Providers use POP3). Email messages may be copied to several email accounts.
b. Email reporting action shall also be used to support alphanumeric paging services, where email servers support pagers.

12. File Write:

a. The ASCII File write reporting action shall enable the operator to append operator defined alarm information to any alarm through a text file. The alarm information that is written to the file shall be completely definable by the operator. The operator may enter text or attach other data point information (such as AHU discharge temperature and fan condition upon a high room temperature alarm).

13. Write Property:

a. The write property reporting action updates a property value in a hardware module.

14. SNMP:

a. The Simple Network Management Protocol (SNMP) reporting action sends an SNMP trap to a network in response to receiving an alarm.

15. Run External Program:
a. The Run External Program reporting action launches specified program in response to an event.

2.9 TRENDS:

A. Trending Capability

1. As the Building Management System devices are engineered, all of the I/O points shall be enabled to trend.
2. Trends shall both be displayed and user configurable through the Web Browser GUI. Trends shall comprise analog, digital or calculated points simultaneously.
3. A trend log's properties shall be editable using the Navigation Tree and Graphic Pane.

B. Viewing Trends:

1. The operator shall have the ability to view trends by using the Navigation Tree and selecting a Trends button in the Graphic Pane. The system shall allow y- and x-axis maximum ranges to be specified and shall be able to simultaneously graphically display multiple trends per graph.

C. Local Trends:

1. Trend data shall be collected locally by Multi-Equipment/Single Equipment general-purpose controllers, and periodically uploaded to the BMS server if historical trending is enabled for the object. Trend data, including run time hours and start time date shall be retained in non-volatile module memory. Systems that rely on a gateway/router to run trends are NOT acceptable.

D. Trend Resolution.

1. Sample intervals shall be as small as one second.
2. Each trended point will have the ability to be trended at a different trend interval.
3. When multiple points are selected for displays that have different trend intervals, the system will automatically scale the axis.

E. Dynamic Update.

1. Trends shall be able to dynamically update at operator-defined intervals.

F. Zoom/Pan.

1. It shall be possible to zoom-in on a particular section of a trend for more detailed examination and 'pan through' historical data by simply scrolling the mouse.
G. Numeric Value Display.
   1. It shall be possible to pick any sample on a trend and have the numerical value displayed.

H. Copy/Paste
   1. The operator shall have the ability to pan through a historical trend and copy the data to the clipboard using standard keystrokes (i.e. CTRL+C, CTRL+V).

2.10 NETWORK SERVER CONTROLLERS (NSC)

A. Schneider Electric Unit Model: Automation Server (ASPXX) or Approved equal.

B. Network Router Controllers shall combine both network routing functions, control functions, and server functions into a single unit.

C. The BACnet NSC shall be classified as a “native” BACnet device, supporting the BACnet Network Server Controller (B-BC) profile. Controllers that support a lesser profile such as B-SA are not acceptable. NSCs shall be tested and certified by the BACnet Testing Laboratory (BTL) as BACnet Network Server Controllers (B-BC).

D. The Network Server Controller shall provide the interface between the LAN or WAN and the field control devices, and provide global supervisory control functions over the control devices connected to the NRS.

E. The NSCs shall be capable of whitelisting IPs to restrict access to a pre-defined list of hosts or devices.

F. Whitelisting of file extensions for documents shall be capable.

G. Encrypted and authenticated communication shall be configurable for non-open protocol communications using TLS 1.2.

H. The NSCs shall support Simple Network Management Protocol version 3 (SNMPv3) for monitoring of the NSCs using a Network Management Tool.

I. The NSCs shall support remote system logging for used by System Information and Event Monitoring (SIEM) software.

J. They shall also be responsible for monitoring and controlling their own HVAC equipment such as an AHU or boiler.

K. They shall also contain graphics, trends, trend charts, alarm views, and other similar presentation objects that can be served to workstations or web-based
interfaces. A sufficient number of NSCs shall be supplied to fully meet the requirements of this specification and the attached point list.

L. It 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 by means of an Internet site including automatic synchronization
   6. Native integration of LonWorks controller data and Modbus controller data or BACnet controller data and Modbus controller data
   7. Network Management functions for all LonWorks based devices

M. Hardware Specifications
   1. Memory:
      a. The operating system of the controller, application programs, and all other portions of the configuration database, shall be stored in non-volatile, FLASH memory. Servers/Controllers shall contain enough memory for the current application, plus required history logging, plus a minimum of 20% additional free memory.

   2. Each NRC shall provide the following on-board hardware for communication:
      a. Two 10/100b Ethernet for communication to Workstations, other NRCs, IP field bus controllers, other SDCUs, and onto the internet.
         o The two Ethernet ports shall support active switch and BACnet/IP communication protocols.
         o Support IPv4 addressing
         o Ethernet port 1 shall support static or DHCP client configuration for communication to Workstation or other NSCs
         o Ethernet port 2 shall support switch mode or DHCP server to set addressing of DHCP client devices
         o It shall be possible to disable Ethernet port 2
         o In DHCP server mode, the Ethernet port 2 shall support 50 BACnet/IP field controllers in daisy chain configuration directly from the port
         o Each NSC shall be able to support a total of 250 IP SDCUs in daisy chain configuration (5 sub networks via switch)
         o If using RSTP (Rapid Spanning Tree Protocol) with a managed switch (with IEEE 802.1W or IEEE 802.1Q-2014 support), Ethernet port 2 shall support up to 39 devices
Each NSC shall be able to support a total of 234 IP SDCUs in RSTP configuration (6 sub networks via managed switch)

Where a switch is needed, use an EtherWAN EX63402-01B, or other equal and approved equivalent.

b. Two RS-485 ports for communication to BACnet MSTP bus or serial Modbus (software configurable)

c. One TP/FT port for communication to LonWorks devices.

d. One device USB port

e. One host USB port

3. The NSC shall conform to a small footprint no larger than 100W x 125H x 75D mm (3.94W x 4.92H x 2.95D in).

N. Modular Expandability:

1. The system shall employ a modular I/O design to allow expansion. Input and output capacity is to be provided through plug-in modules of various types. It shall be possible to combine I/O modules as desired to meet the I/O requirements for individual control applications.

2. One shall be able to “hot-change” (hot-swap) the I/O modules preserving the system on-line without any intervention on the software; addressing and configuration shall be automatic.

3. If for any reason the backplane of the modular I/O system were to fail, I/O module addresses will be protected.

O. Hardware Override Switches:

1. All digital outputs shall, optionally, include three position manual override switches to allow selection of the ON, OFF, or AUTO output state. These switches shall be built into the unit and shall provide feedback to the controller so that the position of the override switch can be obtained through software. In addition each analog output shall be equipped with an override potentiometer to allow manual adjustment of the analog output signal over its full range, when the 3 position manual override switch is placed in the ON position.

P. Universal Input Temperatures

1. All universal inputs directly connected to the NSC via modular expansion shall be capable of using the following thermistors for use in the system without any external converters needed.

   a. 10 kohm Type I (Continuum)
   b. 10 kohm Type II (I/NET)
   c. 10 kohm Type III (Satchwell)
   d. 10 kohm Type IV (FD)
   e. Linearized 10 kohm Type V (FD w/11k shunt)
   f. Linearized 10 kohm (Satchwell)
   g. 1.8 kohm (Xenta)
h. 1 kohm (Balco)
  i. 20 kohm (Honeywell)
  j. 2.2 kohm (Johnson)

2. In addition to the above, the system shall be capable of using the below RTD sensors, however it is not required that all universal inputs be compatible with them.
   a. PT100 (Siemens)
   b. PT1000 (Sauter)
   c. Ni1000 (Danfoss)

Q. Local Status Indicator Lamps:
   1. The NSC shall provide as a minimum LED indication of CPU status, Ethernet LAN status, and field bus status. For each input or output, provide LED indication of the value of the point (On/Off). The LED indication shall support software configuration to set whether the illumination of the LED corresponds to On or Off or whether the color when illuminated is Red or Green.

R. Real Time Clock (RTC):
   1. Each NSC shall include a real time clock, accurate to 10 seconds per day. The RTC shall provide the following: time of day, day, month, year, and day of week. Each NSC will allow for its own UTC offset, depending upon the time zone. When the time zone is set, the NSC will also store the appropriate times for daylight savings time.
   2. The RTC date and time shall also be accurate, up to 30 days, when the NSC is powerless.
   3. No batteries may be used to for the backup of the RTC.

S. Power Supply:
   1. The 24 VDC power supply for the NSCs shall provide 30 watts of available power for the NSC and associated IO modules. The system shall support the use of more than one power supply if heavily power consuming modules are required.
   2. The power supply, NSC, and I/O modules shall connect power wise and communication wise via the separate terminal base allowing for ease of replacement and no separate or loose wiring.

T. Automatic Restart After Power Failure:
   1. Upon restoration of power after an outage, the NSC shall automatically and without human intervention update all monitored functions, resume operation based on current, synchronize time and status, and implement special start-up strategies as required.

U. Data Retention:
   1. During a power failure, the NSC shall retain all programs, configuration data, historical data, and all other data that is configured to be retained.
There shall be no time restriction for this retention and it must not use batteries to achieve it.

V. Software Specifications
1. The operating system of the controller, application programs, and all other portions of the configuration database such as graphics, trends, alarms, views, etc., shall be stored in non-volatile, FLASH memory. There will be no restrictions placed on the type of application programs in the system. Each NSC shall be capable of parallel processing, executing all control programs simultaneously. Any program may affect the operation of any other program. Each program shall have the full access of all I/O facilities of the processor. This execution of control function shall not be interrupted due to normal user communications including interrogation, program entry, printout of the program for storage, etc.

2. Each NSC shall have an available capacity of 4 GB of memory. This shall represent 2 GB for application and historical data and 2 GB dedicated for backup storage.

W. User Programming Language:
1. The application software shall be user programmable. This includes all strategies, sequences of operation, control algorithms, parameters, and setpoints. The source program shall be either a script-based structured text or graphical function block based and fully programmable by the user. The language shall be structured to allow for the configuration of control programs, schedules, alarms, reports, telecommunications, local displays, mathematical calculations, and histories. Users shall be able to place comments anywhere in the body of either script or function block programs.

2. Network Server Controllers that use a “canned” program method will not be accepted.

X. Control Software:
1. The NSC shall have the ability to perform the following pre-tested control algorithms:
   a. Proportional, Integral plus Derivative Control (PID)
   b. Two Position Control
   c. Digital Filter
   d. Ratio Calculator
   e. Equipment Cycling Protection

Y. Mathematical Functions:
1. Each controller shall be capable of performing basic mathematical functions (+, -, *, /), squares, square roots, exponential, logarithms, Boolean logic statements, or combinations of both. The controllers shall be capable of performing complex logical statements including operators such as >, <, =, and, or, exclusive or, etc. These must be able to be used in the same
equations with the mathematical operators and nested up to five parentheses deep.

Z. NSCs shall have the ability to perform any or all of the following energy management routines:
1. Time of Day Scheduling
2. Calendar Based Scheduling
3. Holiday Scheduling
4. Temporary Schedule Overrides
5. Optimal Start
6. Optimal Stop
7. Night Setback Control
8. Enthalpy Switchover (Economizer)
9. Peak Demand Limiting
10. Temperature Compensated Duty Cycling
11. CFM Tracking
12. Heating/Cooling Interlock
13. Hot/Cold Deck Reset
14. Hot Water Reset
15. Chilled Water Reset
16. Condenser Water Reset
17. Chiller Sequencing

AA. History Logging:
1. Each NSC controller shall be capable of LOCALLY logging any input, output, calculated value or other system variable either over user defined time intervals ranging from 1 second to 1440 minutes or based upon a user configurable change of value. A minimum of 1000 logs, with a minimum of 100,000 records, shall be stored. Each log can record either the instantaneous, average, minimum or maximum value of the point. Logged data shall be downloadable to a higher level NSC long term archiving based upon user-defined time intervals, or manual command.
2. For extended trend logging a minimum of 1500 trends shall be capable, with a minimum number of 600,000 records within.
3. Management of a power meter replacement to ensure meter log data is accurate shall be possible in the NSC.
4. Every hardware input and output point, hosted within the NSC and attached I/O modules, shall be trended automatically without the requirement for manual creation, and each of these logs shall log values based upon a change of value and store at least 500 trend samples before replacing the oldest sample with new data.
5. The presentation of logged data shall be built into the server capabilities of the NSC. Presentation can be in time stamped list formats or in a chart format with fully configurable pen colors, weights, scales and time spans.
6. Tooltips shall be present, magnetic, and visible based on users preference.
7. Comments shall be visible whenever viewing the trend log list.
8. System shall give indication of memory usage and be able to alert the user if too many logs are allocated.

BB. Alarm Management:
1. For each system point, alarms can be created based on high/low limits or in comparison to other point values. All alarms will be tested each scan of the NSC and can result in the display of one or more alarm messages or reports.
2. There is no limit to the number of alarms that can be created for any point.
3. Alarms can be configured to be generated based upon a single system condition or multiple system conditions.
4. Alarms will be generated based on an evaluation of the alarm conditions and can be presented to the user in a fully configurable order, by priority, by time, by category, etc. These configurable alarm views will be presented to a user upon logging into the system regardless of whether the log in takes place at a WorkStation or a Webstation.
5. The alarm management system shall support the ability to create and select cause and action notes to be selected and associated with an alarm event. Checklists shall also be possible in order to present to an operator a suggested mode of troubleshooting. When acknowledging an alarm, it shall be possible to assign it to a user of the system such that the user is notified of the assignment and is made responsible for the alarm resolution.
6. Alarms must be capable of being routed to any BACnet workstation that conforms to the B-OWS device profile and uses the BACnet/IP protocol.

CC. Embedded Web Server
1. Each NSC must have the ability to serve out web pages containing the same information that is available from the WorkStation. The development of the screens to accomplish shall not require any additional engineering labor over that required to show them at the WorkStation itself.
2. The NSC shall be configurable to logging all Embedded Web Server access attempts.
3. The NSC shall have the option to redirect HTTP based Embedded Web Server connections to secure, HTTPS connections.
4. The NSC shall authenticate and authorize all users connecting to the Embedded Web Server.
5. The NSC shall provide to ability to configure an automatic logoff for Embedded Web Server users that have not had any activity for an adjustable time period.

2.11 BACNET IP FIELDBUS CONTROLLERS

A. Schneider Electric Models: MP-X and RP-C or Approved equal.
B. Controllers – BACnet/IP Protocol

1. All BACnet/IP Fieldbus controllers shall be BACnet Testing Laboratory listed (v12 or later) as specified BACnet Advanced Application Controller (B-AAC)
2. All BACnet/IP Fieldbus controllers shall use the following communication specifications and achieve performance as specified herein:
   a. All controllers shall be able to communicate peer-to-peer without the need for a NSC
   b. Any BACnet/IP Fieldbus controllers on the Ethernet Data Link/Physical layer shall be able to act as a Master to allow for the exchange and sharing of data variables and messages with any other controller connected on the same communication cabling. Slave controllers are not acceptable.

C. The BACnet/IP Fieldbus controllers shall be equipped with 2x 10/100bT Ethernet communication ports with active switch and will support BACnet/IP communication protocols with the following configurations:
   1. Supporting IPv4 addressing
   2. Supporting Static IP setting, DHCP client and Auto-IP address acquisition
   3. It shall be possible to disable Ethernet port 2

D. Topologies
   1. BACnet/IP Fieldbus controllers shall support daisy chain topology of up to 50 controllers. In case of any disruption to the communication, a system alarm shall notify the NSC/BMS of the point disruption has occurred.
   2. BACnet/IP Fieldbus Controllers shall support RSTP loop whereby up to 39 controllers are supported.
      a. In case of any disruption there shall be no communication interruption
      b. In case of any disruption there shall be system alarms that will inform the operator of the disruption

E. Performance
   1. Each BACnet/IP Fieldbus Controllers shall have a 32-bit microprocessor operating at 500 MHz and support a BACnet protocol stack in accordance with the ANSI/ASHRAE Standard 135-2008 and the BACnet Device Profile supported.
   2. They shall be multi-tasking, real-time digital control processors consisting of communication controllers, controls processing, power supplies with built-in inputs and outputs.

F. Programmability
1. The BACnet/IP Fieldbus controllers shall support both script programming language and graphical that will be consistent with the NSC.
2. The control program will reside within the same enclosure as the input/output circuitry, that reads inputs and controls outputs.
3. All control sequences programmed into the BACnet/IP Fieldbus Controllers shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.
4. BACnet/IP Fieldbus controllers shall communicate with the Network Server Controller (NSC) via a BACnet/IP connection at a baud rate of not less than 100 Mbps.
5. BACnet/IP Fieldbus controllers shall support a dedicated communications port for connecting and supplying power to a matching room temperature and/or humidity sensor and/or CO2 and/or presence detector that does not utilize any of the I/O points of the controller.
6. BACnet/IP Fieldbus controllers (Excluding VAV) shall support an add-on display to supply and provide access in real-time for monitoring inputs and overriding of outputs.
7. The override functionality must be supported by a dedicated processor to assure reliable operation (overriding of output).
8. Each BACnet/IP Fieldbus controller shall have sufficient memory, to support its own operating system and databases, including:
   a. Control processes
   b. Energy management applications
   c. Alarm management
   d. Historical/trend data
   e. Maintenance support applications
   f. Custom processes
   g. Manual override monitoring
9. Each BACnet/IP Fieldbus controller shall support local trend data up to 2x the built-in I/O and at a minimum be capable of holding 5 days @ 15 min intervals locally.
10. The BACnet/IP Fieldbus controller analog or universal input shall use a 16 bit A/D converter.
11. The BACnet/IP Fieldbus controller analog or universal output shall use a 10 bit D/A converter.
12. Built-in I/O: each BACnet/IP Fieldbus controllers shall support:
   a. At minimum 8 and up to 20 configurable IO channels to monitor and to control the following types of inputs and outputs without the addition of equipment inside or outside the DDC Controller cabinet.
      1) Universal Inputs – the following thermistors for use in the system without any external converters needed.
         10 kohm Type I (Continuum)
         10 kohm Type II (I/NET)
         10 kohm Type III (Satchwell)
         10 kohm Type IV (FD)
Linearized 10 kohm Type V (FD w/11k shunt)
Linearized 10 kohm (Satchwell)
1.8 kohm (Xenta)
1 kohm (Balco)
20 kohm (Honeywell)
2.2 kohm (Johnson)
PT100 (Siemens)
PT1000 (Sauter)
Ni1000 (Danfoss)

2) Analog inputs
   Current Input - 0-20 mA
   Voltage Input 0-10 Vdc

3) Digital inputs from dry contact closure, pulse accumulators, voltage sensing.

4) Digital outputs

5) Analog outputs of 4-20 mA and/or 0-10 Vdc

13. Real Time Clock (RTC):
   a. Each BACnet/IP Fieldbus controller shall include a real time clock, accurate to +/-1 minute per month. The RTC shall provide the following: time of day, day, month, year, and day of week.
   b. The RTC date and time shall also be accurate, up to 7 days, when the BACnet/IP Fieldbus controller is powerless.
   c. No batteries may be used to for the backup of the RTC.

14. The BACnet/IP Fieldbus controller for Variable Air Volume (VAV) applications
   a. The BACnet/IP Fieldbus controller for VAV applications shall include a built-in ‘flow thru’ differential pressure transducer
   b. The VAV differential pressure transducer shall have a measurement range of 0 to 1 in. W.C. and measurement accuracy of ±5% at 0.001 to 1 in. W.C. and a minimum resolution of 0.001 in. W.C., insuring primary air flow conditions shall be controlled and maintained to within ±5% of setpoint at the specified minimum and maximum air flow parameters
   c. The BACnet/IP FieldBus controller for VAV applications shall support a dedicated commissioning tool for air flow balancing
   d. The BACnet/IP Fieldbus controller for VAV applications shall require no programing for air balancing algorithm
   e. All balancing parameters shall be synchronized in NSC

15. Each BACnet/IP Fieldbus controller shall have a minimum of 10% spare capacity for each point type represented on the controller for future point connection

16. Power Requirements.: 24VDC (21 to 33 VDC) and 24 VAC +/-20% with local transformer power
G. Commissioning Tool - The BACnet/IP Fieldbus controller shall be supported via a
dedicate mobile based commissioning tool for configuration, programming, air
balancing and I/O checkout
1. The Commissioning Tool shall be supported across: iOS, Android and
Windows 10 platforms
2. The Commissioning Tool shall be available for download on App Store,
Google Store and Windows Store
3. Commissioning Tool Interface to BACnet/IP Fieldbus controllers shall be via
a Bluetooth adapter interface through the Intelligent Space Sensor or via a
Wi-Fi access point on the LAN
4. Functionality
   a. Device Configuration – the Commissioning Tool shall be able to set or
      edit all Network configurations associated with the BACnet/IP Fieldbus
      controller
   b. Programming – The Commissioning Tool shall be able to load offline
      engineered applications directly in to the controller directly
   c. Air Balancing
      1) The Commissioning Tool shall allow the air balancer to manually
         control the action of the actuator including the following
         function: open VAV damper, close VAV damper, open all VAV
         dampers, and close all VAV dampers.
      2) The Commissioning Tool shall be able to generate Air Balancing
         report
   d. IO Checkout
      1) The Commissioning Tool shall be able to support overriding of
         the outputs and reading value of inputs live
      2) The Commissioning Tool shall be able to support generation of
         I/O checkout report
   e. There shall be no limit to the number of Commissioning Tools that can
      be used on a network segment, however, one connection per
      controller is recommended

H. Intelligent Space Sensors - The BACnet/IP Fieldbus controller shall support a
dedicated RJ45 communication port to communicate and power up to 4
intelligent wall mount sensors without the use of on board inputs or outputs
1. The Intelligent Space Sensor shall communicate with the BACnet/IP Fieldbus
controller through the sensor port and via category 5 or category 6 cable
2. The Intelligent Space Sensor shall provide 2 RJ45 communication ports that
will allow communication with parent BACnet/IP Field controller upstream
and additional Intelligent Space Sensors downstream
3. The Intelligent Space Sensor shall provide ambient space condition sensing
without the use of hardware I/O

I. Each Intelligent Space Sensor shall provide a color touch display with:
1. Minimum 61 mm (2.4”) by 61 mm (2.4”) display
2. Backlit

J. The Intelligent Space Sensor shall be capable of displaying measured space temperature from 0 to 50 °C (32 to 122 °F) with accuracy of ±0.2 °C (±0.4 °F) selectable for 0.1 or 1 degree display resolution of °F or °C
1. Sensing Element: 10k Type 3 Thermistor
2. Accuracy of ±0.2 °C (±0.4 °F)
3. Resolution: 0.1 or 1 degree display resolution
4. Range: 0 to 50 °C (32 to 122 °F)

K. The Intelligent Space Sensor shall have the option for humidity sensor support sensing humidity from 0 % RH to 100 % RH Digital humidity indication (selectable for 0.1 or 1% RH with selectable display resolution of 0.1 or 1 % RH
1. Accuracy: ±2 % RH
2. Resolution: 0.1 or 1 % RH
3. Range: 0 % RH to 100 % RH

L. The Intelligent Space Sensor shall have the option for support of CO2 sensor with display resolution with 0 to 2000 ppm resolution
1. Accuracy: ±30 ppm ±2% of measured value
2. Range: 0 to 2,000 ppm
3. Operating elevation: 0 to 16,000 ft.
4. Temperature dependence: 0.11% FS per °F
5. Stability: <2% of FS over life of sensor (15 years)
6. Sensing method: Non-dispersive infrared (NDIR), diffusion sampling

M. The Intelligent Space Sensor shall have the option for motion sensor

N. Display options: The Intelligent Space Sensor shall be capable of displaying the following elements:
1. Space temperature
2. Cooling space temperature set point
3. Heating space temperature set point
4. Current heating or cooling mode
5. Current occupancy mode
6. Fan speed
7. Current time

2.12 SYSTEM TOOLS

C. Automated Engineering Tool (AET)

1. The AET shall be a software package enabling a computer platform to be used as a stand-alone engineering configuration tool for a EcoStuxure BMS server.
2. The AET shall provide an archive database for the configuration and application data.

3. The AET shall have the same look-and-feel at the User Interface (UI) regardless of whether the configuration is being done online or offline.

4. The AET shall include the following features:
   a. Basic system navigation tree for connected networks
   b. BACnet™ enabled devices
   c. Customized user navigation trees
   d. Point naming operating parameter setting
   e. Graphic diagram configuration
   f. Alarm and event message routing
   g. Graphical logic connector tool for custom programming
   h. Global editing for multiple updates on any text in a target application or template.
   i. Downloading, uploading, and archiving databases

5. The AET shall have the capability to automatically discover field devices on connected buses and networks. Automatic discovery shall be available for the following field devices:
   a. BACnet™ Devices

6. The AET shall be capable of programming the Field Equipment Controllers.
   a. The AET shall provide the capability to configure, simulate, and commission the Field Equipment Controllers.
   b. The AET shall allow the FECs to be run in Simulation Mode to verify the applications.
   c. The AET shall contain a library of standard applications to be used for configuration.

7. The AET shall be capable of programming the field devices.
   a. The AET shall provide the capability to configure, simulate, and commission the field devices.
b. The AET shall allow the field devices to be run in Simulation Mode to verify the applications.

c. The AET shall contain a library of standard applications to be used for configuration

2.13 SYSTEM INPUT SENSORS

A. General Requirements

1. Installation, testing, and calibration of all sensors, transmitters, and other input devices shall be provided to meet the system requirements.

B. Temperature Sensors

1. Outside Air Temperature Sensors
   a. Outdoor Air Temperature Transmitter shall contain a 20K-ohm thermistor temperature sensors with an accuracy of ± 0.5 ° F mounted in an enclosure rated for outdoor use.
   b. 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.
   c. These devices shall have accuracy of ±0.5 ° F over the entire range.
   d. Acceptable Manufacturers:
      1) Schneider Electric
      2) Or Approved Equal.

2. Space Temperature Sensors
   a. Space Temperature Transmitter shall contain an RTD sensing element to monitor room air temperatures in the range of 30°F to 90°F, unless indicated otherwise. The transmitter shall be factory calibrated to an accuracy of ± 1%. The assembly shall be installed within a metal ventilated enclosure suitable for wall mounting. The output shall be compatible with the panel it serves. Transmitter shall be factory calibrated to an accuracy of ± 1% over the full range.
      1) Schneider Electric
      2) Or Approved Equal.

C. Current Switches (CS)

1. Current-operated switches shall be self-powered, solid state with an adjustable trip current.
2. The switches shall be selected by the BMS Contractor (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. Schneider Electric
   b. Senva
   c. Veris Industries
   d. Or Approved Equal

D. Smoke and Heat Detectors

1. Smoke and heat detectors shall be furnished as specified elsewhere in Division 16 for installation under Division 15.
2. All wiring for smoke duct detectors shall be provided under Division 16, Fire Alarm System.

2.14 SYSTEM OUTPUT DEVICES

A. Control Relays

1. 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.
2. All panel mounted control relays shall:
   a. be plugged in type with an interchangeable module (Ice-Cube)
   b. be mounted on a sub base and wired to numbered terminals strips.
   c. be DPDT with indicating lamp.
3. Remotely mounted 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.
4. All control relays shall be labeled with UR symbol and UL listed.
5. Acceptable Manufacturers:
a. Functional Devices  
b. Veris Industries  
c. IDEC  
d. Or approved equal.

B. Control Power Transformers & Power Supplies

1. Control transformers shall be UL listed, Class 2 current-limiting type, or shall be furnished with over-current protection in both primary and secondary circuits for Class 2 service.
2. Unit power output shall match the required output current and voltage requirements. Current output shall allow for a 50% safety factor. Output ripple shall be 3.0 mV maximum Peak-to-Peak. Regulation shall be 0.10% line and load combined, with 50 microsecond response time for 50% load changes. Unit shall have built-in over-voltage protection.
   a. Unit shall operate between 32 F and 120 F.  
   b. Unit shall be UL recognized.
3. Acceptable Manufacturers:
   a. Veris Industries  
   b. Functional Devices  
   c. Or approved equal.

C. Tamper or Vandal Resistant Covers

1. Provide the required tamper-resistant or vandal-resistant enclosures/covers for protection of thermostats, sensors, or other control devices in areas where tampering or vandalism may occur. The enclosures/covers shall be designed to withstand tampering or damage and abuse common in many public access spaces and other areas.
2. Where applicable, enclosures/covers shall have tamper-proof socket head screws.
3. Where the Unit manufacturer provides the space temperature sensor, a Tamper resistant cover shall also be provided by the UM.

D. Local Control Enclosures and Panels

1. All indoor control cabinets shall be fully enclosed NEMA 1 construction with (hinged door) key-lock latch and removable sub panels. A single key shall be common to all field panels and sub panels.
2. The enclosure shall be of steel construction with baked enamel finish, NEMA 1 rated with a hinged door and keyed lock. The enclosure will be
sized for twenty percent spare mounting space. All locks will be keyed identically.

3. 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.

4. Provide ON/OFF power switch with over-current protection for control power sources to each local panel.

5. A convenience 120 VAC duplex receptacle shall be provided in each enclosure, fused on/off power switch, and required transformers.

6. All control panels shall be factory constructed, incorporating the BMS manufacturer’s standard designs and layouts.

7. 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.

8. 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.

9. All I/O connections on the BACnet DDC controller shall be provide via removable or fixed screw terminals.

10. 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.

11. All wiring shall be neatly installed in plastic trays or tie-wrapped.

12. Control Panels shall be rated for the environment in which they are located.

13. Acceptable manufacturers

   a. Kele or approved equal.

E. BMS Control Cabling

1. General:

   a. Provide copper wiring, plenum cable, and raceways as specified in the applicable sections of Division 16 unless otherwise noted herein.

   b. All insulated wire to be copper conductors, UL labeled for 90 °C minimum service.

   c. Electronic and fiber-optic cables for control wiring are specified in Electrical Section "Voice and Data Communication Cabling."

2. Communication and Control Wiring
a. Wire Sizing and Insulation

1) Wiring shall comply with minimum wire size and insulation based on services listed below:

- a) Service  
  - Minimum Gage/Type: 12 Ga Solid  
  - Insulation Class: 600 Volt
- b) AC 24 VAC Power  
  - Minimum Gage/Type: 10 Ga Solid  
  - Insulation Class: 600 Volt
- c) DC 24 VDC Power  
  - Minimum Gage/Type: 14 Ga Stranded  
  - Insulation Class: 600 Volt
- d) Class 1  
  - Minimum Gage/Type: 18 Ga Stranded  
  - Insulation Class: 300 Volt
- e) Class 2  
  - Minimum Gage/Type: 18 Ga Stranded  
  - Insulation Class: 300 Volt
- f) Class 3  
  - Minimum Gage/Type: 18 Ga Stranded  
  - Insulation Class: 300 Volt

b. Provide plenum-rated cable when open cable is permitted in supply or return air plenum where allowed.

3. Control Power Wiring:

a. 24 VAC control power wiring > 200 feet distance shall use minimum 12 gage.

4. 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.

5. Communication Wiring

a. Ethernet Cable shall be minimum CAT5e minimum
b. Secondary level network shall be 24 gage, TSP, low capacitance cable

6. Approved Cable Manufacturers:

a. Anixter  
b. Belden  
c. Actassi  
d. Or Approved Equal

PART 3 - EXECUTION

3.1 OVERVIEW

A. General:

1. Install system and materials in accordance with manufacturer's instructions, and as detailed on the project drawing set.
2. Line and low voltage electrical connections to control equipment shown specified or shown on the control diagrams shall be furnished and installed by the Control System Contractor in accordance with these specifications.
3. Equipment furnished by the Mechanical Contractor that is normally wired before installation shall be furnished completely wired. Control wiring normally performed in the field will be furnished and installed by the Control System Contractor.
4. All control devices mounted on the face of control panels shall be clearly identified as to function and system served with permanently engraved phenolic labels.

3.2 BMS SPECIFIC REQUIREMENTS

A. Graphic Displays
   1. Provide a color graphic system flow diagram display for each system with all points as indicated on the point list. All terminal unit graphic displays shall be from a standard design library.
   2. User shall access the various system schematics via a graphical penetration scheme and/or menu selection.

B. End Device Actuation
   1. All damper and valve actuation shall be DDC electronic.

C. Controls shall be provided by the BMS manufacturer as specified herein.

D. Control Type
   1. Heat Pump Unit Equipment
      a. Controls shall be provided by the Equipment manufacturer as specified herein.
      b. Controlled with a BACnet DDC Controller.
      c. Integrated to the Schneider Electric or approved equal Graphical User Interface.

   2. Condensate Pumps
      a. Controls shall be provided by BMS contractor as specified herein.
      b. Controlled with a BACnet DDC Controller.
      c. Integrated to the Schneider Electric or approved equal Web Graphical User Interface.

3.3 EXAMINATION

A. Conditioned Power
1. Verify that conditioned power supply is available to the operator workstation.

B. Emergency Power

1. Verify that emergency power supply is connected to panels designated as such.

C. NEC Code Compliance

1. All wiring shall be installed in accordance with all applicable electrical codes and will comply with equipment manufacturer's recommendations. Should any discrepancy be found between wiring specifications in this section and Electrical sections, the stricter wiring requirements will prevail.

3.4 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Control and Network wiring Installation:

1. All electrical control wiring to the control panels shall be the responsibility of the BMS Contractor (BMSC).
2. All wiring shall be in accordance with the Project Electrical Specifications (Division 16), the National Electrical Code and any applicable local codes.
3. Control wiring shall be of adequate length for the installation. Excess wire shall not be looped or coiled in the controller cabinet.
4. Use approved optical isolation and lightning protection when penetrating building envelope.
5. Read installation instructions carefully. Any unavoidable deviations shall be approved by owner's rep prior to installation.

B. Component Installation references:

1. Install raceways, boxes, and cabinets according to Electrical Section "Raceways and Boxes."
2. Install building wire and cable according to Electrical Section "Conductors and Cables."
3. Install signal and communication cable according to Electrical Section "Voice and Data Communication Cabling."
4. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
5. Install exposed cable in raceway.
6. Install concealed cable in raceway or use plenum cable installed in workmanlike fashion.
7. Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path.
8. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
9. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
10. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
11. All wire will be copper and meet the minimum wire size and insulation class listed below:

C. Control Power Wiring:

1. 120-volt AC circuits used for the Building Management System shall be taken from panel boards and circuit breakers provided by Division 16.
2. BMS power circuits shall be dedicated to the BMS devices and shall not be used for any other purposes.
3. BACnet DDC terminal unit controllers may use power from the equipment power circuits.
4. All NEC Class 1 (line voltage) wiring shall be UL Listed and installed approved conduit according to NEC and Division 16 requirements.
5. Control Power wiring must meet NEC; minimum 12 gauge, stranded, THHN
6. Control Power and Class One wiring may be run in the same conduit.
7. Control Power Wiring must be in ¾” EMT where concealed or exposed.
8. Where different wiring classes terminate within the same enclosure, maintain clearances and install barriers per the National Electric Code.

D. BMS Raceway

1. Conduit Raceway
   a. All conduit, wiring, accessories and wiring connections required for the installation of the Building Management System, as herein specified, shall be provided by the BMS Contractor (BMSC) unless specifically shown on the Electrical Drawings under Division 16 Electrical.
   b. All wiring shall be installed in conduit or raceway except as noted elsewhere in this specification.
   c. All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the surface to which they are attached.
   d. Include one pull string in each conduit 3/4 in. or larger.
   e. All wiring in mechanical, electrical, or service rooms—or where subject to mechanical damage—shall be installed in conduit.
   f. Conceal all conduit, except within mechanical, electrical, or service rooms.
   g. Conduit in finished areas shall be concealed in ceiling cavity spaces, plenums, furred spaces and wall construction.
h. Exposed conduit will run parallel to or at right angles to the building structure.
i. Install conduit to maintain a minimum clearance of 15 cm (6 in.) from high-temperature equipment (e.g., steam pipes or flues).
j. Class 2 and 3 wiring and communications wiring may be run in the same conduit.

2. Support:
   a. Secure conduit with conduit clamps fastened to the structure and spaced according to code requirements.
   b. Conduit and pull boxes shall not be hung on flexible duct strap or tie rods.
   c. Conduits shall not be run on or attached to ductwork

3. Couplings and Terminations:
   a. Conduit sections shall be joined with couplings (according to code).
   b. Conduit section terminations shall be made with fittings at boxes, as needed.
   c. Conduit section terminations not ending in boxes shall have bushings installed.

4. Class Separation
   a. Where different wiring classes terminate within the same enclosure, maintain clearances and install barriers per the National Electric Code.

5. Dry locations
   a. Set screw fittings are acceptable for dry interior locations.

6. Exterior & High Moisture Prone Locations
   a. Watertight compression fittings shall be used for exterior locations and interior locations subject to moisture.
   b. Provide conduit sealoff fitting where exterior conduits enter the building or between areas of high temperature/moisture differential.

7. Flexible metallic conduit:
   a. Flexible metallic conduit shall be used for connections to motors, actuators, controllers, and sensors mounted on vibration producing equipment.
   b. Flexible metal conduits shall not exceed 3 ft. in length and shall be supported at each end.
   c. Minimum Flexible metal conduit is ½ in.
d. Flexible Metal Conduit may be used within partition walls. Flexible Metal Conduit shall be UL listed.

e. Liquid-tight flexible conduit shall be used in exterior locations and interior locations subject to moisture, including chiller and boiler rooms, liquid-tight, flexible metal conduits shall be used.

8. Surface Raceway

a. Where it is not possible to conceal raceways in finished locations, surface raceway (Wiremold) may be used as approved by the Architect.

b. Metallic surface raceway may be used in finished areas on masonry walls. All surface raceway in finished areas must be color matched to the existing finish within the limitations of standard manufactured colors.

E. Conduit and Raceway Sizing:

1. The sizing, type and provision of conduit and raceways shall be the design responsibility of the BMS Contractor (BMSC).

2. If complications arise, however, due to the incorrect selection of cable, cable trays, raceways and/or conduit by the BMS Contractor (BMSC), the BMS Contractor (BMSC) shall be responsible for all costs incurred in replacing the selected components.

F. Expansion Joints

1. Adhere to this specification’s Division 16 requirement where conduit crosses building expansion joints.

G. Junction Boxes

1. Junction boxes shall be provided at all cable splices, equipment termination, and transitions from EMT to flexible conduit.

2. Interior dry location J-boxes shall be galvanized pressed steel, nominal four-inch square with blank cover.

3. Exterior and damp location JH-boxes shall be cast alloy FS boxes with threaded hubs and gasketed covers.

3.5 BMS CONTROL WIRING

A. Code Compliance

1. All wiring shall be installed in accordance with all applicable electrical codes and will comply with equipment manufacturer's recommendations. Should any discrepancy be found between wiring specifications in this
section and Division 16 Electrical sections, the stricter wiring requirements will prevail.

2. All wiring shall comply with the requirements of applicable portions of all local and national electric codes, unless specified otherwise in this section.

B. Wire Rating:

1. Where the space above the ceiling is a supply or return air plenum, the wiring shall be plenum rated. Teflon wiring can be run without conduit above suspended ceilings.
2. EXCEPTION: Any wire run in suspended ceilings that is used to monitor critical life safety systems or control critical equipment shall be in conduit.
3. Control wire shall be plenum rated stranded #18 gauge with minimum 300 VAC insulation. Input wiring shall be shielded & fire rated Teflon jacketed where concealed but accessible.

C. Installation:

1. Wires are to be kept a minimum of three (3) inches from hot water, steam, or condensate piping.
2. Wire will not be allowed to run across telephone equipment areas.
3. Where the wires leave the conduit system, they shall be protected by a plastic insert.
4. Wiring is to be run parallel along a surface or perpendicular to it and neatly tied at 10 ft. intervals.

D. Class 2 Wiring

1. All low-voltage wiring shall meet NEC Class 2 requirements. (Low-voltage power circuits shall be sub fused when required to meet Class 2 current limit.)
2. Class 2 signal wiring and 24 VAC power can be run in the same conduit.
3. Do not install Class 2 wiring in conduit containing Class 1 wiring or tubing.
4. Boxes and panels containing high voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).
5. Where Class 2 wires are in concealed and in accessible locations, including ceiling return air plenums, approved cables not in conduit may be used provided that cables are UL Listed for the intended application.

E. Cable Support

1. Plenum rated cable shall be supported from or anchored to structural members.
2. Cables shall not be supported by or anchored to ductwork, electrical conduits, piping, or ceiling suspension systems.
F. Wiring Device Terminations

1. All wire-to-device connections shall be made at a terminal block or wire nut.
2. All wire-to-wire connections shall be at a terminal strip or wire nut.
3. Exposed terminations shall not be acceptable.
4. Terminations shall be contained within either the device or local junction box.
5. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

G. No Splices:

1. All plenum rated wiring shall be installed as continuous lengths, with no splices permitted between termination points when that length is commercially available.
2. All wiring in conduit shall be installed as continuous lengths, with no splices permitted between termination points or junction boxes.

H. Grounding:

1. Provide for complete grounding of all applicable signal and communications cables, panels and equipment so as to ensure system integrity of operation.
2. Ground cabling and conduit at the panel terminations.
3. Avoid grounding loops.
4. Grounding of network wiring shall be in accordance with NEC regulations article on “Communications Circuits, Cable, and Protector Grounding.”
5. When a cable enters or exits a building, a lightning arrestor must be installed between the lines and ground.
6. The lightning arrestor shall be installed according to the manufacturer's instructions.

I. BACnet Communication Wiring

1. The contractor shall adhere to the items listed in the “BMS Wiring” article in Part 3 of the specification.
2. All cabling shall be installed in a neat and workmanlike manner.
3. Do not install communication wiring in conduit or raceway containing Class 1 or other Class 2 wiring.
4. The Maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.
5. The BMS Contractor (BMSC) shall verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.
J. BMS wire labeling:
   1. All communication wiring shall be labeled to indicate origination and destination data.
   2. Cable types specified shall be color coded for easy identification and troubleshooting

K. Wall and Floor Penetrations
   1. Provide fire stopping for all penetrations used by dedicated BMS conduits and raceways.
   2. All openings in fire proofed or fire stopped components shall be closed by using approved fire resistive sealant.
   3. All wiring passing through penetrations, including walls shall be in conduit or enclosed raceway.
   4. Penetrations of floor slabs shall be by core drilling. All penetrations shall be plumb, true, and square.

3.6 FIELD DEVICE INSTALLATION

A. Division 15 Mechanical Contractor
   1. The mechanical contractor shall install all mechanical devices i.e. control valves, dampers, temperature wells, pressure taps, airflow stations, etc....
   2. All Input devices shall be installed per the device manufacturer recommendation.
   3. Locate components of the BMS in accessible local control panels wherever possible.

B. BMS Enclosures
   1. The BMS panels shall be located as indicated at an elevation of not less than 2 feet from the bottom edge of the panel to the finished floor.
   2. Each cabinet shall be anchored per the manufacturer’s recommendations.
   3. The BMS Contractor (BMSC) shall be responsible for coordinating panel locations with other trades and electrical and mechanical contractors.

C. Relay outputs
   1. Transient suppression shall be provided across all coils. Suppression devices shall limit transients to 150% of the rated coil voltage.

D. Outside Air Sensors
   1. Sensors shall be mounted on the North wall to minimize solar radiant heat impact or located in a continuous intake flow adequate to monitor outside air conditions accurately.
2. Sensors shall be installed with a rain proof, perforated cover.

E. Space Sensors:

1. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above the floor or per ADA requirements.
2. Provide lockable tamper-proof covers in public areas and/or where indicated on the plans.

F. Low Temperature Limit Switches:

1. Install on the discharge side of the first water or steam coil in the air stream.
2. Mount element horizontally across duct in a serpentine pattern insuring each square foot of coil is protected by 1 foot of sensor.
3. For large duct areas where the sensing element does not provide full coverage of the air stream, provide additional switches as required to provide full protection of the air stream.

G. Control Output Devices

1. All output devices shall be installed per the manufacturer’s recommendation.
2. The mechanical contractor shall install all in-line devices such as control valves, dampers, airflow stations, pressure wells, etc.
3. Device, pilot positioners shall be installed to allow for proper sequencing.

3.7 PROJECT SITE CLEANING

A. Installation Debris

1. The BMS Contractor (BMSC) shall clean up all debris resulting from their activities daily. The contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.
2. At the completion of work in any area, the contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.
3. At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.8 COMPONENT IDENTIFICATION

A. Cables
1. Identify all control wires with labeling tape or sleeves using either words, letters, or numbers that can be exactly cross-referenced with as-built drawings.

B. Enclosures

1. All field enclosures, other than controllers, shall be identified with a bakelite nameplate. The lettering shall be in white against a black or blue background.

C. Junction Boxes

1. Junction box covers will be marked to indicate that they are a part of the BAS system.

D. Field Devices

1. All I/O field devices (except space sensors) that are not mounted within FIPs shall be identified with name plates.
2. All I/O field devices inside FIPs shall be labeled.

3.9 COMPONENT INSTALLATION LOCATIONS

A. Device Locations

1. The location of sensors is per mechanical and architectural drawings.

B. Space Sensors

1. Space humidity or temperature sensors will be mounted away from machinery generating heat, direct light and diffuser air streams.

C. Outside Air Conditions

1. Outdoor air sensors will be mounted on the northerly facing directly in the outside air.
2. Install these sensors such that the effects of heat radiated from the building or sunlight is minimized.

D. Enclosures

1. Field enclosures shall be located immediately adjacent to the controller panel(s) to which it is being interfaced.

3.10 BMS ACCEPTANCE:

A. Prior to acceptance
1. The BMS shall undergo a series of performance tests to verify operation and compliance with this specification. The tests described in this section are in addition to the installation, start-up, and debugging process BMS Contractor (BMSC) performs as a necessary part of the “Control System Checkout and Testing”

B. BMS Initial device checkout and testing

1. Upon completion of the control device installation, the BMS Contractor (BMSC) shall load all system software and start-up the system. The BMS Contractor (BMSC) shall perform all necessary calibration, testing and debugging and perform all required operational checks to insure that the system is functioning in full accordance with these specifications.
2. The Equipment Manufacturer shall provide separate startup services for the unit manufacturers BACnet controllers.

C. Expertise:

1. The BMS shall be set up and checked by factory trained competent technicians skilled in the setting and adjustment of the BMS equipment used in this project. These technicians are to be experienced in the type of HVAC systems associated with this project.
2. The BMS Contractor (BMSC) shall perform tests to verify proper performance of components, routines and points. Repeat tests until proper performance results. This testing shall include a point-by-point log to validate 100% of the input and output points of the DDC system operation.

D. Point-to-Point Checkout.

1. Each I/O device (both field mounted as well as those located in field interface panels) shall be inspected and verified for proper installation and functionality. A checkout sheet itemizing each device shall be filled out, dated and approved by the BMS Contractor (BMSC) for submission to the owner or owner’s representative.

E. Controller and Workstation Checkout.

1. A field checkout of all controllers and front end equipment (computers, printers, modems, etc.) shall be conducted to verify proper operation of both hardware and software. A checkout sheet itemizing each device and a description of the associated tests shall be prepared and submitted to the owner or owner’s representative by the completion of the project. All approved submitted sequences will be tested by the control contractor before acceptance testing described below.

F. Control Device Verification:
1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
5. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
6. Check temperature instruments and material and length of sensing elements.
7. Check control valves. Verify that they are in correct direction.
8. Check DDC system as follows:
   a. Verify that DDC controller power supply is from emergency power supply, if applicable.
   b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
   c. Verify that spare I/O capacity has been provided.
   d. Verify that DDC controllers are protected from power supply surges.
9. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

G. Control System Inputs and Outputs:

1. Check analog inputs at 0, 50, and 100 percent of span.
2. Check analog outputs using milli-ampere meter at 0, 50, and 100 percent output.
3. Check digital inputs using jumper wire.
4. Check digital outputs using ohmmeter to test for contact making or breaking.

H. Temperatures:

1. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
2. Calibrate temperature switches to make or break contacts.

I. Notification of Testing:

1. The engineer and owner shall be notified at least 10 days in advance of the start of the testing procedures. The engineer shall opt to be present to observe and review these tests.

J. Testing:

1. Acceptance Check Sheet
a. A check sheet shall include all points & functions of the BMS as indicated on the point list included in this specification.
b. Submit the check sheet to the Engineer for approval
c. The Engineer will use the check sheet as the basis for acceptance with the BMS Contractor (BMSC).

2. The BMS Contractor (BMSC) shall provide at least two trained persons equipped with two-way communication and shall demonstrate a percentage of the actual field operation of each control and sensing point for all modes of operation including:

3. Response Testing:

a. The purpose is to demonstrate to the owner expected response and action of the BMS.

1) “Day”, Night”, “Occupied”, “Unoccupied”
2) Fire/smoke alarm events
3) Seasonal changeovers
4) Power failure and restoration modes.

b. Additionally, the following items shall be demonstrated:

1) Control loop response.

   a) The BMS Contractor (BMSC) shall supply trend data output in a graphical form showing the step response of each control loop.
   b) The test shall show the loop’s response to a change in set point, which represents a change of actuator position of at least 25% of its full range.
   c) The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop.
   d) The trend data shall show for each sample the set point, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control shall require further tuning by the Contractor.

2) Demand Limiting (if applied)

   a) The BMS Contractor (BMSC) shall supply a trend data output showing the action of the demand-limiting algorithm.
   b) The data shall document the action on a minute-by-minute basis over at least a 30-minute period. Included in the trend shall be building kW, demand limiting set point, and the status of sheddable equipment outputs.
3) Optimum Start/Stop.
   a) The BMS Contractor (BMSC) shall supply a trend data output showing the capability of the algorithm.
   b) The change-of value trends shall include the output status of all optimally started and stopped equipment, as well as temperature sensor inputs of affected areas.

4) Interface to the Building’s fire alarm system.

4. Operational Test:
   a. After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
   b. Test and adjust controls and safeties.
   c. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
   d. Test each point through its full operating range to verify that safety and operating control set points are as required.
   e. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
   f. Test each system for compliance with sequence of operation.
   g. Test software and hardware interlocks.

5. Retesting
   a. Any tests that fail to demonstrate the operation of the system shall be repeated at a later date. The contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.

K. BMS Acceptance

1. The BMS acceptance shall be contingent upon completion and review of all corrected deficiencies. The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved as required in Part 1, “Submittals.”

2. All application software will be verified and compared against the sequences of operation. Control loops will be exercised by inducing a setpoint shift of at least 10% and observing whether the system successfully returns the process variable to setpoint. Record all test results and attach to the Test Results Sheet.

3. Test each alarm in the system and validate that the system generates the appropriate alarm message, that the message appears at all prescribed destinations (workstations or printers), and that any other related actions
occur as defined (i.e. graphic panels are invoked, reports are generated, etc.). Submit a Test Results Sheet to the owner.

4. Perform an operational test of each unique graphic display and report to verify that the item exists, that the appearance and content are correct, and that any special features work as intended. Submit a Test Results Sheet to the owner.

5. Perform an operational test of each third party interface that has been included as part of the automation system. Verify that all points are properly polled, that alarms have been configured, and that any associated graphics and reports have been completed. If the interface involves a file transfer over Ethernet, test any logic that controls the transmission of the file, and verify the content of the specified information.

6. At the completion of the Acceptance Testing, this BMS Contractor (BMSC) shall demonstrate the sequence of operations for each system to the Architect or his representative.

7. All tests described in this specification shall have been performed to the satisfaction of both the engineer and owner prior to the acceptance of the control system as meeting the requirements of completion. Any tests that cannot be performed due to circumstances beyond the control of the contractor may be exempt from the completion requirements if stated as such in writing by the engineer. Such tests shall then be performed as part of the warranty.

### 3.11 OWNER OPERATOR TRAINING:

A. Initial Training

1. During system commissioning and at such time acceptable performance of the Building Management System hardware and software has been established, the BMS Contractor (BMSC) shall provide on-site operator instruction to the owner's operating personnel.

2. Operator instruction shall be done during normal working hours and shall be performed by a competent representative familiar with the system hardware, software and accessories.

B. Training Sessions:

1. The BMS Contractor (BMSC) shall provide 8 total hours of comprehensive training in multiple sessions for system orientation, product maintenance and troubleshooting, programming and engineering.

C. Training Personnel:

1. A factory-authorized service representative shall provide training to the Owner's personnel. The training shall include instruction of the owners’ designated personnel on the operation and maintenance of the entire BMS.
2. This orientation shall, at a minimum, consist of:

   a. A review of the project as-built drawings
   b. The BMS software layout and naming conventions
   c. A walk-through of the facility to identify panel and device locations

3.12 WARRANTY PERIOD SERVICES AND COVERAGE

A. Warranty Period (Labor and Materials)

   1. Equipment, materials and workmanship incorporated into the work shall be warranted for a period of two year from the time of system acceptance.

B. Remote Connectivity:

   1. The Owner shall provide all TCP/IP services and connections for remote site access for the BMS Contractor (BMSC) to perform warranty response work.
   2. This connection shall be maintained throughout the warranty period at the Owner’s cost. The BMS Contractor (BMSC) shall identify the specific connection requirements in a shop drawing submittal.
   3. This requirement provides several functions including remote alarm notifications, remote connectivity for both the owner and BMS Contractor (BMSC)’s response. Failure of the owner to provide this remote connectivity will relieve the BMS Contractor (BMSC) of the initial response times.

C. BMS System Access:

   1. The owner shall grant the BMS Contractor (BMSC) reasonable access to the BMS during the warranty period.
   2. Remote access to the BMS (for the purpose of diagnostics and troubleshooting, via the Internet, during the warranty period) will be allowed.

D. Warranty Repair &/or replacement:

   1. Within this period, upon notice by the Owner, any defects in the BMS due to faulty materials, methods of installation or workmanship shall be promptly repaired or replaced by the BMS Contractor (BMSC) at no expense to the Owner.

E. Final Adjustments:

   1. When requested by the owner within the warranty period, the BMS Contractor (BMSC) shall provide remote seasonal adjustments to the system to suit actual conditions.
END OF SECTION 15900
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
   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 contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" 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 Contractor Qualifications: Engage a TAB entity certified by AABC, NEBB or TABB.
   1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC, NEBB or TABB.
   2. TAB Technician: Employee of the TAB contractor and who is certified by AABC, NEBB or TABB as a TAB technician.

B. TAB Conference: Meet with 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:
      b. The TAB plan.
      c. Coordination and cooperation of trades and subcontractors.
      d. Coordination of documentation and communication flow.

C. Certify TAB field data reports and perform the following:
   1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

D. TAB Report Forms: Use standard TAB contractor's forms approved by 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 contractors 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 Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

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

E. Examine 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 contract documents, existing conditions, and as-built conditions pertaining to the HVAC systems.

D. Mechanical Contractor 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.


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 Contract Documents.

2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.7 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum-airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan.
Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
3. Measure total system airflow. Adjust to within indicated airflow.
4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
   a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
   a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.
7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
8. Record final fan-performance data.

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.
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.

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 Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: Prepare 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 contractor.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:
   a. Indicated versus final performance.
   b. Notable characteristics of systems.
   c. Description of system operation sequence if it varies from the Contract Documents.
12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:
   a. Settings for outdoor-, return-, and exhaust-air dampers.
   b. Conditions of filters.
   c. Cooling coil, wet- and dry-bulb conditions.
   d. Face and bypass damper settings at coils.
   e. Fan drive settings including settings and percentage of maximum pitch diameter.
   f. Inlet vane settings for variable-air-volume systems.
   g. Settings for supply-air, static-pressure controller.
   h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.

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 Contract Documents in the final report.

B. Final Inspection:

1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Owner, Construction Manager, or Commissioning Authority.

2. The TAB contractor'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 contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.
D. Prepare test and inspection reports.

3.21 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
SECTION 15993 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes control sequences for HVAC systems, subsystems, & equipment.

B. Related Sections include the following:
   1. Section “Instrumentation & Control for HVAC” for control equipment, devices & for submittal requirements.
   2. ATC diagrams for Unit configuration, ATC 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 ATC Contractor and to be interfaced to the associated work of other related trades.

E. ATC Contractor (ATC): 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 ATC 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 ATC 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. ATC Network: The total digital on-line real-time interconnected configuration of ATC 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. ATC Integration: The complete functional and operational interconnection and interfacing of all ATC work elements and nodes in compliance with all applicable codes, standards and ordinances so as to provide a single coherent ATC 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 ATC Contractor’s cost to the designated third party trade contractor for installation. ATC Contractor shall connect furnished items to the ATC, 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 ATC 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 ATC 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 ATC industry for real-time, on-line, integrated ATC 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. Abbreviations:

1. The following abbreviations and acronyms may be used in describing the work of this Division, Additional acronyms shall be declared throughout the specifications:

2. Organization and project entities

   a. ASHRAE - American Society of Heating, Refrig. & Air Cond. Engineers
   b. ATC - Division 15 Automatic Temperature Controls Contractor
   c. EC - Division 16 Electrical Contractor
   d. GC - General Contractor
   e. MC - Division 15 Mechanical Contractor
   f. UM - Unit Manufacturer, Equipment

3. 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. AI / AO - Analog Input / Analog Output
   d. CI / CO - Configurable Input / Configurable Output
   e. DI / DO - Digital Input / Digital Output
   f. DDC - Direct Digital Control
   g. I/O - Input/Output point
   h. NO / NC - Normally Open / Normally Closed
   i. SR/NSR - Spring Returned / Non-Spring Returned

4. 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 - Random Access Memory
   g. TCP/IP - Transmission Control Protocol/Internet Protocol
   h. UPS - Uninterruptible Power Supply
5. Major HVAC Equipment Abbreviations
   a. AC/ACCU - Air Conditioning Unit/ Air Cooled Condensing Unit
   b. BB / FTR - Baseboard Radiation / Fintube Radiation

6. Ancillary HVAC Equipment Abbreviations
   a. EDH - Electric Duct Heater
   b. EF - Exhaust Fan
   c. HP - Heat Pump
   d. RP - Radiant Panel
   e. UH/CUH - Unit Heater / Cabinet Unit Heater

7. Field Devices Abbreviations
   a. CT/CS - Current transducer/ Current Switch
   b. F/SD - Fire/Smoke Damper
   c. ES - End-Switch
   d. LDS - Liquid Detection Switch
   e. LCD / LED - Liquid Crystal Display / Light Emitting Diode
   f. M - Actuator Operated Damper
   g. MS / VFD - Motor Starter / Variable Frequency Drive
   h. OCC - Occupancy Sensor
   i. PDT - Pressure Differential Transducer
   j. PDS - Pressure Differential Switch
   k. R - Control Pilot Relay
   l. SD - Smoke Detector or Smoke Damper
   m. SPDT / SPST - Single Pole Double Throw / Single Pole Single Throw
   n. SW - Switch
   o. T/TS - Temperature / Temperature Sensor
   p. TC - Thermostat switch

8. Project delineation and information Abbreviations
   a. NIC / FBO - Not In Contract / Furnished by Others
   b. TBA/TBD - To Be Advised / To Be Determined

9. 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 & ATC DIAGRAMS

A. Project ATC Diagrams

1. The Sequences of Operations detailed below are predicated on the specific Project ATC diagrams.
2. Reference the ATC Diagrams for the Unit configuration, ATC 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 (ATC).

1.5 RESPONSIBILITIES

A. Automatic Temperature Control (ATC) Contractor's Responsibilities:

1. The ATC contractor (ATC) shall provide, field install & wire all necessary software & hardware, wiring, & computing equipment in compliance with this specification. The ATC contractor shall also provide programming, interface design, startup services by competent technicians that regularly employed by the ATC contractor with full responsibility for proper operation of the control system including debugging & proper calibration of each component in the entire system
2. The ATC contractor (ATC) shall provide low voltage (24V and under) 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 ATC contractor (ATC) to provide a fully coordinated & operational Automatic Temperature Controls system
2. Refer to this & the specific equipment specifications & schedules for devices provided, installed & wired by the HVAC equipment Unit manufacturers (UM) & those by the ATC contactor (ATC).

C. Equipment Unit Manufacturer (UM) Responsibilities

1. The Equipment Unit Manufacturer (UM) shall provide the equipment and field labor to meet the sequence requirements of this specification & schedules sections. Factory provided technician shall provide unit/BMS start-up and coordinate with the ATC contractor for full integration into the building automation system.

2. The Equipment Unit Manufacturer (UM) shall provide factory installation & wiring of the ATC provided controls, when specified to be factory installed.

1.6 ENERGY RECOVERY UNITS- (ERU-2, ERU-6) - [SERVES: VAV BOXES]

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 Schneider Electric EcoStruxure 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. “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.

E. “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 Communications) 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.).

F. Supply Fan and Exhaust Fan Variable Frequency Drives (VFDs)

1. During Normal Operations:
   a. The Supply Fan VFD shall run to maintain the duct static pressure set point of 1.5”w.c. (adj.).
   b. The associated VAV boxes downstream shall maintain the minimum CFM set point (see mechanical schedule).
   c. The associated remote exhaust damper shall open to maintain the same minimum CFM set point as the associated VAV box. (CFM set point determined by the air balancer).
   d. Exhaust fans are direct drive electrically commutated motor(s) (ECM). Powered exhaust control options are as follows:
      1) 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.
      2) Speed Control: The exhaust fan(s) will run at a constant speed.
      3) Network Control: Exhaust fan speed is commanded from the building automation system.
      4) 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.

2. During High Carbon Dioxide Levels:
   a. (As detected by VAV carbon dioxide space sensor) The associated VAV box shall modulate open to allow more outside air into the space.
   b. The associated ERU unit shall speed up the supply fan to maintain the duct static pressure set point.
   c. Exhaust fans are direct drive electrically commutated motor(s) (ECM). Powered exhaust control options are as follows:
      1) 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.
atmospheric pressure. The exhaust fan(s) shall modulate to maintain the building pressure set point.

2) Speed Control: The exhaust fan(s) will run at a constant speed.

3) Network Control: Exhaust fan speed is commanded from the building automation system.

4) 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.

G. 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 Rebel 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 both cooling and dehumidification or a call for dehumidification only. 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. Rebel’s 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.

H. 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.

I. 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.

J. 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

K. 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.).

L. Operator & Graphical User Interface requirements
1. The ATC Control Diagrams & the table below shall provide for Operator Control of the HVAC equipment:

<table>
<thead>
<tr>
<th>Energy Recovery Unit(s) ERU-2, ERU-6</th>
<th>I/O Points</th>
<th>Software Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point Name/Description/Legend</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X = DDC I/O L=Local Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A = Adjustable O = Override</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply Fan Start/Stop (SFSS)</td>
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<td>X</td>
</tr>
<tr>
<td>Supply Fan VFD Signal (SFS)</td>
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<td></td>
</tr>
<tr>
<td>Supply Fan VFD Alarm Status (SFAS)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Supply Fan Status (SFCS)</td>
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<tr>
<td>Exhaust Fan Start/Stop (EFSS)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Exhaust Fan VFD Signal (EFS)</td>
<td>X</td>
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</tr>
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<td>Exhaust Fan VFD Alarm Status (EFAS)</td>
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<td></td>
</tr>
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<td>Exhaust Fan Status (EFCS)</td>
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<tr>
<td>Discharge Air Temperature (DAT)</td>
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<td>Outside Air Damper (OAD)</td>
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<tr>
<td>Discharge Air Temp. Setpoint (DASP)</td>
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</tr>
<tr>
<td>Alarm Reset</td>
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<td>X X X X</td>
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<tr>
<td>Fan Failure (FANFAIL)</td>
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<td>X X X On</td>
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<tr>
<td>Fan in Hand (FANHAND)</td>
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<td>X X ON</td>
</tr>
<tr>
<td>Discharge Temp High Alarm (DATHI)</td>
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<td>A X &gt;110°F</td>
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<tr>
<td>Discharge Temp Low Alarm (DATLO)</td>
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<td>A X &lt;55°F</td>
</tr>
<tr>
<td>Heating Failure (HEATFAIL)</td>
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<td>A X On</td>
</tr>
<tr>
<td>Gas Heating Coil Enable/Disable (HED)</td>
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</tr>
<tr>
<td>Gas Heating Control Signal (GHCS)</td>
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</tr>
<tr>
<td>DX Cooling Enable/Disable (DXED)</td>
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</tr>
<tr>
<td>DX Cooling Control Signal (DXCS)</td>
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<td></td>
</tr>
<tr>
<td>Hot Gas Reheat Enable/Disable (HGRHED)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Hot Gas Reheat Control Signal (HGRHCS)</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
1.7 ENERGY RECOVERY UNITS- (ERU-5) (SERVES VRV SYSTEM)

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 Schneider Electric EcoStruxure 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. “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.

E. “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 Communications) 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) setpoint (DATSP) of 64°F (adj.).

F. Supply Fan and Exhaust Fan Variable Frequency Drives (VFDs)

1. During Normal Operations:
a. The Supply Fan VFD shall run to maintain the duct static pressure set
point of 1.5”w.c. (adj.).
b. The associated VAV boxes downstream shall maintain the minimum
CFM setpoint (see mechanical schedule).
c. The associated remote exhaust damper shall open to maintain the
same minimum CFM setpoint as the associated VAV box. (CFM set
point determined by the air balancer).
d. Exhaust fans are direct drive electrically commutated motor(s) (ECM).
 Powered exhaust control options are as follows:
   1) 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 setpoint.
   2) Speed Control: The exhaust fan(s) will run at a constant speed.
   3) Network Control: Exhaust fan speed is commanded from the
       building automation system.
   4) 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.

G. 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 Rebel 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 both cooling and
dehumidification or a call for dehumidification only. 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. Rebel’s 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.

H. 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.

I. 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.
J. 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

K. 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.).

L. Operator & Graphical User Interface requirements
   1. The ATC Control Diagrams & the table below shall provide for Operator Control of the HVAC equipment:

<table>
<thead>
<tr>
<th>Energy Recovery Unit(s) ERU-5</th>
<th>I/O Points</th>
<th>Software Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point Name/Description/Legend</td>
<td>A</td>
<td>AO</td>
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<tr>
<td>X = DDC I/O L=Local Control</td>
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<tr>
<td>A = Adjustable O = Override</td>
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<td>Supply Fan Start/Stop (SFSS)</td>
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<td>Supply Status (SFCS)</td>
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<td>Outside Air Damper (OAD)</td>
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<td>Exhaust Air Damper (EAD)</td>
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<td>Fan in Hand (FANHAND)</td>
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<td>X</td>
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</tr>
<tr>
<td>Discharge Temp Low Alarm (DATLO)</td>
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<td>A</td>
</tr>
<tr>
<td>Heating Failure (HEATFAIL)</td>
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<td>A</td>
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<tr>
<td>Gas Heating Coil Enable/Disable (HED)</td>
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<td>Gas Heating Control Signal (GHCS)</td>
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<td>DX Cooling Enable/Disable (DXED)</td>
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<tr>
<td>DX Cooling Control Signal (DXCS)</td>
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<tr>
<td>Leak Detector (LD)</td>
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</tr>
</tbody>
</table>

1.8 ENERGY RECOVERY UNITS- (ERU-1)

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 Schneider Electric EcoStruxure 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. “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.

E. “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 Communications) 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.).

F. Supply Fan and Exhaust Fan Variable Frequency Drives (VFDs)
1. During Normal Operations:
   a. The Supply Fan VFD shall run to maintain the duct static pressure set point of 1.5”w.c. (adj.).
   b. The associated VAV boxes downstream shall maintain the minimum CFM set point (see mechanical schedule).
   c. The associated remote exhaust damper shall open to maintain the same minimum CFM set point as the associated VAV box. (CFM set point determined by the air balancer).
   d. Exhaust fans are direct drive electrically commutated motor(s) (ECM). Powered exhaust control options are as follows:
      1) 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.
2) **Speed Control:** The exhaust fan(s) will run at a constant speed.
3) **Network Control:** Exhaust fan speed is commanded from the building automation system.
4) **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.

---

**G. 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 Rebel 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 both cooling and dehumidification or a call for dehumidification only. 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. Rebel’s 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.

H. 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.

I. 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.

J. 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

K. 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.).

L. Operator & Graphical User Interface requirements
1. The ATC Control Diagrams & the table below shall provide for Operator Control of the HVAC equipment:

<table>
<thead>
<tr>
<th>Energy Recovery Unit(s) ERU-1</th>
<th>I/O Points</th>
<th>Software Point</th>
<th>Initial-Alarm Setting</th>
</tr>
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<tbody>
<tr>
<td>Point Name/Description/Legend</td>
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<tr>
<td>X = DDC I/O L=Local Control</td>
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<tr>
<td>A = Adjustable O = Override</td>
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</tr>
<tr>
<td>Supply Fan Start/Stop (SFSS)</td>
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</tr>
<tr>
<td>Supply Fan VFD Signal (SFS)</td>
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<td>Supply Fan VFD Alarm Status</td>
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<td>(SFAS)</td>
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<td>Supply Fan Status (SFCS)</td>
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<td>Exhaust Fan Start/Stop (EFSS)</td>
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<td>Exhaust Air Damper (EAD)</td>
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</tr>
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<td>(Seq.)</td>
</tr>
<tr>
<td>(DASP)</td>
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</tr>
<tr>
<td>Alarm Reset</td>
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<td>X</td>
<td>X X X X</td>
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<td>Fan Failure (FANFAIL)</td>
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<td>Gas Heating Coil Enable/Disable(HED)</td>
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<td>Gas Heating Control Signal (GHCS)</td>
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<td>Return Air Temp. (RAT)</td>
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</table>
1.9 ENERGY RECOVERY UNITS- (ERU-3 AND ERU-4) - [SERVES: VAV BOXES WITH PURGE MODE]

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 Schneider Electric EcoStruxure 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. “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.

E. “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 Communications) 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.).

F. Supply Fan and Exhaust Fan Variable Frequency Drives (VFDs)

1. During Normal Operations:
   a. The Supply Fan VFD shall run to maintain the duct static pressure set point of 1.5”w.c. (adj.).
   b. The associated VAV boxes downstream shall maintain the minimum CFM set point (see mechanical schedule).
   c. The associated remote exhaust damper shall open to maintain the same minimum CFM set point as the associated VAV box. (CFM set point determined by the air balancer).
   d. The Exhaust Fan VFD shall track the Supply Fan VFD speed.

2. During High Carbon Dioxide Levels:
   a. (As detected by VAV carbon dioxide space sensor) The associated VAV box shall modulate open to allow more outside air into the space.
   b. The associated ERU unit shall speed up the supply fan to maintain the duct static pressure set point.
   c. 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.

3. During Purge Mode
   a. Once a “Purge” Button is pressed the associated VAV box damper shall open to the maximum position to provide the maximum CFM. (20 mins. adjustable).
   b. The associated remote exhaust air damper shall open to the maximum position.
c. The ERU Supply Fan VFD shall run to maintain the duct static pressure set point of 1.5”w.c. (adj.)
d. 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.

G. 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 Rebel 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 both cooling and dehumidification or a call for dehumidification only. 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. Rebel’s 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.

H. **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.

I. **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.

J. **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

K. **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.).

L. Operator & Graphical User Interface requirements

1. The ATC Control Diagrams & the table below shall provide for Operator Control of the HVAC equipment:

<table>
<thead>
<tr>
<th>Energy Recovery Unit(s) ERU-3 and ERU-4 I/O Points</th>
<th>Software Point</th>
<th>Initial-Alarm Setting</th>
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<tbody>
<tr>
<td>Point Name/Description/Legend</td>
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<tr>
<td>X = DDC I/O L=Local Control</td>
<td></td>
<td></td>
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<tr>
<td>A = Adjustable O = Override</td>
<td></td>
<td></td>
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<tr>
<td>Supply Fan Start/Stop (SFSS)</td>
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<td>X</td>
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<tr>
<td>Supply Fan VFD Signal (SFS)</td>
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<td>Supply Fan VFD Alarm Status (SFAS)</td>
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<td>Supply Fan Status (SFCS)</td>
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<td>Exhaust Fan Start/Stop (EFSS)</td>
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<td>Exhaust Fan VFD Signal (EFS)</td>
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<td>Exhaust Fan VFD Alarm Status (EFAS)</td>
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<td>Discharge Air Temperature (DAT)</td>
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<tr>
<td>Discharge Temp Low Alarm (DATLO)</td>
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<td>A X &lt;55°F</td>
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<td>Heating Failure (HEATFAIL)</td>
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<td>Gas Heating Coil Enable/Disable (HED)</td>
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<td>Gas Heating Control Signal (GHCS)</td>
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<td>DX Cooling Enable/Disable (DXED)</td>
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<td>DX Cooling Control Signal (DXCS)</td>
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<td>Hot Gas Reheat Enable/Disable (HGRHED)</td>
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<td>Energy Recovery Wheel Enable/Disable (ERWED)</td>
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<tr>
<td>Leak Detector (LD)</td>
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</tbody>
</table>

1.10 VARIABLE AIR VOLUME ROOFTOP UNIT (RTU-1)-[SERVES: VAV BOXES]

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. “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.

F. “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 & FVAV 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 & FVAV 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 (OAMINS) & 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 (OAMINS); 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.

G. **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 Rebel 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 both cooling and dehumidification or a call for dehumidification only. 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. Rebel’s 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.

H. 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.

I. Leak Detection
   1. A Condensate Pan switch shall provide an alarm to the BMS when there is liquid detected in the drain pan.
J. 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

K. 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.).

L. Operator & Graphical User Interface requirements
1. The ATC Control Diagrams & the table below shall provide for Operator Control of the HVAC equipment:

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<thead>
<tr>
<th>Rooftop Unit (RTU-1, RTU-2 and RTU-3)</th>
<th>I/O Points</th>
<th>Software Point</th>
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<tbody>
<tr>
<td>Point Name/Description/Legend</td>
<td>Al AO BI BO AV BV Schedule Trend Alarm GUI</td>
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<tr>
<td>X = DDC I/O L=Local Control</td>
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<td>A = Adjustable O = Override</td>
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<tr>
<td>BACnet Communications Interface</td>
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<tr>
<td>Points</td>
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<td>Supply Fan Status (SFCS)</td>
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<td>Direct eXpansion Stages (CLG#)</td>
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<td>Gas Heating (HTG#)</td>
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</tr>
<tr>
<td>Discharge Air Temperature (DAT)</td>
<td>X</td>
<td>X X X X</td>
</tr>
</tbody>
</table>

Initial-Alarm Setting

| Mixed Air Temperature (MAT) | X | X | X | X | X |
| Return Air Temperature (RAT) | X | X | X | X | X |
| Return Air Humidity (RAH) | X | X | X | X | X |
| Return Air Damper (RAD) | X | X | X | X | X |
| Outside Air Damper (OAD) | X | X | X | X | X |
| Filter (FLTR) | X | X | X | X | X |
| Smoke Detector (SD) | X | 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 Position (OAMINSP) | X | X | by Bal |
| Alarm Reset | X | X | X | X | X |
| Fan Failure (FANFAIL) | X | 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 | X |

1.11 VARIABLE AIR VOLUME BOXES (HOT WATER REHEAT)

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 ATC Contractor shall provide the BACnet DDC controllers and sensing devices. The Unit Manufacturer (UM) shall factory mount the ATC contractor’s DDC controllers/actuators.
3. The Mechanical contractor (MC) shall provide coordination between the Unit Manufacturer (UM) & the ATC contractor (ATC).
4. The following sequence of operations shall be the responsibility of the ATC Contractor (ATC).

C. Scheduling

1. The schedule shall be communicated to the Schneider Electric EcoStruxure BACnet IP DDC controller as established in the GUI.

D. “Unoccupied” Mode:

1. During the unoccupied heating mode, the VAV box damper heating control valve shall remain under control to maintain the unoccupied heating space temperature set point of 60°F (adj.). The VAV box damper shall modulate closed to its minimum airflow (CFM) position as required.

2. During the unoccupied cooling mode, the VAV box damper shall modulate open from its minimum airflow (CFM) position to its maximum airflow (CFM) position as required to maintain the unoccupied cooling space temperature set point of 80°F (adj.). The VAV box heating control valve shall remain closed.

E. “Occupied” Mode:

1. During the occupied heating mode, on a drop in space temperature, the VAV box damper shall modulate closed from its maximum airflow (CFM) position to its minimum airflow (CFM) position as required to maintain the space temperature set point of 72°F (adj.). When the VAV box damper has reached its minimum airflow (CFM) position and the space temperature continues to dall then the VAV box heating control valve shall modulate to maintain the space temperature set point. As the space temperature begins to rise the reverse shall occur.

2. During the occupied cooling mode, on a rise in space temperature, the VAV box damper shall modulate open from its minimum airflow (CFM) position to its maximum airflow (CFM) position as required to maintain the space temperature. The VAV box heating control valve shall remain closed.
F. "Occupied High Carbon Dioxide Level" Mode:

1. During the occupied high carbon dioxide mode of operations the VAV shall modulate open to provide more conditioned outside air into the space. The associated remote exhaust damper shall open to track the associated VAV box damper position.

2. Once the carbon dioxide level is below set point of 900 ppm (adj.), the VAV box and the associated remote exhaust damper shall revert back to the occupied normal operations.

G. Alarms & Safeties Monitoring:

1. High Space Carbon Dioxide Levels (HCO2L): An alarm shall be generated when the space carbon dioxide levels are above 900ppm (adj.).

2. Hi/Low Discharge Air Temp: When the Discharge Air Temperature (DAT) is > 120 °F (adj.) < 50 °F (adj.).

3. Hi/Low Space Air Temp: When the Space Temperature (TS) is > 85 °F (adj.) < 55 °F (adj.).

H. Operator & Graphical User Interface requirements

1. The ATC Control Diagrams & the table below shall provide for Operator Control of the HVAC equipment:

<table>
<thead>
<tr>
<th>VAV Boxes-with Hot Water Reheat</th>
<th>I/O Points</th>
<th>Software Point</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AI</td>
<td>AO</td>
</tr>
<tr>
<td>Discharge Air Temperature (DAT)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Space Temperature (TS)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>VAV Box Damper Position (VAVDP)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Supply Air CFM (SACFM)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Carbon Dioxide Levels (CO2)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>VAV Box Damper Command (VAVDC)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Hot Water Control Valve (HWV)</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

1.12 VARIABLE AIR VOLUME BOXES-[SERVES: VRV HEAT PUMPS]

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 ATC Contractor shall provide the BACnet DDC controllers and sensing devices. The Unit Manufacturer (UM) shall factory mount the ATC contractor’s DDC controllers/actuators.
3. The Mechanical contractor (MC) shall provide coordination between the Unit Manufacturer (UM) & the ATC contractor (ATC).
4. The following sequence of operations shall be the responsibility of the ATC Contractor (ATC).

C. Scheduling

1. The schedule shall be communicated to the Schneider Electric BACnet IP DDC controller as established in the GUI.

D. “Unoccupied” Mode:

1. During the unoccupied mode, the VAV box damper shall be in the normally closed position.

E. “Occupied Normal” Mode:

1. During the occupied normal mode of operations the VAV shall open to the minimum CFM position (see mechanical schedule).
2. The associated remote exhaust damper shall open to the minimum CFM position.

F. “Occupied High Carbon Dioxide Level” Mode:

1. During the occupied high carbon dioxide mode of operations the VAV shall modulate open to provide more conditioned outside air into the space. The associated remote exhaust damper shall open to track the associated VAV box damper position.
2. Once the carbon dioxide level is below set point of 900 ppm (adj.), the VAV box and the associated remote exhaust damper shall revert back to the occupied normal operations.

G. “Occupied Purge” Mode:

1. A pushbutton shall enable the occupied purge mode.
2. During the occupied purge mode of operations, the associated VAV box and remote exhaust damper shall modulate open to the maximum CFM position.
3. The associated Energy Recovery Unit shall modulate its supply fan VFD to maintain a duct static pressure set point of 1.5"w.c.

4. The occupied purge mode of operations shall be energized for 20 mins. (adj.) and there shall be (6) incremented speed changes to the associated supply fan VFD. Once the 20 mins. (adj.) has expired; the VAV box and associated remote exhaust damper shall revert back to the occupied normal mode of operations.

H. Alarms & Safeties Monitoring:
1. High Space Carbon Dioxide Levels (HCO2L): An alarm shall be generated when the space carbon dioxide levels are above 900ppm (adj.).
2. Hi/Low Discharge Air Temp: When the Discharge Air Temperature (DAT) is > 120 °F (adj.) < 50 °F (adj.).
3. Hi/Low Space Air Temp: When the Space Temperature (TS) is > 85 °F (adj.) < 55 °F (adj.).

I. Operator & Graphical User Interface requirements

1. The ATC Control Diagrams & the table below shall provide for Operator Control of the HVAC equipment:

<table>
<thead>
<tr>
<th>VAV Boxes</th>
<th>I/O Points</th>
<th>Software Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point Name/Description/Legend</td>
<td>AI</td>
<td>AO</td>
</tr>
<tr>
<td>X = DDC I/O L=Local Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A = Adjustable O = Override</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discharge Air Temperature (DAT)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Space Temperature (TS)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>VAV Box Damper Position (VAVDP)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Supply Air CFM (SACFM)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Carbon Dioxide Levels (CO2)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>VAV Box Damper Command (VAVDC)</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

1.13 REMOTE EXHAUST DAMPERS

A. Reference the ATC diagrams for Unit configuration, ATC devices, point types & locations

B. Coordination:

1. The ATC Contractor (ATC) shall provide the remote exhaust dampers and damper actuators.
2. The ATC Contractor shall provide the BACnet DDC controllers and sensing devices.
3. The Mechanical contractor (MC) shall install the remote exhaust dampers provided by the ATC contractor (ATC).
4. The following sequence of operations shall be the responsibility of the ATC Contractor (ATC).

C. Scheduling

1. The schedule shall be communicated to the Schneider Electric EcoStruxure BACnet IP DDC controller as established in the GUI.

D. “Unoccupied” Mode:
1. During the unoccupied mode, the remote exhaust damper shall be in the normally closed position.

E. “Occupied Normal” Mode:
1. During the occupied normal mode of operations the remote exhaust damper shall open to the minimum CFM position. (Track VAV damper position).

F. “Occupied High Carbon Dioxide Level” Mode:
1. During the occupied high carbon dioxide mode of operations, the associated remote exhaust damper shall open to track the associated VAV box damper position
2. Once the carbon dioxide level is below set point of 900 ppm (adj.), the VAV box and the associated remote exhaust damper shall revert back to the occupied normal operations.

G. “Occupied Purge” Mode:
1. A pushbutton shall enable the occupied purge mode.
2. During the occupied purge mode of operations, the associated remote exhaust damper shall modulate open to the maximum CFM position.
3. The occupied purge mode of operations shall be energized for 20 mins. (adj.) and there shall be (6) incremented speed changes to the associated supply fan VFD. Once the 20 mins. (adj.) has expired; the VAV box and associated remote exhaust damper shall revert back to the occupied normal mode of operations.

H. The ATC Contractor shall provide an Airflow Station to monitor the exhaust CFM leaving each room.

I. Operator & Graphical User Interface requirements
1. The ATC Control Diagrams & the table below shall provide for Operator Control of the HVAC equipment:

<table>
<thead>
<tr>
<th>Remote Exhaust Damper</th>
<th>I/O Points</th>
<th>Software Point</th>
<th>Initial-Alarm Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point Name/Description/Legend</td>
<td>X = DDC I/O L=Local Control A = Adjustable O = Override</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remote Exhaust Damper Command (REDC)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remote Exhaust Damper Position (REDP)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exhaust Air CFM (EACFM)</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

1.14 VARIABLE REFRIGERANT VOLUME-VRV HEAT PUMPS

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 Schneider Electric EcoStruxure BACnet IP DDC controller as established in the GUI.

D. “Unoccupied” Mode:

1. During the unoccupied mode, the VRV Heat Pump supply fan shall be de-energized.
2. “Unoccupied Cooling” Mode:
   a. Once the space temperature is above the unoccupied cooling temperature set point of 85°F (adj.), the supply fan shall be energized and the VRV coil shall be set to cooling to maintain the unoccupied cooling set point.
3. “Unoccupied Heating” Mode:
   a. Once the space temperature is below the unoccupied heating temperature set point of 60°F (adj.), the supply fan shall be energized and the VRV coil shall be set to heating to maintain the unoccupied heating set point.

E. “Occupied” Mode:
   1. During the occupied mode of operations, the VRV Heat Pump supply fan shall be energized to run continuously.
   2. “Occupied Cooling” Mode:
      a. Once the space temperature is above the occupied cooling temperature set point of 75°F (adj.), the VRV coil shall be set to cooling to maintain the space temperature set point of 75°F (adj.).
   3. “Occupied Heating” Mode:
      a. Once the space temperature is above the occupied heating temperature set point of 70°F (adj.), the VRV coil shall be set to heating to maintain the space temperature set point of 70°F (adj.).

F. Low Leak Detector
   1. The unit manufacturer shall provide a low leak condensate detector. Upon activation the VRV Heat Pump shall send an alarm to the BMS front-end and shutdown the VRV Heat Pump unit.

G. Alarms & Safeties Monitoring:
   1. Hi/Low Space Air Temp: When the Space Temperature (TS) is > 85 °F (adj.) < 55 °F (adj.).
   2. Low Leak Detection Alarm (LLDA)

H. Operator & Graphical User Interface requirements
   1. The ATC Control Diagrams & the table below shall provide for Operator Control of the HVAC equipment:

<table>
<thead>
<tr>
<th>VRV Heat Pumps</th>
<th>I/O Points</th>
<th>Software Point</th>
<th>Initial-Alarm Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point Name/Description/Legend</td>
<td>X = DDC I/O L=Local Control A = Adjustable O = Override</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Space Temperature (TS)</td>
<td>X</td>
<td>X X X</td>
<td></td>
</tr>
<tr>
<td>Supply Fan Start/Stop Command (SFSSC)</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Supply Fan Status (SFS)</td>
<td>X</td>
<td>X X</td>
<td></td>
</tr>
<tr>
<td>Low Leak Detection Alarm (LLDA)</td>
<td>X</td>
<td>X X</td>
<td></td>
</tr>
</tbody>
</table>
1.15 SPLIT SYSTEM AC UNITS

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 DDC controller, sensors, relays & status sensors.
   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. "Unoccupied" Mode:
   1. During the unoccupied mode, the Split System AC unit supply fan shall be de-energized.

D. "Occupied" Mode:
   1. During the occupied mode of operations, the Split System AC unit supply fan shall be energized to run continuously and to maintain the space temperature set point of 72°F (adj.).

E. Monitor Space Temperature
   1. The ATC Contractor shall provide a space temperature sensor that shall be monitored and tied into the BMS.

F. Operator & Graphical User Interface requirements
   1. The ATC Control Diagrams & the table below shall provide for Operator Control of the HVAC equipment:

<table>
<thead>
<tr>
<th>Split System AC Unit</th>
<th>I/O Points</th>
<th>Software Point</th>
<th>Initial-Alarm Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point Name/Description/Legend</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X = DDC I/O L=Local Control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A = Adjustable O = Override</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Space Temperature (TS)</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
1.16 PREP ROOM EXHAUST FAN CONTROL

A. The ATC contractor (ATC) shall provide a Control Relay (R) & a Current Switch (CS) to monitor the status of the Exhaust Fan. An alarm shall be generated when the status of the Fan does not meet the commanded sequence after 30 seconds.(BACnet DDC Controlled Only)

1. “Occupied”:
   a. The Exhaust Fans shall be energized and run continuously 24 hours/7 days a week.

B. Operator & Graphical User Interface requirements

1. The ATC Control Diagrams & the table below shall provide for Operator Control of the HVAC equipment:

<table>
<thead>
<tr>
<th>Prep Room Exhaust Fans</th>
<th>I/O Points</th>
<th>Software Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point Name/Description/Legend</td>
<td>AI</td>
<td>AO</td>
</tr>
<tr>
<td>X = DDC I/O L=Local Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A = Adjustable O = Override</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exhaust Fan Command (SS)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Exhaust Fan Status (CS)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Exhaust Fan Failure Alarm (EFFAIL)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Exhaust Fan In Hand Alarm (EFHAND)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. The ATC Control Diagrams & the table below shall provide for Operator Control of the HVAC equipment:

<table>
<thead>
<tr>
<th>Exhaust Fans – General Interlock</th>
<th>I/O Points</th>
<th>Software Point</th>
<th>Initial-Alarm Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point Name/Description/Legend</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X = DDC I/O L=Local Control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A = Adjustable O = Override</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AO</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BO</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schedule</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trend</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alarm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GUI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exhaust Fan Command (SS)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exhaust Fan Status (CS)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exhaust Fan Failure Alarm (EFFAIL)</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Exhaust Fan In Hand Alarm (EFHAND)</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

1.18 ELECTRIC ROOM EXHAUST FAN

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. Operation:
   1. The exhaust fan shall cycle when the space Temperature (TC) is greater than the space thermostat set point of 80 F(ADJ). Upon activation of exhaust fan mechanical room louver motorized damper shall open to provide make up air.

C. Operator & Graphical User Interface requirements
   1. Local manual adjustment and settings only.

1.19 CABINET HEATER / UNIT HEATER - ELECTRIC

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. Operation:
   1. The Return Air Temperature (TC) sensor shall cycle the Unit’s Fan and Electric Heating Coil to maintain the Local Heating Setpoint (LHSP). When the Return Air Temperature (TC) is less than the Local Space Temperature (LHSP) Heating setpoint, the Unit’s Fan and Electric Heating Coil shall cycle.
“On”. When the Space Temperature (TC) is greater than the Local Heating Setpoint (LHSP) the Unit’s Fan and Electric Heating Coil shall cycle “Off”.

C. Operator & Graphical User Interface requirements
1. Local manual adjustment and settings only.

1.20 DATA ROOM & OTHER INDIVIDUAL SPLIT SYSTEM SERVING IT STORAGE AND EMR

A. Coordination:
1. The BMS contractor (BMSC) shall provide a BACnet DDC controller, control valves, sensors, relays, status sensors; Provide a control panel with a lead AC unit selector switch shall allow manual selection of the lead unit or automatic rotation between the AC units. Provide a Current Switch (CS) “on” each unit which shall be commanded “on” the standby unit & indicate & alarm when the lead AC unit fails to operate after a delay of 30 seconds. Provide a Space Temperature Sensor (RMT) which shall be commanded “on” the standby unit & indicate & alarm when the Space Temperature rises 2 °F above the Space Cooling Setpoint (CSP) initially set at 70 °F
2. The unit manufacturer shall provide the units with integral controls as outlined under the Equipment specifications & schedules.
3. The Mechanical contractor (MC) shall coordinate the controls between unit manufacturer & the ATC system manufacturer for a complete integrated system

B. Scheduling:
1. The unit shall be operated in the “Occupied” mode 24 hours/ 365 days/year. The ability to operate in the “Unoccupied” mode shall be programmed for future use as necessary.

C. Rotation:
1. The lead AC Unit shall be alternated “on” a weekly basis.

D. “Occupied” mode:
1. The unit Supply Fan shall run continuously

E. Mechanical Cooling:
1. The Space Temperature (RMT) sensor shall, through the unit’s BACnet DDC controller, shall be command “on” the cooling “on” the lead unit to maintain the Space Cooling setpoint (CSP). When the Space Temperature (RMT) is > the space air-cooling temperature setpoint, the BACnet DDC controller shall stage “on” the cooling. When the Space Temperature (RMT) is < the Space Cooling Setpoint (CSP), the unit’s BACnet DDC controller shall reverse the sequence above.
F. Dehumidification mode:
1. When the air humidity is > 50% r.h. (adj.), the CRAC shall be placed in the dehumidification mode.
2. Hot Gas Reheat: The CRAC units Hot Gas Reheat shall be used as the primary reheat source when the Direct expansion Cooling (DX) is being used for dehumidification.
3. The mechanical cooling & the Hot Gas Reheat coil shall be enabled to maintain the desired level of humidity.

G. Operator & Graphical User Interface requirements
1. The ATC Control Diagrams & the table below shall provide for Operator Control of the HVAC equipment:

<table>
<thead>
<tr>
<th>Units</th>
<th>Interface Point</th>
<th>Schedule</th>
<th>Trend</th>
<th>Alarm</th>
<th>GUI</th>
<th>Initial-Alarm Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point Name/Description/Legend</td>
<td>AV</td>
<td>BV</td>
<td></td>
<td></td>
<td>GUI</td>
<td>Initial-Alarm Setting</td>
</tr>
<tr>
<td>X = DDC I/O L=Local Control A = Adjustable O = Override</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BACnet Communications Interface Points</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Unit Occupancy</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit Status</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit Fault</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>On</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct eXpansion Stages (CLG#)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chilled Water Valve (CHWV) (Critical Room Only)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative Humidity Setpoint (RHSP)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>50% r.h.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discharge Air Temperature (DAT)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filter (FLTR)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drip pan Liquid Detector Sensor (LDS)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>On</td>
<td></td>
</tr>
<tr>
<td>Local Alarm Audible/Visual</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>On</td>
<td></td>
</tr>
<tr>
<td>Alarm Reset</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fan Failure (FANFAIL)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>On</td>
<td></td>
</tr>
<tr>
<td>Fan in Hand (FANHAND)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>ON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Space Temperature High Alarm (TSHI)</td>
<td>A</td>
<td>A</td>
<td>X</td>
<td>&gt;78°F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Space Temperature Low Alarm (TSLO)</td>
<td>A</td>
<td>A</td>
<td>X</td>
<td>&lt;55°F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dirty Filter (FLTR)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>On</td>
<td></td>
</tr>
<tr>
<td>High Humidity (HRH)</td>
<td>A</td>
<td>A</td>
<td>X</td>
<td>&gt;70% r. h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooling Failure (CLGFAIL)</td>
<td>A</td>
<td>A</td>
<td>X</td>
<td>On</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heating Failure (HEATFAIL)</td>
<td>A</td>
<td>A</td>
<td>X</td>
<td>On</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1.21 FUME HOOD EXHAUST FAN

A. The ATC contractor (ATC) shall provide a Current Switch (CS) to monitor the status of the Exhaust Fan.

1. “Local On/Off Control”:
   a. The Fume hood Exhaust Fan Manufacturer shall provide a local on/off switch to energize/de-energize the kiln exhaust fan.

B. Operator & Graphical User Interface requirements

1. The ATC Control Diagrams & the table below shall provide for Operator Control of the HVAC equipment:

<table>
<thead>
<tr>
<th>Fume Exhaust Fan</th>
<th>I/O Points</th>
<th>Software Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exhaust Fan Status (CS)</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

1.22 DUST COLLECTOR

A. The ATC contractor (ATC) shall provide a Current Switch (CS) to monitor the status of the Dust Collector Fan.

1. “Local On/Off Control”:
   a. The Dust Collector Manufacturer shall provide a local on/off switch to energize/de-energize the fan.

B. Operator & Graphical User Interface requirements

1. The ATC Control Diagrams & the table below shall provide for Operator Control of the HVAC equipment:

<table>
<thead>
<tr>
<th>Dust Collector</th>
<th>I/O Points</th>
<th>Software Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dust Collector Status (CS)</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
1.23 ELECTRIC UNIT HEATER/CABINET HEATER/RADINAT PANEL

A. The ATC contractor (ATC) shall provide a thermostat, strap-mount aquastat and a hot water control valve.

1. “Occupied”:
   a. During the occupied mode, the unit heater shall start/stop the supply fan to maintain the space temperature set point of 72°F (adj.).
   b. A current sensor shall monitor the supply fan status.

2. “Unoccupied”
   a. During the unoccupied mode, the unit heater shall be off.

B. Operator & Graphical User Interface requirements

1. The ATC Control Diagrams & the table below shall provide for Operator Control of the HVAC equipment:

<table>
<thead>
<tr>
<th>Hot Water Unit Heater</th>
<th>I/O Points</th>
<th>Software Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point Name/Description/Legend</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X = DDC I/O</td>
<td>L=Local Control</td>
<td></td>
</tr>
<tr>
<td>A = Adjustable</td>
<td>O = Override</td>
<td></td>
</tr>
<tr>
<td>Supply Fan Command (SFC)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Supply Fan Status (SFS)</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

1.24 MAKEUP AIR UNIT – KITCHEN HOOD EXHAUST FAN

A. Coordination:

1. The Kitchen Exhaust Hood manufacturer (UM) shall provide a Manual Operation switch and provide all necessary internal control components not provided by the ATC contractor.

2. The ATC contractor (ATC) shall provide all control devices/interlocks not provided by the kitchen hood manufacturer.

B. Scheduling:

1. The Kitchen hood Exhaust Fans shall be manually scheduled by an on & off local control panel.

C. Operator & Graphical User Interface requirements

1. The ATC Control Diagrams & the table below shall provide for Operator Control of the HVAC equipment:
<table>
<thead>
<tr>
<th>Makeup Air and Kitchen Exhaust Fans</th>
<th>I/O Points</th>
<th>Software Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point Name/Description/Legend</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X = DDC I/O L=Local Control</td>
<td>AI</td>
<td>X</td>
</tr>
<tr>
<td>A = Adjustable O = Override</td>
<td>AO</td>
<td></td>
</tr>
<tr>
<td>BI</td>
<td>BO</td>
<td></td>
</tr>
<tr>
<td>AV</td>
<td>BV</td>
<td></td>
</tr>
<tr>
<td>Schedule</td>
<td>Trend</td>
<td>Alarm</td>
</tr>
<tr>
<td>GUI</td>
<td>Initial-Alarm Setting</td>
<td></td>
</tr>
<tr>
<td>Exhaust Fan Status (CS)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1.25 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:

<table>
<thead>
<tr>
<th>Condensate Pump Status (CPS)</th>
<th>I/O Points</th>
<th>Software Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>X = DDC I/O L=Local Control</td>
<td>AI</td>
<td>X</td>
</tr>
<tr>
<td>A = Adjustable O = Override</td>
<td>AO</td>
<td></td>
</tr>
<tr>
<td>BI</td>
<td>BO</td>
<td></td>
</tr>
<tr>
<td>AV</td>
<td>BV</td>
<td></td>
</tr>
<tr>
<td>Schedule</td>
<td>Trend</td>
<td>Alarm</td>
</tr>
<tr>
<td>GUI</td>
<td>Initial-Alarm Setting</td>
<td></td>
</tr>
<tr>
<td>Low Leak Detector Status (LLDS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X = DDC I/O L=Local Control</td>
<td>AI</td>
<td>X</td>
</tr>
<tr>
<td>A = Adjustable O = Override</td>
<td>AO</td>
<td></td>
</tr>
<tr>
<td>BI</td>
<td>BO</td>
<td></td>
</tr>
<tr>
<td>AV</td>
<td>BV</td>
<td></td>
</tr>
<tr>
<td>Schedule</td>
<td>Trend</td>
<td>Alarm</td>
</tr>
<tr>
<td>GUI</td>
<td>Initial-Alarm Setting</td>
<td></td>
</tr>
</tbody>
</table>

1.26 AIR BALANCING

A. The Air Balancer contractor (TAB) shall provide the initial air balancing & setting of the design minimum & maximum air flow.

1.27 GRAPHICAL USER INTERFACE (GUI)

A. The ATC contractor (ATC) shall provide a Panel Mounted connected Liquid Crystal Display the ability to read, adjust & 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 & any other variable for the adjustment & operation of the system. Demonstrate the operation of the system to the owner prior to acceptance of the system.

B. Graphical User Interface Demostration

1. Demonstrate the Graphics, trending & communications setup to the owner prior to acceptance of the system.

C. Alarm Notification

1. The system shall notify the owner of an alarming condition via a Visual Alerts & Audible sounds locally at the GUI. If connected via a TCP/IP connection, an e-mail sent depending on user configuration.
2. Any maintenance worker shall be capable of interrogating the alarm using the Laptop workstation browsers (via. the internet)

1.28 GLOBAL OUTSIDE AIR TEMPERATURE

A. The ATC contractor (ATC) shall provide, install & wire an Outside Air temperature & humidity sensors with weather/sunshields enclosure on the northern exposure of the building.

B. Operator & Graphical User Interface requirements

1. The ATC Control Diagrams & the table below shall provide for Operator Control of the HVAC equipment:

<table>
<thead>
<tr>
<th>Global Outside Air Temperature</th>
<th>I/O Points</th>
<th>Software Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point Name/Description/Legend</td>
<td>Al AO Bi BO AV BV Sched Trend Alarm GUI Initial-Alarm Setting</td>
<td></td>
</tr>
<tr>
<td>X = DDC I/O L=Local Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A = Adjustable O = Override</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>I/O Points</th>
<th>Software Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside Air Temperature (OAT)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Highest Values (Past24 hours)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Lowest Values (Past 24 Hours)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Calculated ° Days (Monthly)</td>
<td>X</td>
<td>X Calc.</td>
</tr>
</tbody>
</table>

1.29 COMMISSIONING

A. Startup:
1. The ATC system shall be set up & checked by factory trained competent technicians skilled in the setting & adjustment of the ATC equipment used in this project.

2. The technicians are to be experienced in the type of HVAC systems associated with this project.

B. Demonstration:

1. At the completion of the commissioning, The ATC contractor (ATC) shall: demonstrate the sequence of operations for each system to the Architect or representative.

1.30 OWNER TRAINING

A. Onsite Training

1. The ATC contractor (ATC) shall provide general HVAC systems training of 40 hours which shall include operating instruction, and review of wiring and control diagrams showing complete layout of each system. The ATC contractor (ATC) shall engage manufacturer certified technician to assist during ATC training.

2. The ATC contractor (ATC) shall also include an additional 16 hours of training for unit maintenance and filter changing.

3. The ATC contractor (ATC) shall provide an additional 80 hours of control system training which consist of minimum (20) 4-Hour sessions or broken into segments as determined by the owner. This instruction period is in addition to the hours specified for maintenance service and other instruction.

1.31 SYSTEM REMOTE SUPPORT

A. The Owner shall provide a secure TCP/IP connection to the ATC System for the first year of the warranty period.

B. The ATC contractor (ATC) shall provide the owner with ability to connect to the system from a remote location for a period of one year after the system has been accepted. The ATC contractor shall also maintain at his office the backup copies of the ATC software, graphics & programming; assist via remote connection to the system & identify & correct any system problems.
PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 15993
PART 6 - ELECTRICAL WORK
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. Voice Evacuation fire alarm system.
2. Fire-alarm control panel.
4. System smoke detectors.
5. Heat detectors.
7. Device guards.
10. Addressable interface device.
11. Digital alarm communicator transmitter.
12. Radio alarm transmitter.

1.3 DEFINITIONS

A. EMT: Electrical Metallic Tubing.

B. FACP: Fire Alarm Control Panel.

C. HLI: High Level Interface.


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.

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.

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:

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.
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.
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. Product: Subject to compliance with requirements, provide product by the following:
   1. Notifier by Honeywell, Model #NFS2-3030D.
   2. Or Engineer approved equal.

B. The FACP shall be capable of communicating over a Local Area Network (LAN) or Wide Area Network (WAN) utilizing a peer-to-peer, inherently regenerative communication format and protocol. The network shall support communication speed up to 100 Mb support up to 100 panels / nodes per network.

C. The system shall be programmable, configurable and expandable in the field without the need for special tools, laptop computers, or other electronic interface equipment. There shall be no firmware changes required to field modify the system time, point information, equations, or annunciator programming/information. It shall be possible to program through the standard FACP keyboard all system functions.

D. General Requirements for Fire-Alarm Control Panel:
   1. Pre-signal and Positive Alarm Sequence: The system shall provide means to cause alarm signals to only sound in specific areas with a delay of the alarm from 60 to up to 180 seconds after start of alarm processing. In addition, a
Positive Alarm Sequence selection shall be available that allows a 15-second time period for acknowledging an alarm signal from a fire detection/initiating device. If the alarm is not acknowledged within 15 seconds, all local and remote outputs shall automatically activate immediately.

2. Smoke Detector Pre-alarm Indication at Control Panel: To obtain early warning of incipient or potential fire conditions, the system shall support a programmable option to determine system response to real-time detector sensing values above the programmed setting. Two levels of Pre-alarm indication shall be available at the control panel: alert and action.

3. Alert: It shall be possible to set individual smoke detectors for pre-programmed pre-alarm thresholds. If the individual threshold is reached, the pre-alarm condition shall be activated.

4. Action: If programmed for Action and the detector reaches a level exceeding the pre-programmed level, the control panel shall indicate an action condition. Sounder bases installed with either heat or smoke detectors shall automatically activate on action Pre-Alarm level, with general evacuation on Alarm level.

5. The system shall support a detector response time to meet world annunciation requirements of less than 3 seconds.

6. Device Blink Control: Means shall be provided to turn off detector/module LED strobes for special areas.

7. NFPA 72 Smoke Detector Sensitivity Test: The system shall provide an automatic smoke detector test function that meets the sensitivity testing requirements of NFPA 72.

8. Programmable Trouble Reminder: The system shall provide means to automatically initiate a reminder that troubles exist in the system. The reminder will appear on the system display and (if enabled) will sound a piezo alarm.

9. On-line or Off-line programming: The system shall provide means to allow panel programming either through an off-line software utility program away from the panel or while connected and on-line. The system shall also support upload and download of programmed database and panel executive system program to a Personal Computer/laptop. A single change to one CPU database shall not require a data-base download to other CPUs.

10. History Events: The panel shall maintain a history file of the last 4000 events, each with a time and date stamp. History events shall include all alarms, troubles, operator actions, and programming entries. The control panels shall also maintain a 1000 event Alarm History buffer, which consists of the 1000 most recent alarm events from the 4000 event history file.

11. Smoke Control Modes: The system shall provide means to perform FSCS mode Smoke Control to meet NFPA-92A and 90B and HVAC mode to meet NFPA 90A.

12. The system shall provide means for all SLC devices on any SLC loop to be auto programmed into the system by specific address. The system shall
recognize specific device type ID's and associate that ID with the corresponding address of the device.

13. Passwords and Users: The system shall support two password levels, master and user. Up to 9 user passwords shall be available, each of which may be assigned access to the programming change menus, the alter status menus, or both. Only the master password shall allow access to password change screens.

14. Block Acknowledge: The system shall support a block Acknowledge for Trouble Conditions.

15. Sensitivity Adjust: The system shall provide Automatic Detector Sensitivity Adjust based on Occupancy schedules including a Holiday list of up to 15 days.

16. Environmental Drift Control: The system shall provide means for setting Environmental Drift Compensation by device. When a detector accumulates dust in the chamber and reaches an unacceptable level but yet still below the allowed limit, the control panel shall indicate a maintenance alert warning. When the detector accumulates dust in the chamber above the allowed limit, the control panel shall indicate a maintenance urgent warning.

17. Custom Action Messages: The system shall provide means to enter up to 100 custom action messages of up to 160 characters each. It shall be possible to assign any of the 100 messages to any point.

18. Local Mode: If communication is lost to the central processor the system shall provide added survivability through the intelligent loop control modules. Inputs from devices connected to the SLC and loop control modules shall activate outputs on the same loop when the inputs and outputs have been set with point programming to participate in local mode or when the type codes are of the same type: that is, an input with a fire alarm type code shall activate an output with a fire alarm type code.

19. Read status preview - enabled and disabled points: Prior to re-enabling points, the system shall inform the user that a disabled device is in the alarm state. This shall provide notice that the device must be reset before the device is enabled thereby avoiding activation of the notification circuits.

20. Custom Graphics: When fitted with an LCD display, the panel shall permit uploading of a custom bit-mapped graphic to the display screen.

21. Multi-Detector and Cooperating Detectors: The system shall provide means to link one detector with up to two detectors at other addresses on the same loop in co-operative multi-detector sensing. There shall be no requirement for sequential ad-dresses on the detectors and the alarm event shall be a result of all cooperating detectors chamber readings.

22. ACTIVE EVENT: The system shall provide a Type ID called FIRE CONTROL for purposes of air-handling shutdown, which shall be intended to override normal operating automatic functions. Activation of a FIRE CONTROL point shall cause the control panel to (1) initiate the monitor module Control-by-Event, (2) send a message to the panel display, history buffer,
installed printer and annunciators, (3) shall not light an indicator at the control panel, (4) shall display ACTIVE on the LCD as well a display a FIRE CONTROL Type Code and other information specific to the device.

23. NON-FIRE Alarm Module Reporting: A point with a type ID of NON-FIRE shall be available for use for energy management or other non-fire situations. NON-FIRE point operation shall not affect control panel operation nor shall it display a message at the panel LCD. Activation of a NON-FIRE point shall activate control by event logic but shall not cause any indication on the control panel.

24. Mass Notification Override: The system shall be UL 2572 listed for Mass Notification and shall be capable, based on the Risk Analysis, of being programmed so that Mass Notification/Emergency Communications events take precedence over fire alarm events.

25. Security Monitor Points: The system shall provide means to monitor any point as a type security.

26. One-Man Walk Test: The system shall provide both a basic and advanced walk test for testing the entire fire alarm system. The basic walk test shall allow a single operator to run audible tests on the panel. All logic equation automation shall be suspended during the test and while annunciators can be enabled for the test, all shall default to the disabled state. During an advanced walk test, field-supplied output point programming will react to input stimuli such as logic equations. When points are activated in advanced test mode, each initiating event shall latch the input. The advanced test shall be audible and shall be used for pull station verification, magnet activated tests on input devices, input and output device and wiring operation/verification.

27. Permitted zone types shall be general zone, releasing zone and special zone. Each output point (control module, panel circuit module) can support a list of up to 10 zones including general zone, logic zone, releasing zone and trouble zone. It shall be possible for output points to be assigned to list general alarm. Non-Alarm or Supervisory points shall not activate the general alarm zone.

28. Multiple agent releasing zones: The system shall support up to 10 releasing zones to protect against 10 independent hazards. Releasing zones shall provide up to three cross-zone and four abort options to satisfy any local jurisdiction requirements.

29. Alarm Verification, by device, with timer and tally: The system shall provide a user-defined global software timer function that can be set for a specific detector. The timer function shall delay an alarm signal for a user-specified time period and the control panel shall ignore the alarm verification timer if another alarm is detected during the verification period. It shall also be possible to set a maximum verification count between 0 and 20 with the "0" setting producing no alarm verification. When the counter exceeds the threshold value entered, a trouble shall be generated to the panel.
E. System Point Operations:

1. Any addressable device in the system shall have the capability to be enabled or disabled through the system keypad or video terminal.
2. System output points shall be capable of being turned on or off from the system keypad or the video terminal.
3. Point Read: The system shall be able to display the following point status diagnostic functions without the need for peripheral equipment. Each point shall be annunciated for the parameters listed:
   a. Device Status.
   b. Device Type.
   c. Custom Device Label.
   d. Software Zone Label.
   e. Device Zone Assignments.
   f. Analog Detector Sensitivity.
   g. All Program Parameters.
4. System History Recording and Reporting: The fire alarm control panel shall contain a history buffer that will be capable of storing up to 4000 system events. Each of these events will be stored, with time and date stamp, until an operator requests that the contents be either displayed or printed. The contents of the history buffer may be manually reviewed; one event at a time, and the actual number of activations may also be displayed and or printed. History events shall include all alarms, troubles, operator actions, and programming entries.
5. The history buffer shall use non-volatile memory. Systems which use volatile memory for history storage are not acceptable.
6. Automatic Detector Maintenance Alert: The fire alarm control panel shall automatically interrogate each intelligent system detector and shall analyze the detector responses over a period of time.
7. If any intelligent detector in the system responds with a reading that is below or above normal limits, then the system will enter the trouble mode, and the particular Intelligent Detector will be annunciated on the system display, and printed on the optional system printer. This feature shall in no way inhibit the receipt of alarm conditions in the system, nor shall it require any special hardware, special tools or computer expertise to perform.
8. The system shall include the ability (programmable) to indicate a "pre-alarm" condition. This will be used to alert maintenance personal when a detector is at 80% of its alarm threshold in a 60 second period.

2.4 MANUAL FIRE-ALARM BOXES

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in
contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Single-action mechanism, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
2. 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.
3. Station Reset: Key- or wrench-operated switch.
4. 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.
5. Weatherproof Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.
6. In addition to devices shown on the project drawings, provide an additional (3) devices including wiring, testing and programming, location as directed by the engineer.

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 project drawings, provide an additional (5) devices including wiring, testing and programming, location as directed by the engineer.

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.
7. In addition to devices shown on the project drawings, provide an additional (3) devices including wiring, testing and programming, location as directed by the engineer.

2.6 PROJECTED BEAM SMOKE DETECTORS

A. Projected Beam Light Source and Receiver: Designed to accommodate small angular movements and continue to operate and not cause nuisance alarms.

B. The detector shall be capable of being tested remotely via a keyswitch. And shall be equipped with an integral sensitivity test feature.

C. Detector Address: Accessible from fire-alarm control unit and able to identify the detector's location within the system and its sensitivity setting.

D. 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 average value.
   4. Present sensitivity selected.
   5. Sensor range (normal, dirty, etc.).

2.7 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 project drawings, provide an additional (5) devices including wiring, testing and programming, location as directed by the engineer.

2.8 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Individually addressed, connected to a signaling-line circuit, equipped for mounting as indicated, and with screw terminals for system connections.

B. Speaker: Subject to compliance with requirements, provide SpectraAlert by Systems Sensor or comparable product:
   1. The speaker shall be listed to UL 1480 for Fire Protective Signaling Systems. It shall be a dual-voltage transformer speaker capable of operation at 25.0 or 70.7 nominal Vrms. The speaker shall have a frequency range of 400 to 4,000 Hz and shall have an operating temperature between 32°F and 120°F. It shall mount to a 4 x 4 x 2 1/8-inch back box.
   2. A universal mounting plate shall be used for mounting ceiling and wall speaker products. The notification appliance circuit and amplifier wiring shall terminate at the universal mounting plate.
   3. Speakers shall be plug-in and shall have the ability to check wiring continuity via a shorting spring on the universal mounting plate. The shorting spring shall also provide tamper resistance via an open circuit if the device is removed. Speaker design shall isolate speaker components to reduce ground fault incidents.
   4. The speaker shall have power taps (from ¼ watt to 2 watts) and voltage that are selected by rotary switches. All models shall have a maximum sound output of 86 dB at 10 feet and shall incorporate an open back construction.
   5. All notification appliances shall be backward compatible.

C. Speaker/Strobe: Subject to compliance with requirements, provide SpectraAlert by Systems Sensor or comparable product:
   1. The speaker strobe shall be listed to UL 1971 and UL 1480 and be approved for fire protective signaling systems. It shall be a dual-voltage transformer speaker strobe capable of operation at 25.0 or 70.7 nominal Vrms. The speaker shall have a frequency range of 400 to 4,000 Hz and shall have an operating temperature between 32°F and 120°F. It shall mount to a 4 x 4 x 2 1/8-inch back box.
   2. A universal mounting plate shall be used for mounting ceiling and wall speaker strobe products. The notification appliance circuit and amplifier wiring shall terminate at the universal mounting plate and shall operate on a nominal 12 or 24 volts (includes fire alarm panels with built in sync).
   3. Speaker strobes shall be plug-in and shall have the ability to check wiring continuity via a shorting spring on the universal mounting plate. The
shorting spring shall also provide tamper resistance via an open circuit if the device is removed. Speaker strobe design shall isolate speaker components to reduce ground fault incidents.

4. The speaker strobe shall have power taps (from ¼ watt to 2 watts) and voltage that are selected by rotary switches. All models shall have a maximum sound output of 86 dB at 10 feet and shall incorporate an open back construction. The strobe shall consist of a xenon flash tube with associated lens/reflector system and operate on either 12V or 24V. The strobe shall also feature selectable candela output, providing options for 15 or 15/75 candela when operating on 12V and 15, 15/75, 30, 75, 110, or 115 when operating on 24V. The strobe shall comply with NFPA 72 and the Americans with Disabilities Act requirement for visible signaling appliances, flashing at 1 Hz over the strobe’s entire operating voltage range.

5. All notification appliances shall be backward compatible.

6. Strobe lights shall meet the requirements of the ADA, UL Standard 1971 and be fully synchronized.

D. In addition to devices shown on the project drawings, provide an additional (5) devices including wiring, testing and programming, location as directed by the engineer.

2.9 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.

2.10 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.

2.11 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.

2.12 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 local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over 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.

C. 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.
5. Communications failure with the central station or fire-alarm control unit.

D. 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.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.13 SYSTEM PRINTER
A. Printer shall be listed and labeled as an integral part of fire-alarm system.

2.14 DEVICE GUARDS
A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.
   1. Factory fabricated and furnished by 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.
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.


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.
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
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.

B. Provide arch-flash 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 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 - PRODUCTS

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.
5. Working distance.
6. Incident energy.

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.
5. Incident energy.
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:
   4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
   5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
   6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

2.2 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory 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, bolted pressure-type, with at least two bolts.
   1. Pipe Connectors: Clamp type, sized for pipe.

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. 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.

3.2 EQUIPMENT GROUNDING

A. 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. Flexible raceway runs.
5. Armored and metal-clad cable runs.

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.

3.4 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.

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.

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.
   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
B. Comply with NFPA 70.
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


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


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.
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.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, Type 6/6 nylon.
   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.

C. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, self-locking.
   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.

   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.

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:

1. AFC Cable Systems, Inc.
3. O-Z/Gedney; EGS Electrical Group LLC.
4. 3M; Electrical Products Division.
5. Tyco Electronics Corp.
6. Or approved equal.

B. 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.
7. Maverick Tube Corporation.
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:

   1. Cooper B-Line, Inc.
   2. Hoffman.
   3. Square D; Schneider Electric.
   4. Or approved equal.

B. ENT: NEMA TC 13.

C. RNC: NEMA TC 2, Type EPC-80-PVC, unless otherwise indicated.

D. LFNC: UL 1660.
E. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.

F. 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.
   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.
   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.
7. RACO; a Hubbell Company.
10. Spring City Electrical Manufacturing Company.
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:
      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:
   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:
   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-inch thickness 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-lbf vertical 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 inch away 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-inch trade 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-lb tensile 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 F of 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 inches in 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-inch sieve to No. 4 sieve 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-inch annular 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-inch annular 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-inch annular 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
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.
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:
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:
   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.
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. 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. Or approved equal.

B. 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.

C. 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.

2.2 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. Or approved equal.

   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.
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 (where shown on plans).
2. Diesel engine and 72 hour subbase fuel tank (where shown on plans).
3. Unit-mounted cooling system.
4. Unit-mounted control and monitoring.
5. Performance requirements for sensitive loads.
6. 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. 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.
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).

C. Qualification Data: For manufacturer and testing agency.

D. 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.
4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.

6. Report of exhaust emissions showing compliance with applicable regulations.


E. Field quality-control test reports.

F. 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.

G. 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: 2 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 Contract 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:
   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.

   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.


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.


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.


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.
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.
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 datalink 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.
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.


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.


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:
   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.

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).
   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.
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.

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.
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.
   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.


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.


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.
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.

**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
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. 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.

C. Qualification Data: For manufacturer and testing agency.

D. Field quality-control test reports.

E. 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 project 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 project 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 project 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 project 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 project 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 project 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.


   a. Normal Power Supervision: Green light with nameplate engraved "Normal 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 project 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.


   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.
4. Square D; a brand of Schneider Electric.
5. Or approved equal.

B. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Panel mounted.
3. Sections front and rear aligned.

C. Nominal System Voltage: As indicated on project drawings.

D. Main-Bus Continuous: As indicated on project drawings.

E. Enclosure: Steel, NEMA 250, Type 1 or Type 3R as indicated on project 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-resistant 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.
4. Copper feeder circuit-breaker line connections.
5. Tin-plated aluminum feeder circuit-breaker line connections.
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.
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 graph 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 fail 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
   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.


B. Incoming Mains Location: Top and bottom as requested.

C. Phase, Neutral, and Ground Buses:

   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.

   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.

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.
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 contract 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.
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 contract 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.
   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.
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.


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-inch empty conduits from Panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.
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.


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:

3. Powersmiths.
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
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.
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 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.
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. LED Lighting fixtures.
   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. Basis of Design Products: Subject to compliance with requirements, provide product indicated on Drawings.
   1. Or approved equal.

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.


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.
   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 16520 - SITE 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 DESCRIPTION OF WORK

A. Section includes exterior luminaries, poles, building mounted lights and accessories.

B. Related Sections:
   1. Section 02248 – Shoring and Bracing
   2. Section 02200 – Earthwork
   3. Section 02514 – Site Work Concrete
   4. Section 03300 – Cast In Place Concrete
   5. AIA A232 & Section 00800 - Submittals

1.3 REFERENCES

A. American National Standards Institute:
   2. ANSI C82.4 - American National Standard for Ballasts-for High-Intensity-Discharge and Low-Pressure Sodium Lamps (Multiple-Supply Type).
   3. ANSI O5.1 - Wood Poles, Specifications and Dimensions.

1.4 SUBMITTALS

A. AIA A232 and Section 00800- Submittal Procedures

B. Shop Drawings: Provide signed and sealed drawings by a licensed Engineer in the State of New Jersey for all concrete foundations.

C. Product Data: Submit dimensions, ratings, and performance data.
1.5 **PAYMENT**

A. All materials required to install a complete site lighting system shall be included in the lump sum price. Payment for site lighting shall include, but is not limited to, luminaires with photocell, light poles, light bases, mounting hardware, trenching, handholes, duct banks, conduit, wiring, and circuitry.

1.6 **COORDINATION**

A. Section 01040 - Administrative Requirements: Coordination and project conditions.

B. Furnish bolt templates and pole mounting accessories to installer of pole foundations.

**PART 2 PRODUCTS**

2.1 **MANUFACTURER**

A. Furnish poles and fixtures in accordance with the Luminaire Schedule, plans and details as provided on the drawings. Other manufacturers will be considered only if the Engineer can determine that the equipment proposed is equal to the equipment specified.

**PART 3 EXECUTION**

3.1 **EXAMINATION**

A. Verify foundations are adequate to receive fixtures.

3.2 **EXISTING WORK**

A. Disconnect and remove abandoned exterior luminaries.

3.3 **INSTALLATION**

A. Install concrete bases for lighting poles at locations as indicated on Drawings, in accordance with Section 02514.

B. Install poles plumb. Install shims to adjust plumb. Grout around each base.

C. Install lamps in each luminaire.
D. Bond and ground luminaries, metal accessories and metal poles in accordance with NEC.

3.4 FIELD QUALITY CONTROL

A. AIA A232 and Division 1 - Quality Requirements: Field inspecting, testing, adjusting, and balancing.

B. Operate each luminaire after installation and connection. Inspect for improper connections and operation.

3.5 ADJUSTING

A. Section AIA A232 and Section 01700 - Execution and Closeout Requirements: Testing, adjusting, and balancing.

B. Aim and adjust luminaries to provide illumination levels and distribution as indicated on Drawings.

3.6 CLEANING

A. Section AIA A232 and Section 01700 - Execution and Closeout Requirements: Final cleaning.

B. Clean photometric control surfaces as recommended by manufacturer.

C. Clean finishes and touch up damage.

3.7 PROTECTION OF FINISHED WORK

A. Section AIA A232 and Section 01700 - Execution and Closeout Requirements: Protecting finished work.

B. Relamp luminaries having failed lamps at Substantial Completion.

END OF SECTION 16520
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: Two 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 product indicated on Drawings:
   1. Acuity Brands 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 16560 – THEATRICAL SYSTEMS

PART 1 GENERAL

1.1 INTENT
1. The specification section covers the fabrication, furnishing, delivery, installation, coordination, and operation of the Theatrical Systems and related equipment.
2. The project drawings are to be considered part of these specifications. Drawings are diagrammatic, unless detailed dimensioned drawings are included. Drawings show approximate locations of equipment. Exact locations are subject to the approval of the Architect/Owner's Representative.
3. Typical details are shown for the installation of various devices. The details do not apply to all situations. Installation methods for all work shall be subject to the construction manager's approval.

1.2 DEFINITIONS
A. For this project, the following entities are referenced:
   1. Owner: West Windsor – Plainsboro Regional School District
   2. Consultant: Starlite
   3. Contractor: General Contractor (GC)
   4. EC: Electrical subcontractor to the Contractor
   5. TSC: Theatrical subcontractor to the Electrical subcontractor
B. For this project, the following terms are defined as:
   1. Furnish, shall mean that the appropriate EC or TSC is responsible for acquisition and delivery of equipment and the installation shall be by others.
   2. Install, shall mean that the appropriate Contractor, EC, or TSC shall install items or equipment furnished by others.
   3. Provide, shall mean that the appropriate EC or TSC is responsible for furnishing and installing said item or equipment.
   4. By Others, shall mean work that is not part of the trade’s scope of work.
   5. By Owner, shall mean work that will be performed by the Owner or Owner’s agents at Owner’s cost.
   6. As Required, shall mean as required by regulatory bodies, by referenced standard, by existing conditions, by generally accepted construction practice, or by the contract documents.
   7. Equal, Accepted Equal, Approved Equal, shall mean as accepted in writing, by Architect/Consultant as being of equivalent quality, utility, function, efficiency, and appearance.
   8. Low-voltage, Cabling, Wiring, shall mean low-voltage power or signal cabling and/or wiring to include single or multiple conductor, twisted pair, coaxial, fiber optic, category, power over Ethernet, and the like.

1.3 RELATED SECTIONS AND DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions of Division 1, apply to the work of this section.
B. For alternate bid items, see specification Section 01030.
C. The EC and TSC shall examine the full set of construction drawings and specifications and ascertain all aspects of the scope of work described within this specification.
1.4  SCOPE

A. Provide all materials, items, engineering, labor, and work necessary for complete, safe, fully functional professionally installed system as specified, including:
   1. Tools, scaffolding, equipment, labor, and supervision, even though they may not be specifically enumerated.
   2. Verification of dimensions and conditions at the job site.
   3. Coordination of the work with the work of any other trade contractors who also may be working in the project space in a manner which will avoid conflict or interference and which will ensure proper sequence and avoid delay in the completion of any part or the entire Project.
   4. Notification to the Architect/Engineer of any conditions, measurements, quantities, or other data, as required for proper execution, fit and completion of all work, and for safe and proper operating clearances.
   5. Shipment of equipment to job site and the secured storage of all non-fixed equipment.
   6. Installation and completion, in accordance with these specifications, related drawings, the equipment manufacturer’s recommendations, established trade criteria, and all applicable code requirements.
   7. Inspection, demonstration, and necessary adjustment of the completed installation by the EC’s and TSC’s installation personnel.
   8. Preparation and submission of complete submittal drawings, as-built drawings, and operational and maintenance manuals.

B. Work Included (TSC): The work of this section shall include, but not be limited to the following:
   1. Provide custom rigging safety signage.
   2. Provide new curtains, tracks, rigging system, and related hardware.
   3. Furnish panels and transformer(s).
   4. Furnish specialty system receptacles including connector strips.
   5. Provide lighting fixtures, extension cables, and accessories.
   6. Provide curtains, tracks, rigging system, and related hardware.
   7. Provide LED stage work lights.
   8. Provide bright colored vinyl batten caps on all pipe battens and rotodraper pipes. Fill in lineset number and batten capacity.
   9. Provide comprehensive interactive “magic sheet” in the lighting console program.
   10. Hang and focus all lighting fixtures as shown on the Lighting Plot.
   11. Provide wiring, digital audio console, and processing equipment.
   12. Provide custom input/output panels.
   13. Provide all wiring necessary for a complete system.
   14. Install new or relocate existing architectural lighting button stations as shown in drawings and provide and install all conduit, wiring, back boxes, and blank cover plates. All conduit for low-voltage wiring to have plastic bushings installed.
   15. Provide all rack mount hardware, screws, blanks, cable management, rack rails, connectors, and interconnecting wiring for a complete professional system.
   16. Provide Owner training, manuals, and as-built drawings as described herein.
   17. Provide equipment as listed in bill of materials and/or shown on drawings.
   18. Provide all compiled & un-compiled software and software files.
19. This Project requires all incidental or related items necessary to complete the Work as described herein, even though they may not be specifically enumerated. The extent of Work of this section is indicated by the drawings, sketches, specifications and schedules. TSC shall provide all fixtures, devices, tools, materials, accessories, labor, and other items to deliver a complete job in all aspects.

C. Work Included (Electrical Subcontractor): The work of this section shall include, but not be limited to the following:
   1. Demolition of unused electrical boxes, conduit, receptacles, pathways, and wiring.
   2. Temporary lighting until installed building lighting is complete and programmed.
   3. Install receptacles.
   4. Install transformers and panels.
   5. Provide all conduit, wiring, breakers, back boxes and junction boxes (not specifically provided by TSC), and terminations providing line voltage to all panels, racks, receptacles, disconnects, devices, and power distribution equipment.
   6. Provide all conduit and wiring and all line voltage terminations including the circuits that terminate at the junction boxes mounted on the connector strips in the auditorium. The connector strips are factory pre-wired.

D. Related Work: Related work which is not included in this section:
   1. All specifications and drawings in this contract are considered related work including Rigging, Lighting, Telecommunications, Structural, and Electrical.

1.5 ERRORS AND OMISSIONS

A. Any errors, omissions, or ambiguities found in these documents does not relieve the Contractor, EC, or TSC of the responsibility of providing all items necessary for a complete, safe, fully functional system. The Contractor, EC, and TSC shall provide complete working systems within the intent and meaning of the contract documents. All items of labor, material, and equipment not specifically described herein or detailed on the drawings but incidental to or necessary for the completion of the work shall be considered as included without extra cost. Any errors, omissions, or ambiguities shall be brought to the attention of the Owner and Consultant for clarification.

B. Where discrepancies occur between drawings, specification, and/or bill of materials, the contractors shall seek clarification, otherwise, the greater quantity shall prevail.

1.6 GENERAL REQUIREMENTS

A. Field Conditions: This project consists of work in an existing venue. All bidders are strongly encouraged to survey and inform themselves of the areas where the work is to be performed prior to bid. No additional compensation or time extension will be given for conditions of which bidder could have been fully aware prior to bid.

B. Safety: The system shall conform to all applicable code requirements and shall be provided in conformance to the highest industry standards of operation and practices. All materials, arrangements, and procedures shall comply with applicable code requirements, allowing the end user to arrange and operate a safe assembly and
C. Insurance: In the absence of more stringent requirements, the Contractor, EC, and TSC shall maintain sufficient injury and property liability insurance coverage throughout the project's scheduled timetable, including workmen's compensation coverage for their employees.

1.7 TSC QUALIFICATIONS

A. All equipment shall be the responsibility of a single TSC who shall own and operate a full-time, staffed shop for the fabrication, assembly, and installation of theatrical equipment. This TSC shall assume complete responsibility for the fabrication, transportation, and installation of the work in this section and shall hold the Owner, Architect, and all their employees and Consultants harmless for any costs for errors or omissions associated with the work of this section and any action arising therefrom.

B. The TSC shall have a recommended ten (10) years' experience in the installation of similar equipment and systems for professional and educational buildings. The TSC shall provide references of at least (3) installations of comparable scope performed by the TSC, including location, description, name, address, and telephone numbers of the architects, consultants, and owners with contact persons for each.

C. The TSC shall be located within a recommended fifty (50) mile radius from the project location. Furthermore, the TSC must have a staffed office/warehouse to fully support the project.

D. The TSC and all persons performing theatrical rigging system or related work shall be under the direct supervision of an ETCP Certified Theater Rigger (Entertainment Technician Certification Program) in good standing for the duration of the project.

E. The TSC and all persons performing audio/visual system or related work shall be under the direct supervision of a CTS-I or CTS-D (Certified Technology Specialist) in good standing for the duration of the project.

F. The TSC and all persons performing programming of equipment or related work shall be under the direct supervision of a Certified Programmer from manufacturers of each type of equipment.

G. The TSC must have a SMAART, SysTune, or SIM analysis equipment and a trained authorized operator for this equipment for final set up.

H. The TSC is a dealer or authorized agent for the major equipment listed.

1.8 SUBMITTALS

A. Drawings:
   1. Drawings of the audio, video, and control system shall be submitted to document the primary elements of the integrated theatrical system and to show all information necessary to fully explain the design features, appearance, function, fabrication and the integrated use of the system.
   2. Drawings or screen shots of the proposed layouts of all graphical user interface (GUI) for all touch panels.
3. Detailed written narratives of the control system, integration and communication of equipment, typical operation, and control feedback methods for keeping the system synchronized.
4. Control system button/fader station labeling, color, functionality, indicator color, on status, off status, locked status, and feedback.
5. Riser/functional diagrams shall be provided to explain the power and control wiring, wire selection, wiring numbering, patch points, and termination requirements.
6. Proposed rack and desk layouts, panel layouts and locations, and labeling of panels.
7. Drawings of proposed mounting methods for all equipment, including rigging details, final locations with all focus information, section drawings with mounting heights and weights for all equipment.
8. Structural attachment details shall be reviewed and stamped by a New Jersey State licensed Professional Engineer. This should include attachment details, rigging details, suspension details, mounting details, etc.
9. Drawings shall be approved before any fabrication or installation may begin.
10. The drawings shall be no less detailed than as provided in the contract documents.
11. Reproductions of contract documents are not acceptable as shop drawings and will be rejected. The TSC must submit their own original drawings. Architectural backgrounds will be provided.
12. System plans, elevations, and sections shall be submitted on minimum D-size (24” x 36”) sheets, and shall be drawn in no less than ¼” = 1’0” scale.
13. Submit in quantities as required by the front end documents.

B. Data Sheets: In addition to drawings, the TSC shall submit Manufacturer Data Sheets for all standard equipment.
   1. All data sheets shall contain full information on dimensions, construction, applications, load ratings, etc.
   2. Data sheets shall be properly identified as to their intended use. Any options or variations shall be clearly noted.
   3. Submit in quantities as required by the front end documents.

C. Other Documents
   1. Submit TSC Qualifications and proof of certifications as listed above in Section 1.7.
   2. Submit color swatches and options to Owner for selection.
   3. Submit lighting console patch sheet (channel schedule), magic sheet screen shot, and show file.
   4. Submit proposed IP addressing scheme with network settings.

D. Approvals: All submissions must be approved per the requirements of the project’s general conditions prior to the beginning of any fabrication, installation, or erection. Such approval does not relieve the Contractor, EC, nor TSC of the responsibility of providing equipment in accordance with the specifications or of providing full operational and safe systems.

1.9 WARRANTY & INSPECTIONS

A. Special Warranty: The TSC shall provide a two (2) year written guarantee against defects in materials and workmanship. Within this period, the TSC shall provide any
required replacement within 30 days of written notification by the Owner, except for safety related items that shall be corrected within 24 hours of notification. All products shall have a manufacturer’s warranty for the duration of this period. Subsequent to the expiration of the guarantee period, the TSC agrees to furnish repair and maintenance service, at the Owner’s expense, within 30 days of request for such service.

B. Post Installation Inspection: After installation is complete, the TSC shall fully inspect the rigging portions of the Theatrical System and provide a detailed written report with pictures. Inspection shall comply with ANSI E1.47.

C. Future Inspections: The TSC shall offer the Owner estimated costs of an annual rigging and safety inspection and report.

1.10 SYSTEM DESCRIPTIONS

1. Playhouse AV System
   a. Mixing Console: The primary mixing console will be located in the control room countertop. The mixing console will be connected to a digital stage box in the equipment racks located in the equipment closet which is adjacent to the auditorium. The digital stage box will have microphone/line level inputs extended to input and output (I/O) plates located at the four corners of the stage, stage ceiling, and large group instruction rooms. Also connected to the stage box will be the wireless microphone receivers and audio from video sources.
   
   b. DSP & Modes: The Digital Signal Processor will be connected to the digital stage box as well as two of the wireless microphone receivers, 6 wired microphone connections around the stage and audio from video sources. The DSP will be programmed to have two modes for the AV system: Simple Mode & Advanced Mode.
      1) Simple Mode will provide all controls of audio volume, video sources, etc. on the Touch Screen Controllers for events where only a few audio sources are needed; such as Assemblies, Meetings, etc.
      2) Advanced Mode will still use the Touch Screen Controller for video source control, but utilize the Mixing Console for the audio sources. Advanced mode is intended to be use for larger events where a multitude of audio inputs will be used or there will be many changes happening during the event; such as Plays, Musicals, Concerts, etc.

   c. Loudspeakers: The sound system will operate as a mono system with full range, 2-way speaker cabinets and 18” cardioid subwoofers to provide added low-frequency response. Two delay fill speakers will provide sound for each large group instruction room. When the airwalls are closed, and the LGIs are operating independently, they will operate as a stereo system.

   d. Stage Monitors: There will be four dedicated line level monitor channels with connections on the I/O plates

   e. Hearing Assistance: An RF assistive listening system will be installed to be utilized by persons with hearing disabilities. Hearing assistance will be provided in all system modes per ADA requirements for voice lift
amplification.

f.  Projection: There will be a HD video projector at the back of the seating area projecting onto a motorized projection screen on stage. HDMI & VGA inputs are located on both sides of the stage and in the control room. Each LGI has a HD projector and motorized projections screen. There is a multi-format memory/disc player in the AV booth. Source selection for the video system will be done via the Touch Panels.

g.  AV Network: Many of the AV components require network connections for the system to operate. Static IP addresses should be used for all devices. The AV network is physically separate network and not connected to any building networks or internet. Switches & Access Points will be configured for all devices requirements to coexist on the AV Network. Wi-Fi access should be DHCP, password protected, and is intended for wireless control of the Mixing Console.

1)  TSC to include network configuration and programming to and from lighting network for UDP control and integration.

2)  TSC to verify proposed network design can accommodate all AV and lighting traffic and that they can coexist and/or be segregated on VLANs and maintain the control intent of the overall systems.

3)  The network shall be extended via fiber to the Dance Classroom system.

h.  System Presets & Programming: Program all software and adjust settings as required by the specifications.

1)  All Touch Panels will default to a splash screen with school logo on startup. Upon input press, and selection of which mode is needed for the event (Simple/Advanced) a password page is required.

   a)  The LGI touch panels will default to LGI operation and have a selection option to operate the Playhouse system.

2)  The password must be user changeable via a utility page & there must be a back-door password which cannot be changed.

3)  Power sequencing of the system will be activated once a mode is selected and the correct password is entered. System Mode will be changeable back and forth via a utility page without powering down the system.

4)  System Off will be selectable from every page and will include a safety pop-up of System Shutdown “Yes” or “No” to avoid accidental shutdowns.

5)  Startup and shutdown timers or “hour glasses” will be used to inform the user of the remaining time for the sequence until the system is ready to be used.

6)  When the Emergency Mute is triggered by the fire alarm, all system outputs will be muted and a pop-up will appear on the Touch Screen Controllers Indicating “Emergency Mute has been Triggered. All System Outputs have been Muted”

7)  Simple Mode will minimally have the following controls on the Touch Screen Controllers:

   a)  Volume, Mute, EQ presets for Microphone Inputs (Lav, Handheld, Ear, Podium, etc.)

   b)  Volume & Mute for Program Audio

   c)  Monitor 1 Volume, Mute, and individual mutes for sources
sent to Monitor 1 Output
d) Video Source Selection with preview window & ability to make it full screen on the touch panel
e) Projector Power
f) Screen Controls
g) Blu-ray Transport Controls

8) Advanced Mode will minimally have the following controls:
a) Subwoofer source selection
b) Video Source Selection with preview window & ability to make it full screen on the touch panel
c) Projector Power
d) Screen Controls
e) Blu-ray Transport Controls

9) Lighting page to include (8) presets, house light intensity controls, virtual button station controls, and button station lock-out. The (8) presets shall be recordable (snapshot lighting console) and able to be labeled directly from the touch panel. There shall also be a button for lighting system power on/off. All systems shall work together and provide feedback to each other such that the LED indicators show the correct preset, state, and/or level. TSC shall coordinate with lighting system manufacturer on programming. Control integration shall be UDP over the network. In the LGIs, there shall also be a fader for intensity control of the room lighting.

2. Dance Classroom AV System
a. DSP & Modes: The Digital Signal Processor will be connected to the wireless microphone receivers and wired microphone connections around the room and audio from video sources. The DSP will be programmed to have one mode for the AV system: Simple Mode.
   1) Simple Mode will provide all controls of audio volume, video sources, etc. on the Touch Screen Controllers
b. Loudspeakers: The sound system will operate as a mono system with full range, 2-way speaker cabinets and subwoofers to provide added low-frequency response.
c. AV Network: Many of the AV components require network connections for the system to operate. Static IP addresses should be used for all devices. The AV network is physically separate network and not connected to any building networks or internet. Switches & Access Points will be configured for all devices requirements to coexist on the AV Network. Wi-Fi access should be DHCP, password protected, and is intended for wireless control of the Mixing Console.
   1) TSC to include network configuration and programming to and from lighting network for UDP control and integration.
   2) TSC to verify proposed network design can accommodate all AV and lighting traffic and that they can coexist and/or be segregated on VLANs and maintain the control intent of the overall systems.
   3) The network shall be extended via fiber from the Playhouse system.
d. System Presets & Programming: Program all software and adjust settings as required by the specifications.
   1) All Touch Panels will default to a splash screen with school logo on startup. Upon input press, and selection of which mode is
needed for the event (Simple/Advanced) a password page is required.

2) The password must be user changeable via a utility page & there must be a back-door password which cannot be changed.

3) Power sequencing of the system will be activated once a mode is selected and the correct password is entered. System Mode will be changeable back and forth via a utility page without powering down the system.

4) System Off will be selectable from every page and will include a safety pop-up of System Shutdown “Yes” or “No” to avoid accidental shutdowns.

5) Startup and shutdown timers or “hour glasses” will be used to inform the user of the remaining time for the sequence until the system is ready to be used.

6) When the Emergency Mute is triggered by the fire alarm, all system outputs will be muted and a pop-up will appear on the Touch Screen Controllers Indicating “Emergency Mute has been Triggered. All System Outputs have been Muted”

7) Simple Mode will minimally have the following controls on the Touch Screen Controllers:
   a) Volume, Mute, EQ presets for Microphone Inputs (Lav, Handheld, Ear, Podium, etc.)
   b) Volume & Mute for Program Audio
   c) Monitor 1 Volume, Mute, and individual mutes for sources sent to Monitor 1 Output
   d) Video Source Selection with preview window & ability to make it full screen on the touch panel
   e) Screen Controls
   f) Motorized Shade Controls (Alt. Bid)

8) Lighting page (Alt. Bid) to include (8) recordable presets (snapshot lighting console) and able to be labeled directly from the touch panel. There shall also be a button for lighting system power on/off. All systems shall work together and provide feedback to each other such that the LED indicators show the correct preset, state, and/or level. TSC shall coordinate with lighting system manufacturer on programming.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Quality Statement: While the equipment specifications contained herein may be based upon the standard equipment of particular approved manufacturers, the individual component specifications are provided solely to set a minimum level of quality. Under no circumstances will equipment of lesser quality be accepted for this project.

1. Substitutions: May be permitted after contract award, but only with the written permission of the Architect/Consultant. The proposed substitutes must be equal or exceed the specified products in quality, performance, function, and apply to the system concept in the original manner.
   a. TSC substitution request shall include the item to be substituted, the unit
price of each item, the advantages, and product data.
b. If any of the specified equipment is no longer available, the TSC may make recommendations to the Consultant.

C. It is the responsibility of the Contractor, EC, and TSC to ensure all equipment meets or exceeds specifications and will be reviewed by the Architect/Consultant.

2.2 STANDARDS

A. Installation and equipment shall conform to the latest federal, state, and local regulations, codes and industry standards. Where conflicts exist, the most stringent code or regulation shall apply.
1. Standards Organizations include:
   a. ASTM, ANSI, SAE, ASME, AES, EIA, IEEE, IEC, NEC, NEMA, NFPA, SMPTE, TIA, UL, ASTME, OSHA, USITT, PLASA

B. In order to establish minimum standards of safety, the following factors shall be used:
   1. Cables and fittings 10:1 Safety Factor
   2. Cable bending ratio Sheave tread diameter is 30 times cable diameter
   3. Maximum fleet angle 1.5 degrees
   4. Steel 1/5 of yield
   5. Bolts SAE J429 Grade 5 (ISO R898 Class 8.8)
   6. Threaded Rod ASTM A449

C. Components:
   1. Fasteners shall have a minimum SAEJ429 Grade 5 or ISO R898 Class 8.8 or ASTM A449 rating. Fasteners shall be self-locking or secured by alternate means to prevent loosening including lock washers, mousing, and thread locker.
   2. If welding shall be required, it must be performed in accordance with current AWS standards.

2.3 RIGGING HARDWARE

A. Lift Cables (Wire Rope):
   1. All lift cables shall be 7 x 19 construction, galvanized aircraft cable, sized as required and with ultimate breaking strengths as follows:
      a. 1/8" diameter 2,000 lbs
      b. 3/16" diameter 4,200 lbs
      c. ¼" diameter 7,000 lbs
      d. 5/16" diameter 9,800 lbs
      e. 3/8" diameter 14,400 lbs
   2. Damaged or deformed cable shall not be used. All wire rope rigging shall be installed so as to prevent abrasion of the wire rope against any part of the building construction or other equipment.
   3. Wire rope shall not contact any part of the building structure.
   4. Lift lines shall be fabricated of continuous un-spliced lengths of material.
   5. In applications where reverse bends are incorporated, the wire rope service lift shall be decreased as determined by a qualified person.

B. Cable fittings & Terminations
   1. Swaged sleeve fittings shall be copper Nicopress. Swaged fittings shall be
installed per the fitting manufacturer’s instructions, using the appropriate tools, and checked with the appropriate Nicopress Go-No-Go gauge. Tape loose ends of wire rope after swage has been installed. No steel wire rope may be secured with threaded compression type fittings (i.e. Crosby clamps).

2. All wire rope eyes shall be formed over galvanized metal wire rope thimbles that are sized in accordance with the wire rope diameter.

3. All termination hardware shall be load rated and sized for the working load limit of the line it is used on. Shackles, wire rope clips, eyebolts, eye nuts, and turnbuckles shall be of forged steel construction only. Screw pin shackles and turnbuckles with screw pin jaws shall be provided with a redundant fixing means after pin insertion. The fixing method shall be performed in accordance with the manufacturer’s recommendations.

4. All hardware shall be installed and used in accordance with the manufacturer’s recommendations.

5. All hardware shall have thread locker applied.

C. Other

1. All suspended items must have a safety cable as a means of secondary support. In the case which an item is suspended by four or more points, additional safety cables are not required.

2.4 OTHER REQUIREMENTS

A. All materials used in this project shall be new, unused, and of the latest design. Refurbished and obsolete materials are not permitted.

B. Fabrication:

1. The mechanical fabrication and workmanship shall incorporate best practices for good fit and finish. There shall be no burrs or sharp edges.

2. All moving parts shall have specified tolerances. Sheaves shall run plumb and true and shall not scrape housings.

3. All equipment shall be fabricated to facilitate future maintenance and replacement.

C. Finishes:

1. All finishes are to be black, unless specified otherwise. If the manufacturer offers a choice of color finish, samples/swatches are to be provided to the Owner.

2. All turnbuckles, clips, tracks, chains, and other items of incidental hardware shall be furnished plated or painted. Wire rope is not to be painted.

3. All finishes shall be returned to their original finish and condition after any cutting, patching, or other work.

4. Exception 1: where hardware is visible to patrons/audience and/or the general public, it must be painted to blend in with surrounding aesthetics. This includes any rigging or conduit in the house.

5. Exception 2: conduit and boxes mounted to black stage walls, to be painted flat black.

2.5 EQUIPMENT SPECIFICATIONS

A. General

1. Equipment is specified on a basis of system design. It is specified by
manufacturer and model number.

a. The current manufacturer’s data sheet for each referenced piece of equipment in force at the date of issuance of this specification will be the basis for the specifications of the referenced equipment.

b. Any product accessories such as power supplies, rack mount kits, connectors, adapters, network cables, or other small items are the responsibility of TSC whether or not they are called out in detail within these specifications.

c. The following products/manufacturers indicate the Basis of Design. Substitutions may be submitted after project award for review.

B. Portable Cable Labeling
1. All portable cables shall have the following labeling via heat shrink, printed cable, or labels underneath of clear heat shrink:

2. Color code for length
   a. 3'/5' – Black
   b. 10'/15' – Red
   c. 25' – Blue
   d. 50' – Yellow
   e. 75' – Green
   f. 100' – White

3. Owner/Project Name

C. Stage Curtains
1. Shall comply with NFPA 701.

D. Bill of Materials

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<td>14RU Mobile Rack</td>
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<td>PTRK-14</td>
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<td>90</td>
<td>Grommet Kit, 4&quot;</td>
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<td>91</td>
<td>Wide SR Series Rack, SR28-46-32</td>
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<td>SR28-46-32</td>
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<td>92</td>
<td>Vented Front Door, 46 Space SR Series Rack</td>
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<td>6&quot; Fan Kit for 28&quot; SR Rack</td>
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<td>24 Joint, Slim Power Strip, 20-amp</td>
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<td>Drawer, 3RU, Textured</td>
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<td>Vertical &amp; Horizontal Lacer Strips</td>
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<td>Blank Rack Panels &amp; Hardware</td>
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<td>Custom Power Power Raceway</td>
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<td>Stationary 3-Channel RF Transmitter (72 MHz)</td>
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<td>Universal Antenna Kit (72 and 216 MHz)</td>
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<td>Assistive Listening Notification Signage Kit</td>
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<td>6 Ch. Stereo Audio DA</td>
<td>Extron</td>
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<td>Rack Shelf</td>
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<td>1X24 CAT6 Keystone Patch Panel</td>
<td>Bittree</td>
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<td>Network Based Digital Intercom Belt Pack</td>
<td>Green Go</td>
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<td>Single-ear headset</td>
<td>Clear-Com</td>
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<td>dB Technologies</td>
<td>FM 10</td>
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<td>121</td>
<td>Hanging Microphone Module w/ cable</td>
<td>AKG</td>
<td>HM1000</td>
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<td>Microphone Cardioid Capsule</td>
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<td>Boundary Layer Microphone</td>
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<td>Dynamic Instrument Microphone</td>
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<td>Condenser Instrument Microphone</td>
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<td>SM137</td>
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<td>133</td>
<td>Closed-Back Dynamic Monitor Headphones</td>
<td>Audio Technica</td>
<td>ATH-M60x</td>
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<td>Audio Technica</td>
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<td>Short Tripod w/ Boom Mic Stand</td>
<td>K&amp;M</td>
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<td>Stackable Mic Stand</td>
<td>K&amp;M</td>
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<td>137</td>
<td>Tripod Mic Stand w/Boom - Black</td>
<td>K&amp;M</td>
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<td>138</td>
<td>Cardioid Podium Microphone 23&quot;</td>
<td>Earthworks</td>
<td>FMR600</td>
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<td>139</td>
<td>Lectern Microphone Shock Mount</td>
<td>CAD</td>
<td>GSM-1</td>
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<td>iOS App: Crestron Electronics</td>
<td>Mobile Pro</td>
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<td>152</td>
<td>iOS App: Shure</td>
<td>ShurePlus Channels</td>
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<td>153</td>
<td>iOS App: Electronic Theatre Controls</td>
<td>ETC</td>
<td>iRFR-BTS</td>
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<td>iOS App: Crestron Electronics</td>
<td>Mobile Pro</td>
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<td>156</td>
<td>Fiber Patch Panel</td>
<td>Cleerline</td>
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**Base Bid: Dance Classroom**

**Item:** | **Manufacturer:** | **Model:** | **Qty:** | **Notes:** | **ID:**
---|---|---|---|---|---
1 | 8" Ultra Coaxial Two-Way Loudspeaker | Martin | CDD8 | 6 | SPK-D1,-D2,-D3,-D4,-D5,-D6 |
2 | 10" Slimline Direct Radiating Subwoofer | Martin | SX110 | 2 | SPK-D51,-D52 |
3 | 2000W 4-Channel Q-SYS Network Amplifier | QSC | CX-Q2X4 | 1 | AMP4 |
4 | Unified Core 24 I/O Audio DSP | QSC | CORE 110 | 1 | DSP2 |
5 | 10" Touch Screen Controller | Crestron | TSW-1060-B-5 | 1 | TP-D1 |
6 | 3 Series Control System | Crestron | CP3N | 1 | CTL2 |
7 | Dante Audio Wall Plate-BT/2xRCA/3.5 | Avterio Tech | unD508T | 1 | DNTM1 |
8 | Digital Wireless Beltpack System | Shure | QLX1493 | 2 | WMR21,22 |
9 | Wideband UHF 4-Way Active Antenna Splitter | Shure | UA844+SWB/LC | 1 | WAS10 |
10 | Handheld Transmitter w/ Beta Head | Shure | QLXD2/B58 | 2 | |
11 | 10-Port Pre-Configured Network Switch | QSC | NS-1108P | 1 | NET6 |
12 | Bidirectional Unbal. Stereo Network Interface | RDL | SF-BNC2 | 2 | DNTM,3 |
13 | Rack Mounted Battery Charger | Shure | SBRC-US | 1 | |
14 | Charging Module For SB900A | Shure | SBC-AX | 4 | |
15 | Rechargeable Lithium-Ion Battery | Shure | SB900A | 8 | |
16 | SubPlate UPS Support Bracket, SR Series | Middle Atlantic | SR-UPS-BKT | 1 | |
17 | Grommet Kit, 4" | Middle Atlantic | GK-4G | 1 | |
18 | Wide SR Series Rack, SR28-46-32 | Middle Atlantic | SR28-46-32 | 1 | ER3 |
19 | Vented Front Door, 46 Space SR Series Rack | Middle Atlantic | LVF028-46 | 1 | |
20 | 6" Fan Kit for 28" SR Rack | Middle Atlantic | SR28-FK6-32 | 1 | |
21 | 4RU 28" Wide Rail Kit | Middle Atlantic | SR28-RR46 | 1 | |
22 | Thermostatic Fan Controller | Middle Atlantic | FC4-1CA | 1 | |
23 | 24 Outlet, Slim Power Strip, 20-amp | Middle Atlantic | PD-2420SC-N5 | 2 | 2 per Rack (1-UPS, 1-Switched) |
24 | Rack Screw | Middle Atlantic | HW500 | QTY as Necessary | |
25 | Drawer, 3RU, Textured | Middle Atlantic | TD3 | 2 | |
26 | Vertical & Horizontal Lacer Strips | Middle Atlantic | QTY as Necessary | |
27 | Blank Rack Panels & Hardware | Middle Atlantic | QTY as Necessary | |
28 | Multi-Mount Series Power Strip | Middle Atlantic | PD-2015R-N5 | 1 | |
29 | Custom PDW Power Racingway | Middle Atlantic | PDW-2400-500 | 1 | See Drawings |
30 | Pure Sine Wave Un-Interruped Battery Backup | Middle Atlantic | UPS-2200R | 1 | |
31 | Power Conditioner | Furman | PL-PRO-DAC | 1 | |
32 | 24-Port POE Gigabit Network Switch | Cisco | SG350X-24MP-K9 | 1 | NET5 |
33 | Network Based Digital Intercom Belt Pack | Green Go | GGG-8PX | 10 | |
34 | Single-ear headset | Clear-Com | CC-110-X4 | 8 | |
35 | EtherCon Ethernet Cables | LEX | CAT6-EC-25 | 2 | custom labeling, see spec |
PART 3 EXECUTION

3.1 INSTALLATION

A. Installation of this equipment shall only be performed by trained professional TSCs. Installation shall be performed in a workmanlike manner and shall strictly adhere to the standards of these specifications and manufacturer’s installation requirements. Where necessary, the installer may make adjustments to accommodate unforeseen impediments to installation. The completed work must achieve all functional, electrical, safety and appearance requirements as established in these specifications.

B. Work shall be performed in accordance with OSHA and local codes.

C. On site welding shall only be performed per current AWS D1.1 standards and with advanced approval from the Architect or Construction Manager.

D. The Contractor, EC, and TSC shall each be responsible for storage of stage equipment, tools, and its equipment during the period of installation.

E. The TSC and all persons performing theatrical rigging system or related work shall be under the direct supervision of an ETCP Certified Theater Rigger (Entertainment Technician Certification Program) in good standing for the duration of the project.

F. The TSC and all persons performing theatrical, electrical, system or related work shall be under the direct supervision of an ETCP Certified Electrician (Entertainment Technician Certification Program) in good standing for the duration of the project.

G. The TSC and all persons performing audio/visual system or related work shall be under the direct supervision of a CTS-I or CTS-D (Certified Technology Specialist) in good standing for the duration of the project.

H. The TSC and all persons performing programming of equipment or related work shall...
be under the direct supervision of a Certified Programmer from manufacturers of each type of equipment.

I. The Contractor, EC, and TSC shall be responsible for all clean up related to its work, including the removal of packing materials etc. and the protection of existing surfaces or equipment. Repairs to damage caused by the Contractor, EC, or TSC to any item or surface are the sole responsibility of the damager.

J. The equipment described in this section is considered to be finished equipment and is to be protected during and after installation from excessive dirt and damage caused by other work.

K. All equipment and the areas around the equipment shall be cleaned prior to final inspection and acceptance.
   1. In the event that a site condition will not allow for visual inspection at final acceptance, Contractor, EC, and TSC shall thoroughly document by photograph and submit. For example, rigging installed above a gypsum ceiling or wood blocking inside of a wall.

L. All circuits, panels, boxes, plates, receptacles, and the like shall be properly labeled in a clear permanent professional manner. Provide engraved faceplates stating circuit number(s) and panel fed from. Alternately, engraved 2-ply plastic plates (lamacoid) may be attached to panels and faceplates. P-touch printed stickers are not acceptable. In addition, all panels must have printed schedules inserted in document holders. Provide document holders for all panels.
   1. Colonial Engraving Co., Inc. 17 Route 125, Unit 2, Kingston, NH 03848, 603.347.1749; or approved equal

M. Wiring Methods
   1. Splicing of cables is not permitted between terminations.
   2. All signal wire and cable shall be combed straight and bundled with cable ties every six to twelve inches of laced and anchored as needed. Use proper tooling to insure cable ties or lacing is installed at the proper tension. Do not crush the cable.
   3. All data cable shall be combed straight and bundled with hook and loop (Velcro) tie wraps every six to twelve inches and anchored as needed. Do not crush the cable. Do not use nylon tie wraps (Zip Ties).
   4. Wire and cable shall be formed in either a vertical or a horizontal relationship to equipment or termination point with proper bending radii, service loop, and support. Provide ampler service loops at each termination so that plates, panels, patch bays, and equipment can be removed for service and inspection.
   5. All wires and cables are to be permanently identified at each wire and cable end. This applies to interconnecting cables inside the racks.
   6. All low voltage wire/cable ends are to be covered with heat shrink tubing.
   7. Wire nuts are not permitted on low/voltage wiring.

N. Conduits and Cable Separation (See drawings for additional information)
   1. All conduit to be EMT style unless noted otherwise. See painting/finish requirements in 2.4.C.
   2. No conduit to be filled greater than 40%.
   3. All conduits to have a pull string installed after pulling all wiring with the
intention for future use.

4. All conduits must be continuous and installed per NEC requirements.
5. All conduits for low-voltage wiring must have plastic bushings installed.
6. Conduits shall have separation by type (see drawings).
7. Close proximity conduit/cable crossing is to be done perpendicularly at 90°.
8. It may not be possible to fulfill these requirements at the entry/exit of enclosures, boxes, and related devices. However, the intent of these guidelines is for the EC to provide the stated separation wherever physically possible and specifically where the path of adjacent conduit will be parallel for distances greater than 10’.
9. Maintain a minimum of 12” separation between fluorescent lighting fixtures and all ballasts.
10. Maintain a minimum of 96” separation between ≥15kVA transformers.

3.2 COMPLETION INSPECTION AND TESTING (FINAL ACCEPTANCE)

A. Upon completing the installation of all equipment specified under this section, the EC and TSC shall notify the Owner/Architect, who will schedule an inspection.

B. At the time of inspection, the EC and TSC shall furnish sufficient workers to operate all equipment and to perform such adjustments and tests as may be required by the Architect and/or Owner.
   1. All racks must be open and accessible. Tools must be available to remove any plates, panels, for inspection.
   2. Documentation must be available for reference.
   3. The system must be completely installed, tested, and all equipment fully operational.
   4. Testing to include:
      a. Testing shall be in accordance to ANSI 10:2013 and shall include, but not be limited to:
         1) All circuits are operational and match dimmer/panel schedules. Test with a circuit tester.
         2) All circuits, panels, boxes, plates, receptacles, and the like are properly labeled in a clear permanent professional manner.
         3) Verify that the system is free from RF pickup and oscillation with no input as well as normal operating levels.
         4) Check each loudspeaker with a phase measuring device for proper polarity.
         5) Equalize all systems to conform to the specified initial performance criteria.
         6) Measure each system to verify adherence to the performance specification frequency response. Measure at least 12 points including extremities within the seating area at 4 KHz for coverage uniformity. Correct any problems.
         7) Isolated ground circuit integrity.
      b. With high quality digital program material set the equalized systems for average levels of 90 dB check for unusual distortions or rattles. Also apply a constant sine wave sweep from 80 Hz – 12,000 Hz at a level providing average levels of 86 dB measured at standing ear height. Walk through all systems and check for unusual distortions or rattles. Correct any problems. If the problem is outside of the system, bring the
source to the attention of the Owner.

c. Adjust controls for optimum the signal to noise ratio of all systems relative to the performance requirements of this specification. Adjust all inputs, equalizers, limiters, etc. to provide equal relative loudness of music and voice sources with typical input levels. Adjust all equalizers, delays, etc. for use as called for within the specification.

d. Verify all systems inputs, outputs, wireless equipment for proper operation and functionality.

3.3 OWNER TRAINING AND MANUALS

A. The TSC will provide a training program at the project location for sixteen (16) hours of training in four (4) hour increments. This training may be spread out over a six month period. This includes proper use, operation, trouble shooting, and instruction of all equipment and features of the system. Coordinate with the Owner and his/her staff on scheduling training and topics to be covered.

B. Upon completion of the work, the TSC shall submit detailed Operation & Maintenance Manuals including as-built shop drawings, equipment descriptions, any required certificates or warranties, SDS sheets, and serial numbers. Submit in quantities as required by the front end documents.

C. Provide physical hard copies and electronic copies of Operation & Maintenance Manuals for the Owner and Consultant.

END OF SECTION 16560
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
   7. ADA “Americans with Disabilities Act”
   8. FCC's OET 65 Standards "Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields".

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

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 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 MHz.

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