VOLUME 2 OF 2

FORT SUMTER NATIONAL HISTORICAL PARK

PMIS No. 316098

REPLACE HVAC SYSTEMS AT
LIBERTY SQUARE VISITOR EDUCATION CENTER

DIVISION 2 – 49 CONSTRUCTION SPECIFICATIONS

Prepared for:

FORT SUMTER NATIONAL HISTORICAL PARK
Charleston, South Carolina

SOUTH CAROLINA
LICENSED PROFESSIONAL ENGINEER
No. 42216
CHRISTIAN GELLER
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NATIONAL PARK SERVICE
INTERIOR REGION 2
SOUTH ATLANTIC GULF
EAST MAJOR AQUISTION BUYING OFFICE

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DIVISION 02

EXISTING CONDITIONS

SECTION 02 05 00

GENERAL SITE CONSTRUCTION REQUIREMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The work of this Section includes the general procedures and requirements for Site Work.

PART 2 - PRODUCTS - NOT USED.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Site Verification of Conditions

1. Contractor shall perform necessary potholing or locating of underground utilities and services. Perform minor, investigative excavations to verify location of various existing underground facilities at sufficient locations to assure that no conflict with the proposed work exists and sufficient clearance is available to avoid damage to existing facilities.
2. Upon discovery of conflicts or problems with existing facilities or construction documents, notify Contracting Officer within 24 hours.
3. Existing mapping may be used to approximate locations of existing utilities. Contractor is responsible for determining actual locations of all utilities.

3.2 PREPARATION

A. Protection

1. Spillage -
   a. Avoid spillage by covering and securing loads when hauling on or adjacent to public streets or highways.
   b. Remove spillage and sweep, wash, or otherwise clean project, streets, and highways.
2. Dust Control: See Division 01 Section 01 57 23.
3. Sediment & Erosion Control: See Division 01 Section 01 57 23.
4. Existing Plants and Features: Do not damage tops, trunks, and roots of existing trees and shrubs on site which are intended to remain. Do not use heavy equipment within branch spread. Interfering branches may be removed only with permission of Contracting Officer. Do not damage other plants and features which are to remain.

3.3 REPAIR / RESTORATION - NOT USED.

3.4 FIELD QUALITY CONTROL

A. Notify Contracting Officer 48 hours before performing excavation or fill work.

B. If work has been interrupted by weather, scheduling, or other reason, notify Contracting Officer 24 hours minimum prior to intended resumption of grading or compacting.

C. NPS reserves right to require additional testing to re-affirm suitability of completed work including compacted soils which have been exposed to adverse weather conditions.

END OF SECTION

SECTION 02 41 00

DEMOLITION & ABANDONMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. The work of this Section includes all demolition, removal, salvage and disposal of existing structures, piping, pavement and other miscellaneous materials.

1.2 SUBMITTALS

A. As specified in Division 01 Section 01 33 23 “Submittal Procedures.”

B. Certifications and Testing consistent with Division 01 Section 01 33 23 “Submittal Procedures” and including:

1. Permit for transport and disposal of debris.
2. Proposed method of demolition, proposed schedule, sequence of work, and proposed method and schedule for removing, maintaining, and re-establishing facilities and utilities prior to scheduling the preconstruction meeting.

1.3 SITE CONDITIONS

A. Protection

1. Erect barriers, fences, guardrails, enclosures, chutes, and shoring around all construction activities to protect personnel, structures, and utilities remaining intact.
2. Protect designated trees and plants from damage.

B. Maintaining Traffic

1. Assure minimum interference with roads, streets, driveways, sidewalks, and adjacent facilities.

C. Utility Lines and Services

1. Keep existing structures to remain and adjacent structures intact and in operation.
2. Obtain permission to disrupt any utilities or services temporarily or permanently.
3. Coordinate with utility company for disconnecting existing service on structures to be demolished.
4. Coordinate with Park for services to be disconnected and schedule with utility company. Schedule and coordinate with Park and utility company far enough in advance so as to not delay work.

D. Prior to demolishing a utility or facility, notify the Contracting Officer 3 days in advance, and plan the demolition such that the demolition will not create an unsafe condition or interfere with ongoing operations.

E. Where demolition must occur in such a sequence that a portion of this facility must remain operational, coordinate this aspect with the Contracting Officer.

F. Do not burn waste material. All organic material removed from the construction area must be properly chipped and recycled or removed from the Park and properly disposed.

G. Provide adequate fire protection. Keep area clear of hazardous substances and debris.

H. Maintain access to exits at all time.

I. Separate demolition area from building to remain with temporary dustproof partitions.

J. Provide temporary weather protection to prevent damage to structure and interior area.

K. Explosives are not permitted.

PART 2 - PRODUCTS

2.1 BACKFILL MATERIALS

A. Native soils, stone, gravel, or sand, free from debris, frozen materials, and roots and other organic matter may be used for backfill of demolition areas that are not designated for new construction. Pieces of concrete and masonry smaller than 1 square foot and suitably shaped for compaction may be used in backfill more than 1 foot below finished grade. Restrictions to Backfill:

B. See Section 01 11 00 – Summary of Work; Subsection 1.4.C Preservation of Natural Features Item 4.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that areas to be demolished are unoccupied and discontinued in use.

B. Do not commence work until conditions are acceptable to Contracting Officer

3.2 PREPARATION

A. Arrange for and verify termination of utility services to include capping lines.

B. Remove items scheduled to be salvaged and place in designated storage area.

3.3 DEMOLITION/ABANDONMENT

A. All debris from demolition and abandonment shall be removed off the Park and disposed of in a legal manner. Any material which the Contracting Officer may wish to save or reuse shall be stored per the Contracting Officer direction.

B. General

1. Dampen debris and use temporary enclosures as necessary to control dust.
2. Do not use water to the extent it causes flooding, contaminated runoff, or icing.
3. Break concrete and masonry into sections less than 3 feet in any dimension and dispose of off-site.
4. Repair damage to adjacent structures.
5. Make neat saw cuts around areas of concrete to be removed, where remaining concrete is to be incorporated into new work.
6. Remove existing exposed piping to the extent shown on the Drawings.
7. Remove buried piping to the extent shown on the Drawings.
8. All equipment to be removed or replaced shall be done so in a safe manner and such that the equipment and any associated piping or wiring is not damaged.
9. All debris from demolition and abandonment shall be removed off the Park and disposed of in a legal manner. Any material which the Contracting Officer may wish to salvage shall be cleaned and stored per the Contracting Officer's direction and requirements of this specification.

3.4 HAZARDOUS MATERIALS

A. If suspected hazardous materials are encountered during demolition of existing facilities, all work is to be stopped immediately and the Contracting Officer is to be immediately notified.

3.5 DISPOSAL

A. Place demolition debris in debris boxes onsite for weekly removal.

B. Dispose of unsuitable and excess material off-site. Contractor shall recycle all recyclable demolished materials. Contractor shall submit names and contact information for proposed recyclers to the Contracting Officer prior to beginning demolition. Only materials not suitable for recycling shall be disposed of in a land fill.

C. Disposal of demolition material shall be in accordance with all EPA, OSHA, and State requirements for materials disposal.

3.6 SALVAGE

A. Carefully remove items to be salvaged and delivered to Contracting Officer's storage

1. Store and protect items indicated to be salvaged.

2. Replace any items damaged through carelessness in removal, storage, or handling with new items of same type.
3. Do not reuse materials or equipment not specifically indicated or specified to be reused.

B. Preparation of Equipment for Storage

1. Identify each component with markings or tags to show its position in the assembly and the assembly of which it belongs.
2. Place small parts in wooden boxes and clearly mark contents on the outside.
3. Thoroughly clean and dry equipment.
4. Coat unpainted surfaces with 2 coats of rust-preventive compound.
5. Attach unit to suitable crate bottom.
6. Enclose unit in polyethylene film and seal all seams and the film to the base of the unit with tape.
7. Construct crate of wooden slats around top and sides of unit.
8. Attach permanent instruction tag to outside of crate stating, “This unit has been prepared for storage.”

END OF SECTION

DIVISION 05

METALS

SECTION 05 12 00

STRUCTURAL STEEL FRAMING

PART 1 – GENERAL

1.1 SUMMARY

A. Related Documents:

1. Drawings and general provisions of the Subcontract apply to this Section.
2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:

1. Structural steel framing members, support members, bracing members and connections.
2. Base plates, leveling plates, anchor bolts, leveling nuts, shear stud connectors, deformed bars welded to structural steel, and bolts.
3. Verification of anchor bolt setting and levels to assure adequate fit of the steel work.

C. Related Sections:

1. Division 01 Section "General Requirements."
2. Division 01 Requirements "Construction Waste Management".
3. Division 05 Section “Metal Fabrications”

1.2 REFERENCES

A. General:

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.
3. Refer to Division 01 Section "General Requirements" for the list of applicable regulatory requirements.

B. Federal Specifications:

1. FF-B-56IC - Bolts, (Screw), Lag
2. FF-B-588C (1) - Bolt, Toggle; and Expansion Sleeve, Screw
3. FF-S-92B (1) - Screw, Machine; Slotted, Cross-recessed or Hexagonal Head
4. FF-W-84A (3) - Washer, Lock (Spring)
5. FF-W-92A (1) - Washer, Flat (Plain)

C. RR-G-66ID - Grating; Metal, Bar Type (Floor, Except for Naval Vessels)

D. ASTM International:

1. ASTM A27 / A27M Standard Specification for Steel Castings, Carbon, for General Application
2. ASTM A47 / A47M Standard Specification for Ferritic Malleable Iron Castings
3. ASTM A53 / A53M Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
4. ASTM A108 Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
5. ASTM A123 / A123M Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
6. ASTM A153 / A153M Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
7. ASTM A283 / A283M Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
8. ASTM A307 Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
9. ASTM A325 Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
10. ASTM A385 Practice for Providing High-Quality Zinc Coatings (Hot-Dip)
11. ASTM A490 Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength
12. ASTM A500 / A500M Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
13. ASTM A525 General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
14. ASTM A36 / A36M Standard Specification for Carbon Structural Steel
15. ASTM A572 / A572M Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
16. ASTM A780 Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
17. ASTM A992 / A992M Standard Specification for Structural Steel Shapes
18. ASTM D2092 Recommended Practices for Preparation of Zinc-Coated Steel Surfaces for Painting
19. ASTM F1554 Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

E. American Welding Society:

1. AWS D1.1 - Structural Welding Code

F. American Institute of Steel Construction (AISC):

1. AISC 303 – Code of Standard Practice for Steel Buildings and Bridges except the following shall be added to 3.1 (f): Horizontal and vertical dimensions may not be shown entirely on the Structural Drawings.
2. AISC 340 - Seismic Provisions for Structural Steel Buildings, Including Supplement 1
3. AISC 358 – Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications

4. AISC 360 – Specification for Structural Steel Buildings
5. AISC -Steel Construction Manual
6. RCSC -Research Council on Structural Connections "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts

G. Federal Emergency Management Agency (FEMA):

1. FEMA 353 – Recommended Specifications in Quality Assurance for Steel Moment Frame Construction in Seismic Applications

H. Steel Structures Painting Council (SSPC):

1. SSPC – SP No. 6, Commercial Sand Blasting

1.3 SUBMITTALS

A. Submit under provisions of Division 01 Section "General Requirements."

B. Shop drawings for structural steel fabrications shall be submitted for review prior to fabrication. Examples include, but are not limited to:

1. Complete fabrication and erection plans and procedures giving full information on aspects of the erection which will affect alignment, plumb and dimensional accuracy of the structure.
2. Connections including size and spacing of bolts and welds.
3. Indicate profiles, sizes, spacing, and locations of structural members, openings, camber, and attachments. Indicate welded connections with AWS welding symbols. Indicate net weld lengths. Details of welding materials, equipment, sequence and technique to be used. Shop and erection details incorporating seismic critical welds shall include explicit references to corresponding weld procedure specifications.
4. The Subcontractor shall survey, review and confirm as-built conditions prior to developing shop drawings. Field modifications to suit as-built conditions shall be at the Subcontractor’s expense.

C. Welding Procedure Specifications: Subcontractor shall submit welding procedure specifications (WPS) for each shop and field welding joint type and process to the Contract Officer Representative for review.

1. The WPS shall be prepared and signed by a welding professional whose qualifications include a minimum of 5 years’ experience with the welding technologies proposed.
2. The WPS shall include, at a minimum, the information specified in AWS 01.1, Section 3 and the supplemental provisions of Annex H.
3. Prequalified WPS may be used provided they meet the requirements of AWS D1.1, Section 3 for prequalified welds.
4. Any single deviation from the AWS 01.1 requirements for prequalified welds shall necessitate qualification by test per AWS 01.1, Section 4. WPS that are qualified by testing shall conform the additional requirements of AWS 01.1, Annex IV and shall include the corresponding Procedure Qualification Records (PQRs).

5. WPS for seismic critical welds shall conform to the additional requirements of AWS D1.8, Section 6.1.

D. Welder Performance Qualification Records (WPQR): Subcontractor shall submit WPQR for each shop and field welder to the University's Testing Agency for review.

E. Welders' Certificates: Documentation certifying each welder employed on the work meets AWS qualifications.

F. Manufacturer's Certificate: Submit certification that manufactured products (including bolts, nuts and washers) meet or exceed specified requirements. Manufactured products are to be delivered in unopened containers. Certification numbers must appear on product containers for bolts, nuts and washers and the numbers shall correspond to the identification numbers on the Manufacturer's Certificate. The Manufacturer's symbol and grade markings must appear on bolts, nuts and washers. Submit manufacturer’s certification that structural shapes contain specified percentage recycled material.

G. Product data: Submit certification that manufactured products meet or exceed specified requirements.

1. Weld filler material including filler metal Charpy V-Notch test values, electrodes, fluxes and shield gases.
2. Prime paint.

H. Mill Test Reports: Submit mill test reports indicating structural strength, destructive and nondestructive test analysis and chemical analyses from each heat of steel used in the work.

1.4 QUALITY ASSURANCE

A. Fabricate structural steel members in accordance with AISC specifications.

B. Welders shall be qualified in accordance with AWS D1.1 for each process, position, and joint configuration.

C. Maintain one copy of each referenced document on site.

D. Fabricator Qualifications: The Company shall submit written documentation of experience in performing the work of this Section prior to award of the Subcontract.

E. Erector Qualifications: Company with a documented experience in performing the work of this Section.

F. The design of connections not detailed on the Drawings shall be under the direct supervision of a Structural Engineer experienced in design of this work and licensed in the State of South Carolina.

1.5 TESTS AND INSPECTIONS

A. Notification:

1. The Subcontractor shall notify the Contracting Officer Representative of work to be tested and inspected. Notification shall be sufficiently in advance to allow scheduling of tests and inspections, but not less than 24 hours.
2. The Subcontractor shall immediately notify the Project Manager if quality assurance tests and inspection requirements have not been met.

B. Quality Assurance Tests and Inspections:

1. General: Quality assurance tests and inspections shall be the responsibility of the Subcontractor. The Subcontractor shall retain a testing agency, referred to herein as the Testing Agency, who shall perform the required tests and inspections, prepare written summary reports of tests and inspections, and review submittals.
2. The Testing Agency shall submit written procedures, qualifications and reports as specified in ANSI/AISC 341, Appendix Q, Section Q4.
3. The Testing Agency shall perform tests and inspections per CBC, Chapter 17 and as follows:
   a. Collect and review certified mill analysis reports.
   b. Review steel identification per CBC Section 2203.2.
   c. Collect and review certificates of conformance. Materials not accompanied by manufacturer certificates shall be tested by the Subcontractor's Testing Agency.
   d. Welding Tests and Inspections:
      1) Personnel performing welding inspections and nondestructive testing shall meet the minimum qualifications specified in AWS D1.1, Section 6.
      2) Personnel performing welding inspections and nondestructive testing on seismic critical welds shall meet the additional qualifications specified in AWS D1.8, Section 7.
      3) Review shop and field WPS in accordance with AWS D1.1 and D1.8. 4) Confirm welders, welding foreman, and QC Inspectors have a copy of the approved WPS.
      4) Confirm welders, welding foreman and QC inspectors have a copy of the approved WPS.
      5) Review WPQR in accordance with AWS D1.1 and D1.8 for the welds to be performed.
      6) Confirm welding equipment settings, voltage and amperage at point of welding.
      7) Perform visual inspection of shop and field welds in accordance with ANSI/AISC 341, Appendix Q, Section Q5.1. Inspections for items marked P (Perform) for both QC and QA inspections shall be the performed by the University's Testing Agency. Acceptance criteria for visually inspected welds shall be in accordance with AWS D1.1, Section 6.
      8) Perform nondestructive tests (NDT) of shop and field welds in accordance with ANSI/AISC 341, Appendix Q, Section Q5.2, except as noted below. Provide NDT equipment as required to perform specified tests.
         a) Ultrasonic testing (UT) shall conform to AWS D1.8, Section 7.10.
         b) The rate of ultrasonic testing on complete joint penetration (CJP) groove welds may be reduced to 25-percent for an individual welder or welding operator after sufficient project experience is demonstrated per Appendix Q, subsection Q5.2g. However, no reduction in testing frequency shall be permitted for demand critical welds.

c) Magnetic Particle (MP) testing shall conform to AWS D1.8, Section 7.9.
d) The rate of magnetic particle testing on CJP groove welds may be reduced to 1 O-percent for an individual welder or welding operator after sufficient project experience is demonstrated per Appendix Q, subsection Q5.2h. However, no reduction in testing frequency shall be permitted for demand critical welds.

e. High-Strength Bolting Tests and Inspections:
   1) Sample and test high strength bolts, nuts and washers in accordance with the requirements of the Specification for Structural Joints Using ASTM A 325 or A 490 Bolts.
   2) Inspect installation of high strength bolts per ANSI/AISC 341, Appendix Q, Section Q5.3. Inspections for items marked P (Perform) for both QC and QA inspections shall be the performed by the University's Testing Agency.
f. Welded and bolted connections that fail to meet the acceptance criteria specified shall be re-inspected and/or re-tested after corrections have been made by the Subcontractor.
g. Welded Studs: Inspect size, number, placement, and welding of welded studs in accordance with Section 7 of AWS D1.1.
h. The Testing Agency shall review Subcontractor quality control test and inspection reports.

1.6 SUBCONTRACTOR'S ENGINEERING SERVICES

A. General: Where engineering services are required herein, the Subcontractor shall retain a Structural Engineer registered in the State of South Carolina, referred to herein as the Subcontractor's Engineer.

   1. Where explicitly allowed, a Civil Engineer registered in the State of South Carolina is acceptable as the Subcontractor's Engineer.
   2. Documents prepared by the Subcontractor's Engineer shall be stamped and signed.

B. Shoring: The Subcontractor's Engineer shall design, detail, inspect, and provide scheduled procedures for shoring of composite steel framing where needed, The design shall conform to the applicable Federal, State and local requirements, Drawings shall include detailed procedures and schedules for installation, sequencing and removal of shoring.

1.7 FIELD MEASUREMENTS

A. Verify that field measurements are as indicated on the Shop Drawings.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Plate, bars and channels: ASTM A36 unless otherwise noted in the drawings.

B. Bolts and Nuts: Bolts in structural steel connections shall be ASTM A325 unless designated as A490 on the drawings. Nuts shall be ASTM A563 Grade C or DH. Patented, high strength steel connectors conforming to ASTM F1852 must be submitted for approval by the University and will not be permitted at slip critical bolted connections. Where galvanized connectors are called for on the drawings, they shall be galvanized in accordance with ASTM A153. Bolts conforming ASTM A307 and nuts conforming to ASTM A563 may be used in stair, handrail, miscellaneous steel, and timber connections.

C. Washers shall be flat and either circular, square, or rectangular conforming to ASTM F436 Type 1. The finish of washers is to match the nut. A325 bolts shall have washers under the head and A490 bolts shall have hardened washers under the head and the nut.

D. Welding Materials: Filler metals shall conform to Table 4.1 of AWS D1.1. Electrodes and equipment settings shall be as recommended by the filler metal manufacturer for the position, thickness and conditions of use. electrodes and filler metal shall be low hydrogen types. FCAW wire diameter shall not exceed the values in Section 4.14.1 of AWS D1.1. In addition, filler metal for Seismic Critical Welds shall be capable of producing welds with Charpy V-Notch test values conforming to the AISC 341.

E. Sliding Bearing Plates: Teflon coated.

F. Shop and Touch-Up Primer: Tnemic Series V10, Maclac 42 Series or an approved equal free of chromate and lead with volatile organic compounds less than 340 grams per liter.

G. Touch-up Primer for Galvanized Surfaces: Zinc rich type.

2.2 CONNECTIONS

A. Unless otherwise noted in the drawings, shop connections shall be welded and field connections, except moment connections, shall be bolted. Weld only in accordance with approved welding procedures.

B. Unless otherwise noted on the drawings, bolted connections shall be 3/4-inch diameter A325-N; connections shall have a minimum of two bolts. Shoulder bolts with hex nut and lock washers shall be used in slotted connections with the washer covering the slot in positions.

C. Unless connections are detailed in the drawings, the Subcontractor is responsible for the design of connections.

D. All elements of a connection shall be designed to resist the loads and moments shown on the drawings; if the reaction or load is not shown on the drawings, connections are to be designed as follows:

1. Beam connections are to be designed to resist one half the allowable load for the appropriate span given in the Tables 3-6 through 3-9 in the AISC Manual of Steel Construction. Beam connections will be in accordance with the AISC Manual of Steel Construction. The minimum connection angle length will be half the depth of the beam depth.
2. Horizontal and vertical bracing connections shall have a minimum of two bolts.

E. Gusset plates connecting horizontal and vertical bracing to beams and/or columns shall be connected to both adjacent members; where this is not practical, provision shall be made for the moment induced by the eccentricity of the load to the work point of the connection. Gusset plates for horizontal bracing shall be located within the top two rows of bolts of beam connection angles, unless otherwise noted on the drawings. The minimum thickness of gusset plates in single shear shall be 5/16-inch (7.94 m) for bolts in single shear and 3/8-inch (9.50 mm) for bolts in double shear.

2.3 FABRICATION

A. Fabricate structural steel in accordance with the applicable provisions of the AISC Specifications for Structural Steel Buildings. Where practical, fabricate and assemble in the shop.

B. Obtain field measurements necessary for steel fabrication.

C. Perform high strength shop bolting in accordance with the appropriate ASTM specification. Complete high strength shop bolting before welding.

D. Dimensional tolerances:

1. Overall length of members with both ends milled may vary by 1/32-inch (33.53 mm).
2. Overall length of members without milled ends may vary by 1/16-inch (1.59 mm) for lengths less than 30 feet (9 m).

E. Where structural joints are welded, the detail of the joints, welding technique, weld quality and appearance, and methods for correcting defective welds shall conform to the AISC Code of Standard Practice and AWS D1.1. Welding procedure and sequence shall conform to AWS B2.1. surfaces to be welded shall be clean and free of rust, paint, or galvanizing. Burned or flame cut edges shall be chipped clean and wire brushed.

F. Where milling is indicated on the drawings, the contact surfaces shall be machined true to obtain full and complete contact.

G. Structural members are selected from generally available rolled sections; however, if the specified sections are not available, the Subcontractor shall provide sections with equivalent physical properties after approval by and at no additional cost to the Park.

2.4 FINISH

A. Prepare structural component surfaces in accordance with Division 09 Painting Sections."

B. Shop prime structural steel members. Apply two coats of different colored primer to areas which will be inaccessible after erection or assembly. Do not prime surfaces that will be fireproofed, in contact with concrete, within 3 inches of field welds, or on the faying surface of high strength bolted friction connections.

C. Galvanize structural steel members indicated on the Drawings as galvanized in accordance with ASTM A123 and A385 after fabrication. Prepare galvanized surfaces to be painted in accordance with ASTM D2092 and shop coat with a compatible primer. Repair damaged galvanizing in accordance with ASTM A780.

2.5 SOURCE QUALITY CONTROL

A. Shop inspection and testing will be performed under provisions of Division 01.

B. Subcontractor shall furnish samples as required for testing at no additional cost.

C. The Subcontractor's Testing Laboratory will:

1. Review manufacturer's test reports for compliance with specified requirements.
2. Review welding procedure specifications.
3. Verify material identification.
4. Inspect high strength bolted connections as required by CBC Section 1704.3 and in conformance with RCSC Specification.
5. Inspect welding as required by CBC Section 1704.3.
6. Nondestructive test complete penetration groove welds larger than 5/16 inches by ultrasonic methods for conformance with the weld quality and standard of acceptance of AWS D1.1 for welds subject to tensile stress.
11. Faulty and Defective Welding: Any welding performed without inspection, or not in compliance with the approved WPS, or displaying cracks, slag inclusion, lack of fusion, undercut or other defects defined by the AWS, ascertained by visual or nondestructive means, shall be removed, and properly replaced by the subcontractor and re-inspected by the Testing Agency all at the subcontractor's expense.

D. Periodically, inspect and test stud welding as required by CBC Section 1704; in accordance with AWS D1.1 review pre-production testing and qualification, periodically inspect welding and perform verification inspection and testing.

PART 3 - EXECUTION

3.1 PREPARATION

A. Furnish and install temporary supports and internal braces necessary to support structural steel during erection. Temporary supports and braces shall be adequate for anticipated wind, seismic, equipment and erection loads. Remove temporary shoring after the steel erection is complete.

B. After completion of welds, remove weld tabs (spillage dams) in accordance with AWS D1.1 provisions for dynamically loaded structures. After completion of full penetration groove welds, remove backing bars in accordance with AWS D1.1 provisions for dynamically loaded structures, inspect the weld and reinforce the groove weld with a fillet weld. Peening of thick welds shall be performed in accordance with AWS D1.1.

3.2 EXAMINATION

A. Verify that field conditions are acceptable and are ready to receive work.

B. Beginning of installation means Subcontractor accepts that existing conditions meet the requirements for installation.

3.3 ERECTION

A. Erect structural steel in accordance with the AISC Specifications for Structural Steel Buildings, except as modified herein. Where members cannot be properly assembled due to mis fabrication or deformation due to handling or transportation, the condition shall be reported to the Contracting Officer Representative with a proposed method of correction for approval. Erect steel to the lines and grades indicated on the drawings and in accordance with the Erection Drawings.

B. During erection beams and vertical bracing are to be secured with at least two bolts prior to releasing the hoisting cable.

C. Perform high strength bolting in accordance with the appropriate ASTM specification. Complete high strength bolting before field welding.

D. Do not field cut or alter structural members without approval of the Contracting Officer Representative.

E. After erection, prime welds, abrasions, and surfaces that are not shop-primed, except surfaces to be in contact with concrete.

F. Where field welding to existing structural members is required, the Subcontractor shall confirm the weldability of the existing steel by cutting or drilling samples and having them tested by the Subcontractor's Independent Testing Laboratory. The testing laboratory shall recommend the location for taking samples, provide a report on weldability, recommend the type of electrode and weld, and inspect the final welds. The Subcontractor will be responsible for preparing the existing steel for welding and touch of the surfaces.

3.4 ERECTION TOLERANCES

A. Tolerances shall be in accordance with the AISC Code of Standard Practice. Crane rail tolerances shall comply with CMAA Specification 70.

3.5 INSPECTION AND TESTING

A. The Subcontractor shall be responsible for in-house visual inspection and implementing a quality control program.

B. The Testing Agency will inspect and test field high strength bolting and welding in accordance with Paragraph 2.5.

C. Notify the Contracting Officer Representative of the fabrication and erection schedules in writing. The schedules shall include time to observe shop assembly, make visual inspections, nondestructive tests of welds, observe erection and perform field testing. Prior to welding, provide the Contracting Officer Representative with two weeks written notification, including quantity, type, duration, shift(s) and location, of welding activities to be performed. Costs associated with delays resulting from noncompliance with the notification requirements will be borne by the Subcontractor. Fabrications performed without reviewed shop drawings, reviewed weld procedures, material certifications or the specified notification of welding activities shall be considered defective work and subject to rejection. Defective work rejected by the Park shall be corrected by the Subcontractor at no additional cost to the Park.

3.6 WASTE MANAGEMENT

A. Conform with Division 01 Section "Construction Waste Management."

B. Collect scraps and cut-offs and place designated areas for recycling.

C. Separate other waste materials in accordance with the Waste Management Plan and place designated areas for recycling.

END OF SECTION

SECTION 05 14 00

LOUVERS & VENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Extruded aluminum stationary Miami-Dade approved louvers.

1.2 RELATED SECTIONS

A. Section 07 15 00 – Sheet Metal Water Proofing

B. Section 09 90 00 – Paints and Coating

1.3 REFERENCES

A. AAMA 2604 – High Performance Organic Coatings on Architectural Extrusions and Panels.

B. AAMA 2605 – High Performance Organic Coatings on Architectural Extrusions and Panels.

C. AMCA 500-L – Test Methods for Louvers.

D. AMCA 511 – Certified Ratings Program for Air Control Devices.

E. ASCE 7 – Minimum Design Loads for Buildings and Other Structures.

F. ASTM B209 – Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.

G. ASTM B221 – Standard Specifications for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.

H. ASTM D822 – Standard Practice for Filtered Open-Flame Carbon-Arc Exposure of Paint and Related Coatings.

I. ASTM D4214 – Standard Test Method for Evaluating the Degree of Chalking of Exterior Paint Films.

J. ASTM D2244 – Standard Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates.

K. ASTM E330 – Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights, and Curtain Walls by Uniform Static Air Pressure Difference.

L. Miami-Dade County Building Code Compliance Office (BCCO)

M. Living Building Challenge – Red List Chemicals

1.4 SUBMITTALS

A. Submit under provisions of Section 01 30 00

B. Product Data: For each product to be used, including:

1. Manufacturer's product data including performance data.
2. Installation Instructions
3. Maintenance and Operations Manuals
4. Health Product Declarations (HPDs) and Declare Labels

C. Shop Drawings

1. Submit shop drawings indicating materials, construction, dimensions, accessories, installation details, and connection methods and means.

D. Samples

1. Submit color chip sample for units with factory-applied paint.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. The manufacturer shall have implemented the management of quality objectives, continual improvement, and monitoring of customer satisfaction to assure that customer needs and expectations are met.

B. Production Qualifications:

1. Louvers shall be licensed to bear AMCA Certified Ratings Seal. Ratings based on tests and procedures performed in accordance with AMCA 511 and comply with AMCA Certified Ratings Program. AMCA Certified Ratings Seal applies to air performance and water penetration ratings.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly indicating manufacturer and material.

B. Storage: Store materials in a dry area indoors, protected from damage and in accordance with manufacturer's instructions.

C. Handling: Protect materials and finishes during handling and installation to prevent damage.

D. Store and dispose of solvent-based materials, and materials used with solvent-based materials, in accordance with requirements of local authorities having jurisdiction.

1.7 PROJECT CONDITIONS

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

B. Field Measurements: Verify actual dimensions of openings by field measurements before fabrication. Coordinate field measurements and fabrication schedule with construction progress to avoid construction delays.

1.8 WARRANTY

A. Manufacturer shall provide a standard limited warranty for louver systems for a period of 1 year from date of installation, no more than 18 months after shipment from manufacturing plant. When notified in writing from the Owner of a manufacturing defect, manufacturer shall promptly correct deficiencies without cost to the owner.

B. Manufacturer shall provide 20 year limited warranty for fluoropolymer-based finish on aluminum substrates.

1. Finish Coating shall not peel, blister, chip, crack, or check.
2. Chalking, fading, or erosion of finish when measured by the following tests:
   a. Finish coating shall not chalk in excess of 8 numerical ratings when measured in accordance with ASTM D4214.
   b. Finish coating shall not change color or fade in excess of 5 NBS units as determined by ASTM D2244 and ASTM D822
   c. Finish coating shall not erode at a rate in excess of .01 mils/year.

PART 2 - PRODUCTS

2.1 MANUFACTURER

1. Industrial Louvers Inc. (ILI) - Contact: 511 South 7th Street, Delano, MN 55328; Telephone: (763) 972-2981; Fax: (763) 972-2911.
2. Other Available Manufacturers – subject to compliance with requirements stated within.

2.2 EXTRUDED ALUMINUM WEATHER RESISTANT LOUVERS

A. Fabrication:

1. Model: 653XPDC
2. Frame:
   a. Frame Depth: 6 inches (152.4 mm)

b. Frame height 84”
c. Frame to fit with in post spacing.
d. Material: Extruded aluminum, 6063-T6
e. Wall Thickness: 0.081 inch (2.1 mm), nominal

3. Blades:
a. Style: Drainable
b. Material: Extruded aluminum, 6063-T6
c. Wall Thickness: 0.081 inch (2.1 mm), nominal
d. Angle: 37.5 degrees
e. Centers: 4.25 inches (108 mm), nominal

B. Performance Data:

1. Performance Ratings: Product must be licensed to bear the AMCA Certified Ratings Seal for water and Air Performance.
a. Based on testing 48 inches by 48 inches (1219 mm by 1219 mm) size unit in accordance with AMCA 500-L
2. Free Area: 54.8% (8.77 sq.ft.)
3. Water Penetration: Maximum of .01 ounces at an air flow of 1193 FPM.
4. Static Pressure Loss: Not more than .15 inch of water gauge at an air flow of 964 FPM free area velocity.
5. Miami-Dade County Test Protocols
a. TAS-201
b. TAS-202
c. TAS-203
d. Miami-Dade County Notice of Acceptance #13-0909.09

2.3 LOUVER ACCESSORIES

A. Exterior Aluminum Sill: Provide sill flashing of same material and finish as louvers where indicated on the drawings.

B. Louver Screens: Provide framed removable, re-wire-able screens for exterior louvers.

1. Bird Screen:
a. Aluminum: Aluminum, ½ inch by 0.063 inch (12.7 mm by 1.6 mm), expanded, flattened.
2. Insect Screen:
a. 18 x 14 aluminum charcoal mesh 0.011 inch (0.28 mm) diameter wire.

C. Hinged Panel Section: Provide required hardware and accessories for a door swing per manufacturer at location shown on drawings. The panel section shall be the encompass the full height and width of the wall section between two posts.

a. Contractor to coordinate with manufacturer to ensure the panel section can be locked and secured with key access.

2.4 FABRICATION

A. Fabrication Requirements:

1. Performance: Fabricate as required for optimum performance with respect to water penetration, strength, durability, and appearance.
2. Size: Fabricate louvers in walls to meet dimensions indicated on Contract Documents.
3. Field Measurement: Verify size, location, and placement of louvers before fabrication.
4. Shop Assembly:
   a. Fabricate to minimize field adjustments, splicing, mechanical joints and field assembly of units.
   b. Preassemble units in shop to greatest extent possible and disassemble as necessary for shipping and handling.
   c. Clearly mark units for reassemble and coordinated installation.
5. Accessories: Include supports, anchorages and accessories required for complete assembly.
6. Vertical Mullions: Provide vertical mullions of type and spacing indicated but not further apart than recommended by the manufacturer.
7. Horizontal Mullions: Provide horizontal mullions at horizontal joints between louver units except where continuous vertical assemblies are indicated.
8. Connections: Join frame and blade members to one another by mechanical fastener, except where field bolted connections between frame members are made necessary by size of louvers.
9. Spacing: Maintain equal blade spacing to produce uniform appearance.

2.5 FINISHES (FACTORY)

A. General: Comply with NAAMM “Metal Finishes Manual” for finish designations and application recommendations, except as otherwise indicated. Apply finishes in factory. Protect finishes on exposed surfaces prior to shipment. Remove scratches and blemishes from exposed surfaces that will be visible after completing finishing process. Provide color as indicated or, if not otherwise indicated, as selected by architect.

B. Standard mill finish.

C. Prime Coat:

1. Apply alkyd prime coat following chemical cleaning and pretreatment.
2. Primer preparation for field painting.

D. Fluorocarbon Three Coat Coating:

1. Coating shall conform to AAMA 2605.
2. Louvers to be finished with a minimum 1.4 mil (0.035 mm) thick full strength 70% resin, 3 coat Fluoropolymer system.
3. All aluminum shall be thoroughly cleaned, etched, and given a chrome-free conversion pretreatment before application of coating. Coating shall be ILFI LBC Red List Declared.

E. Clear Anodize

1. Class II Clear Anodize
   a. Comply with Aluminum Association AA-C22A31. Clear anodized finish 204-R1

b. Apply finish following chemical etching and pretreatment
c. Minimum thickness: 0.4 mils (0.01 mm)

F. Color Anodize

1. Class I Bronze Anodize
a. Light, Medium, Dark, Champagne
b. Comply with Aluminum Association AA-C2242 or AA-C2244.
c. Apply finish following chemical etching and pretreatment
d. Minimum thickness: 0.7 mils (0.018mm).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and openings for compliance with requirements for installation tolerances and other conditions affecting performance.

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

3.2 PREPARATION

A. Clean opening thoroughly prior to installation.

B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

3.3 INSTALLATION

A. Install louvers at locations as indicated on the drawings and in accordance with the manufacturer's instructions.

B. Install louvers plumb, level, in plane of wall, and in alignment with adjacent work.

C. Install joint sealants as specified by manufacturer's instructions.

3.4 CLEANING

A. Clean louver surface in accordance with manufacturer's instructions.

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

END OF SECTION

SECTION 05 43 00

SLOTTED CHANNEL FRAMING

PART 1 – GENERAL

1.1 SUMMARY

A. Framing shall be a strut type metal framing system (Strut System)

B. Strut System shall be used:

1. To support mechanical and electrical equipment and devices.
2. For structural applications as applicable.

C. Strut System and components must be supplied from a single approved Manufacturer.

1.2 QUALITY ASSURANCE

A. Manufacturer's qualifications:

1. The manufacturer shall have at least 10 years' experience in manufacturing Strut Systems.
2. The manufacturer must certify in writing all components supplied have been produced in accordance with an established quality assurance program.

B. Work shall meet the requirements of the following standards:

1. Federal, State and Local codes
2. American Iron and Steel Institute (AISI) Specification for the Design of Cold-Formed Steel Structural Members 2001 Edition
3. American Society for Testing and Materials (ASTM)
4. Metal Framing Manufacturer's Association (MFMA)

1.3 SUBMITTALS

A. Structural calculations by a Registered Professional or Structural Engineer in the State of the Project's location for approval by the Professional of Record. Calculations may include, but are not limited to:

1. Description of design criteria
2. Stress and deflection analysis
3. Selection of framing members, fittings, and accessories

B. Assembly drawings necessary to install the Strut System in compliance with the Contract Drawings.

C. Pertinent manufacturers published data.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. All material is to be delivered to the work site in original factory packaging to avoid damage to the finish.

B. Upon delivery to the work site, all components shall be protected from the elements by a shelter or other covering.

1.5 WARRANTY

A. Manufacturer shall warrant for 1 year from the shipment date that products will be free from defects in material or manufacture. In the event of any such defect in violation of the warranty, Manufacturer shall have the option to repair or replace any such defective product.

B. Installer shall warrant for 1 year from the date of completion of work that the work will be free of defects in installation. In the event of any such defect in violation of the warranty, Installer shall have the option to repair or replace any such defective product.

PART 2 – PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Strut System and components UNISTRUT

B. Strut System and components FLEX STRUT

C. Or approved equal

2.2 MATERIALS

A. All channel members shall be fabricated conforming to one of the following ASTM specifications:

1. Plain Carbon Steel: ASTM 1011 SS Grade 33
2. Pre-Galvanized Carbon Steel: A 653 Grade 33
3. UNISTRUT DEFENDER™: ASTM 1046 SS Grade 33
4. Stainless Steel: A 240 (Type 304)
5. Aluminum: B 221 (Type 6063-T6)

B. All fittings shall be fabricated conforming to one of the following ASTM specifications:

1. Carbon Steel: All carbon steel fittings shall be fabricated from steel that meets/exceeds the physical requirements of ASTM A1011 SS Grade 33and conforms to one of the following ASTM specifications:
   a. ASTM 575

b. ASTM 576
c. ASTM 36
d. ASTM 635
e. ASTM1059
f. ASTM 1046

2. Stainless Steel:
   a. ASTM 240 (Type 304 or Type 316)
   b. ASTM 276 (Type 304 or Type 316)
3. Aluminum:
   a. B 209 (Type 1100F or Type 5052-H32)

C. Any substitutions of product or manufacturer must be approved in writing ten days prior to bid date by the Professional of Record.

2.3 FINISHES

A. FACTORY PAINTED

1. Channel
   a. Rust inhibiting thermoset acrylic enamel paint applied by electrodeposition after cleaning and phosphating, and thoroughly baked.
2. Fittings
   a. Polyester powder coat after cleaning and phosphating, and thoroughly baked.
3. Color shall be FHWA Highway Green, Color Tolerance Chart, PR Color No. 4
4. Hardness = 2H
5. Performance
   a. Salt Spray per ASTM B117
      i. Scribed: Exceed 400 hours
      ii. Unscribed: Exceed 600 hours
   b. Nominal chalking at 1,000 hours per weatherometer G-23 test
   c. No checking at 1,000 hours per weatherometer G-23 test

B. ELECTRO-GALVANIZED per ASTM B 633 Type III SC 1

C. PRE-GALVANIZED per ASTM A653

1. Zinc coated by hot-dipped process prior to roll forming at the steel mill
2. Zinc coating thickness shall be G90 (0.75 mil = 0.45 oz./ sq. ft. surface area)

D. HOT-DIPPED GALVANIZED per ASTM A123 or A153

1. Zinc coated after all manufacturing operations are complete
2. Zinc coating thickness shall be G65 (2.6 mils = 1.50 oz./ sq. ft. surface area)

E. UNISTRUT DEFENDER™ per ASTM A1046 and A1059

1. Strut coated per A1046 to a mass of 0.45 oz./ sq. ft. surface area
2. Fittings coated per A1059 to a thickness of 30 microns and/or A1046 to a mass of 0.45 oz./sq. ft. surface area.

PART 3 – EXECUTION

3.1 EXAMINATION

A. The installer shall inspect the work area prior to installation. If work area conditions are unsatisfactory, installation shall not proceed until satisfactory corrections are completed.

3.2 INSTALLATION

A. Installation shall be accomplished by a fully trained manufacturer authorized installer.

B. Set Strut System components into final position true to line, level and plumb, in accordance with approved drawings.

C. Anchor material firmly in place and tighten all connections to their recommended torques.

3.3 CLEANUP

A. Upon completion of this section of work, remove all protective wraps and debris.

B. Repair any damage due to installation of this section of work.

3.4 PROTECTION

A. During installation, it shall be the responsibility of the installer to protect this work from damage.

B. Upon completion of this scope of work, it shall become the responsibility of the general contractor to protect this work from damage during the remainder of construction on the project and until substantial completion.

END OF SECTION

SECTION 05 50 00

METAL FABRICATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Miscellaneous steel framing and supports.
2. Shelf angles.
3. Miscellaneous steel trim.

B. Products furnished, but not installed, under this Section include the following:

1. Anchor bolts, steel pipe sleeves,
2. Steel weld plates and angles (Embeds) for casting into concrete for applications where they are not specified in other Sections.

1.2 ACTION SUBMITTALS

A. Product Data: For the following:

1. Prefabricated metal items.
2. Paint products.
3. Grout.

B. Shop Drawings: Show fabrication and installation details. Include plans, elevations, sections, and details of metal fabrications and their connections. Show anchorage and accessory items.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes acting on exterior metal fabrications by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects.

1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces

2.2 METALS

A. Metal Surfaces, General: Provide materials with smooth, flat surfaces unless otherwise indicated. For metal fabrications exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.

B. Steel Plates, Shapes, Angles and Bars: ASTM A 36.

C. Stainless-Steel Bars and Shapes: ASTM A 276, Type 304

D. Steel Tubing: ASTM A 500, cold-formed steel tubing.

E. Steel Pipe: ASTM A 53, Standard Weight (Schedule 40) unless otherwise indicated.

F. Slotted Channel Framing: Cold-formed metal box channels (struts) complying with MFMA-4.

1. Size of Channels: As indicated on Structural plans.

G. Cast Iron: Gray iron, ASTM A 48.

H. Aluminum 6061, ASTM B221.

2.3 FASTENERS

A. General: Unless otherwise indicated, provide Type 304 stainless-steel fasteners for exterior use and zinc-plated fasteners with coating complying with ASTM B 633 or ASTM F 1941, Class Fe/Zn 5, at exterior walls. Select fasteners for type, grade, and class required.

1. Provide stainless-steel fasteners for fastening aluminum.
2. Provide stainless-steel fasteners for fastening stainless steel.
3. Provide stainless-steel fasteners for fastening nickel silver.

B. Cast-in-Place Anchors in Concrete: Either threaded type or wedge type unless otherwise indicated; galvanized ferrous castings, either ASTM A 47malleable iron or ASTM A 27 cast steel. Provide bolts, washers, and shims as needed, all hot dip galvanized per ASTM F 2329.

C. Post-Installed Anchors: Torque-controlled expansion anchors or chemical anchors.

1. Material for Interior Locations: Carbon-steel components zinc plated to comply with ASTM B 633 or ASTM F 1941, Class Fe/Zn 5, unless otherwise indicated.
2. Material for Exterior Locations and Where Stainless Steel Is Indicated: Alloy stainless-steel bolts, ASTM F 593, and nuts, ASTM F 594.

D. Slotted-Channel Inserts: Cold-formed, hot-dip galvanized-steel box channels (struts) complying with MFMA-4, 1-5/8 by 7/8 inches by length indicated with anchor straps or studs not less than 3 inches long at not more than 8 inches o.c. Provide with temporary filler and tee-head bolts, complete with washers and nuts, all zinc-plated to comply with ASTM B 633, Class Fe/Zn 5, as needed for fastening to inserts.

2.4 MISCELLANEOUS MATERIALS

A. Low-Emitting Materials: Paints and coatings shall comply with the testing and product requirements of the South Carolina Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. Shop Primers: Provide primers that comply with Section 09 90 00 “Paints & Coatings.”

C. Universal Shop Primer: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79 and compatible with topcoat.

1. Use primer containing pigments that make it easily distinguishable from zinc-rich primer.

D. Water-Based Primer: Emulsion type, anticorrosive primer for mildly corrosive environments that is resistant to flash rusting when applied to cleaned steel, complying with MPI#107 and compatible with topcoat.

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

E. Epoxy Zinc-Rich Primer: Complying with MPI#20 and compatible with topcoat.

1. Products: Subject to compliance with requirements.

F. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.

G. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

H. Non-shrink, Nonmetallic Grout: Factory-packaged, non-staining, non-corrosive, nongaseous grout complying with ASTM C 1107. Provide grout specifically recommended by manufacturer for interior and exterior applications.

I. Concrete: Comply with requirements in Section 03 30 00 "Cast-in-Place Concrete" for normal-weight, air-entrained, concrete with a minimum 28-day compressive strength of 3500 psi.

2.5 FABRICATION, GENERAL

A. Shop Assembly: Preassemble items in the shop to greatest extent possible. Use connections that maintain structural value of joined pieces.

B. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges. Remove sharp or rough areas on exposed surfaces.

C. Weld corners and seams continuously to comply 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. At exposed connections, finish exposed welds and surfaces smooth and blended.

D. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners or welds where possible. Locate joints where least conspicuous.

E. Fabricate seams and other connections that are exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.

F. Where units are indicated to be cast into concrete or built into masonry, equip with integrally welded steel strap anchors not less than 8 inches from ends and corners of units and 24 inches o.c.

2.6 SHELF ANGLES

A. Fabricate shelf angles from steel angles of sizes indicated and for attachment to concrete framing. Provide horizontally slotted holes to receive 3/4-inch bolts, spaced not more than 6 inches from ends and 24 inches o.c., unless otherwise indicated.

B. For cavity walls, provide vertical channel brackets to support angles from backup masonry and concrete.

C. Galvanized shelf angles located in exterior walls.

D. Prime shelf angles located in exterior walls with primer specified in Section 09 90 00 "Paints & Coatings."

E. Furnish wedge-type concrete inserts, complete with fasteners, to attach shelf angles to cast-in-place concrete.

2.7 MISCELLANEOUS STEEL TRIM

A. Unless otherwise indicated, fabricate units from steel shapes, plates, and bars of profiles shown with continuously welded joints and smooth exposed edges. Miter corners and use concealed field splices where possible.

B. Provide cutouts, fittings, and anchorages as needed to coordinate assembly and installation with other work.

C. Galvanize exterior miscellaneous steel trim.

D. Prime exterior miscellaneous steel trim with primer specified in Section 09 90 00 “Paints & Coatings.”

2.8 STEEL WELD PLATES AND ANGLES

A. Provide steel weld plates and angles not specified in other Sections, for items supported from concrete construction as needed to complete the Work. Provide each unit with no fewer than two integrally welded steel strap anchors for embedding in concrete.

2.9 FINISHES, GENERAL

A. Finish metal fabrications after assembly.

2.10 STEEL AND IRON FINISHES

A. Galvanizing: Hot dip galvanize items as indicated to comply with ASTM A 153/A 153M for steel and iron hardware and with ASTM A 123/A 123M for other steel and iron products.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.

B. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot dip galvanized after fabrication and are for bolted or screwed field connections.

C. Field Welding: Comply with the following requirements:

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. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

D. Fastening to In-Place Construction: Provide anchorage devices and fasteners where metal fabrications are required to be fastened to in-place construction.

E. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.

3.2 INSTALLING BEARING AND LEVELING PLATES

A. Clean concrete and masonry bearing surfaces of bond-reducing materials and roughen to improve bond to surfaces. Clean bottom surface of plates.

B. Set bearing and leveling plates on wedges, shims, or leveling nuts. After bearing members have been positioned and plumbed, tighten anchor bolts. Do not remove wedges or shims but, if protruding, cut off flush with edge of bearing plate before packing with non-shrink grout. Pack grout solidly between bearing surfaces and plates to ensure that no voids remain.

3.3 ADJUSTING AND CLEANING

A. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas. Paint uncoated and abraded areas with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.

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

END OF SECTION

DIVISION 07

THERMAL & MOISTURE PROTECTION

SECTION 07 15 00

SHEET METAL WATERPROOFING

PART 1 - GENERAL

1.1 SCOPE OF WORK

A The Work required under this section consists of all shop and field fabricated. sheet metal flashing and trim and related items necessary and required to complete the Work as indicated in this specification.

B Contractor shall provide all items, articles, materials, operations, or methods. specified herein, including all labor, materials, equipment, and incidentals. necessary and required for completion of the work.

C Protect dissimilar metals by installing barrier sheets between them. Install barriers between metals where there is more than 0.15 V difference in the Anodic Index.

D Sheet metal work shall include the following:

1 Coated metal flashings installed where membrane and metal come into contact.
2 Close of back of Louver.
3 Provide rust treatment at areas exhibiting rust and at areas susceptible to rust.
4 Install reinforced waterproofing acrylic mastic and membrane at joints.

1.2 REFERENCES

A American Society for Testing and Materials (ASTM) Standards.

B Sheet Metal and Air Conditioning Contractors National Association

C (SMACNA) Architectural Sheet Metal Manual.

1.2 QUALITY ASSURANCE

A Installer: All work of this Section must be performed by a licensed sheet metal contractor with at least five years of successful experience with installation of sheet metal flashing and trim similar in type and scope to project requirements.

B Quality Standard: Fabricate and install sheet metal work in accordance with Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA) "Architectural Sheet Metal Manual", unless specifically indicated otherwise.

1.3 TECHNICAL SUBMITTALS

A Submittal requirements: Contractor shall highlight anything in the submittal package that conflicts with or changes specifications or drawings. Include a reason for the change. Any submittals that alter existing specifications or drawings shall be approved by the engineer and Park prior to implementation.

B The following submittals are to be made in conjunction with any other submittal requirements set forth in the bid documents.

C The contractor shall submit the following upon request of the Park or engineer:

1 Manufacturer specification data sheets. Submit for the following products:
   a. Specified sheet metal.
   b. Gutter coating system.
   c. HVAC duct coating system.

D Manufacturer literature describing the installation procedure of the specified system. Shop drawings of any details that may be different than the NRCA or SMACNA standard details included in these specifications. This includes manufacturer detail drawings that may be different than NRCA or SMACNA drawings. All flashing detail designs shall be approved by the Park.

E Material safety data sheets for all products used under this section.

1.4 WARRANTY & GUARANTEE

A For all work performed under this section, the Sheet Metal and/or Roofing Contractor shall furnish to the Park a 5 year guarantee against labor and/or material leaks AND defects for all labor and materials installed under this contract. This guarantee shall also cover any and all labor and materials necessary to repair or replace any materials that are damaged or deteriorated as a result of material and/or improper or inadequate workmanship.

B Duct coating and gutter coating: The Materials Manufacturer shall provide a standard warranty covering material deficiencies for at least a period of ten (10) years from the date of acceptance by the Park. This written warranty will be provided by the material manufacturer and will cover material for at least 10 years without a cost to the Government.

PART 2 - PRODUCTS

2.1 SHEET STEEL FOR GUTTER REPAIR

A Note – when repairing a gutter section, match sheet metal both in composition and shape (profile). When replacing a whole section of gutter or installing new gutter, use any of the following: Galvanized Steel Sheet: ASTM A 526, commercial quality, G-90 hot dip galvanized. Minimum thickness: 24 gage (0.0239 inch), unless otherwise shown on the drawings or specified herein. Galvanized steel sheets shall be acid etched prior to receiving a paint finish.

2.2 COATED SHEET METAL

A Sheet metal that must be tied into single ply systems such as metal edging and drain flanges may be provided by the manufacturer of the single ply system being used.

2.3 FASTENERS

A Nails: Shall be hot-dipped, galvanized. All nails shall be approved type and selected for their intended use.

B Screws: Minimum No. 8 size screw with watertight neoprene washers under screw head where exposed shall be used for the fastening of sheet metal into wood nailers. Self-tapping, #3 sheet metal screws of ½" length shall be used for the fastening of sheet metal to sheet metal. All screws shall be of corrosion resistant metal of same material as the material being fastened. All exposed fasteners shall have 5/8" steel/neoprene washers under head.

C Screws at sight screens shall be stainless steel and match existing diameter and length. Screws shall have rubber washers.

2.4 ACCESSORY MATERIALS

A Sealant: Elastomeric sealant shall be a low modulus, high performance, one part polyurethane type conforming to Federal Specifications No. TT-S00230C, Type II, Class A, such as Sonolastic NP-1 by Sonneborn Building Products, Sikaflex-15LM or approved equal.

B Solder: ASTM B 32-89, 50/50 tin-lead, rosin flux shall conform to Federal Specification O-F-506C, Type I, Form A or B.

2.5 COATING MATERIALS

A Exterior duct coating:

1 Acrylic elastomeric coating suitable for application over metal surfaces as manufactured by United Coating or National Coatings.
2 Duct joints shall receive a three course of approved polyester reinforcing and butter grade acrylic mastic.

PART 3 - EXECUTION

3.1 EXAMINATION

A Examine substrates and conditions under which products of this section are to be installed and verify that work may properly commence. Do not proceed with the Work until unsatisfactory conditions have been fully resolved.

B Verify that nailers, blocking, and other attachment provisions for sheet metal work are properly located and securely fastened to resist effects of wind and thermal stresses.

3.2 PREPARATION

A Verify shapes and dimensions of surfaces to be covered before fabricating sheet metal.

1 Verify that surfaces to receive sheet metal are smooth, clean of all foreign matter, dry, and have no water or moisture present in any form.

3.3 SHEET METAL INSTALLATION

A Sheet metal work shall be executed in a first-class, workmanlike manner in accordance with standard shop practices. Comply with sheet metal manufacturer's installation methods and recommendations in the SMACNA "Architectural Sheet Metal Manual".

B The sheet metal work shall be accurately formed to dimensions and shapes detailed or required. Broken shapes shall finish with true, straight, sharp lines, and angles; and where intersecting, shall be coped to a precise fit and be securely soldered and scraped smooth. Lock seam work shall be made flat and true to line, sweated full of solder.

C All sheet work shall be so formed and installed as to provide suitable allowance for expansion and contraction without causing undue stresses in any part of the completed work and shall finish water and weather tight throughout. Provide movement joints at maximum spacing of ten feet. No joints within 2 feet of corner or intersection.

D Mechanically fasten and solder all joints, splices and transitions that are not designed for expansion. Fasten metal by solid riveting or forming double lock seams. Seal by continuous soldering.

E Galvanic Action Protection: Isolate different metal types from each other to prevent galvanic action.

F Use elastomeric sealant where necessary to make a watertight installation.

G Form a ½ - inch hem on the underside of all exposed edges.

H Fabricate cleats and attachment devices from same material as sheet metal component being anchored or from compatible, noncorrosive metal recommended by sheet metal manufacturer. The gage thickness shall be as recommended by SMACNA for application but in no case less than gage of metal being secured.

I Heat weldable coated metal flashings provided by single ply manufacturer such as edge “edges and flanges” shall be installed in accordance with manufacturer guidelines. Coated metal shall be used for all metal that needs to be sealed into the single ply membrane including but not limited to metal edges and scuppers.

J Soldered Joints:

1 Clean surfaces to be soldered, removing oils and foreign matter.
2 Pre-Tin edges of sheets to be soldered to a width of 1-1/2 inches.
3 Soldering shall be done with well heated soldering irons. Do not use torches for soldering.

K Heat surfaces to receive solder and flow solder into joint. Fill joint completely.

L Completely remove all flux spatter from exposed surfaces with a solution of washing soda in water.

3.4 EXTERIOR DUCT WATERPROOFING

A Replace flex connectors.

1 At areas of damaged sheet metal, repair ductwork in accordance with SMACNA requirements.

B At areas of surface rust, prepare and rustproof.

C Coatings & Wrappings for Process Corrosion Protection or as approved by the manufacturer providing the materials for duct coating.

D If required by the manufacturer, install primer over sheet metal ductwork.

E Install butter grade mastic and reinforcing membrane over all duct joints.

F Install acrylic coating over entire ductwork as specified. Coating shall be applied in a two-coat application at the rates approved by the manufacturer.

3.5 PAINTING

A All surfaces of exterior sheet metal work (except exposed ducting that is to be waterproofed) that will be exposed after installation shall be thoroughly cleaned with an acid wash and shall be primed and painted to match existing building finish on adjacent sheet metal surfaces.

3.6 INSPECTION

A Before completing the work, COR shall carefully examine, and if necessary, test all sheet metal work and equipment specified herein, and Contractor shall make all repairs to the work if damaged, leaving it in a condition satisfactory of the Park.

3.7 CLEAN UP

A All debris and/or rubbish resulting from the operations of this Work shall be cleaned up and removed from the work site as the work progresses. Contractor shall be responsible for removal of refuse by all subcontractors working under its direction.

END OF SECTION

SECTION 07 21 16

FIBERGLASS BATT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A Section Includes: Fiberglass batt thermal insulation for exterior envelope assemblies.

1.2 SUBMITTALS

A Product Data: Submit product characteristics, performance criteria, and limitations, including installation instructions.

B Sustainable Design: Submit manufacturer's sustainable design certifications as specified with each product.

1.3 QUALITY ASSURANCE

A Sustainable Design: Provide products which have received the following certifications:

1. UL Certified Environmental Product Declaration in accordance with ISO 14025. Applies to PINK Next Gen™ Fiberglas™ Insulation Faced and Unfaced insulation.

B GREENGUARD Indoor Air Quality Certified® and GREENGUARD Children & Schools Certified℠, applies to PINK Next Gen™ Fiberglas™ Insulation Unfaced Batts and PINK Next Gen™ Fiberglas™ Insulation Faced Batts and Rolls.

C GREENGUARD Formaldehyde Free, applies to PINK Next Gen™ Fiberglas™ Insulation Unfaced and PINK Next Gen™ Fiberglas™ Insulation Faced Batts and Rolls.

1. Scientific Certification Systems SCS-MC-01025, SCS Certified minimum 65% recycled glass content (with at least 41% post-consumer recycled and the balance of pre-consumer recycled glass content), applies to PINK Next Gen™ Fiberglas™ Insulation Unfaced Batts and Rolls.
2. Scientific Certification Systems SCS-MC-02676, SCS Certified minimum 58% recycled glass content (with at least 36% post-consumer recycled and the balance of pre-consumer recycled glass content), applies to PINK Next Gen™ Fiberglas™ Insulation Faced Batts and Rolls.

D Preconstruction Meeting: Convene a minimum of two weeks prior to commencing work of this section. Agenda shall include materials proposed for use, sequence of construction and coordination with installation of adjacent and covering materials.

1.4 DELIVERY, STORAGE, AND HANDLING

A Delivery: Deliver materials to the job site in original packages, containers, or bundles bearing the brand name and manufacturer's identification.

B Storage: Store materials in dry locations with adequate ventilation, free from water, and in such a manner to permit easy access for inspection and handling.

C Handling: Handle using procedures recommended by the manufacturer for materials and personnel.

1.5 WARRANTY

A Warranty: Provide manufacturer's standard limited warranty against manufacturing defects.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A Thermal Insulation: PINK Next Gen™ Fiberglas™ Insulation by Owens Corning Insulating Systems, Toledo, OH 43659; www.owenscorning.com.

2.2 MATERIALS

A PINK Next Gen™ Fiberglas™ Insulation Unfaced Batt Insulation: ASTM C 665, Type I, preformed formaldehyde free glass fiber batt type, unfaced. Includes Unfaced PINK Next Gen™ Fiberglas™, Unfaced PINK Next Gen™ Fiberglas™ Sonobatts® Insulation and PINK Next Gen™ Fiberglas™ Sound Attenuation Batts (SAB) Insulation.

B Noncombustible per ASTM E 136.

C Flame spread less than 25, smoke developed less than 50 per ASTM E84.

D ICC Building Code Construction Classification: All types.

E Water vapor sorption, maximum by weight: not more than 5 percent.

F PINK Next Gen™ Fiberglas™ Insulation Kraft Faced Batt Insulation: ASTM C 665, Type II, Class C preformed formaldehyde free glass fiber batt type, Kraft paper faced one side. Includes Kraft faced PINK Next Gen™ Fiberglas™ Insulation, Kraft faced PINK Next Gen™ Fiberglas™ Sonobatts® Insulation and PINK Next Gen™ Fiberglas™ Insulation ProPink FastBatt Insulation.

G Perm Rating: 1 perm maximum per ASTM E96.

I PINK Next Gen™ Fiberglas™ Flame Spread 25 Insulation: ASTM C 665, Type II (PSK facing), Class A and Type III (FSK facing), Class A preformed formaldehyde free glass fiber batt, poly/scrim/Kraft (PSK) or foil/scrim/Kraft (FSK) faced on one side.

J Flame spread less than 25, smoke developed index less than 50 per ASTM E84.

K Accessories: Provide accessories per insulating system manufacturer's recommendations, including the following:

1. Tape: Polyethylene self-adhering type for Kraft faced insulation and bright aluminum self-adhering type for foil faced insulation.
2. Insulation Fasteners: Impale clip of galvanized steel; type recommended by insulation manufacturer for particular use intended.
3. Mechanical Insulation Fasteners: FM approved, corrosion resistant, size required to suit application.
4. Wire Mesh: Galvanized steel, hexagonal wire mesh.
5. Spindle Fasteners: Corrosion-resistant wire spindles.
6. Ventilation Baffles: Formed plastic, metal, or cardboard sized to fit full width of rafter spaces.

2.3 PERFORMANCE CRITERIA

A Light weight steel Frame Construction - Walls, R-Value: Per ASTM C518.

B R-22, 6 3/4-inch (171mm) thickness, 15 inch (381mm) or 23 inch (584mm) width, 48 inch (1219mm) length.

PART 3 - EXECUTION

3.1 EXAMINATION

A Examine the areas and conditions under which work of this section will be installed. Verify that adjacent materials are dry and ready to receive insulation. Verify mechanical and electrical services within walls have been tested and inspected.

B Provide written report listing conditions detrimental to performance of work in this section. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A Comply with manufacturer's installation instructions and ASTM C1320. Do not use unfaced insulation in exposed applications where there is potential for skin contact and irritation. Kraft and standard foil facings will burn and must not be left exposed. The facing must be installed in substantial contact with the unexposed surface of the ceiling, wall or floor finish. Protect facing from any open flame or heat source.

B Friction-fit blanket insulation in place, until the interior finish is applied. Install batts to fill entire stud cavity, with no gaps, voids, or areas of compression. If stud cavity is less than 8 feet in height, cut lengths to friction fit against floor and ceiling tracks. Walls with penetrations require that insulation be carefully cut to fit around outlets, junction boxes, and other irregularities.

C Do not install insulation on top of or within 3 inches of recessed light fixtures unless the fixtures are approved for such use.

D In crawl spaces and where the underside of floors is exposed to unconditioned space, insulation shall fill the cavity or be installed in contact with the underside of the decking. If vapor retarder is required by local code, a Kraft vapor retarder must be in contact with a 15-minute thermal barrier, typically on the bottom side of the insulation.

E Within exterior wall framing, install insulation between pipes and backside of sheathing. Cut or split insulation material as required to fit around wiring and plumbing.

F Where showers and bathtubs are located on exterior walls, typically install insulation and vapor retarder between units and exterior.

G If eave ventilation baffles are required, install ventilation baffles at eaves to hold insulation down from roof sheathing and provide positive ventilation from eave to attic space.

H Fluff insulation to full thickness for specified R-value before installation. Do not compress insulation in the cavity during installation, creating gaps or voids that could diminish thermal value.

I Trim insulation neatly to fit spaces. Fill miscellaneous gaps and voids with insulation.

J Fit insulation tight in spaces and tight to exterior side of mechanical and electrical services within the plane of insulation.

K For unfaced batt insulation, install with friction fit or retain in place with manufacturer's recommended fasteners or mesh.

L For batt insulation with factory-applied facing, install with vapor retarder membrane facing warm in the winter side of building spaces or as specified by local building code. Lap ends and side flanges of membrane over or between framing members. Tape to seal tears, cuts or misalignments in membrane.

M Secure insulation in place using one of the following methods: Friction fit; staple or nail facing flanges in place as needed, tape in place, retain in place with spindle fasteners, retain in place with wire mesh secured to framing members.

3.3 PROTECTION

A Protect installed insulation from damage due to weather and physical abuse until protected by permanent construction.

END OF SECTION

SECTION 07 84 00

FIRESTOPPING

PART 1 - GENERAL

1.1 SUMMARY

A Furnish and install tested and listed firestopping systems, combination of materials, or devices to form an effective barrier against the spread of flame, smoke and gases, and maintain the integrity of fire resistance rated walls, partitions, floors, and ceiling-floor assemblies, including through-penetrations and construction joints and gaps.

1. Through-penetrations include the annular space around pipes, tubes, conduit, wires, cables, and vents.
2. Construction joints include those used to accommodate expansion, contraction, wind, or seismic movement; do not allow firestopping material to interfere with the required movement of the joint. Gaps requiring firestopping include gaps between the curtain wall and the floor slab and between the top of the fire-rated walls and the roof or floor deck above and at the intersection of shaft assemblies and adjoining fire resistance rated assemblies.

1.2 REFERENCES

A The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

B ASTM INTERNATIONAL (ASTM) ASTM E84

1. (2023) Standard Test Method for Surface Burning Characteristics of Building Materials ASTM E119
2. (2022) Standard Test Methods for Fire Tests of Building Construction and Materials ASTM E699
3. (2009) Standard Practice for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating of Building Components ASTM E814 (2013a; R 2017) Standard Test Method for Fire Tests of Penetration Firestop Systems ASTM E1399/E1399M
4. (1997; R 2022) Standard Test Method for Cyclic Movement and Measuring the Minimum and Maximum Joint Widths of Architectural Joint Systems ASTM E1966
5. (2015; R 2019) Standard Test Method for SECTION 07 84 00 Page 4 Fire-Resistive Joint Systems ASTM E2174
6. (2020a) Standard Practice for On-Site Inspection of Installed Firestop Systems ASTM E2307
7. (2020) Standard Test Method for Determining Fire Resistance of Perimeter Fire Barrier Systems Using Intermediate-Scale, Multi-story Test Apparatus ASTM E2393

8. (2020a) Standard Practice for On-Site Inspection of Installed Fire Resistive Joint Systems and Perimeter Fire Barriers FM GLOBAL (FM) FM 4991
9. (2013) Approval of Firestop Contractors FM APP GUIDE (updated on-line) Approval Guide http://www.approvalguide.com/ INTERNATIONAL CODE COUNCIL (ICC) ICC IBC
10. (2021) International Building Code UNDERWRITERS LABORATORIES (UL) UL 723
11. (2020) UL Standard for Safety Test for Surface Burning Characteristics of Building Materials UL 1479
12. (2015; Reprint May 2021) Fire Tests of Through-Penetration Firestops UL 2079
13. (2015; Reprint Jul 2020) Tests for Fire Resistance of Building Joint Systems UL Fire Resistance (2014) Fire Resistance Directory

1.3 SEQUENCING

A Coordinate the specified work with other trades. Apply firestopping materials, at penetrations of pipes and ducts, prior to insulating, unless insulation meets requirements specified for firestopping. Apply firestopping materials. at building joints and construction gaps, prior to completion of enclosing walls or assemblies. Locate cast-in-place firestop devices and install them in place before concrete placement. Install pipe, conduit or cable bundles through cast-in-place device after concrete placement but before area is concealed or made inaccessible. Firestop material must be inspected and approved prior to final completion and enclosing of any assemblies that may conceal installed firestop.

1.4 SUBMITTALS

A Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

1. SD-02 Shop Drawings
2. Firestopping System; G
3. SD-03 Product Data Firestopping Materials; G
4. SD-06 Test Reports Inspection; G
5. SD-07 Certificates
6. Inspector Qualifications
7. Firestopping Materials
8. Installer Qualifications; G

1.5 QUALITY ASSURANCE

A Installer Engage an experienced Installer who is:

1. FM Research approved in accordance with FM 4991, operating as a UL Certified Firestop Contractor, or

2. Certified, licensed, or otherwise qualified by the firestopping manufacturer as having the necessary staff, training, and a minimum of 3 years' experience in the installation of manufacturer's products in accordance with specified requirements. Submit documentation of this experience. A manufacturer's willingness to sell its firestopping products to the Contractor or to an installer engaged by the Contractor does not in itself confer installer qualifications on the buyer. The Installer must be a trained representative of the manufacturer (not distributor or agent) in the proper selection and installation procedures. Obtain and submit installer's written certification of training and retain proof of certification for duration of firestop installation.

B Inspector Qualifications The inspector must meet the criteria contained in ASTM E699 for agencies involved in quality assurance and must have a minimum of 2 years' experience in construction field inspections of firestopping systems, products, and assemblies. The inspector must be completely independent of, and divested from, the installer, the manufacturer, and the supplier of any material or item being inspected. The inspector must not be a competitor of the installer, the contractor, the manufacturer, or supplier of any material or item being inspected. Include with the qualifications submittal, a notarized statement assuring compliance with the requirements stated herein.

1.6 DELIVERY, STORAGE, AND HANDLING

A Deliver materials in the original unopened packages or containers showing name of the manufacturer and the brand name. Store materials off the ground, protected from damage and exposure to elements and temperatures in accordance with manufacturer requirements. Remove damaged or deteriorated materials from the site. Use materials within their indicated shelf life.

PART 2 - PRODUCTS

2.1 FIRESTOPPING SYSTEM

A Submit detail drawings including manufacturer's descriptive data, typical details conforming to UL Fire Resistance or other details certified by another nationally recognized testing laboratory, installation instructions or UL listing details for a firestopping assembly in lieu of fire-test data or report. For those firestop applications for which no UL tested system is available through a manufacturer, submit a manufacturer's engineering judgment, derived from similar UL system designs or other tests for review and approval prior to installation. Submittal must indicate the firestopping material to be provided for each type of application. When more than a total of 5 penetrations and/or construction joints are to receive firestopping, provide drawings that indicate location, "F" "T" and "L" ratings, and type of application. Also, submit a written report indicating locations of and types of penetrations and types of firestopping used at each location; record type by UL list printed numbers.

2.2 FIRESTOPPING MATERIALS

A Provide firestopping materials, supplied from a single domestic manufacturer, consisting of commercially manufactured, asbestos-free, nontoxic products FM APP GUIDE approved, or UL listed, for use with applicable construction and penetrating items, complying with the following minimum requirements:

B Fire Hazard Classification Provide material that has a flame spread of 25 or less, and a smoke developed rating of 50 or less, when tested in accordance with ASTM E84 or UL 723. Provide an approved firestopping material as listed in UL Fire Resistance or by a nationally recognized testing laboratory.

C Toxicity Provide material that is nontoxic and carcinogen free to humans at all stages of application or during fire conditions and does not contain hazardous chemicals or require harmful chemicals to clean material or equipment.

D Fire Resistance Rating Firestop systems must be UL Fire Resistance listed or FM APP GUIDE approved with "F" rating at least equal to fire-rating of fire wall or floor in which penetrated openings are to be protected. Where required, firestop systems must also have "T" rating at least equal to the fire-rated floor in which the openings are to be protected.

E Through-Penetrations Firestopping materials for through-penetrations, as described in paragraph SUMMARY, must provide "F", "T" and "L" fire resistance ratings in accordance with ASTM E814 or UL 1479. Provide fire resistance ratings as follows:

1. Penetrations of Fire Resistance Rated Walls and Partitions F Rating = Rating of wall or partition being penetrated.
2. Penetrations of Fire Resistance Rated Floors, Floor-Ceiling Assemblies and the Ceiling Membrane of Roof-Ceiling Assemblies F Rating = 1 hour, T Rating = 1 hour. Where the penetrating item is outside of a wall cavity the F rating must be equal to the fire resistance rating of the floor penetrated, and the T rating must be in accordance with the requirements of ICC IBC.
3. Penetrations of Fire and Smoke Resistance Rated Walls, Floors, Floor-Ceiling Assemblies, and the ceiling membrane of Roof-Ceiling Assemblies F Rating = 1 hour, T Rating = 1 hour and L Rating = .5

F Construction Joints and Gaps

1. Fire resistance ratings of construction joints, as described in paragraph SUMMARY, and gaps such as those between floor slabs and curtain walls must be the same as the construction in which they occur.

G Material Certification

1. Submit certificates attesting that firestopping material complies with the specified requirements. Provide certification of compliance with UL 1479 for all intumescent firestop materials used in through penetration systems.

PART 3 – EXECUTION

3.1 PREPARATION

A. Areas to receive firestopping must be free of dirt, grease, oil, or loose materials which may affect the fitting or fire resistance of the firestopping system. For cast-in-place firestop devices, formwork or metal deck to receive device prior to concrete placement must be sound and capable of supporting device. Prepare surfaces as recommended by the manufacturer.

3.2 INSTALLATION

A Completely fill void spaces with firestopping material regardless of geometric configuration, subject to tolerance established by the manufacturer. Firestopping systems for filling floor voids 100 mm 4 inches or more in any direction must be capable of supporting the same load as the floor is designed to support or be protected by a permanent barrier to prevent loading or traffic in the firestopped area. Install firestopping in accordance with manufacturer's written instructions. Provide tested and listed firestop systems in the following locations, except in floor slabs on grade:

1. Penetrations of duct, conduit, tubing, cable and pipe through floors and through fire-resistance rated walls, partitions, and ceiling-floor assemblies.
2. Penetrations of vertical shafts such as pipe chases, elevator shafts, and utility chutes.
3. Gaps at the intersection of floor slabs and curtain walls, including inside of hollow curtain walls at the floor slab.
4. Gaps at perimeter of fire-resistance rated walls and partitions, such as between the top of the walls and the bottom of roof decks.
5. Construction joints in floors and fire rated walls and partitions.
6. Other locations where required to maintain fire resistance rating of the construction.

B Insulated Pipes and Ducts

1. Cut and remove thermal insulation where pipes or ducts pass through firestopping, unless insulation meets requirements specified for firestopping. Replace thermal insulation with a material having equal thermal insulating and firestopping characteristics.

C Fire Dampers

1. Install and firestop fire dampers in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION. Firestop installed with fire damper must be tested and approved for use in fire damper system. Firestop installed with fire damper must be tested and approved for use in fire damper system.

D Data and Communication Cabling

1. Seal cabling for data and communication applications with re-enterable firestopping products and devices as indicated.
2. Re-Enterable Devices

E Provide firestopping devices that are pre-manufactured modular devices, containing built-in self-sealing intumescent inserts. Allow for cable moves, additions or changes without the need to remove or replace any firestop materials. Devices must be capable of maintaining the fire resistance rating of the penetrated membrane at 0 percent to 100 percent visual fill of penetrants; while maintaining "L" rating of <10 cfm/sf [measured at ambient temperature and 205 degrees C 400 degrees F at 0 percent to 100 percent visual fill.

1. Re-Sealable Products Provide firestopping pre-manufactured modular products, containing self-sealing intumescent inserts. Allow for cable moves, additions or changes. Provide devices capable of maintaining the fire resistance rating of the penetrated membrane at 0 percent to 100 percent visual fill of penetrants.

3.3 INSPECTION

A For all projects, do not cover or enclose the fire stopped areas until inspection is complete and approved by the Contracting Officer. Inspect the applications initially to ensure adequate preparations (clean surfaces suitable for application, etc.) and periodically during the work to assure that the completed work has been accomplished according to the manufacturer's written instructions and the specified requirements. Submit written reports indicating locations of and types of penetrations and types of firestopping used at each location; record type by UL listed printed numbers.

B Inspection Standards all firestopping in accordance with ASTM E2393 and ASTM E2174 for firestop inspection, and document inspection results to be submitted.

C Inspection Reports Submit inspection report stating that firestopping work has been inspected and found to be applied according to the manufacturer's recommendations and the specified requirements.

END OF SECTION

SECTION 07 90 00

JOINT SEALERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including Division 1 Specification Sections, apply to work of this Section.

1.2 SECTION INCLUDES

A. Interior Joint Sealers

B. Exterior Joint Sealers

1.3 SUBMITTALS

A. Refer to Division 1 of the specifications for submittal procedures.

B. Low Emitting Materials:

1. Submit certification statement on company letterhead specific to products supplied on this project that clearly states the VOC levels of sealants used during construction inside the building envelope and that they do not exceed levels per LEED™.
2. Submit certification statement on company letterhead specific to products supplied on this project that clearly states the VOC levels of primers used during construction inside the building envelope and that they do not exceed levels per LEED™

C. Product data for each product specified.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this Section with minimum 5 years' experience.

B. Applicator Qualifications: Company specializing in performing the work of this Section with minimum 5 years' experience.

1.5 ENVIRONMENTAL REQUIREMENTS

A. Maintain temperature and humidity recommended by the sealant manufacturer during and after installation.

1.6 COORDINATION

A. Coordinate the work with all Sections referencing this Section.

1.7 GUARANTEE

A. The Contractor shall guarantee the sealant installation for a period of 5 years against defects in installed materials and workmanship including a 5-year watertight warranty. Correct any sealant that is found to be defective, improperly installed or leaks within a 5-year period at no cost to the Owner.

PART 2 - PRODUCTS

2.1 SEALANTS

A. Type A - Exterior Joint Sealant: Silicon; ASTM C920, Type S, Grade NS, Class 50, Uses NT, M, G, A and O; single component.

1. Color: Color as selected to match adjacent material, selected from manufacturer's full range of available colors.
2. Product: Similar to 795 Silicone Building Sealant manufactured by Dow Corning.
3. Applications:
   a. Masonry control joints – (sand sealant to match mortar joint).
   b. Joints between window frames and adjacent construction – (match frame color).
   c. Joints between door and louver frames and adjacent construction– (match mortar color at brick veneer).
   d. Exposed joints in prefinished metal panels.

B. Type B - Exterior Joint Sealant: Polyurethane; ASTM C920, Type S, Grade NS, Class 25, Uses NT, M, G, A and O.

1. Color: Color as selected to match adjacent material, selected from manufacturer's full range of available colors.
2. Product: Dynatrol I XL single component or Dynatrol II two component (as required to achieve required color) manufactured by Pecora, or approved.
3. Applications:
   a. Sealant for sheet metal reglet and flashing installation/joints.
   b. Exterior locations requiring painted finish over sealant.
   c. Other exterior joints for which no other sealant is indicated.

C. Type C - Exterior Metal Lap Joint Sealant: Butyl rubber, nondrying, non-skinning, non-curing.

1. Product: Similar to BC-158 Butyl Rubber Sealant manufactured by Pecora or approved.
2. Applications:
   a. Concealed sealant bead in lap joints for sheet metal work.
   b. Concealed sealant bead in lap joints in prefinished wall and roof panels
   c. Sealant for bedding door thresholds.
   d. Do not use in any location exposed to view or exposed to the sun.

D. Type D - General Purpose Interior Sealant: Siliconized acrylic emulsion latex; ASTM C834, single component, paintable.

1. Product: Similar to AC-20+Silicone manufactured by Pecora or similar by Tremco or approved.
2. Color: Match color of adjacent materials; or as selected by Contracting Officer.
3. LEED™ Requirement – Low Emitting Materials Credit EQc4.1: VOC levels of sealants used during construction inside the building envelope shall not exceed 250 grams per liter.
4. Applications:
   a. Interior wall and ceiling control joints.
   b. Joints between interior door/relite frame and wall surfaces.
   c. Joints between interior side of window frames and wall surfaces.
   d. Between GWB and other materials.
   e. Joints between counter backsplash and wall.
   f. Other interior joints for which no other type of sealant is indicated.

E. Type E - Plumbing Fixture/Tile Sealant: Neutral-curing silicone; ASTM C920, Class 50; single component, mildew resistant.

1. Product: Similar to 898 Sanitary Mildew Resistant Silicone Sealant manufactured by Pecora or approved.
2. Color: Match color of plumbing fixture or adjacent materials as approved by Contracting Officer.
3. LEED™ Requirement – Low Emitting Materials Credit EQc4.1: VOC levels of sealants used during construction inside the building envelope shall not exceed 250 grams per liter.
4. Applications: Use for:
   a. Joints between plumbing fixtures and counter, floor and wall surfaces.
   b. Interior joints in stone and ceramic tile or between tile and adjacent materials.

F. Type G – Exterior Concrete Pavement Joint Sealant: Polyurethane, single component, pourable grade, moisture cured.

1. Color: Match concrete color.
2. Manufacturer/Product: Pecora Urexpan NR-201, or approved
3. Applications: Use for:
   a. Expansion, Contraction and Construction joints in exterior concrete pavement.

2.3 ACCESSORIES

A. Primer: Non-staining type, recommended by sealant manufacturer to suit application.

1. LEED™ Requirement - Low Emitting Materials Credit EQc4.2: VOC levels of primers used during construction inside the building envelope shall not exceed 750 grams per liter.

B. Joint Cleaner: Non-corrosive and non-staining type, recommended by sealant manufacturer; compatible with joint forming materials.

C. Joint Backing: Round closed cell foam rod compatible with sealant; type recommended by sealant manufacturer for type of sealant; ASTM D1667, oversized as recommended by sealant manufacturer.

D. Bond Breaker: Pressure sensitive tape recommended by sealant manufacturer to suit application.

PART 3 - EXECUTION

3.1 COORDINATION

A. Review, coordinate and accommodate work of other trades that interface with, affect or are affected by the work of this Section so as to facilitate the execution of the overall Work of this project in a coordinated and efficient manner.

B. Coordinate work sequence and installation with work of other trades to provide a weathertight installation at exterior applications.

3.2 EXAMINATION

A. Inspect the substrate surfaces and joint openings and confirm they are ready to receive sealant work.

B. Confirm that joint size, configuration, and conditions conform to sealant manufacturer's requirements so as to achieve manufacturer's published sealant performance.

C. Verify that joint backing and release tapes are recommended for use by sealant manufacturer with the specified sealant.

D. Do not start sealant installation until substrate surfaces and joint openings conform to sealant manufacturer’s requirements.

E. Start of sealant installation indicates installer’s acceptance and confirmation that substrate, joint openings and conditions are in conformance with sealant manufacturer’s requirements.

3.3 PREPARATION

A. Thoroughly clean and prepare joint substrate surfaces in accordance with sealant manufacturer's instructions to achieve published sealant performance.

B. Remove loose materials and foreign matter which might impair adhesion of sealant.

C. Clean and prime joints in accordance with manufacturer's instructions.

D. Protect elements surrounding the work of this Section from damage or disfigurement.

3.4 INSTALLATION

A. Perform work in accordance with sealant manufacturer's requirements for preparation of surfaces and material installation instructions to achieve published sealant performance.

B. Measure joint dimensions and size joint backers to achieve width-to-depth ratio, neck dimension, and surface bond area as recommended by manufacturer.

C. Install bond breaker where joint backing is not used.

D. Install sealant free of air pockets, foreign embedded matter, ridges, and sags.

E. Apply sealant within recommended application temperature ranges. Consult manufacturer when sealant cannot be applied within these temperature ranges.

F. Tool joints concave.

3.5 CLEANING

A. Clean adjacent soiled surfaces.

3.6 PROTECTION OF FINISHED WORK

A. Protect sealants until cured.

END OF SECTION

DIVISION 09

FINISHES

SECTION 09 29 00

GYPSUM BOARD ASSEMBLIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including Division 1 Specification Sections, apply to work of this Section.

1.2 SECTION INCLUDES

A. Interior Gypsum Board (GWB)

B. Water Resistant Panels (WRGWB)

C. Tile Backer Board (TBB)

D. Finishing Gypsum Board

1.3 REFERENCES

A. All references shall be the latest adopted edition.

B. ASTM C36 - Standard Specification for Gypsum Board

C. ASTM C475 - Standard Specification for Joint Compound and Joint Tape for Finishing Gypsum Board

D. ASTM C630 - Standard Specification for Water-Resistant Gypsum Backing Board

E. ASTM C840 - Standard Specification for Application and Finishing of Gypsum Board

F. ASTM C1002 - Standard Specification for Steel Drill Screws for the Application of Gypsum Panel Products or Metal Plaster Bases

G. ASTM C1178 - Standard Specification for Glass Mat Water-Resistant Gypsum Backing Panel

H. GA-214 - Recommended Levels of Gypsum Board Finish; Gypsum Association

I. GA-216 - Application and Finishing of Gypsum Board; Gypsum Association

1.4 SUBMITTALS

A. Refer to Division 1 of the specifications for submittal procedures.

B. Product Data: Submit manufacturer's product data for each proposed product sufficient to show compliance with each product specified.

1.5 QUALITY ASSURANCE

A. Applicator Qualifications: Company specializing in performing the work of this Section with minimum 5 years of consecutive successful experience.

1.6 REGULATORY REQUIREMENTS

A. Conform to applicable codes and installation requirements for fire rated assemblies indicated on drawings.

1.7 DELIVERY, STORAGE & HANDLING

A. Deliver materials in original and unopened packages, containers, or bundles, with brand names and manufacturer's labels intact and legible.

B. Stack gypsum board products flat and level, properly supported to prevent sagging or damage to ends and edges. Store materials in dry location, fully protected from weather and direct exposure to sunlight.

C. Store corner bead and other metal and plastic accessories to prevent bending, sagging, distortion, or other mechanical damage.

1.8 PROJECT CONDITIONS

A. Environmental Conditions: Establish and maintain environmental conditions for applying and finishing gypsum board to comply with ASTM C840 requirements or gypsum board manufacturer's recommendations, whichever are more stringent.

B. Ventilation: Provide controlled ventilation during joint finishing operations, to eliminate excessive moisture. Avoid drafts during hot, dry weather to prevent finishing materials from drying too quickly.

PART 2 - PRODUCTS

2.1 GYPSUM BOARD MATERIALS (GWB)

A. Gypsum Board (GWB): ASTM C36; Type X, fire rated, UL or WH tested and listed; sizes to minimize joints in place; ends square cut.

1. Thickness: 5/8 inch.
2. Edges: Tapered.
3. Length: Longest length possible for least number of butt joints.

B. Water Resistant Panels (WRGWB):

1. Manufacturers/Products:
   a. G-P Gypsum DensArmor Plus
   b. USG Fiberock Brand Aqua-Tough Interior Panels
2. Location: Where shown or indicated on Drawings.
3. Thickness: 5/8”
4. Edges: Tapered
5. Size: Largest size practicable to minimize joints in place.
6. Ends: Square cut
7. Standards: Conform to ASTM C1278 and physical property requirements of ASTM C630 and C1178.

2.3 ACCESSORIES

A. Acoustic Sealant: Non-hardening, non-skinning, for use in conjunction with gypsum board; Similar to USG Sheetrock Acoustical Sealant or similar.

B. Outside Square Corners: Galvanized metal corner bead factory clad with paper tape; Beadex Microbead or equal.

C. Angled Corners: Similar to Beadex B1 Flex 100’ Tape-On Flexible Corner Bead, or equal.

D. GWB Abuts Dissimilar Material (Exposed to View): Galvanized metal J-shaped trim factory clad with paper; similar to Beadex B9J Tape-On “J” Trim or equal.

   1. GWB Abuts Windows: Provide temporary heavy weight cardboard strip 3 inches wide between trim and face of window frame to protect frame from dirt and damage.

E. Control Joint: GA 216; roll-formed metal control joint with removable strip, similar to USG No. 93, or equal.

F. Joint Materials: Provide products by manufacturer of gypsum board. Conform to ASTM C475 and as recommended by gypsum board manufacturer for project conditions.
   1. Interior Applications – Gypsum board (except Water Resistant Panels): Ready-mixed vinyl-based joint compound:
      a. Taping Compound: Type specifically formulated for embedding tape and accessories and for pre-filling.
      b. Topping Compound: Type specifically formulated for finishing drywall over taping compound.
      c. Joint Tape: Manufacturer's standard paper reinforcing tape.
   2. Water Resistant Panels: Similar to Sheetrock Brand Durabond Setting- Type Joint Compound or Sheetrock Brand Easy Sand Joint Compound manufactured by U.S. Gypsum.
      a. Joint Tape: Paper tape, Similar to Sheetrock Brand Joint Tape manufactured by U.S. Gypsum.

G. Sealer: Product specifically recommended by gypsum board manufacturer for sealing gypsum board prior to texturing.

H. Screws: Conform to ASTM C1002; bugle-head steel, self-drilling type, black phosphate finish.

1. Exterior Gypsum Sheathing Board, GWB Roof Board & Water Resistant Panels: Provide with yellow zinc corrosion resistant coating.

J. Nails: Not allowed.

PART 3 - EXECUTION

3.1 COORDINATION

A. Review, coordinate and accommodate work of other trades that interface with, affect or are affected by the work of this Section so as to facilitate the execution of the overall Work of this project in a coordinated and efficient manner.

B. Coordinate installation and requirements of fire rated assemblies with other trades affected.

C. Inspect finished surfaces with Section 09 90 00 painting applicator and project superintendent, mark areas that require additional finishing.

3.2 EXAMINATION

A. Verify that project conditions are appropriate for work of this Section to commence.

B. Confirm that the framing is straight, is within specified tolerances and meets minimum allowable deflection requirements.

C. Confirm that utility rough-in fits properly within framing width and will not prevent GWB from fitting tight to face of framing members.

D. Confirm that there is adequate temporary heat and light.

E. Beginning of installation indicates acceptance of framing and conditions.

3.3 PROTECTION

A. Protect unsealed concrete floors from contact with GWB dust, taping mud and primer/surfacer using heavy paper or other method.

3.4 GYPSUM BOARD INSTALLATION

A. Install GWB in conformance with ASTM C840, GA-216, and manufacturer's installation instructions.

1. Install in longest lengths possible for minimum number of joints.
2. Install to minimize butt end joints, especially in highly visible locations.

3. Comply with the installation requirements of fire rated assemblies listed on the Drawings.
4. Water Resistant Panels: Use corrosion resistant screws.

B. Install full width panels with cut pieces only at top of wall (no "belly bands").

C. Place wrapped edges adjacent to one another; do not place cut edges or butt ends adjacent to wrapped edges.

D. Maintain 1/4 inch maximum gap between bottom of gypsum board and floor.

E. Single-Layer Fire-Rated: Install gypsum board, with edges and ends occurring over firm bearing.

F. Double-Layer Installation: Use gypsum backing board for first layer, placed perpendicular to framing or furring members. Place second layer parallel to first layer. Offset joints of second layer from joints of first layer.

G. Acoustic Sealant: Install at all sound walls in accordance with manufacturer's instructions and as follows:

1. Place continuous bead at perimeter of each layer of gypsum board.
2. Seal around all penetrations by conduit, pipe, ducts, rough-in boxes, and at other similar penetrations.

H. Installation on Metal Framing: Use screws for attachment of all gypsum board.

3.5 INSTALLATION OF TRIM & ACCESSORIES

A. Corner Beads & Reveals: Install at external corners in a single full length piece free of butt joints, using longest practical lengths, no short pieces; place into a solid bed of soft joint compound for secure installation.

1. Align bead straight and plumb.
2. Align juncture with other corner bead flush.

B. J-Shaped Edge Trim: Install at any exposed to view location where gypsum board abuts any dissimilar material or ends with exposed edge.

1. Install heavy cardboard continuously at window perimeter to protect frame from dirt and damage.

C. Control Joints: Place control joints consistent with lines of building spaces and as follows:

1. As determined by installer to avoid cracking in finished surfaces, generally not more than 30 feet apart on walls and ceilings over 50 feet long. Location and layout subject to Contracting Officer’s approval; review with Contracting Officer prior to starting installation.

3.6 JOINT TREATMENT

A. Finish gypsum board (whether exposed to view or not) in accordance with GA-214 to the following minimum level of finish:

1. Painted Finish Exposed To View: GA Level 5, substitute a coat of Primer/Surfacer (15 – 20 wet mil thickness) in lieu of skim coating with joint compound; sand surface of Primer-Surfacer smooth.
2. Surfaces in mechanical/electrical and storage rooms: GA Level 4
3. Concealed from view with adhered surface finish (sheet vinyl or rubber base, plastic laminate, FRP panels, etc.): GA Level 3
4. Concealed from view without surface finish above suspended lay-in ceilings: GA Level 1
5. Exterior Gypsum Sheathing Board: No finish when joints are butted tight except as required to achieve required fire rating in accordance with fire test/listing.
6. Concealed From View With Tile Finish: No joint treatment this Section.

B. Tape, fill, and sand exposed joints, edges, and corners to produce smooth surface ready to receive finishes.

1. Feather coats of joint compound so that camber is maximum 1/32 inch.

3.7 TOLERANCES

A. Gap between Bottom of GWB and Floor: 1/4 inch Maximum.

B. Maximum Variation of Finished Gypsum Board Surface from True Flatness: 1/8 inch in 10 feet in any direction.

C. Butt Joint Finishing: Not readily visible under the normal lighting conditions found for any given area/surface.

D. Finishing Tolerances: All exposed surfaces shall be smooth and free from visible ridges, waves, ripples, holes, defects, delamination, roughness, depressions, screw pops, etc. Taped joints shall not be visible after finish paint application.

3.8 CLEAN UP

A. Remove all excess gypsum board and finishing materials from the site.

B. Remove gypsum board scraps and dust from all concealed spaces including interior spaces of wall framing.

C. Remove gypsum dust, taping mud and primer/sealer completely from window frames, door frames, subfloor surfaces and any surface/material exposed to view.

1. Subfloor cleanliness/condition shall conform to floor covering installation requirements.

END OF SECTION

SECTION 09 51 10

SUSPENDED ACOUSTICAL CEILINGS

PART 1 - GENERAL

1.1 REFERENCES

A. ASTM C635 - Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings.

B. ASTM C636 - Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels.

C. ASTM E580 - Practice for Application of Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels in Areas Requiring Seismic Restraint.

D. ASTM E1264 - Classification of Acoustical Ceiling Products.

E. Ceilings and Interior Systems Contractors Association (CISCA) - Acoustical Ceilings: Use and Practice.

1.2 SUBMITTALS

A. Product Data: Provide data on metal grid system components.

B. Samples: Submit two samples full size illustrating material and finish of acoustical units.

1.3 REGULATORY REQUIREMENTS

A. Conform to applicable code for combustibility requirements for materials.

B. International Building Code (IBC) Seismic.

1.4 ENVIRONMENTAL REQUIREMENTS

A. Maintain uniform temperature of minimum 60 degrees F and maximum humidity of 40 percent prior to, during, and after acoustical unit installation

1.5 EXTRA MATERIALS

A. Provide 10 additional 24”x48” extra tiles in cartons to Owner.

PART 2 - PRODUCTS

2.1 MANUFACTURERS - SUSPENSION SYSTEM

A. Armstrong, referenced specification.

B. Chicago Metallic Corporation.

C. Donn Corporation.

2.2 SUSPENSION SYSTEM MATERIALS

A. Non-fire Rated Grid: ASTM C635, intermediate duty throughout; exposed T; components die cut and interlocking, Armstrong Prelude.

B. All components of suspended ceiling system from one manufacturer. Provide all compression struts and other related elements to comply with seismic requirements for locality in which installation to occur.

C. Grid Materials: Commercial quality cold rolled steel with hot-dipped galvanized coating.

D. Exposed Grid Surface Width: 15/16 inch.

E. Grid Finish: As selected by Contracting Officer.

F. Accessories: Stabilizer bars, clips, splices, edge moldings, hold down clips and manufactured compression posts, Donn or approved, required to complete and compliment suspended grid system and conform to UBC seismic forces in suspension work.

G. Support Channels and Hangers: Galvanized steel; size and type to suit application, seismic requirements, and ceiling system flatness requirement specified. Where employing indirect-hung suspension system, furnish 1-1/2 inch cold-rolled carrying channels, 475 lbs. per 1,000 lin. ft. galvanized or protective painted.

H. Hanger Wires: Galvanized, soft-annealed mild steel wire of gauge certified by load test data as capable of carrying five times the design load but in no case less than No. 12 gauge or UL requirements, whichever is greater; with indirect-hung suspension systems, conform to ML/SFA and UL Specifications for galvanized wire size, type and spacing requirements.

I. Hangers: Conforming to ASTM C636 and as approved. Main runners for 2 or 4 feet o.c. as approved; support wire 3 feet o.c. maximum or UL requirements. Comply to more restrictive requirement. Attach hangers to steel joists whenever possible. Where directly attaching hangers to metal decking, provide anchor capable of sustaining 100-lbs. tensile live loading minimum, or greater as otherwise specified, and as approved by Contracting Officer.

J. Cross Runners: As required for lay-in panel system and as required for mechanical and electrical equipment and fixture support.

K. Paint finish for exposed, Armstrong "Second Look II" system members; paint galvanized steel with Armstrong "Low Gloss Grid" finish.

2.3 ACOUSTICAL UNITS

A. ACT

1. Armstrong #1732 (24” x 24” x 5/8”) and Armstrong #1834 (24” x 48” x 5/8”).
2. Edge detail: Angled regular.
3. Color: Selected by Contracting Officer.
4. Finish: Fine fissured with “Humaguard Plus”.

2.4 ACCESSORIES

A. Touch-up Paint: Type and color to match acoustical and grid units.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify site conditions.

B. Verify that layout of hangers will not interfere with other work.

3.2 INSTALLATION - LAY-IN GRID SUSPENSION SYSTEM

A. Install suspension system in accordance with ASTM C636 and as supplemented in this section.

B. Install system in accordance with ASTM E580 seismic requirements.

C. Install system capable of supporting imposed loads to a deflection of 1/360 maximum.

D. Locate system on room axis according to reflected plan.

E. Install after major above ceiling work is complete. Coordinate the location of hangers with other work.

F. Coordinate the installation of hanger clips during steel deck erection. Provide additional hangers and inserts as required.

G. Hang suspension system independent of walls, columns, ducts, pipes and conduit. Where carrying members are spliced, avoid visible displacement of face plane of adjacent members.

H. Where ducts or other equipment prevent the regular spacing of hangers, reinforce the nearest affected hangers and related carrying channels to span the extra distance.

I. Do not support components on main runners or cross runners if weight causes total dead load to exceed deflection capability. Support fixture loads by supplementary hangers located within 6 inches of each corner; or support components independently.

J. Do not eccentrically load system, or produce rotation of runners. Where fixture installation would produce rotation of runners, provide stabilizer bars.

K. Install edge molding at intersection of ceiling and vertical surfaces, using longest practical lengths. Miter corners. Provide edge moldings at junctions with other interruptions.

L. Form expansion joints as required. Form to accommodate plus or minus 1-inch movement. Maintain visual closure.

3.3 INSTALLATION - ACOUSTICAL UNITS

A. Install acoustical units in accordance with manufacturer's instructions.

B. Fit acoustical units in place, free from damaged edges or other defects detrimental to appearance and function.

C. Fit border trim neatly against abutting surfaces.

D. Install units after above ceiling work is complete.

E. Install acoustical units level, in uniform plane, and free from twist, warp and dents.

F. Cut panels to fit irregular grid and perimeter edge trim. Double cut and field paint exposed edges of regular units.

G. Where round obstructions occur, provide preformed closers to match edge molding.

3.4 ERECTION TOLERANCES

A. Maximum Variation from Flat and Level Surface: 1/8 inch in 10 feet.

B. Maximum Variation from Plumb of Grid Members Caused by Eccentric Loads: 2 degrees.

END OF SECTION

SECTION 09 90 00

PAINTS & COATINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of contract, including General Conditions and Division 1 Specification Sections, apply to work of this Section.

1.2 SECTION INCLUDES

A. Surface preparation and field painting

1.3 REFERENCES

A. All references shall be the latest adopted edition.

B. MPI – Architectural Painting Specification Manual, as published by the Master Painters and Decorators Association.

C. SSPC – Steel Structures Painting Council, Steel Structures Painting Manual.

1.4 SUBMITTALS

A. Refer to Section 01 33 23 for submittal procedures.

B. Product Data: Provide product data on each different paint finishing product.

C. Paint Schedule: Provide schedule of all proposed paint products for the items to be painted in format matching the Schedule found in Part 3 of this Section.

D. Paint Draw Down Samples: Submit two painted samples, illustrating selected colors for each color and system selected. Submit on heavy paper card stock, 8 x 10 inch in size.

1. Sheen Samples: Submit samples of different sheens for each color as directed by Contracting Officer for selection.

E. Paint-Downs: Paint sample of actual surface/item with each paint color selected by Contracting Officer for review and approval of prior to applying any paint finish coats as follows (sizes listed are minimum):

1. Interior Wall: 100 square feet.
2. Exterior Wall: 100 square feet.

F. LEED™ Documentation: Provide LEED™ documentation related to LEED™ Construction IAQ Management Plan EQc3.1 & EQc3.2 as determined by Contractor for compliance with General LEEDTM Product Requirements.

1. Low Emitting Materials EQ Credit 4.2: Submit certification statement on company letterhead specific to products supplied on this project that clearly states the VOC levels of paints and coatings used during construction inside the building envelope and conforms to Green Seal Standard GS-11 and contains the following statement: This product meets Green Seal GS-11 environmental standards for volatile organic compounds (VOCs) and other ingredients.

1.5 QUALITY ASSURANCE

A. Single Source Responsibility: All paint products used for painting a given material/surface shall be manufactured by the same company.

B. Applicator Qualifications: Company specializing in performing the work of this section with minimum five years successful experience.

1.6 REGULATORY REQUIREMENTS

A. Conform to applicable code for flame and smoke rating requirements for products and finishes.

1.7 DELIVERY, STORAGE, AND PROTECTION

A. Deliver products to site in sealed and labeled containers; inspect to verify acceptability.

B. Container Label: Include manufacturer's name, type of paint, brand name, lot number, brand code, coverage, surface preparation, drying time, cleanup requirements, color designation, and instructions for mixing and reducing.

C. Paint Materials: Store at minimum ambient temperature of 45 degrees F and a maximum of 90 degrees F, in ventilated area, and or as required by manufacturer's instructions and/or MPI MANUAL.

1.8 ENVIRONMENTAL REQUIREMENTS

A. Provide environmental conditions as required by paint manufacturer, MPI Manual and as follows:

1. Do not apply materials when surface and ambient temperatures are outside the temperature ranges required by the paint product manufacturer’s written licensure.
2. Do not apply exterior coatings during rain or snow, or when relative humidity is outside the humidity ranges required by the paint product manufacturer’s written literature.
3. Provide lighting level of 80 ft. candles measured mid-height at substrate surface.

1.9 EXTRA MATERIALS

A. Supply 5 gallon container of primary interior wall color paint. Supply 1 gallon of other colors and types of paint used on project; store where directed. Containers to be new and unopened.

B. Label each container with color in addition to the manufacturer's label.

PART 2 - PRODUCTS

2.1 LEEDTM REQUIREMENTS

A. Requirements: Construction IAQ Management Plan EQc3.1 & EQc3.2 which are the Contractor’s responsibility to identify, coordinate and document.

1. Low Emitting Materials EQ Credit 4.1: VOC levels of sealants and fillers used during construction inside the building envelope shall not exceed 250 grams per liter.
2. Low Emitting Materials EQ Credit 4.2: VOC levels of paints, coatings, sealers used during construction inside the building envelope shall conform to Green Seal Standard GS-11, Green Seal Standard GC-03, and South Coast Air Quality Management District Rule 1113.

2.2 PAINTS AND COATINGS - GENERAL

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

1. Benjamin Moore
2. ICI Dulux
3. Kelly Moore
4. Master Coating Technologies
5. Parker Paint
6. Sherwin-Williams
7. Tnemec
8. Substitutions: Refer to Division 1 of the specifications.

B. Paints and Coatings: Ready mixed, select products from the MPI Manual Manufacturer's Product List for Manufacturers listed above which installer has used on other projects and are known to provide excellent performance including:

1. A soft paste consistency, capable of being readily and uniformly dispersed to a homogeneous coating.
2. Good hiding characteristics.
3. Good flow and brushing properties.
4. Good mildew-resistance.
5. Capable of drying or curing free of streaks or sags.

C. Certain manufacturer's products may not provide adequate hiding ability with the number of coats specified. Contractor may be required to provide additional coats at no additional cost if products are selected that do not provide adequate hiding ability.

D. Colors: To be selected by Contracting Officer

2.3 ACCESSORY MATERIALS

A. Accessory Materials: Linseed oil, shellac, turpentine, paint thinners and other materials not specifically indicated but required to achieve the finishes specified; commercial quality.

B. Patching Material: Latex-based filler.

C. Sealant: Silicon-latex acrylic sealant as specified in Section 07 90 00.

PART 3 - EXECUTION

3.1 COORDINATION

A. Review, coordinate and accommodate work of other trades that interface with, affect or are affected by the work of this Section so as to facilitate the execution of the overall Work of this project in a coordinated and efficient manner.

B. Coordinate selection of paint products to be applied over prime coats applied by others for compatibility and good adhesion.

C. Coordinate inspection of finish GWB surfaces with Section 09 29 00 prior to start of any painting work; identify and mark any defective areas for correction.

D. Schedule work to follow completion of all dust/dirt producing work.

3.2 GWB FINISH INSPECTION WITH SECTION 09 29 00 & PROJECT SUPERINTENDENT

A. Coordinate an inspection walkthrough of all finished GWB surfaces with Section 09 29 00 and project superintendent using a 500 watt lamp aimed from side; mark any defects in the surface finish.

3.3 EXAMINATION

A. Verify that surfaces are clean and ready to receive paint as required by the product manufacturer.

B. Examine surfaces scheduled to be finished prior to commencement of work. Report any condition that may potentially affect proper application or performance.

C. Test shop-applied primer/paint for proper adhesion and compatibility with subsequent cover materials.

D. Measure moisture content of surfaces. Do not apply finishes unless moisture content of surfaces conforms to the recommendations of the MPI Manual and paint manufacturer.

E. Do not start paint application until problems with substrate surfaces, GWB finish and shop-applied primer/paint have been satisfactorily resolved.

F. Start of installation indicates acceptance of substrate, finish and conditions and responsibility for proper finish and appearance.

3.4 SURFACE PREPARATION

A. Conform to MPI Manual surface preparation recommendations, paint manufacturer's recommendations and the following for preparation of each different surface scheduled to be painted:

B. Substrate: Clean substrate surfaces thoroughly before applying any primer or paint following paint manufacturer's cleaning recommendations; allow substrate to dry thoroughly before starting paint application.

C. Surface Appurtenances: Remove electrical plates, hardware, light fixture trim, escutcheons, and fittings prior to preparing surfaces or finishing.

D. Marks: Seal with shellac those which may bleed through surface finishes.

E. Mildew: Remove mildew by scrubbing with solution of tetra-sodium phosphate and bleach. Rinse with clean water and allow surface to dry.

F. Factory Primed/Painted Items to be Painted: Hand sand factory finished surfaces to provide proper tooth for good adhesion of finish coats.

G. Exterior Galvanized Steel, Stainless Steel and Aluminum: Prepare surfaces to be painted in strict conformance with paint manufacturer's surface preparation requirements.

1. Minimum Preparation: SSPC-SP1 Solvent Cleaning of all surfaces in strict conformance with SSPC Steel Structures Painting Manual requirements. Acid etch surface as specifically recommended by the paint manufacturer.
2. Application of primer shall follow surface preparation immediately within the same day or surfaces will require repeating the preparation procedure.
3. Surface preparation and prime painting shall be scheduled to coincide with warm, dry weather, minimum 60 degrees F and rising.

3.5 PROTECTION

A. Protect all finish surfaces, landscaping, adjacent property, and elements surrounding the work of this Section from overspray, damage, or disfiguration.

B. Maintain subfloor surfaces free from paint and spills using heavy paper or other method.

3.6 APPLICATION

A. Apply products in accordance with manufacturer's instructions and MPI Manual.

B. Apply sufficient wet film thickness to provide good hiding, do not thin product.

C. Where adjacent sealant is to be painted, do not apply finish coats until sealant is applied.

D. Do not apply finishes to surfaces that are not dry.

E. Allow applied coats to dry completely before next coat is applied.

F. Apply each coat to uniform appearance. Apply each coat of paint slightly darker than preceding coat unless otherwise approved.

G. Vacuum clean surfaces of loose particles. Remove dust and particles just prior to applying next coat.

H. Gypsum Board: After paint has been spray or roller applied to uniform wet film thickness, backroll entire surface in same direction to provide uniform texture, reflective value and appearance, free of roller marks or lines.

3.7 FINISHING MECHANICAL AND ELECTRICAL EQUIPMENT

A. Remove louvers, grilles, covers, and access panels on mechanical and electrical components and paint separately.

B. Reinstall electrical cover plates, hardware, light fixture trim, escutcheons, and fittings removed prior to finishing.

3.8 CLEANING

A. Collect waste material which may constitute a fire hazard, place in closed metal containers, and remove daily from site.

3.9 BACK-PRIMING

A. Back-prime the following exterior items prior to installation that are scheduled to be painted:

1. Exterior fascia and trim.

3.10 SURFACES THAT DO NOT REQUIRE PAINT FINISH

A. The Following Work Is Not Field Painted or Finished By This Section:

1. Pavement markings
2. Site furnishings
3. Fire rating labels, equipment serial numbers and capacity labels.
4. Factory finished sheet metal items except as specifically noted in the next paragraph 3.11.
5. Factory finished coiling and rolling doors

6. Aluminum doors and frames
7. Door hardware
8. Glazing
9. Ceramic tile
10. Acoustical ceiling tile and grid
11. Resilient floor coverings and rubber base
12. FRP panels
13. Toilet partitions
14. Fire extinguisher cabinets
15. Toilet & miscellaneous accessories
16. Factory casework
17. Elevator

3.11 SURFACES THAT REQUIRE PAINT FINISH

A. Paint all materials/surfaces described below under SCHEDULE - PAINT SYSTEMS.

B. Firestopping exposed to view.

C. Factory-finished items that require painting:

1. Access panels/doors

D. Roof access hatch.

E. Mechanical and Electrical: Use paint systems defined for the substrates to be finished.

1. Mechanical grilles and louvers
2. Paint all insulated and exposed pipes, conduit, boxes, insulated and exposed ducts, and hangers, brackets, collars and supports to match background surfaces, unless otherwise indicated.
3. Paint shop-primed items.
4. Paint interior surfaces of air ducts that are visible through grilles and louvers with one coat of flat black paint to visible surfaces.
5. Paint mechanical or electrical equipment on building exterior.

3.12 SCHEDULE - PAINT SYSTEMS (ALL WORK IS MPI PREMIUM GRADE)

A. All materials/surfaces scheduled hereinafter shall be painted in accordance with designated MPI or proprietary Systems and Product requirements.

1. Sheen on finish coats shall be as selected by Contracting Officer from manufacturer's paint sheen samples.
2. Use the same manufacturer for each coat specified for a given system, do not intermix different manufacturer's products within the same paint system unless specifically approved by manufacturer(s) and products are known to be compatible for use together.

a. Where primer is applied by others:
   1) Select paint system compatible with primer installed by others.
   2) Test compatibility and adhesion of proposed paint products over primer prior to application.
b. Paint failure due to incompatibility between different manufacturer's products is Contractor's responsibility to correct.

B. Ferrous Metal: Finish all surfaces.

1. Hollow Metal Door Frames (Exterior): Provide paint system specified for Exterior Galvanized Steel.
   a. Application: Spray.
   b. MPI Gloss Level 5

C. Wood:

1. Interior: MPI INT 6.4A
   a. First Coat: Alkyd Primer sealer, MPI Product #45
   b. Second Coat: Interior Latex, MPI Product #52
   c. Third Coat: Interior Latex, MPI Product #52
   d. Application: Spray & back-roll

D. Gypsum Board:

1. Interior: MPI INT 9.2.A.
   a. First Coat: Waterborne primer/sealer, MPI Product #50
   b. Second Coat: Interior latex, MPI Product #43
   c. Third Coat: Interior latex, MPI Product #43
   d. Application: Spray and backroll
   e. MPI Gloss Level: MPI Gloss Level 4 or as selected by Contracting Officer for specific use areas.

E. Cementitious Composition Board (Fiber Cement Siding)

1. Exterior MPI EXT 3.3A
   a. First Coat: Exterior latex low sheen, MPI Product #15
   b. Second Coat: Exterior latex low sheen, MPI Product #15
   c. Third Coat: Exterior latex low sheen, MPI Product #15
   d. Application: Spray and back-roll
   e. MPI Gloss Level: MPI Gloss Level 3 & 4.

END OF SECTION

DIVISION 23

HEATING, VENTILATING, & AIR CONDITIONING

SECTION 23 01 30.51

HVAC AIR DUCT CLEANING

PART 1 – GENERAL

1.1 HEALTH AND SAFETY

A. Safety Standards: cleaning contractors shall comply with all applicable federal, state and local requirements for protecting the safety of the contractors' employees, building occupants, and the environment. In particular, all applicable standards of the Occupational Safety and Health Administration (OSHA) shall be followed when working in accordance with this specification.

B. Occupant Safety: no processes or materials shall be employed in such a manner that they will introduce additional hazards into occupied spaces.

C. Disposal of Debris: all Debris removed from the HVAC System shall be disposed of in accordance with applicable federal, state, and local requirements.

1.2 QUALIFICATION OF THE HVAC SYSTEM CLEANING CONTRACTOR

A. Membership: the HVAC system cleaning contractor shall be a certified member of the National Air Duct Cleaners Association (NADCA) or shall maintain membership in a nationally recognized non-profit industry organization dedicated to the cleaning of HVAC systems.

B. Certification: the HVAC system cleaning contractor shall have a minimum of 1 Air System Cleaning Specialist (ASCS) certified by NADCA on a full time basis or shall have staff certified by a nationally recognized certification program and organization dedicated to the cleaning of HVAC systems.

C. Supervisor Qualifications: a person certified as an ASCS by NADCA or maintaining an equivalent certification by a nationally recognized program and organization, shall be responsible for the total work herein specified.

D. Experience: the HVAC system cleaning contractor shall submit records of experience in the field of HVAC system cleaning as requested by the Owner. Bids shall only be considered from firms which are regularly engaged in HVAC system maintenance with an emphasis on HVAC system cleaning and decontamination.

E. Equipment, Materials and Labor: the HVAC system cleaning contractor shall possess and furnish all necessary equipment, materials, and labor to adequately perform the specified services.

1. The contractor shall assure that its employees have received safety equipment training, medical surveillance programs, individual health protection measures, and manufacturer's product and Material Safety Data Sheets (MSDS) as required for the work by the U.S. Occupational Safety and Health Administration, and as described by this specification.

2. The contractor shall maintain a copy of all current MSDS documentation and safety certifications at the site at all times, as well as comply with all other site documentation requirements of applicable OSHA programs and this specification.
3. Contractor shall submit to the Owner all Material Safety Data Sheets (MSDS) for all chemical products proposed to be used in the cleaning process.

PART 2 - HVAC SYSTEM CLEANING SPECIFICATIONS AND REQUIREMENTS

2.1 SCOPE OF WORK:

A. Scope: this section defines the minimum requirements necessary to render HVAC components clean.

B. The Contractor: shall be responsible for the removal of visible surface contaminants and deposits from within the HVAC system in strict accordance with these specifications.

C. The HVAC system: includes any interior surface of the facility's air distribution system for conditioned spaces and/or occupied zones. This includes the entire heating, air-conditioning and ventilation system from the points where the air enters the system to the points where the air is discharged from the system. The return air grilles, return air ducts (except ceiling plenums and mechanical room) to the Air Handling Unit (AHU), the interior surfaces of the AHU, mixing box, coil compartment, condensate drain pans, humidifiers and dehumidifiers, supply air ducts, fans, fan housing, fan blades, air wash systems, spray eliminators, turning vanes, filters, filter housings, reheat coils, and supply diffusers are all considered part of the HVAC system.

2.2 IN SUMMARY THE CONTRACTOR SHALL CLEAN

A. The full length of all supply air ducts.

B. The full length of all return air ducts.

C. The full length of all outside air ducts.

D. All supply and return air registers and diffusers.

E. All vertical shafts.

F. The dull length of the exhaust air ducts.

G. Exhaust fans and housings.

PART 3 - EXECUTION

3.1 GENERAL HVAC SYSTEM CLEANING REQUIREMENTS

A. Containment: debris removed during cleaning shall be collected and precautions must be taken to ensure that Debris is not otherwise dispersed outside the HVAC system during the cleaning process.

B. Particulate Collection: where the Particulate Collection Equipment is exhausting inside the building, HEPA filtration with 99.97% collection efficiency for 0.3-micron size (or greater) particles shall be used. When the Particulate Collection Equipment is exhausting outside the building, Mechanical Cleaning operations shall be undertaken only with Particulate Collection Equipment in place, including adequate filtration to contain Debris removed from the HVAC system. When the Particulate Collection Equipment is exhausting outside the building, precautions shall be taken to locate the equipment down wind and away from all air intakes and other points of entry into the building.

C. Controlling Odors: all reasonable measures shall be taken to control offensive odors and/or mist vapors during the cleaning process.

D. Component Cleaning: cleaning methods shall be employed such that all HVAC system components must be visibly clean. Upon completion, all components must be returned to those settings recorded just prior to cleaning operations.

E. Air-Volume Control Devices: dampers and any air-directional mechanical devices inside the HVAC system must have their position marked prior to cleaning and, upon completion, must be restored to their marked position.

F. Service Openings: the contractor shall utilize service openings, as required for proper cleaning, at various points of the HVAC system for physical and mechanical entry, and inspection.

1. Contractor shall utilize the existing service openings already installed in the HVAC system where possible.
2. Other openings shall be created where needed and they must be created so they can be sealed in accordance with industry codes and standards.
3. Closures must not significantly hinder, restrict, or alter the airflow within the system.
4. Closures must be properly insulated to prevent heat loss/gain or condensation on surfaces within the system.
5. Openings must not compromise the structural integrity of the system.
6. Construction techniques used in the creation of openings should conform to requirements of applicable building and fire codes, and applicable National Fire Protection Association (NFPA), Sheet Metal & Air Conditioning Contractors' National Association (SMACNA) and National Air Duct Cleaners Association (NADCA) Standards.
7. Cutting service openings into flexible duct is not permitted. Flexible duct shall be disconnected at the ends as needed for proper cleaning and inspection.
8. Rigid fiber glass duct board duct systems shall be resealed in accordance with North American Insulation Manufacturers Association (NAIMA) recommended practices. Only closure techniques which comply with UL Standard 181 or UL Standard 181a are suitable for fiber glass duct system closures.
9. All service openings capable of being re-opened for future inspection or remediation shall be clearly marked and shall have their location reported to the Owner in project report documents.

G. Ceiling sections (tile): The contractor may remove and reinstall ceiling sections to gain access to HVAC systems during the cleaning process.

H. Air distribution devices (registers, grilles & diffusers): The contractor shall clean all air distribution devices.

I. Air handling units, terminal units (VAV, Dual duct boxes, etc.), blowers and fans: The contractor shall insure that supply and return fans and blowers are thoroughly cleaned. Areas to be cleaned include blowers, fan housings, plenums (except ceiling supply and return plenums), scrolls, blades, or vanes, shafts, baffles, dampers, and drive assemblies. All visible surface contamination deposits shall be removed. Contractor shall:

1. Clean all Air Handling Unit (AHU) internal surfaces, components and condensate collectors and drains.
2. Assure that a suitable operative drainage system is in place prior to beginning wash down procedures.
3. Clean all coils and related components, including evaporator fins.

J. Duct Systems: Contractor Shall:

1. Create service openings in the system as necessary in order to accommodate cleaning of otherwise inaccessible areas.
2. Mechanically clean all duct systems to remove all visible contaminants, such that the systems are capable of passing Cleaning Verification Testing.

3.2 MECHANICAL CLEANING METHODOLOGY

A. Source Removal Cleaning Methods: The HVAC system shall be cleaned using Source Removal mechanical cleaning methods designed to extract contaminants from within the HVAC system and safely remove contaminants from the facility. It is the contractor's responsibility to select Source Removal methods which will render the HVAC system Visibly Clean and capable of passing cleaning verification methods. No cleaning method, or combination of methods, shall be used which could potentially damage components of the HVAC system or negatively alter the integrity of the system.

1. All methods used shall incorporate the use of vacuum collection devices that are operated continuously during cleaning. A vacuum device shall be connected to the downstream end of the section being cleaned through a predetermined opening. The vacuum collection device must be of sufficient power to render all areas being cleaned under negative pressure, such that containment of debris and the protection of the indoor environment are assured.
2. All vacuum devices exhausting air inside the building shall be equipped with HEPA filters (minimum efficiency), including hand-held vacuums and wet-vacuums.
3. All vacuum devices exhausting air outside the facility shall be equipped with Particulate Collection including adequate filtration to contain Debris removed from the HVAC system. Such devices shall exhaust in a manner that will not allow contaminants to re-enter the facility. Release of debris outdoors must not violate any outdoor environmental standard, codes or regulations.
4. All methods require mechanical agitation devices to dislodge debris adhered to interior HVAC system surfaces, such that debris may be safely conveyed to vacuum collection devices. Acceptable methods will include those which will not potentially damage the integrity of the ductwork, nor damage porous surface materials such as liners inside the ductwork or system components.

B. Methods of Cleaning Fibrous Glass Insulated Components:

1. Fibrous glass thermal or acoustical insulation elements present in any equipment or ductwork shall be thoroughly cleaned with HEPA vacuuming equipment, while the HVAC system is under constant negative pressure, and not permitted to get wet in accordance with applicable NADCA and NAIMA standards and recommendations.
2. Cleaning methods used shall not cause damage to fibrous glass components and will render the system capable of passing Cleaning Verification Tests.

C. Damaged Fibrous Glass Material:

1. If there is any evidence of damage, deterioration, delaminating, friable material, mold or fungus growth, or moisture such that fibrous glass materials cannot be restored by cleaning or resurfacing with an acceptable insulation repair coating, they shall be identified for replacement.
2. When requested or specified, Contractor must be capable of remediating exposed damaged insulation in air handlers and/or ductwork requiring replacement.
3. Replacement Material: In the event fiber glass materials must be replaced, all materials shall conform to applicable industry codes and standards, including those of UL and SMACNA.
4. Replacement of damaged insulation is NOT covered by this specification.

D. Cleaning of coils

1. Any cleaning method may be used which will render the coil visibly clean. The drain for the condensate drain pan shall be operational. Cleaning methods shall not cause any appreciable damage to, displacement of, inhibit heat transfer, or erosion of the coil surface or fins, and shall conform to coil manufacturer recommendations when available. Coils shall be thoroughly rinsed with clean water to remove any latent residues.

E. Biocidal Agents and Coatings

1. Biocidal agents shall only be applied if active fungal growth is reasonably suspected, or where unacceptable levels of fungal contamination have been verified through testing.
2. Application of any biocide agent used to control the growth of fungal or bacteriological contaminants shall be performed after the removal of surface deposits and debris.
3. Only biocide agents registered by the U.S. Environmental Protection Agency (EPA) shall be used.
4. Biocidal agents shall be applied in strict accordance with manufacturer's instructions.
5. Biocidal coating products for both porous and non-porous surfaces shall be EPA registered water-soluble solutions with supporting efficacy data and MSDS records.
6. Biocidal coatings shall be applied according to manufacturer's instructions. Coatings shall be sprayed directly onto interior ductwork surfaces, rather than "fogged" downstream onto surfaces. A continuous film must be achieved on the surface to be treated by the coating application. Application of any Biocidal coatings shall be in strict accordance with manufacturer's minimum surface application rate standards for effectiveness.

F. Inspection of Work Performed.

1. Contractor is to leave open all cleaning access points until they have been inspected by the Owners construction Representative. The contractor can call for an inspection at any time.
2. Only after each opening has been inspected can the contractor seal up the cleaning access points.
3. The interior of the supply, return and outside air ducts must be visibly clean and pass inspection in order to satisfactorily complete the contract.
4. All air handlers need to be inspected before the access panels and doors are closed. All components of the air handlers must pass inspection in order to satisfactorily complete the project.

END OF SECTION

SECTION 23 01 60.71

REFRIGERANT RECOVERY / RECYCLING

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. Recovery and recycling of refrigeration
2. Recovery equipment

1.3 PERFORMANCE REQUIREMENTS

A. Refrigeration recovery equipment shall comply with Clean Air Act section 608 40cfr Part 82 Subpart F.

1.4 SUBMITTALS

A. Recovery Equipment and Procedure Data: Provide the information for each area of refrigeration recovery.

1. Certification of equipment to be used.
2. Make and model of equipment that refrigeration is recovered from.
3. Total capacity of refrigeration equipment required for proper operation.
4. Total capacity of refrigeration recovered from equipment.
5. Operational condition of equipment.
6. Certification of operator.
7. Recovery calculation of refrigeration showing compliance of the work.
8. Disposal and Recovery facility certification, including NAME of Company and volume recovered.

1.5 QUALITY ASSURANCE

A. Equipment and personnel certification as required by Clean Air Act section 608 40cfr Part 82 Subpart F.

1.6 RECOVERY AND DISPOSAL

A. Facility shall be certified for the recovery of the CFC and meet all requirements per the Clean Air Act

1.7 COORDINATION

A. Coordinate with Park staff to ensure that the equipment is able to be removed from service.

PART 2 – PRODUCTS – Not Used.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Preform all required test per Clean Air Act as they pertain to the recovery and reclamation of refrigerants.

END OF SECTION

SECTION 23 05 00

COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Transition fittings.
3. Dielectric fittings.
4. Mechanical sleeve seals.
5. Sleeves.
6. Escutcheons.
7. Grout.
8. HVAC demolition.
9. Equipment installation requirements common to equipment sections.
10. Painting and finishing.
11. Concrete bases.
12. Supports and anchorages.

1.3 DEFINITIONS

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

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

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

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

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

F. The following are industry abbreviations for plastic materials:

1. CPVC: Chlorinated polyvinyl chloride plastic.
2. PE: Polyethylene plastic.
3. PVC: Polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For the following:

1. Piping materials
2. Joining Materials
3. Transition fittings
4. Dielectric fittings.
5. Mechanical sleeve seals.
6. Sleeves
7. Escutcheons.
8. Grout

B. Welding certificates.

1.5 QUALITY ASSURANCE

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

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

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

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

1.6 DELIVERY, STORAGE, AND HANDLING

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

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

1.7 COORDINATION

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

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

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 23 piping Sections for special joining materials not listed below.

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

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
   a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
   b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
2. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

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

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

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

H. Solvent Cements for Joining Plastic Piping:

1. CPVC Piping: ASTM F 493.
2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

I. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.4 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings: CPVC and PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

1. Available Manufacturers:
   a. Eslon Thermoplastics.

B. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

1. Available Manufacturers:
   a. Thompson Plastics, Inc.

C. Plastic-to-Metal Transition Unions: MSS SP-107, CPVC and PVC four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.

1. Available Manufacturers:
   a. NIBCO INC.
   b. NIBCO, Inc.; Chemtrol Div.

2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C).

1. Available Manufacturers:
   a. Capitol Manufacturing Co.
   b. Central Plastics Company.
   c. Eclipse, Inc.
   d. Epco Sales, Inc.
   e. Hart Industries, International, Inc.
   f. Watts Industries, Inc.; Water Products Div.
   g. Zurn Industries, Inc.; Wilkins Div.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.

1. Available Manufacturers:
   a. Capitol Manufacturing Co.
   b. Central Plastics Company.
   c. Epco Sales, Inc.
   d. Watts Industries, Inc.; Water Products Div.

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Available Manufacturers:
   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Central Plastics Company.
   d. Pipeline Seal and Insulator, Inc.
2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig (1035- or 2070-kPa) minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

1. Available Manufacturers:
   a. Calpico, Inc.
   b. Lochinvar Corp.

G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

1. Available Manufacturers:
   a. Perfection Corp.
   b. Precision Plumbing Products, Inc.

c. Sioux Chief Manufacturing Co., Inc.
d. Victaulic Co. of America.

2.6 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Available Manufacturers:
   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Metraflex Co.
   d. Pipeline Seal and Insulator, Inc.
2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Stainless steel. Include two for each sealing element.
4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.7 SLEEVES

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

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

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with set screws.

E. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.

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

G. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

2.8 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.

1. Finish: Polished chrome-plated.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.

1. Finish: Polished chrome-plated.

E. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.

F. Split-Plate, Stamped-Steel Type: With exposed-rivet]hinge, set screw or spring clips, and chrome-plated finish.

G. One-Piece, Floor-Plate Type: Cast-iron floor plate.

H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.9 GROUT

A. Description: ASTM C 1107, Grade B, non-shrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, non-staining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.

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

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

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

J. Install piping to allow application of insulation.

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

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:
   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
   b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
   c. Insulated Piping: One-piece, stamped-steel type with spring clips.
   d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
   e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
   f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast-brass type with polished chrome-plated finish.
   g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge and set screw.
   h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated finish.
   i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed or exposed-rivet hinge and set screw or spring clips.
   j. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
   k. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with screw or spring clips.
   l. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
2. Existing Piping: Use the following:
   a. Chrome-Plated Piping: Split-casting, cast-brass type with chrome-plated finish.
   b. Insulated Piping: Split-plate, stamped-steel type with concealed or exposed-rivet hinge and spring clips.
   c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
   d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and spring clips.
   e. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.

f. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
g. Bare Piping in Unfinished Service Spaces: Split-casting, cast-brass type with polished chrome-plated finish.
h. Bare Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed or exposed-rivet, hinge and set screw or spring clips.
i. Bare Piping in Equipment Rooms: Split-casting, cast-brass type.
j. Bare Piping in Equipment Rooms: Split-plate, stamped-steel type with set screw or spring clips.
k. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.

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

N. Permanent sleeves are not required for holes formed by removable PE sleeves.

O. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

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

1. Cut sleeves to length for mounting flush with both surfaces.
   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
   a. PVC Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
   b. Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum-board partitions.
   c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing & Trim" for flashing.
      1) Seal space outside of sleeve fittings with grout.
4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealers" for materials and installation.

Q. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches (150 mm) in diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inches (150 mm) and larger in diameter.

3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

R. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

S. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials.

T. Verify final equipment locations for roughing-in.

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

3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

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

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

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

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

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

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

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

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

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

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
3. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
4. PVC Non-pressure Piping: Join according to ASTM D 2855.

J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

K. Plastic Non-pressure Piping Gasketed Joints: Join according to ASTM D 3212.

L. 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.

M. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.3 PIPING CONNECTIONS

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

1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

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

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

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

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

3.5 PAINTING

A. Painting of HVAC systems, equipment, and components is specified in Division 09 Section “Painting & Coating"

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

3.6 CONCRETE BASES

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

1. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

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

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

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

3.8 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.9 GROUTING

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

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

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

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

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION

SECTION 23 05 05

SELECTIVE DEMOLITION FOR HVAC

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes requirements for selective demolition and removal of heating, ventilation and air conditioning systems, controls and automated automation components, and related mechanical components and incidentals required to complete work described in this Section.

1.2 RELATED SECTIONS

A. Section 01 74 19 – Construction Waste Management & Disposal

B. Section 23 08 00 – Commissioning of HVAC.

1.3 REFERENCE STANDARDS

A. CSA Group (CSA)

B. CSA S350, Code of Practice for Safety in Demolition of Structures.

1.4 DEFINITIONS

A. Demolish: Detach items from existing construction and legally dispose of items off site, unless indicated as removed and salvaged, or removed and reinstalled.

B. Remove: Planned deconstruction and disassembly of electrical items from existing construction including removal of conduit, junction boxes, cabling and wiring from electrical component to panel taking care not to damage adjacent assemblies designated to remain; legally dispose of items off site, unless indicated as removed and salvaged, or removed and reinstalled.

C. Remove and Salvage: Detach items from existing construction and deliver them to Contracting Officer ready for reuse.

D. Remove and Reinstall: Detach items from existing construction, prepare them for reuse, and reinstall them where indicated.

E. Existing to Remain: Existing items of construction that are not removed and that are not otherwise indicated as being removed and salvaged or removed and reinstalled.

F. Hazardous Substances: Dangerous substances, dangerous goods, hazardous commodities, and hazardous products may include asbestos, mercury and lead, PCB's, poisons, corrosive agents, flammable substances, radioactive substances, or other material that can endanger human health or wellbeing or environment if handled improperly as defined by the Federal Hazardous Products Act (RSC 1985) including latest amendments.

1.5 ADMINISTRATIVE REQUIREMENTS

A. Coordination: Coordinate work of this Section to avoid interference with work by other Sections.

B. Account for Owner's continued occupancy requirements during selective demolition and schedule staged occupancy and worksite activities.

1.6 SITE CONDITIONS

A. Condition of materials identified as being salvaged or demolished are based on their observed condition on date that tender is accepted.

1.7 SALAVAGE AND DEBRIS MATERIALS

A. Demolished items become Contractor's property and will be removed from Project site; except for items indicated as being reused, salvaged, or otherwise indicated to remain Owner’s property.

B. Carefully remove materials and items designated for salvage and store in a manner to prevent damage or devaluation of materials

PART 2 – PRODUCTS

2.1 MATERIALS

A. Use only new materials required for completion or repair matching materials damaged during performance of work of this Section; new materials are required to meet assembly or system characteristics as existing systems indicated to remain and carry CSA approval labels required by the Authority Having Jurisdiction.

B. Use listed fire stopping materials compatible with existing fire stopping systems where removal or demolition work affects rated assemblies, restore to match existing fire rated performance.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Visit site, thoroughly examine, and become familiar with conditions that may affect the work of this Section before tendering the Bid; The Government will not consider claims for extras for work or materials necessary for proper execution and completion of the contract that could have been determined by a site visit.

B. Identify on-site removal of walls and ceiling to facilitate the work.

C. Identify on-site testing of ductwork and equipment to facilitate the work.

3.2 PREPARATION

A. Protect systems and components indicated to remain in place during selective demolition operations and as follows:

1. Prevent movement and install bracing to prevent settlement or damage of adjacent services and parts of existing buildings scheduled to remain.
2. Notify Contracting Officer and cease operations where safety of buildings being demolished, adjacent structures or services appears to be endangered and await additional instructions before resuming demolition work specified in this Section.
3. Prevent debris from blocking drainage inlets.
4. Protect mechanical systems that must remain in operation.
5. Ensure hazardous materials are removed or abated prior to commencing demolition.
6. For components intended for relocation and reuse, remove, store, protect, clean and reinstall and connect to HVAC systems, and recommission.

B. Sequence demolition work so that interference with the use of the building by the Owner and users is minimized and as follows:

1. Prevent debris from endangering the safe access to and egress from occupied buildings.
2. Notify Contracting Officer and cease operations where safety of occupants appears to be endangered and await additional instructions before resuming demolition work specified in this Section.

3.3 EXECUTION

A. Disconnect and cap gas supply and electrical services in accordance with requirements of local Authority Having Jurisdiction.

B. Do not disrupt active or energized utilities without approval of the Contracting Officer.

C. Erect and maintain dust proof and weather tight partitions to prevent the spread of dust and fumes to occupied building areas; remove partitions when complete.

D. Demolish parts of existing building to accommodate new construction and remedial work as indicated.

E. At end of each workday, leave worksite in safe condition.

F. Perform demolition work in a neat and workmanlike manner:

1. Remove any tools or equipment after completion of work and leave site clean and ready for subsequent renovation work.
2. Repair and restore damages caused as a result of work of this Section to match existing materials and finishes.

G. Conduct demolition of HVAC systems in accordance with local authority having jurisdiction.

3.4 CLOSEOUT ACTIVITIES

A. Arrange for legal disposal and remove demolished materials to accredited provincial landfill site or alternative disposal site (recycle center).

END OF SECTION

SECTION 23 05 13

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 104 F (40 C) and at altitude of 100 feet above sea level.

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

2.3 POLYPHASE MOTORS

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

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

C. 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, Plug fan.

G. Bearings: Re-greasable, 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 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 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

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

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

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

2.5 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: Pre-lubricated, 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

SECTION 23 05 23

GENERAL DUTY VALVES FOR HVAC PIPING

PART 1 - DESIGN DIRECTIVES

1.1 SUMMARY

A. Section includes general duty valves common to most mechanical piping systems. Special duty valves are specified in individual piping system specifications.

B. Valves used in fire protection systems are not included in this section.

1.2 DESIGN CRITERIA

A. Consultant is to confirm the application of the specified valves to insure suitability of use in the specified systems.

B. Dynamic Flow Control Valves:

1. Preferred method of hydronic balancing. Utilize wherever possible in water piping systems.
2. Must have a wye strainer with a 20-mesh stainless steel screen upstream of the valve.
3. Use of pre-assembled dynamic flow control packages are encouraged for use at coils in AHU's and VAV boxes, and other critical hydronic terminals.
4. Conventional type balancing valves are listed for use where dynamic valves are not practical.

C. Pressure Independent Control (PIC) Valves: Government instead of balancing valves.

1. Balancing Valves: Not to serve double duty as isolation valves.
   a. Use when balancing flow through equipment, i.e. heat exchangers, separate coils at units.

D. Hi-Performance Butterfly Valves: Steam service and building hot and chilled water isolation.

E. Triple duty valves are not allowed.

F. Wafer type butterfly valves are not allowed.

1.3 QUALITY ASSURANCE

A. American Society of Mechanical Engineers (ASME) Compliance: Comply with ASME B31.9 for building services piping and ASME B31.1 for power piping.

B. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS) Compliance: Comply with the various MSS Standard Practices referenced.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Keep valves in original shipping containers in a dry location until ready for installation.

PART 2 – PRODUCTS

2.1 VALVE FEATURES, GENERAL

A. In mechanical spaces only, provide chain wheel operators, for valves 2-1/2 inch and larger installed 96 inches or higher above finished floor elevation. Extend chains to an elevation of 60 inches above finished floor elevation.

B. Where insulation is indicated or specified, provide extended stems of suitable length to accommodate the insulation.

2.2 BALL VALVES

A. Ball Valves, 2-1/2 inch and Smaller: Carbon Steel Body. Full port two-piece construction.

1. Ball : 316 stainless-steel
2. Stem; 316 stainless-steel. Blowout proof. Extended stem for insulated piping
3. Seats and Seals: Replaceable TFE
4. Handle: Vinyl covered steel
5. Ends: Threaded
6. Saturated Steam Pressure Rating: 150 psi
7. WOG Pressure: 2000 psi; 1/4 through 1-inch
8. WOG Pressure: 1500 psi; 1-1/4 inch through 2-inch

B. Ball Valves, 3 inch and smaller: Bronze/Brass/Copper body, lead free. Regular port two piece construction. Full port.

1. Ball: B-16 chrome plated
2. Stem: B-16 chrome plated. Blowout-proof. Extended stem for insulated piping
3. Seats and Seals: TFE
4. Handle: Vinyl covered steel
5. Ends: Threaded, solder or press
6. Saturated Steam Pressure: 150 psi saturated steam pressure.
7. WOG Pressure: 400 psi

C. Low Point Drain Valves: ¾-inch inlet. Bronze body. Regular port, two-piece construction.

1. Ball: B-16 chrome plated steel
2. Blowout Proof Stem: B-16 chrome plated steel
3. Seats and Seals: TFE
4. Handle: Vinyl covered steel
5. System End: Thread, solder, or press
6. Opposite End: ¾-inch hose connection with brass cap
7. Saturated Steam Pressure: 150 psi

8. WOG Pressure: 400 psi

2.3 GLOBE VALVES

A. Globe Valves, 2 inches and Smaller: 125 SWP, body and union bonnet of ASTM A 338 malleable iron.

1. Disc and Stem: 13% chromium stainless steel
2. Packing: TFE impregnated, non-asbestos
3. Handwheel
4. Ends: Threaded

2.4 BUTTERFLY VALVES

A. Steam service, and building hot and chilled water isolation (not for Automation Control):

1. Hi-Performance Butterfly Valves 2-1/2 inch and Larger: MSS SP 67; Lug type, bidirectional valves. ANSI Class 150 carbon steel body conforming to ASTM A 216, type WCB.
   a. Disc: 316 stainless-steel
   b. Shaft: 17-4 PH stainless steel
   c. Packing: Filled (reinforced) TFE with TFE packing or extreme seats and enhanced filled TFE packing
   d. Seat Retainer Ring: Bolted in place with stainless steel bolts
   e. Lever Operators: Locks for sizes 2 through 4 inch
   f. Gear Operators: With position indicator for sizes 6 inch or greater
2. Butterfly Valves, 2-1/2 inch and Larger: MSS SP-67. Resilient seated lug type. Ductile iron body
   a. Disc: Aluminum, bronze or 316 stainless steel. Constant contact with seat. Concentric self-centering style. Free floating without the use of pins or fasteners. b. Shaft: Stainless steel.
   c. Seat: EPDM rated for minus 20 to 250 degrees F.
   d. Valve 12 inches or Smaller: Pressure Rating: 175 psi minimum.
   e. Valve 12 inches or Larger: Pressure Rating: 150 psi minimum.
   f. Lever Operators with Locks: For sizes 2 through 4 inch
   g. Gear Operators with Position Indicator: For sizes 6 inch or greater.

2.5 CHECK VALVES

A. Swing Check Valves, 2 inches and Smaller: MSS SP-80 & MSS SP-139, as applicable, Class 125 and 150; cast bronze body and cap conforming to ASTM B-62. Lead Free.

1. Swing: Horizontal swing
2. Pattern: Y,
3. Disc: Bronze.
4. Ends; Class 125: Threaded, solder or press.
5. Ends; Class 150: Threaded
6. Capable of being reground while the valve remains in the line.

7. Class 150: Where system pressure requires, or where Class 125 valves are not available.

B. Swing Check Valves, 2 inches and Smaller: MSS SP-80 Class 300; cast bronze body and cap conforming to ASTM B-61;

1. Swing: Horizontal swing
2. Pattern: Y,
3. Disc: Bronze.
4. Ends: Threaded
5. Capable of being reground while the valve remains in the line.
6. Capable of being reground while the valve remains in the line.
8. Swing Check Valve, 2 inches and Smaller: Malleable iron body, cap, disc, and hinge conforming to ASTM A-338, 300 psi SWP, threaded ends.

C. Swing Check Valve, 4 inch and Larger: MSS SP-71, class 250 cast iron body and cap.

1. Disc for Valves 6 inches or Smaller: Bronze (ASTM B-62)
2. Disc for Valves Larger than 6 inches: Bronze faced iron disk and hinge.
3. Spring Loaded Silent Check Valve, Steam condensate, 3 inch and smaller: MSS SP-61. 18-8 stainless steel construction throughout including guard cage, spring, valve disc, retaining ring and seat. Wafer type. Fully rebuildable.
4. Non-shock Pressure Rating: 300 psi

D. Split Disc Wafer Check Valves: Cast iron body 125lb, ASTM A126-B. Non-slam design, lapped and balanced twin bronze valve plates. Designed to open and close at approximately one-foot differential pressure.

1. Seat: Replaceable EPDM, Trim: 316 stainless-steel
2. Torsion Spring: 316 stainless-steel.

E. Wafer Check Valves: Cast iron body, 125lb., ASTM A126, non-slam design.

1. O-Ring: Replaceable Buna ‘N’ or Viton
2. Disc: 304 stainless-steel,
3. Pin and Spring: 316 stainless-steel

2.6 GLOBE TYPE BALANCING VALVE

A. Provisions for measuring differential pressure, flow rates, flow temperature and air venting as an integral part of the valve body and be of the globe style, wye pattern design.

B. Shutoff: 100% positive. Leakproof shutoff against same fluid pressure as valve body pressure rating.

C. Manufacturer’s preformed insulation covers when valves are installed in insulated piping systems.

D. 3/8 inch through 2 inch: Brass copper alloy construction.

1. Connections: Solder NPT.

2. Minimum of four, 360° rotations of handwheel for maximum setting.

E. 2-1/2 inch and larger: Cast iron body. All other parts of nonferrous copper alloy construction.

1. Connections: flanged.
2. Eight or twelve 360° rotations of handwheel for maximum setting.

2.7 MANUAL BALL TYPE BALANCING VALVE

A. Bronze body, brass ball construction. Teflon seat suitable for use in domestic water systems.

1. Differential pressure ports .
2. Drain/purge port.
3. Memory stop.
4. Calibrated name plate.
5. Optional – Combination balancing valve and strainer. No EPDM O-rings.

2.8 PRESSURE INDEPENDENT BALANCING VALVES

A. Pressure Independent Balancing Valves:

1. Flow Control Cartridge Assembly: Precision ground, stainless steel.
   a. Two PSID control ranges: Control flow within 5% of rated flow.
      1) Minimum range capable of being activated by 2 PSID
   b. Pressure and temperature test ports
   c. Permanently marked to show direction of flow
   d. Body tag to indicate flow rate, model number, and PSID control range.
   e. Warranted by manufacturer for five years from date of shipment.
2. Automatic Valves, 2 inches and smaller:
   a. Bronze Body Rating: 300 PSI up to 250°F
   b. End connection: NPT
   c. Cartridge to be removable without disturbing piping system
   d. Flow Rates: 0.55 to 22.0 GPM in a 2-32 psid range
3. Pre-assembled systems, 2 inch and smaller:
   a. Bronze Body Rating: 300 PSI up to 250□F.
   b. End connection: NPT
   c. Cartridge to be removable without disturbing piping system.
   d. Flow Rates: 0.55 to 22.0 GPM in a 2-32 psid range.
   e. Strainer, blowdown, and one pressure/ temperature port.
   f. Supply Side Component: A single device incorporating an isolation ball valve.
   g. Return Side: Include an accessible flow control valve, isolation valve, two pressure/ temperature ports and the control valve. B. Automatic valves, greater than 2-inch:
4. Ductile or gray iron body be rated at 150 PSI 2. Flange end connections or be a wafer design.
5. Available flow rates of 18 GPM to 6,400 GPM in a 2-32 psid range 4.

PART 3 – EXECUTION

3.1 VALVE INSTALLATIONS

A. Use ball or butterfly valves for shut off-duty; globe, ball, or butterfly for throttling duty. Refer to piping system specification sections for specific valve applications and arrangements.

B. Locate valves in accessible locations, e.g. locate in rooms rather than congested corridors.

C. Install isolation valves and unions for each fixture, control valve and any item or equipment that would require service, whether or not shown on the contract documents, arranged to allow equipment removal without system shutdown or draining. Install isolation valves at all main branches.

D. Install valves in horizontal piping with stem at or above the center of the pipe and in a position to allow full stem movement.

E. In mechanical spaces only, provide chain wheel operators for valves 2 ½" and larger, installed 96" or higher above finish floor elevation. Extend chains to an elevation of 66" above finished floor.

F. Installation of Check Valves: Install for proper direction of flow as follows:

1. Swing Check Valves: Horizontal position with hinge pin level.
2. Wafer Check Valves: Horizontal or vertical position, between flanges.

G. Install drain valves at the low points of all piping (except in LP gas) systems and at all drip legs.

H. Install automatic flow control valves per the manufacturer's written instructions and the following criteria:

1. All automatic flow control valves shall have a 20-mesh strainer upstream of the valve.

I. Where automatic flow control valves control multiple heating devices (i.e. risers, entire floors, etc.), install a valve with a strainer upstream and an isolation valve downstream. Where automatic flow control valves control individual heating terminals, install preassembled systems (strainers on inlet and valves on outlet).

J. Where butterfly type valves are installed as end of service, and are not rated as such, install a minimum 12-inch-long spool piece with weld neck flanges and a blind flange.

3.2 CONNECTIONS

A. For solder connections close ball valves to the full closed position, open globe valves to full-open position.

3.3 FIELD QUALITY CONTROL

A. After piping systems have been tested and put into service, but before final adjusting and balancing, inspect valves for leaks. Adjust or replace packing to stop leaks; replace valves if leak persists.

3.4 VALVE APPLICATIONS

A. Domestic Hot and Cold Water: Bronze bodied ball, globe, and check valves.

B. HVAC Water Systems, less than or equal to 210°F:

1. Resilient seated cast iron butterfly valves
2. Bronze bodied ball, and check valves for copper piping systems.

C. Steel Piping Systems:

1. Forged Steel Ball Valves:
2. Check and Globe Valves:
   a. 2 inches or smaller: Bronze or malleable iron.
   b. Greater than 2 inches: Malleable iron.
   3. Resilient seated cast iron body butterfly valves.

D. Chilled water and hot water systems where piping enters building from central distribution system:

1. High performance butterfly valves

E. Steam and Gravity Condensate:

1. Ball Valves: Stainless steel
2. High-performance butterfly valves: Carbon steel
3. Check Valves: Malleable iron; all sizes

F. Condensate Pump Discharge: Use Spring Loaded Silent Check Valve.

G. Non-slam check valves: Install at discharges of reciprocating equipment, i.e. pump discharges including condensate pumps.

H. Balancing Valves:

1. For HVAC applications, manual balancing valves are preferred. Pressure independent balancing valves may be acceptable.
2. Use ball type balancing valves in domestic hot water recirculating systems.
3. Globe type balancing valves are used in special situations.
4. Balancing valves shall not be used in applications where Pressure Independent Control (PIC) Valves are used.

3.5 VALVE PRESSURE/TEMPERATURE CLASSIFICATION SCHEDULES

A. Valves 2 inches and smaller:

1. Domestic Hot and Cold Water:
   a. Ball Valve: 150 wog. Valve size may be extended to include less than or equal to 3-inch pipeline size.
   b. Check Valve: 125
   c. Globe Valve: 125
2. HVAC Systems less than or equal to 210 degrees F Supply and Return:
   a. Ball Valve: 150 wog. Valve size may be extended to include less than or equal to 3-inch pipeline size.
   b. Check Valve: 150
   c. Globe Valve: N/A
3. Steam, Gravity & Pumped Condensate Return less than or equal to 30 psig:
   a. Ball Valve: 150 wog
   b. Check Valve: 300
   c. Globe Valve: 125

B. Valves 2-1/2 inches and Larger:

1. Domestic Hot and Cold Water:
   a. Ball Valve: 150
   b. Check Valve: 125
   c. Globe Valve: N/A
2. HVAC Systems less than or equal to 210 degrees F Supply and Return:
   a. Ball Valve: 150
   b. Check Valve: 150
   c. Globe Valve: N/A
3. Steam, Gravity & Pumped Condensate Return less than or equal to 30 psig:
   a. Ball Valve: 150
   b. Check Valve: 300
   c. Globe Valve: 125

END OF SECTION

SECTION 23 05 29

HANGERS & SUPPORTS FOR HVAC PIPING & EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Metal framing systems.
3. Fastener systems.
4. Equipment supports.

B. Related Sections:

1. Division 05 Section 05 50 00 - "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Division 23 Section 23 31 13 -"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. 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 HVAC piping and equipment shall withstand the effects of gravity and seismic 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 support 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: Show fabrication and installation details and include calculations for the following, include Product Data for components:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Fiberglass strut systems.
4. Pipe stands.
5. Equipment supports.

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

1. Detail fabrication and assembly of trapeze hangers.
2. Design Calculations: Calculate requirements for designing trapeze hangers.

D. 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. Copper Pipe Hangers:

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

2.2 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
2. Standard: MFMA-4.
3. Channels: Continuous slotted steel channel with in-turned lips.

4. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
6. Metallic Coating: Hot-dipped galvanized.
7. Plastic Coating: PVC.
8. Combination Coating.

B. Non-MFMA Manufacturer Metal Framing Systems:

1. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
2. Standard: Comply with MFMA-4.
3. Channels: Continuous slotted steel channel within turned lips.
4. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
6. Coating: Paint.

2.3 FASTENER SYSTEMS

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

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

2.4 EQUIPMENT SUPPORTS

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

2.5 MISCELLANEOUS MATERIALS

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

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

1. Properties: Non-staining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi (34.5-MPa), 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. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.

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

E. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled fiberglass struts.

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

G. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) 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.

H. 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.

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

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

K. 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.

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

M. 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 (DN 65) 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.

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

O. 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.

P. 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 (DN 100) 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 (DN 100) 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 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
   b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
   c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
5. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

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

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

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

3.3 METAL FABRICATIONS

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

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

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

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

3.4 ADJUSTING

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

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm) .

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 with a brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 painting Sections.

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 and metal framing systems and attachments for general service applications.

F. Use copper-plated pipe hangers and copper or stainless-steel 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 non-insulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C), pipes NPS 4 to NPS 24 (DN 100 to DN 600), requiring up to 4 inches (100 mm) of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 (DN 20 to DN 900), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.

4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 (DN 15 to DN 100), 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 (DN 20 to DN 200).
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
8. Adjustable Band Hangers (MSS Type 9): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8 (DN 10 to DN 200).
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3 (DN 10 to DN 80).
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
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 (DN 100 to DN 900), 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 (DN 100 to DN 900), 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 (DN 65 to DN 900) 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 (DN 25 to DN 750), 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 (DN 65 to DN 600), 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 (DN 50 to DN 1050) 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 (DN 50 to DN 600) 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 (DN 50 to DN 750) 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 (DN 24 to DN 600).
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) 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 (150 mm) for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) 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 (49 to 232 deg C) 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 (340 kg).
    b. Medium (MSS Type 32): 1500 lb (680 kg).
    c. Heavy (MSS Type 33): 3000 lb (1360 kg).
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. 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 (32 mm).
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.

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

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

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

END OF SECTION

SECTION 23 05 33

HEAT TRACING FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes heat tracing for HVAC piping with the following electric heating cables:

1. Self-regulating, parallel resistance.

B. Related Requirements:

1. Section 23 07 19 "HVAC Piping Insulation."
2. Section 26 05 19 "Low-Voltage Electrical Power Conductors & Cables."
3. Section 26 05 26 "Grounding & Bonding for Electrical Systems."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include:
   a. Heating cable data sheet.
   b. HVAC piping freeze protection design guide.
   c. System installation and operation manual.
   d. System installation details.
   e. Connection kits and accessories data sheet.
   f. Controller data sheet.
   g. Controller wiring diagram.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
3. Schedule heating capacity, length of cable, and electrical power requirement for each electric heating cable required.
4. Include heat loss calculations for each pipe including pipe and insulation characteristics, heat loss, and watts per foot supplied by the heating cable.

B. Shop Drawings: For electric heating cable.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.
3. Manufacturer to produce detailed design as described below.

4. Pipe Freeze Protection Detail Drawings: Project-specific Detail Drawings, including details showing:
    a. Installation and positioning of all components.
    b. Proper amounts of tracing for valves, pumps, flanges, fittings, instruments, etc.
    c. Junction box layouts.
5. Control Panel Drawings: Drawings for each control panel shall include the following:
    a. Physical arrangement and structural detail drawings.
    b. Complete power and control wiring diagrams showing all internal wiring connections for electrical and instrument components in each control panel. All wires, terminals, and devices shall be numbered and tagged in accordance with system elementary diagrams.
6. System Wiring Diagram: Project-specific drawings (if applicable) including:
    a. Interconnect of all major components.
    b. Assignment of circuiting.
    c. Connection of circuit wiring in terminal blocks.
    d. Connection of sensor wiring.
    e. Connection of external alarm wiring.
7. Controller Setpoint Schedule (if applicable) showing the following:
    a. Circuit addresses.
    b. Circuit set points,
    c. Circuit alarms and settings.

C. Testing Instructions and Reporting Form: Provide documentation for use in preinstallation testing of heat-tracing system.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For electric heating cables to be included in operation and maintenance manuals.

B. Testing: Completed system test report.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. ISO-09001 registered.
2. Provide products consistent with UL 515, CSA 22.2 No 130.16, and IEEE 515.1 requiremen

B. Installer Qualifications:

1. System Installer to have complete understanding of product and product literature from manufacturer or authorized representative prior to installation.
2. Electrical connections to be performed by licensed electrician.

C. Certification System (Heating Cable and Connection Kits): c-UL-us Listed for freeze protection of metallic and non-metallic piping associated with HVAC and Plumbing systems.

D. Testing: Self-regulating heating cable to be qualified and tested to demonstrate a useful lifetime in excess of 20 years.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site in original, unopened containers or packages with intact and legible manufacturers' labels identifying the following:

1. Product and Manufacturer.
2. Length/Quantity.
3. Lot Number.
4. Installation and Operation Manual.
5. Material Safety Data Sheet (MSDS).

B. Store heating cable in clean, dry location with a temperature range of 0 to 140 deg F (-18 to 60 deg C).

C. Protect heating cable ends from moisture ingress until final termination of the heating cable is complete.

1.8 WARRANTY

A. Manufacturer Limited Warranty: Manufacturer agrees to repair or replace heat tracing products listed below that fail in materials or workmanship within specified warranty period, when such goods are properly installed, operated, and maintained in accordance with product documentation.

1. Covered Products Include:
   a. Heating cables, connection kits, and accessories.
   b. Thermostats, controllers, panels, contactors, sensors, and accessories.
2. Warranty Period: Two years from date of Substantial Completion.

B. Manufacturer’s Extended Warranty: Provide Owner an extended product warranty for heat-tracing products described below.

1. Contractor must complete and forward to Owner the Installation, Inspection, or Commissioning Record(s), and complete manufacturer’s online warranty registration form within 30 days from date of installation.
2. Heating Cable Warranty Period: 10 years from date of Substantial Completion.
3. Heating cables, connection kits and accessories not automatically offered with a 10-year manufacturer's warranty, as a standard matter of course, will not be allowed.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Complete pipe freeze protection system for insulated pipes exposed to the risk of freezing. System consists of a self-regulating heating cable, connection kits, accessories, and energy-efficient control and monitoring controller. The heating cable shall have a polyolefin jacket for aboveground water piping or a fluoropolymer jacket for below-grade piping.

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage manufacturer to design complete and functional heat-tracing system as required by Project documents.

2.3 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

A. Basis-of-Design Product: Subject to compliance with requirements, provide RAYCHEM, a brand of nVent; XL-Trace Edge Pipe Freeze/Flow Maintenance or comparable product by one of the following:

1. Approved Equal

B. Source Limitations: Obtain heat-tracing components and controllers from single manufacturer. To ensure system integrity and meet warranty requirements, only components and controllers supplied by cable manufacturer are to be used.

C. The heating cable and connection kit shall be included in a c-UL-us Listed system.

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

E. Electrical Insulating Jacket: Flame-retardant modified polyolefin.

F. Ground Braid: Tinned-copper braid. Minimum 70 percent for ground path and mechanical ruggedness.

G. Outer Jacket: Required for all applications.

1. For above ground freeze protection of water lines where fuel oil or aqueous chemicals are not present, use a modified polyolefin with ultraviolet inhibitor**.**
2. For below-grade applications, grease waste, or where fuel oil or aqueous chemicals are present, use a fluoropolymer with ultraviolet inhibitor**.**
3. Outer jacket to be printed with cable model number, agency listings, batch number, and meter marks (for ease of installation within maximum circuit length).

H. Maximum Operating Temperature (Power On): 154 deg F (68 deg C) for 3 W/ft. (9.8 W/m),

I. Maximum Exposure Temperature (Power Off): 185 deg F (85 deg C).

J. 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.

K. Capacities and Characteristics:

1. Nominal Heat Output at 50 deg F (10 deg C): 3 W/ft. (9.8 W/m)
2. Piping Diameter: 3”
3. Number of Parallel Cables: 1
4. Electrical Characteristics for Single-Circuit Connection:

2.4 CONTROLS

A. Single Circuit Local Digital Controller.

1. Basis-of Design Product: RAYCHEM; C910-485 or approved equal.
2. Control self-regulating heating cable via an energy saving, programmable single-circuit controller to provide adjustable maintained temperatures in the range of -40 to 140 deg F (-40 to 60 deg C).
3. Provide one controller for each heat-tracing circuit.
4. Controller to include self-test function to verify heat-tracing integrity at least once every 24 hours.
5. Controller Capabilities:
   a. Supply Voltage: 100 to 277 V ac.
   b. Enclosure: NEMA 4X FRP.
   c. Operating Temperature Range: -40 to 140 deg F (-40 to 60 deg C).
   d. Display: Six-character, alphanumeric LED.
   e. Control: DP mechanical relay type.
   f. Control Algorithms: On/Off. Proportional Ambient Sensing Control for energy savings.
   g. Monitoring:
      1) Temperature:
         a) Low Alarm: 0 to 180 deg F (-18 to 82 deg C).
         b) High Alarm: 0 to 200 deg F (-18 to 93 deg C).
      2) Ground Fault:
         a) Alarm Range: 20 to 100 mA.
         b) Trip Range: 20 to 100 mA
      3) Current:
         a) Low Alarm Range: 3. to 20 A, or off.
      4) Autocycle Test: Interval of 1 to 240 minutes or 1 to 240 hours.
   h. Temperature Sensor Inputs:
      1) Quantity: Two.
      2) Type: 100-ohm, platinum, 3-wire, shielded.
   i. Alarm Outputs:
      1) AC Relay: Isolated solid-state triac, SPST, 0.75 A maximum, 100 to 277 VAC nominal.

2) Dry Contact Relay: Pilot duty, 48 V ac/dc, 500mA maximum, 10 V maximum resistive switching.
3) Outputs: Normally Open or Normally Closed.

j. Stored Parameters:
1) Minimum temperature.
2) Maximum temperature.
3) Maximum ground fault current.
4) Maximum heater current.
5) Contactor cycle count.
6) Time in use.

k. Alarm Conditions:
1) Low and High temperature.
2) Low current.
3) Ground fault alarm and trip.
4) RTD failure.
5) Loss of programmed values.
6) EMR failure.

l. Communications:
1) Protocol: Modbus RTU.
2) Topology: Daisy Chain.
3) 26 AWG shielded twisted pair.

6. Temperature Sensors:
a. For each temperature sensing controller, provide at least one of the following:
1) One 100-ohm, platinum, 3-wire, shielded RTD for pipe temperature sensing.
a) Basis-of-Design Product: RAYCHEM; RTD-10CS.
b) Approved Equal
2) One 100-ohm, platinum, 3-wire, shielded RTD for ambient temperature sensing.
a) Basis-of-Design Product: RAYCHEM; RTD-200.
b) Approved Equal

7. Approval: Complete heat trace system (heating cable, connection kits, and controller) shall be listed by a Nationally Recognized Testing (NRTL) and marked for intended use of freeze protection of HVAC piping.

2.5 HEATING CABLE CONNECTION KITS

A. Basis-of-Design Product: RAYCHEM; RayClic or Approved Equal.

B. Provide power connections, splices/tees, and end seal kits to properly connect and terminate heating cable circuit along specified length of piping.

C. Install splices, tees, and crosses underneath pipe insulation with service loops installed to allow for future service of piping.

D. Connection kits shall be rated NEMA 4X to prevent water ingress and corrosion. All components shall be UV stabilized and shall not require cutting into heating-cable core to expose bus wires.

E. Certification: c-UL-us Listed.

F. Locate connection kits above grade for buried applications.

2.6 ACCESSORIES

A. Cable Installation Accessories: Fiberglass tape, cable ties, connection kits, and end seals all furnished by manufacturer, or as recommended in writing by manufacturer.

B. Identification: Provide and install "Electric Heat Traced" labels on exterior of pipe insulation every 10 ft. (3 m) on opposite sides of pipe, and on all splices, tees, crosses, and power connections for entire length of heat traced piping.

C. Warning Labels: Refer to Section 23 05 53 "Identification for HVAC Piping & Equipment."

D. Thermal Pipe Insulation:

1. Pipes to be thermally insulated in accordance with manufacturer's written requirements.
2. Thermal Insulation: Flame retardant, fiberglass with waterproof covering.

2.7 SYSTEM APPROVAL

A. Complete heat trace system (heating cable, connection kits, and controller) shall be listed by a Nationally Recognized Testing Laboratory (NRTL) and marked for intended freeze protection of metallic and non-metallic piping associated with HVAC, Plumbing, and Fire Suppression systems.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces and substrates to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Prior to installation of heating cable system, verify that all piping that will be heat traced has passed all hydrostatic/pressure tests and is signed off by plumbing inspector.
2. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.

B. Preinstallation Testing:

1. Prior to installation of heating cable on piping, an insulation resistance test shall be performed by installing contractor to ensure integrity of heating cable as describe in the installation and maintenance manual.

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

3.2 PREPARATION

A. Protect all heating cable ends from moisture ingress until cable is terminated with end seals.

1. Basis-of-Design Product: RAYCHEM; RayClic-E end seals.

3.3 INSTALLATION

A. All heat-tracing components including power connections, splices, tees, and crosses or end seal, must be installed above grade and protected from abuse or damage. In accordance with NEC and CEC, electrical connections are not permitted to be installed below grade.

B. In the field, all heating cables shall be meggered with a minimum of 2,500 V dc for self-regulating cable. The following field megger readings shall be taken on each heating cable:

1. Heating cable shall be meggered when received at Project site before installation.
2. Heating cable shall be meggered after installation, but before insulation is installed.
3. Heating cable shall be meggered after insulation is installed.
4. Heating cable shall be meggered at final commissioning prior to being energized.
5. Insulation resistance must exceed 1.000 megohms at 2,500 V dc.
6. All results must meet manufacturer’s specification.

C. Install electric heating cables after piping has passed all hydrostatic pressure testing and before insulation is installed.

D. Install electric heating cables in accordance with IEEE 515.1.

E. Install insulation over piping with electric cables in accordance with Section 23 07 19 "HVAC Piping Insulation."

F. Install warning tape on piping insulation where piping is equipped with electric heating cables.

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

3.4 CONNECTIONS

A. Ground equipment in accordance with Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Connect wiring in accordance with Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

C. Pipe Insulation shall be in accordance with Section 23 07 19 "HVAC Piping Insulation" and is required for a properly operating heat trace system.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Initial start-up and field testing (commissioning) of system shall be performed by factory technician in accordance with Owner's requirements.

B. Contractor to perform the following tests and inspections during installation:

1. Heating cable shall be meggered when received at Project site before installation.
2. Heating cable shall be meggered after installation, but before insulation is installed.

3. Heating cable shall be meggered after insulation is installed.
   a. Insulation resistance must exceed 1,000 megohms at 2,500 V dc.
4. All results must meet manufacturer's specification.
5. Test cables for electrical continuity during installation.
6. Test insulation integrity before energizing.
7. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

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

D. Cables will be considered defective if they do not pass tests and inspections in accordance with manufacturer's testing requirements.

E. Prepare test and inspection reports.

3.6 PROTECTION

A. Protect installed heating cables, including nonheating leads, from damage and moisture ingress during construction.

B. Remove and replace damaged heat-tracing cables.

END OF SECTION

SECTION 23 05 48

VIBRATION & SEISMIC CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Isolation pads.
2. Isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Freestanding and restrained spring isolators.
5. Housed spring mounts.
6. Elastomeric hangers.
7. Spring hangers.
8. Spring hangers with vertical-limit stops.
9. Pipe riser resilient supports.
10. Resilient pipe guides.
11. Freestanding and restrained air-mounting system.
12. Restrained vibration isolation roof-curb rails.
13. Seismic snubbers.
14. Restraining braces and cables.
15. Steel and inertia, vibration isolation equipment bases.

1.3 DEFINITIONS

A. ASCE: American Society of Civil Engineers

B. IBC: International Building Code.

C. ICC-ES: ICC-Evaluation Service.

D. SC OSHA : South Carolina Occupational Safety and Health.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading

1. Use the following for the design of seismic supports:
   a. Building Occupancy Category: II

b. Site Class: D
c. Mapped Spectral Response Acceleration at Short Period (SS): 1.33
d. Design Spectral Response Acceleration at Short Period (SDS): 1.064
e. Mapped Spectral Response Acceleration at 1-Second Period (S1): 0.391
f. Design Spectral Response Acceleration at 1-Second Period (SD1): 0.521
g. Seismic Design Category: D

2. Refer to Table 13.6-1 in the ASCE 7-16 for equipment seismic coefficients for mechanical components.

1.5 ACTION 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.
3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

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.
   a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Division 23 Sections for equipment mounted outdoors.
2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
3. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.
4. 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: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

B. Qualification Data: For professional engineer and testing agency.

C. Welding certificates.

D. Field quality-control test reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-mounting systems to include in operation and maintenance manuals.

1.8 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 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. General Requirements

1. Provide a maximum of four vibration isolators located at the corners of the equipment unless approval is obtained for additional isolators. Where feasible, provide three isolators.
2. All vibration isolators shall have markings indicating known undeflected heights.
3. All isolators shall operate in the linear portion of their load versus deflection curve. Load versus deflection curves must be linear over a deflection range 50 percent above the design deflection.
4. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50 percent of the rated deflection.
5. The ratio of lateral to vertical stiffness shall not be less than 0.5 or greater than 1.0.
6. The vertical static deflection for each support point, based upon the load per isolator and isolator stiffness, shall not differ by more than + or – 10 percent.

7. Isolation above the resonant frequency shall follow the theoretical prediction based upon an undamped single degree of freedom system.
8. All neoprene mountings shall have a shore hardness of 50 to 60 after minimum aging of 20 days or corresponding oven aging.
9. All vibration isolation equipment including but not limited to isolators, mountings, brackets, frames etc. that are exposed to moisture, or an outdoor environment shall be coated as follows
   a. All steel parts to be hot-dipped galvanized.
   b. All bolts to be cadmium plated.
   c. All springs to be cadmium plated and neoprene coated.
10. Design deflections for vibration isolators shall be as listed in the Vibration Isolation Schedule, except in the event of unacceptable levels of vibration when the equipment is in operation, due to any of the resonances of the isolated systems coupling, by coincidence, with any of the resonances of the building structure. In this event, the contractor shall bear the cost of changing the isolators to alter the natural frequencies of the isolated systems so that the amplitude of structural vibrations is reduced to acceptable levels.

B. Pads Type P1: Neoprene Pad(s) and Bearing Plate(s): Neoprene pad shall be ribbed or waffled, 5/16 to 1/2-inch thick, 40 Durometer, with a minimum 1/16-inch-thick steel bearing plate on top. Size pad and bearing plate to receive 60 psi load. Provide single or multiple pads and plates in series as specified, with 1/16-inch-thick steel shim between layers. Provide Vibrex RPG-EQ, "NR + plate(s)" by A/B, "W + plate(s) or WM" by Mason, "NPD + plate(s) or NGD" by Kinetics or approved equal.

C. Pads Type P2: Extra Thick Neoprene Pad(s) and Bearing Plate(s): Neoprene pad shall be waffled, 3/4-inch thick, 30 or 40 or 50 Durometer, as scheduled, with a minimum 1/16-inch-thick steel bearing plate on top. Pad areas shall be selected so no more than 15 percent and no less than 10% deflection occurs due to the supported load. Provide single or multiple pads and plates in series as specified with 1/16-inch-thick steel shim between layers. Provide Vibrex ICPG-EQ, "Super W + plate(s) or SWM" by Mason or approved equal.

D. Pads Type P3: Neoprene Bushing for Bolt Holes in Pads: Bushings shall be minimum 3/16-inch thick in all places and maximum 40 Durometer. Provide steel washer to distribute bolt head loads to bushing.

E. Mounts B1: Neoprene isolators shall be double-deflection neoprene-in-shear type with steel-reinforced base. All metal surfaces shall be covered with neoprene. The top and bottom surfaces shall be ribbed. Bolt holes shall be supplied in the base and the top shall have a threaded fastener. Neoprene no harder than 50 Durometer. Provide Vibrex SD, “RVD” by A/B, “ND” by Mason, “RD” by Kinetics or approved equal.

F. Restrained Spring Isolators RS1: Spring with Seismic Restraint and Vertical Travel Limit: with the addition of steel columns on either side of the spring to provide seismic restraint and accommodate vertical travel limit stops.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate permanently bonded to a friction pad of 5/16 to 1/2-inch- thick ribbed or waffled neoprene isolator pad, 40 Durometer hardness, and sized for a load of 60 psi attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Restraint: Mount shall resist a seismic acceleration in any direction of at least 0.5 G or as required by the relevant codes. Travel limit stops shall be capable of serving as blocking during erection of the equipment. A minimum clearance of 1/4-inch shall be maintained around restraining bolts and between the limit stops and the spring so as not to interfere with the spring action.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Provide Vibrex RMU-EQ-SH or RMLS-EQ or approved equal.

G. Elastomeric Hangers H1: A double-deflection neoprene-in-shear element contained in a steel housing. It shall be formed with a projecting neck bushing for the hole in the hanger housing that will prevent metal-to-metal contact between the hanger rod and the housing. The diameter of the hole in the housing shall be sufficient to permit the hanger rod to swing through a 30-degree arc before contacting the hanger housing. Neoprene shall be no harder than 50 Durometer. Provide Vibrex HSS, "BRD" by A/B, "HD" by Mason, "RH" by Kinetics or approved equal.

H. Spring Hanger H2: Vibration isolation hangers shall contain a laterally-stable steel spring set in a neoprene cup manufactured with a bushing to prevent short-circuiting of the hanger rod as it passes through the hanger housing. Spring diameters and hanger housing lower hole sizes shall be large enough to permit the hanger rod to swing through a 30-degree arc before contacting the housing. Provide Vibrex RMXA, "30" by Mason or approved equal.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant neoprene minimum 1/4-inch thick and maximum 50 Durometer. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame designed to properly distribute the spring load on the neoprene and prevent its crushing.
7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

I. Spring Hanger H3: Pre-compressed Spring Hanger delivered pre-compressed to their planned installed deflection to keep pipes or equipment steady during installation. Hangers shall be designed with a slow-release mechanism to free the spring after installation is complete and the spring is fully loaded. Vibration isolation hangers shall contain a laterally stable steel spring set in a neoprene cup manufactured with a bushing to prevent short-circuiting of the hanger rod as it passes through the hanger housing. Spring diameters and hanger housing lower hole sizes shall be large enough to permit the hanger rod to swing through a 30-degree arc before contacting the housing. Great care shall be taken to see that all springs are free to oscillate 0.25-inch. Deflection shall be clearly indicated by means of a scale. Provide Vibrex RMXA- PC, "PC30" by Mason or approved equal.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant neoprene minimum 1/4-inch thick and maximum 50 Durometer. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame designed to properly distribute the spring load on the neoprene and prevent its crushing.
7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

J. Spring Hangers with Vertical-Limit Stop H3: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop. Provide Vibrex RMXA-VLS or approved equal.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

K. Piping Isolation Materials

1. Flexible Pipe Connectors FPC: Flexible pipe connectors shall be fabricated of multiple plies of nylon cord, fabric, and neoprene, vulcanized so as to become inseparable and homogeneous. Straight connectors shall be formed into a double sphere shape. Elbow connectors shall have a single sphere shape at the curve of the unit. Flexible connectors shall be able to accept compressive, elongating, transverse, and angular movements. Flexible connectors shall be selected and specially outfitted if necessary to suit the system temperature, pressure, and fluid type. Connectors for pipe sizes 2 inches and smaller shall have threaded female union couplings on each end. Larger sizes shall be fitted with metallic flange couplings. Control cables shall be provided if required. Provide "MFDEJ” or “SFDEJ" by Mason or approved equal.
2. Pipe Riser Resilient Support RPAG: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch- thick neoprene. Maximum neoprene Durometer 50. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig and for equal resistance in all directions.
3. Resilient Pipe Sleeves RPS1: Resilient Pipe Sleeve at Support or Construction Penetration: Sleeve shall consist of a formed and stiffened galvanized steel sleeve lined on the inside with moisture and vermin resistant felt bonded to the metal sleeve and 1/2 inch thick. Sleeve inside diameter shall equal pipe outside diameter in each application. Sleeve shall be split longitudinally so it can be snapped over pipes and reclosed without damage. Sleeve lengths shall be as recommended by the manufacturer for the given diameters but shall not be less than 3 inches. Provide "PR-Isolator" by Porter- Roemer, "Trisolator" by Stoneman Engineering or approved equal.

4. Resilient Pipe Sleeves RPS2: Resilient Pipe Sleeve at Construction Penetration: This unit shall consist of two bolted pipe halves with 3/4-inch or thicker neoprene sponge bonded to the inner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping. Sleeve shall be 2 inches longer than the thickness of the construction it penetrates. Where pipe temperatures exceed 240°F, use 10-pcf-density glass fiber insulation in lieu of sponge neoprene. Provide "SWS" by Mason, "PS-1-D" by Kinetics or approved equal.

2.2 FLEXIBLE DUCT CONNECTORS

A. Flexible duct connectors shall be woven fiber-glass fabric material with a minimum weight of 24 oz./sq. yd. Connectors shall be minimum of 4 inches long and allow 1 inch of slack at connections. Flexible duct connectors shall have metal collar frames at each end of connections. Flexible Duct Connectors shall be Duro Dyne Durolon or approved equal.

2.3 RESTRAINED VIBRATION ISOLATION ROOF-CURB RAILS (Type C1)

A. General Requirements for Restrained Vibration Isolation Roof-Curb Rails: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic and wind forces.

B. Lower Support Assembly: Formed sheet-metal section containing adjustable and removable steel springs that support upper frame. Upper frame shall provide continuous support for equipment and shall be captive to resiliently resist seismic and wind forces. Lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials and shall be insulated with a minimum of 2 inches of rigid, glass-fiber insulation on inside of assembly.

C. Spring Isolators: Adjustable, restrained spring isolators shall be mounted on 1/4-inch- thick, elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.

1. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or wind restraint.
   a. Housing: Steel with resilient vertical-limit stops and adjustable equipment mounting and leveling bolt.
   b. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2. 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.
   a. Resilient Material: Oil- and water-resistant standard neoprene.

D. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4-inch thick.

E. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counter-flashed over roof materials. Provision shall be made for access ports with waterproof covers at the spring location and 2-inch thermal insulation on the sides of the lower curb.

2.4 VIBRATION ISOLATION EQUIPMENT BASES

A. Base BS1: No Frame Required for Floor Mounting: This base mounting method shall be used only with small pieces of equipment that have an integral casing or base frame that is adequately strong to be supported directly on vibration isolators without deforming the casing or frame or affecting equipment or isolator operation to any significant or noticeable extent. Place vibration isolators directly under equipment or connect steel height-saving brackets to the sides of the equipment and place isolators under brackets. Equipment manufacturer shall approve such mounting.

B. Steel Base BS2: Factory-fabricated, welded, structural-steel bases and rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails. Frames may be rectangular or tee-shaped in plan. The depth of steel frame base members shall be minimum one-tenth the longest dimension of the base. Frame bases shall include side-mounting height-saving brackets for attachment to vibration isolators. Provide Vibrex RMSB, "SFB" by A/B, "WF" by Mason, "SFB" by Kinetics or approved equal.
   a. Include supports for suction and discharge elbows for pumps.
2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

C. Inertia Base BS3: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete. Concrete inertia bases for floor-mounted equipment shall be formed of stone-aggregate concrete (150 lb/cu ft) and appropriate steel reinforcing cast between perimeter structural steel sections. The steel frame and reinforcement shall be supplied by the vibration isolator manufacturer. Concrete shall be provided and poured by the Contractor on site Inertia bases shall be built to form a rigid base that will not twist, rack, deform, deflect, or crack in any manner. Provide Vibrex RMSBI, "Custom" by A/B, "K" by Mason, "CIB" by Kinetics or approved equal.

1. Design Requirements: Lowest possible mounting height with not less than 2 inches or 3 percent of the shorter base dimension, whichever is greater clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
   a. Include supports for suction and discharge elbows for pumps.
2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.5 SEISMIC-RESTRAINT DEVICES

A. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES.

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.
2. 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.
3. Restraint Cables: ASTM A 603 galvanized -steel cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.
4. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

5. 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.
6. 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.
7. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
8. 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.
9. 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.

B. Type I, Equipment Not Vibration Isolated: Attach to the structure in accordance with the Paragraph 2.5.B.

C. Type II, Vibration Isolated Equipment

1. Mount all vibration isolated equipment on rigid steel frames as described in the vibration control specifications unless the equipment manufacturer certifies direct attachment capability.
2. Each isolated frame shall have a minimum of four all directional seismic snubbers located as close to the vibration isolators as possible.
3. The snubber shall consist of interlocking steel members restrained by snubbing material made of bridge bearing neoprene.
4. The snubbers shall contain an elastomeric neoprene one-piece bushing that is replaceable and a minimum of 1/4 inch thick. Snubbers shall be manufactured with an air gap between hard and resilient material of not less than 1/8 inch or more than 1/4 inch. The neoprene bushing shall be capable of rotation to verify that no short circuiting of the vibration isolator exists. Shim snubbers as required to maintain clearances.
5. The snubber end cap shall be removable for inspection of snubber internal clearances.

D. Type III, Seismic Restraint of Suspended Piping

1. Support all piping and ductwork systems per SMACNA "Guidelines for Seismic Restraints of Mechanical Systems and Plumbing Piping Systems", 1998; NFPA Pamphlet 13 and the current local Building Code.
2. Provide restraints for all trapeze mounted piping where the total supported weight is greater than or equal to a 2-1/2-inch pipe, except in equipment rooms where all trapeze mounted piping weight is greater or equal to 1-1/4-inch pipe.
3. Provide restraints for all piping 1-1/4-inch and larger located in boiler rooms, mechanical equipment rooms and refrigeration machinery rooms.
4. Provide restraints for all fuel gas and oil piping, medical gas piping and compressed air piping 1 inch and larger.
5. Cable shall be installed with sufficient slack to avoid short circuiting the vibration isolation.

E. Type IV, Suspended Equipment

1. Utilize a slack cable restraint system.
2. Cables shall be installed with sufficient slack to avoid short circuiting the vibration isolation.

2.6 THRUST RESTRAINT MATERIALS

A. Restraint TR1: Neoprene Restraint: Thrust restraint shall be custom fabricated using a Type B1 neoprene-in-shear isolator and a steel angle. Neoprene isolator bolted to one angle leg opposes equipment thrust; second angle leg bolted to appropriate structure. The steel angle shall be sufficiently rigid and the mounting sufficiently sized and secure to resist the lateral movement of equipment during on-off cycle.

B. Restraint TR2: Steel Spring Restraint: Thrust restraint shall consist of a spring element in series with a neoprene cup. The unit shall be designed to have the same deflection as specified for the base mountings or hangers supporting the equipment. The spring element shall be adjusted in the field to allow for a maximum of 1/4-inch movement during starting or stopping of the equipment. The assembly shall be furnished complete with rods and angle brackets for attachment to both the equipment and the adjacent fixed structural anchor. Provide "WBI or WBD" by Mason or approved equal.

2.7 FACTORY FINISHES

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

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.
2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
3. Baked enamel or powder coat for metal components on isolators for interior use.
4. Color-code or otherwise mark vibration isolation and seismic- and wind-control devices to indicate capacity range.

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 evaluation service member of ICC-ES.

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. Equipment Restraints

1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds .
3. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES providing required submittals for component.

B. Piping Restraints

1. Comply with requirements in MSS SP-127.

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.

C. Piping Isolation

1. Provide piping isolation as indicated in specification or as noted on drawings.
2. Unless otherwise specified, provide resilient support for all HVAC pipes throughout the building. No such piping is to come into rigid contact with the building.
3. Support all piping in mechanical equipment rooms on Type H2 or H3 springs sized for minimum 1-inch static deflection, unless otherwise noted.
4. Support on vibration isolators all piping outside of mechanical equipment rooms which is connected to and within a 30-foot radius of a vibration-isolated piece of equipment. If the piece of equipment is supported on neoprene isolators, support pipes on Type B1 or H1 isolators sized for minimum 0.35-inch deflection. If the piece of equipment is supported on spring isolators, support pipes on Type B2 or H2 or H3 springs sized for minimum 1-inch deflection.
5. Throughout the rest of the building not covered in Paragraph 3 or 4 above, use RPS1 resilient pipe sleeves for support. An alternate to this is 1-inch-thick, 10 pcf-density glass fiber pipe insulation with suitable bearing plates to prevent crushing of insulation and without any steel pin or other rigid connection from plate to pipe through insulation.

D. Installation of Resilient Pipe Supports

1. Provide Type RPS1 or RPS2 or Custom resilient pipe sleeves wherever pipes penetrate construction.
2. Provide Type RPAG resilient pipe anchor/guide where anchors and / or guides are required in horizontal and vertical piping. Connect RPAG units to heavy structure only.
3. Release restraining washers and nuts in order to "free" all pre-compressed spring hangers.

E. Installation of Floor and Rooftop Mounted Equipment

1. Unless otherwise shown or specified, all base-mounted equipment shall be set on 4-inch thick, hard rock concrete housekeeping pads. Vibration isolators and seismic restraints shall be bolted to the housekeeping pad. The pad dimensions shall exceed the equipment footprint (including floor mounts) by at least 24 inches in each direction (i.e. 12 inches per side).
2. Unless otherwise indicated, a minimum clearance of 1 inch shall be provided between the top of a housekeeping pad or floor or roof and the underside of an equipment unit or steel base frame that is vibration-isolated. The minimum clearance where a concrete inertia block is used shall be 2 inches or 3 percent of the base's smaller dimension, whichever is larger. This space shall be cleaned thoroughly of all dirt and debris.
3. For isolation equipment (Mounts S1 and RS1) with neoprene pads bearing directly on structure, fasten the isolator base plates to the building structure with suitable bolts. Isolate steel bolts from steel base plates with neoprene bushings or washers and sleeves (Mount Type P3) minimum 1/4-inch thick and maximum 40 Durometer hardness. Provide steel washers to distribute bolt head loads to neoprene bushings or washers below. Size bolt holes in isolator bases to account for neoprene bushings or sleeves.
4. All bases for pumps shall be of sufficient area to support any required pipe stanchions below pipe elbows.
5. Bases for boilers shall be of sufficient area to support draft fans, if included.
6. Fans and pumps and their respective motors shall always be mounted on a common base.
7. Chillers: seismic restraints shall be provided between the grillage and dunnage steel or structure. Seismic restraints shall be installed and adjusted after isolators have been adjusted.
8. Wind loads shall be accounted for in rooftop installations, including appropriate snubbers and slack-cable restraints.
9. Vibration isolation curbs shall be made weathertight by sealing with flexible aluminum flashing or closed-cell neoprene or flexible vinyl all around the periphery. This weatherproofing shall in no way inhibit the vibration isolation of the spring elements. A closed-cell sponge gasket shall be provided between the equipment unit and the curb to form a weathertight seal.

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

G. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES providing required submittals for component.

H. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

I. 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.

J. 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.

K. 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.

L. Installation of Thrust Restraints: Provide horizontal thrust restraints as scheduled for fans delivering large air quantities and with a tendency to rock back on their spring mounts. Install thrust restraints parallel to the axis of air delivery and in pairs on opposite sides of the fan.

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. Comply with requirements in Section 23 21 13– Hydronic Piping for piping flexible connections.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Tests and Inspections

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Contracting Officer, through Contracting Officer’s Representative, before connecting anchorage device to restrained component (unless post connection testing has been approved), and with at least seven days' advance notice.
3. Obtain Contracting Officer’s Representative approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

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

D. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.7 HVAC VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE SCHEDULE

A. HVAC PIPING VIBRATION ISOLATION SCHEDULE

Description	Design Deflection	Isolator	Seismic Restraint
		Type	Type
Main Horizontal Runs	N/A	RPS1	III
Located within 30’ radius of vibrating equipment with type H1 hanger	N/A	B1 or H1	III
Located within 30’ radius of vibrating equipment with type H2 or H3 hanger	1.0”	B2, H2 or H3	III
Floor Supported	1.0”	S1	-
Main Vertical Risers	N/A	RPAG	N/A
Support at Roof Level	1.0”	-	
All connections to pumps	N/A	FPC	N/A

1. Type P2 pad to be located between chilled water supply and return pipes and support stand.

B. HVAC EQUIPMENT VIBRATION ISOLATION SCHEDULE

Equipment Mark	Design Deflection	Isolator	Frame	Seismic Restraint
		Type	Type	Type
RTU	2.0”	C1	BS2	II

1. Frame may be omitted if a written undertaking can be obtained from equipment manufacturer, stating that factory-supplied frame will be suitable for isolator point-loading and will be adequate seismically, per local Code requirements.
2. Where type RS1 spring mounts with vertical travel limit stops are specified, seismic snubbers may be omitted if a Licensed Structural Engineer verifies that limit stop on RS1 mount will provide sufficient seismic restraint to conform with local Code requirements.
3. Provide seismic restraint calculations for all connections of equipment to support structure.
4. Thrust restraints (TR2) providing 1-inch deflection shall be installed on equipment when the air thrust is greater than 10 percent of the equipment weight.
5. Supply and return fans in package units (RTU) and air handling units (AHU) shall be vibration isolated within the fans enclosures unless noted otherwise.

END OF SECTION

SECTION 23 05 53

IDENTIFICATION FOR HVAC PIPING & EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

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

1.2 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 with the proposed content for each label.

D. Valve-numbering scheme.

E. Valve Schedules: Provide for each piping system. Include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: Brass, 0.032-inch (0.8-mm) minimum thickness, with predrilled or stamped holes for attachment hardware.
2. Letter and Background Color: As indicated for specific application under Part 3.
3. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
4. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances of up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include

secondary lettering two-thirds to three-fourths the size of principal lettering.

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

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch (3.2 mm) thick, with predrilled holes for attachment hardware.
2. Letter and Background Color: As indicated for specific application under Part 3.
3. Maximum Temperature: Able to withstand temperatures of up to 160 deg F (71 deg C).
4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
5. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances of up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
6. Fasteners: Stainless steel rivets or self-tapping screws.
7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

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

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch (3.2 mm) thick, with predrilled holes for attachment hardware.

B. Letter and Background Color: As indicated for specific application under Part 3.

C. Maximum Temperature: Able to withstand temperatures of up to 160 deg F (71 deg C).

D. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

E. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances of up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

F. Fasteners: Stainless steel rivets or self-taping screws.

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

H. Arc-Flash Warning Signs: Provide arc-flash warning signs in locations and with content in accordance with requirements of OSHA and NFPA70E and other applicable codes and standards.

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

2.3 WARNING TAPE

A. Material: Vinyl.

B. Minimum Thickness: 0.005 inch (0.12 mm).

C. Letter, Pattern, and Background Color: As indicated for specific application under Part 3.

D. Waterproof Adhesive Backing: Suitable for indoor or outdoor use.

E. Maximum Temperature: 160 deg F (70 deg C).

F. Minimum Width: 2 inches (50 mm).

2.4 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color coded, with lettering indicating service and showing flow direction in accordance with ASME A13.1.

B. Letter and Background Color: As indicated for specific application under Part 3.

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

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

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings. Also include:

1. Pipe size.
2. Flow-Direction Arrows: Include flow-direction arrows on main distribution piping. Arrows may be either integral with label or applied separately.
3. Lettering Size: Size letters in accordance with ASME A13.1 for piping. At least 1/2 inch (13 mm) for viewing distances of up to 72 inches (1830 mm) and proportionately larger lettering for greater viewing distances.

2.5 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) thick, and having predrilled holes for attachment hardware.

B. Letter and Background Color: As indicated for specific application under Part 3.

C. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

D. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

E. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances of up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

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

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

H. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings. Also include the following:

1. Duct size.
2. Flow-Direction Arrows: Include flow-direction arrows on main distribution ducts. Arrows may be either integral with label or may be applied separately.
3. Lettering Size: Size letters in accordance with ASME A13.1 for piping.

2.6 STENCILS

A. Stencils for Piping:

1. Lettering Size: Size letters in accordance with ASME A13.1 for piping.
2. Stencil Material: Aluminum, brass, or fiberboard.
3. Stencil Paint: Exterior, gloss, alkyd enamel in colors complying with recommendations in ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.
4. Identification Paint: Exterior, alkyd enamel. Paint may be in pressurized spray-can form.
5. Letter and Background Color: As indicated for specific application under Part 3.

B. Stencils for Ducts:

1. Lettering Size: Minimum letter height of 1-1/4 inches (32 mm) for viewing distances of up to 15 ft. (4-1/2 m) and proportionately larger lettering for greater viewing distances.
2. Stencil Material: Aluminum.
3. Stencil Paint: Exterior, gloss, alkyd enamel. Paint may be in pressurized spray-can form.
4. Identification Paint: Exterior, alkyd enamel. Paint may be in pressurized spray-can form.
5. Letter and Background Color: Color as indicated for specific application under Part 3.

C. Stencils for Access Panels and Door Labels, Equipment Labels, and Similar Operational Instructions:

1. Lettering Size: Minimum letter height of 1/2 inch (13 mm) for viewing distances of up to 72 inches (1830 mm) and proportionately larger lettering for greater viewing distances.
2. Stencil Material: Aluminum.
3. Stencil Paint: Exterior, gloss, alkyd enamel. Paint may be in pressurized spray-can form.
4. Identification Paint: Exterior, alkyd enamel. Paint may be in pressurized spray-can form.
5. Letter and Background Color: As indicated for specific application under Part 3.

2.7 VALVE TAGS

A. Description: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) numbers.

1. Tag Material: Brass, 0.04-inch (1.0-mm) or anodized aluminum, 0.031-inch (0.79-mm) minimum thickness, with predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire link chain or beaded chain.

B. Letter and Background Color: As indicated for specific application under Part 3.

C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) 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. Include valve-tag schedule in operation and maintenance data.

2.8 WARNING TAGS

A. 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 (100 by 178 mm).
2. Fasteners: Reinforced grommet and wire or string.
3. Nomenclature: Large-size primary caption, such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Letter and Background Color: As indicated for specific application under Part 3.

PART 3 – EXECUTION

3.1 EXECUTION

A. Within 3 ft. (1 m) of equipment items and other points of origination and termination.

1. Spaced at maximum intervals of 25 ft. (8 m) along each run. Reduce intervals to 10 ft. (3.0 m) in areas of congested piping, ductwork, and equipment.

B. Do not apply plastic pipe labels or plastic tapes directly to bare pipes conveying fluids at temperatures of 125 deg F (52 deg C) or higher. Where these pipes are to remain uninsulated, use a short section of insulation or use stenciled labels.

C. Flow-Direction Arrows: Use arrows to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

D. Pipe-Label Color Schedule:

1. Condenser-Water Piping: White letters on an ANSI Z535.1 safety-green background.

3.2 INSTALLATION OF DUCT LABELS

A. Install self-adhesive duct labels showing service and flow direction with permanent adhesive on air ducts.

1. Provide labels in the following color codes:
   a. For air supply ducts: White letters on blue background.
   b. For air return ducts: White letters on green background**.**
   c. For exhaust-, outside-, relief-, return-, and mixed-air ducts: White letters on green background.

B. Stenciled Duct-Label Option: Stenciled labels showing service and flow direction may be provided instead of plastic-laminated duct labels, at Installer's option.

1. For all air ducts: Black letters on white background.

C. Locate label near each point where ducts enter into and exit from concealed spaces and at maximum intervals of 20 ft. (6 m) where exposed or are concealed by removable ceiling system.

D. Stenciled Access Panels and Door Labels, Equipment Labels, and Similar Operational Instructions:

1. Black letters on White background.

3.3 INSTALLATION OF VALVE TAGS

A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule in the operating and maintenance manual.

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

1. Valve-Tag Size and Shape:
   a. Chilled water : 1-1/2 inches (38 mm), round.
2. Valve-Tag Colors:
   a. For each piping system, use the same lettering and background coloring system on valve tags as used for the Pipe Label Schedule text and background.

3.4 INSTALLATION OF WARNING TAGS

A. Warning Tag Color: Black letters on an ANSI Z535.1 safety-yellow background.

B. Attach warning tags, with proper message, to equipment and other items where required.

END OF SECTION

SECTION 23 05 93

TESTING, ADJUSTING, & BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Testing, Adjusting, and Balancing of Air Systems:
   a. Constant-volume air systems.
   b. Multizone systems.
2. Testing, Adjusting, and Balancing of Hydronic Piping Systems:
   a. Variable-flow hydronic systems.
3. Testing, adjusting, and balancing of equipment.
4. Testing, adjusting, and balancing of existing HVAC systems and equipment.
5. Sound tests.
6. Vibration tests.
7. Duct leakage tests verification.
8. Pipe leakage tests verification.
9. HVAC-control system verification.

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

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

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

F. TDH: Total dynamic head.

G. UFAD: Underfloor air distribution.

1.4 PREINSTALLATION MEETINGS

A. TAB Conference: Conduct a TAB conference after approval of the TAB strategies and procedures plan, to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.

1. Minimum Agenda Items:
   a. The Contract Documents examination report.
   b. The TAB plan.
   c. Needs for coordination and cooperation of trades and subcontractors.
   d. Proposed procedures for documentation and communication flow.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report, as specified in Part 3.

C. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures, as specified in "Preparation" Article.

D. System Readiness Checklists: Within 30 days of Contractor's Notice to Proceed, submit system readiness checklists, as specified in "Preparation" Article.

E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.

F. Certified TAB reports.

G. Sample report forms.

H. 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.

1.6 FINAL TESTING and BALANCING REPORT

A. Provide a final testing and balancing report at final completion.

1.7 QUALITY ASSURANCE

A. TAB Specialists Qualifications, Certified by AABC:

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
2. TAB Technician: Employee of the TAB specialist and certified by AABC.

B. TAB Specialists Qualifications, Certified by NEBB:
1. TAB Field Supervisor: Employee of the TAB specialist and certified by NEBB.
2. TAB Technician: Employee of the TAB specialist and certified by NEBB.

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

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

E. Code and AHJ Compliance: TAB is required to comply with governing codes and requirements of authorities having jurisdiction.

1.8 FIELD CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

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.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

C. Examine the approved submittals for HVAC systems and equipment.

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

E. Examine ceiling plenums and underfloor air plenums used for HVAC to verify that they are properly separated from adjacent areas and sealed.

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 verify that bearings are greased, belts are aligned and tight, filters are clean, 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 temporary and permanent strainers. Verify that temporary strainer screens used during system cleaning and flushing have been removed and permanent strainer baskets are installed and clean.

L. Examine control valves for proper installation for their intended function of isolating, throttling, 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. Examine control dampers for proper installation for their intended function of isolating, throttling, diverting, or mixing air flows.

Q. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.
2. Strategies and step-by-step procedures for balancing the systems.
3. Instrumentation to be used.
4. Sample forms with specific identification for all equipment.

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

1. Airside:
   a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
   b. Duct systems are complete with terminals installed.
   c. Volume, smoke, and fire dampers are open and functional.
   d. Clean filters are installed.
   e. Fans are operating, free of vibration, and rotating in correct direction.
   f. Variable-frequency controllers' startup is complete, and safeties are verified.
   g. Automatic temperature-control systems are operational.
   h. Ceilings are installed.
   i. Windows and doors are installed.
   j. Suitable access to balancing devices and equipment is provided.
2. Hydronics:
   a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
   b. Piping is complete with terminals installed.
   c. Water treatment is complete.
   d. Systems are flushed, filled, and air purged.
   e. Strainers are pulled and cleaned.
   f. Control valves function in accordance with the sequence of operation.
   g. Shutoff and balance valves have been verified to be 100 percent open.
   h. Pumps are started and proper rotation is verified.
   i. Pump gauge connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
   j. Variable-frequency controllers' startup is complete, and safeties are verified.
   k. Suitable access to balancing devices and equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system in accordance with the procedures contained in AABC's "National Standards for Total System Balance", ASHRAE 111, NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.

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

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 23 33 00 "Air Duct Accessories."
3. Where holes for probes are required in piping or hydronic equipment, install pressure and temperature test plugs to seal systems.
4. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish in accordance with Section 23 07 00 "HVAC Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 TESTING, ADJUSTING, AND BALANCING OF HVAC EQUIPMENT

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

1. Motors.
2. Pumps.
3. Fans and ventilators.
4. Cooling towers.
5. Rooftop air-conditioning 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' Record drawings duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

3.6 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. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
   b. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
   c. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
2. Measure fan static pressures as follows:
   a. Measure static pressure directly at the fan outlet or through the flexible connection.
   b. Measure static pressure directly at the fan inlet or through the flexible connection.
   c. Measure static pressure across each component that makes up the air-handling system.
   d. Report artificial loading of filters at the time static pressures are measured.
3. Review Contractor-prepared shop drawings and Record drawings to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Obtain approval from Commissioning Authority for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
5. 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 occurs. 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.

1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.

D. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, speed, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.7 PROCEDURES FOR MULTIZONE SYSTEMS

A. Position the unit's automatic zone dampers for maximum flow through the cooling coil.

B. The procedures for multizone systems will utilize the zone balancing dampers to achieve the indicated airflow within the zone.

C. After balancing, place the unit's automatic zone dampers for maximum heating flow. Retest zone airflows and record any variances.

D. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.
   a. Set outside-air, return-air and relief-air dampers for proper position that simulates minimum outdoor air conditions.
   b. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
   c. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
2. Measure fan static pressures as follows:
   a. Measure static pressure directly at the fan outlet or through the flexible connection.
   b. Measure static pressure directly at the fan inlet or through the flexible connection.
   c. Measure static pressure across each component that makes up the air-handling system.
   d. Report artificial loading of filters at the time static pressures are measured.
3. Review Record drawings to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.

4. Obtain approval from Commissioning Authority for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
5. 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 occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

E. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

F. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlet and outlet airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.

G. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, speed, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.8 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

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

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

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

1. Check expansion tank for proper setting.
2. Check highest vent for adequate pressure.
3. Check flow-control valves for proper position.

4. Locate start-stop and disconnect switches, electrical interlocks, and motor controllers.
5. Verify that motor controllers are equipped with properly sized thermal protection.
6. Check that air has been purged from the system.

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

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

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

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

3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

B. Adjust the variable-flow hydronic system as follows:

1. Verify that the pressure-differential sensor(s) is located as indicated.
2. Determine whether there is diversity in the system.

C. For systems with no flow diversity:

1. Adjust pumps to deliver total design flow.
   a. Measure total water flow.
      1) Position valves for full flow through coils.
      2) Measure flow by main flow meter, if installed.
      3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
   b. Measure pump TDH as follows:
      1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
      2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
      3) Convert pressure to head and correct for differences in gauge heights.
      4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
      5) With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.
   c. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.
2. Adjust flow-measuring devices installed in mains and branches to design water flows.
   a. Measure flow in main and branch pipes.

b. Adjust main and branch balance valves for design flow.
c. Re-measure each main and branch after all have been adjusted.

3. Adjust flow-measuring devices installed at terminals for each space to design water flows.
   a. Measure flow at terminals.
   b. Adjust each terminal to design flow.
   c. Re-measure each terminal after it is adjusted.
   d. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
   e. Perform temperature tests after flows have been balanced.
4. For systems with pressure-independent valves at terminals:
   a. Measure differential pressure and verify that it is within manufacturer's specified range.
   b. Perform temperature tests after flows have been verified.
5. For systems without pressure-independent valves or flow-measuring devices at terminals:
   a. Measure and balance coils by either coil pressure drop or temperature method.
   b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
6. Prior to verifying final system conditions, determine the system pressure-differential set point(s).
7. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
8. Mark final settings and verify that all memory stops have been set.
9. Verify final system conditions as follows:
   a. Re-measure and confirm that total flow is within design.
   b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
   c. Mark final settings.

D. For systems with flow diversity:

1. Determine diversity factor.
2. Simulate system diversity by closing required number of control valves, as approved by Architect.
3. Adjust pumps to deliver total design flow.
   a. Measure total water flow.
      1) Position valves for full flow through coils.
      2) Measure flow by main flow meter, if installed.
      3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
   b. Measure pump TDH as follows:
      1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
      2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
      3) Convert pressure to head and correct for differences in gauge heights.

4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
5) With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.

c. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.

4. Adjust flow-measuring devices installed in mains and branches to design water flows.
   a. Measure flow in main and branch pipes.
   b. Adjust main and branch balance valves for design flow.
   c. Re-measure each main and branch after all have been adjusted.
5. Adjust flow-measuring devices installed at terminals for each space to design water flows.
   a. Measure flow at terminals.
   b. Adjust each terminal to design flow.
   c. Re-measure each terminal after it is adjusted.
   d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
   e. Perform temperature tests after flows have been balanced.
6. For systems with pressure-independent valves at terminals:
   a. Measure differential pressure, and verify that it is within manufacturer's specified range.
   b. Perform temperature tests after flows have been verified.
7. For systems without pressure-independent valves or flow-measuring devices at terminals:
   a. Measure and balance coils by either coil pressure drop or temperature method.
   b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
9. Prior to verifying final system conditions, determine system pressure-differential set point(s).
10. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
11. Mark final settings and verify that memory stops have been set.
12. Verify final system conditions as follows:
    a. Re-measure and confirm that total water flow is within design.
    b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
    c. Mark final settings.

3.10 PROCEDURES FOR MOTORS

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.

2. Motor horsepower rating.
3. Motor rpm.
4. Phase and hertz.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter size and thermal-protection-element rating.
8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.11 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each hydronic 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.

3.12 SOUND TESTS

A. After systems are balanced and Substantial Completion, measure and record sound levels at five locations as designated by the COR.

B. Instrumentation:

1. The sound-testing meter shall be a portable, general-purpose testing meter consisting of a microphone, processing unit, and readout.
2. The sound-testing meter shall be capable of showing fluctuations at minimum and maximum levels, and measuring the equivalent continuous sound pressure level (L_{eq}).
3. The sound-testing meter must be capable of using one-third octave band filters to measure mid-frequencies from 31.5 Hz to 8000 Hz.
4. The accuracy of the sound-testing meter shall be plus or minus one decibel.

C. Test Procedures:

1. Perform test at quietest background noise period. Note cause of unpreventable sound that affects test outcome.
2. Equipment should be operating at design values.
3. Calibrate the sound-testing meter prior to taking measurements.
4. Use a microphone suitable for the type of noise levels measured that is compatible with meter. Provide a windshield for outside or in-duct measurements.
5. Record a set of background measurements in dBA and sound pressure levels in the eight unweighted octave bands 63 Hz to 8000 Hz (NC) with the equipment off.

6. Take sound readings in dBA and sound pressure levels in the eight unweighted octave bands 63 Hz to 8000 Hz (NC) with the equipment operating.
7. Take readings no closer than 36 inches (900 mm) from a wall or from the operating equipment and approximately 60 inches (1500 mm) from the floor, with the meter held or mounted on a tripod.
8. For outdoor measurements, move sound-testing meter slowly and scan area that has the most exposure to noise source being tested. Use A-weighted scale for this type of reading.

D. Reporting:

1. Report shall record the following:
   a. Location.
   b. System tested.
   c. dBA reading.
   d. Sound pressure level in each octave band with equipment on and off.
2. Plot sound pressure levels on Noise Criteria (NC) worksheet with equipment on and off.

3.13 VIBRATION TESTS

A. After systems are balanced and Substantially Completion, measure and record vibration levels on equipment having motor horsepower equal to or greater than 10.

B. Instrumentation:

1. Use portable, battery-operated, and microprocessor-controlled vibration meter with or without a built-in printer.
2. The meter shall automatically identify engineering units, filter bandwidth, amplitude, and frequency scale values.
3. The meter shall be able to measure machine vibration displacement in mils of deflection, velocity in inches per second, and acceleration in inches per second squared.
4. Verify calibration date is current for vibration meter before taking readings.

C. Test Procedures:

1. To ensure accurate readings, verify that accelerometer has a clean, flat surface and is mounted properly.
2. With the unit running, set up vibration meter in a safe, secure location. Connect transducer to meter with proper cables. Hold magnetic tip of transducer on top of the bearing, and measure unit in mils of deflection. Record measurement, then move transducer to the side of the bearing and record in mils of deflection. Record an axial reading in mils of deflection by holding nonmagnetic, pointed transducer tip on end of shaft.
3. Change vibration meter to velocity (inches per second) measurements. Repeat and record above measurements.
4. Record CPM or rpm.
5. Read each bearing on motor, fan, and pump as required. Track and record vibration levels from rotating component through casing to base.

D. Reporting:

1. Report shall record location and the system tested.
2. Include horizontal-vertical-axial measurements for tests.
3. Verify that vibration limits follow Specifications, or, if not specified, follow the General Machinery Vibration Severity Chart or Vibration Acceleration General Severity Chart from AABC's "National Standards for Total System Balance." Acceptable levels of vibration are normally "smooth" to "good."
4. Include in General Machinery Vibration Severity Chart, with conditions plotted.

3.14 DUCT LEAKAGE TESTS

A. Witness the duct leakage testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified limits.

C. Report deficiencies observed.

3.15 PIPE LEAKAGE TESTS

A. Witness the pipe pressure testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified limits.

C. Report deficiencies observed.

3.16 HVAC CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:

1. Verify HVAC control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.17 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 and equipment with fan(s).
2. Measure and record flows, temperatures, and pressures of each piece of equipment in each hydronic system. Compare the values to design or nameplate information, where information is available.
3. Measure motor voltage and amperage. Compare the values to motor nameplate information.
4. Check the refrigerant charge.
5. Check the condition of filters.
6. Check the condition of coils.
7. Check the operation of the drain pan and condensate-drain trap.
8. Check bearings and other lubricated parts for proper lubrication.
9. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. TAB After Construction: Before performing testing and balancing of renovated existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished in accordance with renovation scope indicated by Contract Documents. 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 airflow 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.

3.18 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent. If design value is less than 100 cfm (47 L/s), within 10 cfm (4.7 L/s).
2. Air Outlets and Inlets: Plus or minus 10 percent. If design value is less than 100 cfm (47 L/s), within 10 cfm (4.7 L/s).
3. Heating-Water Flow Rate: Plus or minus 5 percent. If design value is less than 10 gpm (0.63 L/s), within 10 percent.
4. Chilled-Water Flow Rate: Plus or minus 5 percent. If design value is less than 10 gpm (0.63 L/s), within 10 percent.
5. Condenser-Water Flow Rate: Plus or minus 5 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.19 PROGRESS REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for system-balancing devices. Recommend changes and additions to system-balancing devices, to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance-measuring and -balancing devices.

B. Status Reports: Prepare weekly 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.

3.20 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.
3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. 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 specialist.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents, including the following:
    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.
12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans performance forms, including the following:
    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Heating coil, dry-bulb conditions.
    e. Face and bypass damper settings at coils.
    f. Fan drive settings, including settings and percentage of maximum pitch diameter.
    g. Variable-frequency controller settings for variable-air-volume systems.
    h. Settings for pressure controller(s).
    i. Other system operating conditions that affect performance.
16. Test conditions for pump performance forms, including the following:
    a. Variable-frequency controller settings for variable-flow hydronic systems.
    b. Settings for pressure controller(s).
    c. 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 flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Balancing stations.
6. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units, include the following:

1. Unit Data:
    a. Unit identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.

e. Manufacturer's serial number.
f. Unit arrangement and class.
g. Discharge arrangement.
h. Sheave make, size in inches (mm), and bore.
i. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
j. Number, make, and size of belts.
k. Number, type, and size of filters.

2. Motor Data:
   a. Motor make, and frame type and size.
   b. Horsepower and speed.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches (mm), and bore.
   f. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
3. Test Data (Indicated and Actual Values):
   a. Total airflow rate in cfm (L/s).
   b. Total system static pressure in inches wg (Pa).
   c. Fan speed.
   d. Inlet and discharge static pressure in inches wg (Pa).
   e. For each filter bank, filter static-pressure differential in inches wg (Pa).
   f. Preheat-coil static-pressure differential in inches wg (Pa).
   g. Cooling-coil static-pressure differential in inches wg (Pa).
   h. Heating-coil static-pressure differential in inches wg (Pa).
   i. List for each internal component with pressure-drop, static-pressure differential in inches wg (Pa).
   j. Outdoor airflow in cfm (L/s).
   k. Return airflow in cfm (L/s).
   l. Outdoor-air damper position.
   m. Return-air damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:
   a. System identification.
   b. Location.
   c. Coil type.
   d. Number of rows.
   e. Fin spacing in fins per inch (mm) o.c.
   f. Make and model number.
   g. Face area in sq. ft. (sq. m).
   h. Tube size in NPS (DN).
   i. Tube and fin materials.
   j. Circuiting arrangement.
2. Test Data (Indicated and Actual Values):
   a. Airflow rate in cfm (L/s).
   b. Average face velocity in fpm (m/s).
   c. Air pressure drop in inches wg (Pa).
   d. Outdoor-air, wet- and dry-bulb temperatures in deg F (deg C).
   e. Return-air, wet- and dry-bulb temperatures in deg F (deg C).
   f. Entering-air, wet- and dry-bulb temperatures in deg F (deg C).
   g. Leaving-air, wet- and dry-bulb temperatures in deg F (deg C).

h. Water flow rate in gpm (L/s).
i. Water pressure differential in feet of head or psig (kPa).
j. Entering-water temperature in deg F (deg C).
k. Leaving-water temperature in deg F (deg C).
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig (kPa).
n. Refrigerant suction temperature in deg F (deg C).

G. 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 (mm), and bore.
   h. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
2. Motor Data:
   a. Motor make, and frame type and size.
   b. Horsepower and speed.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches (mm), and bore.
   f. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
   g. Number, make, and size of belts.
3. Test Data (Indicated and Actual Values):
   a. Total airflow rate in cfm (L/s).
   b. Total system static pressure in inches wg (Pa).
   c. Fan speed.
   d. Discharge static pressure in inches wg (Pa).
   e. Suction static pressure in inches wg (Pa).

H. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:
   a. System fan and air-handling-unit number.
   b. Location and zone.
   c. Traverse air temperature in deg F (deg C).
   d. Duct static pressure in inches wg (Pa).
   e. Duct size in inches (mm).
   f. Duct area in sq. ft. (sq. m).
   g. Indicated airflow rate in cfm (L/s).
   h. Indicated velocity in fpm (m/s).
   i. Actual airflow rate in cfm (L/s).
   j. Actual average velocity in fpm (m/s).
   k. Barometric pressure in psig (Pa).

I. 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. Airflow rate in cfm (L/s).
   b. Entering-water temperature in deg F (deg C).
   c. Leaving-water temperature in deg F (deg C).
   d. Water pressure drop in feet of head or psig (kPa).
   e. Entering-air temperature in deg F (deg C).
   f. Leaving-air temperature in deg F (deg C).

J. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves, and include the following:

1. Unit Data:
   a. Unit identification.
   b. Location.
   c. Service.
   d. Make and size.
   e. Model number and serial number.
   f. Water flow rate in gpm (L/s).
   g. Water pressure differential in feet of head or psig (kPa).
   h. Required net positive suction head in feet of head or psig (kPa).
   i. Pump speed.
   j. Impeller diameter in inches (mm).
   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 (kPa).
   b. Pump shutoff pressure in feet of head or psig (kPa).
   c. Actual impeller size in inches (mm).
   d. Full-open flow rate in gpm (L/s).
   e. Full-open pressure in feet of head or psig (kPa).
   f. Final discharge pressure in feet of head or psig (kPa).
   g. Final suction pressure in feet of head or psig (kPa).
   h. Final total pressure in feet of head or psig (kPa).
   i. Final water flow rate in gpm (L/s).
   j. Voltage at each connection.
   k. Amperage for each phase.

K. Instrument Calibration Reports:

1. Report Data:
   a. Instrument type and make.
   b. Serial number.
   c. Application.
   d. Dates of use.
   e. Dates of calibration.

3.21 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Owner.

B. Owner shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to the lesser of either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the TAB shall be considered incomplete and shall be rejected.

E. If recheck measurements find the number of failed measurements noncompliant with requirements indicated, proceed as follows:

1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection. All changes shall be tracked to show changes made to previous report.
2. If the second final inspection also fails, Owner may pursue others Contract options to complete TAB work.

F. Prepare test and inspection reports.

3.22 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

SECTION 23 07 00

HVAC 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 duct services:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
7. Outdoor, concealed supply and return.
8. Outdoor, exposed supply and return.

B. Related Sections:

1. Section 23 31 13 "Metal Ducts" for duct liners.

1.3 ACTION SUBMITTALS

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

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

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at 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. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:

1. Sheet Form Insulation Materials: 12 inches (300 mm) square.

2. Sheet Jacket Materials: 12 inches (300 mm) square.
3. 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 E84, 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 23 05 29 "Hangers & Supports for HVAC Piping & 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.

1.8 SCHEDULING

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

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

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.

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

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

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 C534, Type II for sheet materials.

G. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Block Insulation: ASTM C 552, Type I.
2. Special-Shaped Insulation: ASTM C 552, Type III.
3. Board Insulation: ASTM C 552, Type IV.
4. Preformed Pipe Insulation with Factory-Applied ASJ-SSL: Comply with ASTM C 552, Type II, Class 2.
5. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

H. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type II and ASTM C1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

I. 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.

J. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, 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.

K. Mineral-Fiber, Preformed Pipe Insulation

1. 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.

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 C1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C612, Type IB. Nominal density is 2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 INSULATING CEMENTS

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

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

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

2.3 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700 deg F (927 deg C). Comply with ASTM C656, Type II, Grade 6. Tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

B. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

2.4 ADHESIVES

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

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

C. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.

D. Cellular-Glass Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.

E. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class

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

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

H. PVC Jacket Adhesive: Compatible with PVC jacket.

2.5 MASTICS AND COATINGS

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

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-Retarder Mastic: Water based; suitable for indoor use on below ambient services.

1. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
3. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
4. Color: White.

2.6 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
2. Service Temperature Range: 0 to plus 180 deg F (Minus 18 to plus 82 deg C).
3. Color: White.

2.7 SEALANTS

A. Joint Sealants

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Permanently flexible, elastomeric sealant.
3. Service Temperature Range: Minus 100 to plus 300 deg F.
4. 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 (Minus 40 to plus 121 deg C).
4. Color: Aluminum.

C. ASJ Flashing Sealants, and Vinyl 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 (Minus 40 to plus 121 deg C).
4. Color: White.

2.8 FACTORY-APPLIED JACKETS

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

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.
5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perm) when tested according to ASTM E96/E96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.9 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric for Pipe Insulation: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch for covering pipe and pipe fittings.

B. Woven Glass-Fiber Fabric for Duct and Equipment Insulation: Approximately 4 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. inch for covering equipment.

C. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch, in a Leno weave, for duct, equipment, and pipe.

2.10 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. (271 g/sq. m).

2.11 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, 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. Adhesive: As recommended by jacket material manufacturer.
2. Color: White.

D. Jacket:

1. Jacket: Comply with ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
   a. Factory cut and rolled to size.
   b. Finish and thickness are indicated in field-applied jacket schedules.
   c. Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper.
   d. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
2. Jacket: ASTM A167 or ASTM A240/A240M.
   a. Factory cut and rolled to size.
   b. Material, finish, and thickness are indicated in field-applied jacket schedules.
   c. Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper.
   d. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.

B. Outdoor Jacket: 60-mil- (1.5-mm-) thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross laminated polyethylene film covered with white aluminum-foil facing.

2.12 TAPES

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

1. Width: 3 inches (75 mm).
2. Thickness: 11.5 mils (0.29 mm).
3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
6. 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 C1136.

1. Width: 3 inches (75 mm).
2. Thickness: 6.5 mils (0.16 mm).
3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
6. 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. Width: 2 inches (50 mm).
2. Thickness: 6 mils (0.15 mm).
3. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Width: 2 inches (50 mm).
2. Thickness: 3.7 mils (0.093 mm).
3. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

2.13 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A167 or ASTM A240/A240M, Type 304 or Type 316; 0.015 inch (0.38 mm) thick, 1/2 inch (13 mm) wide with wing seal.
2. Aluminum: ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) wide with wing seal.
3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- (3.5-mm-) diameter shank, length to suit depth of insulation indicated.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- (3.5-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030-inch (0.76 mm) thick by 2 inches (50 mm) square.
   b. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
   c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
   b. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
   c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Baseplate: Galvanized carbon-steel sheet, 0.030-inch (0.76 mm) thick by 2 inches (50 mm) square.
   b. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
   c. Adhesive-backed base with a peel-off protective cover.

6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
   a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

D. Wire: 0.062-inch (1.6-mm) soft-annealed, galvanized steel.

2.14 CORNER ANGLES

A. PVC Corner Angles: 30 mils (0.8 mm) thick, minimum 1 by 1 inch (25 by 25 mm), PVC according to ASTM D1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch (1.0 mm) thick, minimum 1 by 1 inch (25 by 25 mm), aluminum according to ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14.

C. Stainless-Steel Corner Angles: 0.024 inch (0.61 mm) thick, minimum 1 by 1 inch (25 by 25 mm), stainless steel according to ASTM A167 or ASTM A240/A240M, 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 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.

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

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- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge.
   a. For below ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.

5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to 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 (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

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

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

3.4 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 (50 mm) 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 (50 mm).
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 (50 mm).

1. Comply with requirements in Section 07 84 13 "Penetration Firestopping."

E. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches (50 mm).
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 84 13 "Penetration Firestopping."

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, vessels, and equipment. 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 CALCIUM SILICATE INSULATION

A. Insulation Installation on Boiler Breechings:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation material.
2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
3. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth. Overlap edges at least 1 inch.

Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.

B. Insulation Installation on Straight Pipes and Tubes:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.
2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

C. 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 cut sections of block insulation of same material and thickness as pipe insulation.
4. Finish flange insulation same as pipe insulation.
   a. Insulation Installation on Pipe Fittings and Elbows:
5. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
6. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
7. Finish fittings insulation same as pipe insulation.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
2. Install insulation to flanges as specified for flange insulation application.
3. Finish valve and specialty insulation same as pipe insulation.

3.7 CELLULAR-GLASS INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes

1. Secure each layer of 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 do not staple longitudinal tabs but 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 cut sections of cellular-glass block insulation of same thickness as pipe 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. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties

1. Install preformed sections of cellular-glass insulation to valve body.
2. 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.

3.8 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

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.

3.9 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.
   a. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
   b. For insulation with factory-applied jackets do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
2. Insulation Installation on Pipe Flanges
   a. Install preformed pipe insulation to outer diameter of pipe flange.
   b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
   d. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.
3. Insulation Installation on Pipe Fittings and Elbows
   a. Install preformed sections of same material as straight segments of pipe insulation when available.
   b. 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.
4. Insulation Installation on Valves and Pipe Specialties
   a. Install preformed sections of same material as straight segments of pipe insulation when available.
   b. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
   c. Arrange insulation to permit access to packing (i.e. removable insulation sections) and to allow valve operation without disturbing insulation.
   d. Install insulation to flanges as specified for flange insulation application.
5. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
   a. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
   b. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
   c. 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

1) 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.
2) 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.
3) Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
4) Do not over compress insulation during installation.
5) Impale insulation over pins and attach speed washers.
6) 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.

d. 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 1 edge and 1 end of insulation segment. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

1) Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
2) 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 2 times the insulation thickness but not less than 3 inches.

e. 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.

f. 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.

g. 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.

6. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

a. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of duct and plenum surfaces.

b. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions, adhesive can be omitted from top surface of horizontal rectangular ducts.

c. 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

1) 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.
2) 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.
3) Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

4) Do not over compress insulation during installation.
5) 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.

d. 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 1 edge and 1 end of insulation segment. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   1) Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   2) 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 2 times the insulation thickness but not less than 3 inches.

e. 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.

f. 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.

3.10 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 50 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 over compress 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.
   a. Stagger joints between insulation layers at least 3 inches.
   b. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
   c. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
   d. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.
7. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
   a. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
   b. Seal longitudinal seams and end joints.
8. Insulation Installation on Pumps
   a. 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.
   b. Fabricate boxes from aluminum, at least 0.060 inch thick.
   c. 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.

3.11 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 (50-mm) overlap at seams and joints.
   2. Embed glass cloth between two 0.062-inch- (1.6-mm-) 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 (38-mm) laps at longitudinal seams and 3-inch- (75-mm) 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 (25-mm) 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 (50-mm) 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 (300 mm) o.c. and at end joints.

3.12 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.

3.13 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 09 90 00 "Paints & Coatings."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
   a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

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

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

3.14 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 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(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

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

3.15 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
7. Outdoor, concealed supply and return.
8. Outdoor, exposed supply and return.

B. Items Not Insulated:

1. Fibrous-glass ducts.
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.
7. Factory-insulated access panels and doors.

3.16 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, rectangular, round and flat-oval, supply and return -air duct insulation shall be the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 3/4-lb/cu. ft. nominal density.

B. Concealed, supply and return -air plenum insulation shall be the following:

1. Mineral-Fiber Board: 1-1/2 inches thick and 3/4-lb/cu. ft. nominal density.

C. Exposed, in conditioned space not supplied by duct system, rectangular, round and flat-oval, supply and return -air duct insulation shall be the following:

1. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

D. Exposed in mechanical rooms, rectangular, round and flat-oval, supply and return -air duct insulation shall be the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

E. Exposed in mechanical rooms, supply and return -air plenum insulation shall be the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

F. Exposed in unconditioned spaces, rectangular, round and flat-oval, supply and return - air duct insulation shall be the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

G. Exposed in unconditioned spaces, supply and return -air plenum insulation shall be the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

H. Concealed, rectangular, round and flat-oval, outside air-air duct insulation shall be the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 3/4-lb/cu. ft. nominal density.

I. Concealed, outside-air plenum insulation shall be the following:

1. Mineral-Fiber Board: 1-1/2 inches thick and 3/4-lb/cu. ft. nominal density.

J. Exposed in mechanical rooms, rectangular, round and flat-oval, outside -air duct insulation shall be the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

K. Exposed in mechanical rooms, outside -air plenum insulation shall be the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

L. Exposed in mechanical rooms, rectangular, round and flat-oval, outside -air duct insulation shall be the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

M. Exposed in mechanical rooms, outside -air plenum insulation shall be the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

3.17 ABOVEGROUND, OUTDOOR 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.

1. Concealed, rectangular, round and flat-oval, supply and return-air duct insulation shall be one of the following:
   a. Mineral-Fiber Board Insulation: 2 inches thick and 3-lb/cu. ft. nominal density.
2. Concealed, supply and return-air plenum insulation shall be one of the following:
   a. Mineral-Fiber Board Insulation: 2 inches thick and 3-lb/cu. ft. nominal density.
3. Exposed, rectangular, round and flat-oval, supply and return-air duct insulation shall be one of the following:
   a. Mineral-Fiber Board Insulation: 2 inches thick and 3-lb/cu. ft. nominal density.
4. Exposed, supply and return-air plenum insulation shall be one of the following:
   a. Mineral-Fiber Board Insulation: 2 inches thick and 3-lb/cu. ft. nominal density.
5. Exposed, rectangular, round and flat-oval, exhaust-air duct insulation shall be one of the following:
   a. Mineral-Fiber Board Insulation: 2 inches thick and 3-lb/cu. ft. nominal density.
6. Exposed, exhaust-air plenum insulation shall be one of the following:
   a. Mineral-Fiber Board Insulation: 2 inches thick and 3-lb/cu. ft. nominal density.

3.18 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.

3.19 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F

1. All Pipe Sizes: Insulation shall be one of the following with vapor barrier:
   a. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick.

B. Chilled Water, below 40 Deg F

1. Smaller than NPS 1: Insulation shall be the following with vapor barrier:
   a. Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inches thick.
2. NPS 1 and larger: Insulation shall be the following with vapor barrier:
   a. Mineral-Fiber, Preformed Pipe, Type I: 2 inches thick.

C. Chilled Water, 40 Deg F and above

1. Smaller than NPS 1.5: Insulation shall be the following with vapor barrier:
   a. Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inches thick.
2. NPS 2 and Smaller, 3' or less from coil connection and where physical constraints do not permit insulation listed in the paragraph above cannot be installed:
   a. Flexible Elastomeric: 3/4 inch thick.
3. NPS 1.5 and larger: Insulation shall be the following with vapor barrier:
   a. Mineral-Fiber, Preformed Pipe, Type I: 2 inches thick.

D. Hot Service Drains

1. All Pipe Sizes: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe, Type I or II: 1 inch thick.

E. Hot Service Vents

1. All Pipe Sizes: Insulation shall be one of the following:
   a. Calcium Silicate: 1-1/2 inches thick.
   b. Mineral-Fiber, Preformed Pipe, Type I or II: 1 inch thick.

3.20 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Chilled Water, below 40 Deg F

1. Smaller than NPS 1: Insulation shall be the following with vapor barrier:
   a. Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inches thick.
   b. Cellular glass, Preformed Pipe: 1-1/2 inches thick.
2. NPS 1 and larger: Insulation shall be the following with vapor barrier:
   a. Mineral-Fiber, Preformed Pipe, Type I: 2 inches thick.
   b. Cellular glass, Preformed Pipe: 2 inches thick.

B. Chilled Water, 40 deg F and above

1. Smaller than NPS 1: Insulation shall be the following with vapor barrier:
   a. Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inches thick.
   b. Cellular glass, Preformed Pipe: 1-1/2 inches thick.
2. NPS 1 and larger: Insulation shall be the following with vapor barrier:
   a. Mineral-Fiber, Preformed Pipe, Type I: 2 inches thick.
   b. Cellular glass, Preformed Pipe: 2 inches thick.

C. Hot Service Drains

1. All Pipe Sizes: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

D. Hot Service Vents

1. All Pipe Sizes: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type II: 1 inch thick.

3.21 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.

   1. Ducts and Plenums, Concealed: None.
   2. Ducts and Plenums, Exposed in occupied spaces: None.

B. Ducts and Plenums, Exposed in mechanical rooms

   1. Woven Glass-Fiber Fabric

C. Piping, Concealed: None.

D. Piping, Exposed in occupied spaces

   1. PVC: 30 mils thick.

E. Piping, Exposed, in mechanical rooms and below 10 feet from finished floor level

   1. PVC: 30 mils thick.

3.22 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. Ducts and Plenums, Concealed: None.

C. Internally insulated ducts and plenums: None

D. Externally insulated Ducts and Plenums, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches: Painted Aluminum, Smooth: 0.016-inch thick.

E. Ducts and Plenums, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches: Painted Aluminum, Smooth: 0.016-inch thick.

F. Piping, Concealed: None.

G. Piping, Exposed: Aluminum, Stucco Embossed Finish: 0.024-inch thick, with Z- Shaped locking seam.

END OF SECTION

SECTION 23 07 13

DUCTWORK INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Related Documents:

1. Drawings and general provisions of the Subcontract apply to this Section.
2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:

1. Ductwork insulation.
2. Insulation jackets.
3. Insulation vapor barriers.

C. Related Sections:

1. Division 01 Sections
2. Division 23 Section "Ductwork".

1.2 REFERENCES

A. General:

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.
3. Refer to Division 01 Section "General Requirements" for the list of applicable regulatory requirements.
4. Refer to Division 23 Section "Common Results for HVAC" for codes and standards, vibration and noise, and other general requirements.

B. ASTM International:

1. ASTM C553 Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
2. ASTM C612 Standard Specification for Mineral Fiber Block and Board Thermal Insulation
3. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials

C. Code of Federal Regulations 29 CFR 1910.7 Definitions and Requirements for a Nationally Recognized Testing Laboratory (NRTL)

D. NFPA - National Fire Protection Association:

1. NFPA 255 Surface Burning Characteristics of Building Materials

E. Underwriters Laboratory (UL):

1. UL Building Materials List
2. UL 723 Surface Burning Characteristics of Building Materials

1.3 INSULATION WORK REQUIREMENTS

A. Insulate HVAC ductwork as follows:

1. Unless indicated otherwise, new HVAC supply and return air ductwork shall be externally insulated.
   a. Insulate cold room supply and exhaust ducts.
2. If ducts are internally insulated, they are not externally insulated unless specifically directed.
3. Transfer and exhaust ducts are internally insulated only if specifically directed.
4. Install an insulation jacket on externally insulated HVAC ductwork located outdoors; and indoors except in mechanical rooms and above ceilings.
5. Insulate outside air intake ducts if located in non-mechanical room indoors space.

1.4 SUBMITTALS

A. Submit under provisions of Division 23 Section "Common Results for HVAC - Review of Materials" and Division 01 Section "General Requirements."

B. Product Data: Include product description, list of materials, coating sample, and thickness for each service, manufacturer's installation instructions, and locations.

1.5 QUALITY ASSURANCE

A. Applicator: Assure that applicator is a company specializing in ductwork insulation application with 3 years relevant experience.

B. Materials: Listed by a nationally recognized testing laboratory (NRTL) recognized under 29 CFR 1910.7; flame-spread/fuel-contributed/smoke-developed ratings of 25/50/50 in accordance with UL 723.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Substitutions: Under provisions Division 01 Section "General Requirements - Materials and Equipment".

2.2 MATERIALS

A. Type A: For externally-insulated, round ductwork, insulation shall be flexible glass fiber; ASTM C612; commercial grade; "k" value of 0.29 at 75 deg F (24 deg C); 0.002-inch (0.05 mm) foil-scrim facing.

B. Type B: For externally-insulated, square or rectangular ductwork, insulation shall be rigid glass fiber; ASTMC612, class 1; "k" value of 0.24 at 75 deg F (24 deg C); 0.002-inch (0.05 mm) foil-scrim facing.

C. Type C: For internally-insulated rectangular ductwork, insulation shall be flexible sheet glass fiber; ASTM C553; "k" value of 0.24 at 75 deg F (24 deg C); 1.5 lb/cu ft. (24 kg/cu. m) minimum density; coated air side for maximum 4,000 ft/min (1219 m/min) air velocity.

D. Type D: Same as Type C except cover with 2 mil mylar sheeting and 22-gauge (0.85 mm) galvanized metal sheeting with 5/32-inch (4 mm) diameter holes staggered 3/16 inch (4.7 mm) with 60 percent minimum open area over the mylar sheeting.

E. Type E: For internally-insulated round ductwork, insulation shall consist of pre-formed glass fiber sections tightly fit into round ducts and fittings, consisting of ASTM C553 glass fiber, “K” value of 0.24 at 75 deg F (24 deg C); 1.5 lb/cu ft. (24 kg/cu. m) minimum density, and coated on the air side.

F. Vapor Barrier: Non-flammable, fire-resistant, polymeric resin, compatible with the insulation.

G. Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.

   1. 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).

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

   1. 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).

I. Lagging Adhesive: Fire resistive in accordance with ASTM E84, NFPA 255, UL 723 or comparable standard by a nationally recognized testing laboratory (NRTL) recognized under 29 CFR 1910.7. 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 meeting 40 CFR 59, Subpart D (EPA Method 24).

J. PVC Jacket Flashing Sealants:

1. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

K. Impale Anchors: Galvanized steel, 12 gauge (2.5mm), self-adhesive pad.

L. Tie Wire: Annealed steel, 16 gauge (1.5mm).

M. The use of products with asbestos content is prohibited.

2.3 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."

B. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

1. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
   a. 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).

C. Natural-Fiber Duct Liner: 85 percent cotton, 10 percent borate, and 5 percent poly-binding fibers, treated with a microbial growth inhibitor and complying with NFPA 90A or NFPA 90B.

1. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
   a. 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).

PART 3 - EXECUTION

3.1 PREPARATION

A. Install materials after ductwork has been tested and approved.

B. Clean surfaces for adhesives.

C. Install materials in accordance with manufacturer's instructions.

D. Install without sag on underside of ductwork. Use adhesive or mechanical fasteners where necessary to prevent sagging.

E. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.

F. Exterior Insulation (Type A or Type B) Application

1. Secure insulation with vapor barrier with wires. Secure insulation without vapor barrier with staples, tape, or wires.
2. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.
3. Seal jacket joints with vapor barrier adhesive or tape to match jacket.
4. Continue insulation with vapor barrier through penetrations.

G. Rectangular Duct Internal Insulation (Type C and D) Application

1. Insulate ducts where shown on the Drawings, on the inside.

H. Only where specifically shown on the Drawings, provide specified perforated sheet metal liner over mylar sheeting fully isolating insulation fibers from the air stream.

1. Attach insulation to duct with 100 percent coverage adhesive plus Omark 12-gauge Insul-Pin, Duro Dyne, or equal, metal clips, with self-locking steel washers, attached to sheet metal with pin welder gun on no less than 18 inches (450 mm) O.C. longitudinally 6 inches (150 mm) O.C. along joints, and 4" from sides. Installed insulation shall be rated for 4,000 ft/min (1219 m/min) air velocity. Clip off pins inside ducts.
2. Treat factory, shop, and field cut edges with a high-density spray on and/or brush-on mastic to lock in fibers and to keep the liner from tearing.
3. Repair damaged liner prior to installing ductwork.
4. All adhesive and insulation material shall be fire-retardant, and U.L. listed.
5. Submit duct sample of liner, its attachment, and edge treatment.

I. Round Duct Internal Insulation (Type E) Application:

1. As an option to internally lined round duct, provide internally lined rectangular duct with equivalent cross-sectional area and Type C liner.
2. Insulate ducts where shown on the Drawings, on the inside.
3. Coat interior duct surfaces with adhesive prior to installation.
4. Insert liner sections into straight ducts and fittings, achieving a tight fit.
5. Treat factory, shop, and field cut edges with high density spray-on and/or brush-on mastic to lock in fibers and keep the liner from tearing.
6. Repair damaged liner prior to installing ductwork.
7. All adhesive and insulation material shall be fire-retardant and U.L. listed.
8. Submit duct sample of liner, its attachment, and edge treatment.

J. Fire Rated Duct Wrap (Type F) Application:

1. Install fire-rated duct wrap in accordance with the manufacturer's directions. Provide number of layers as needed to achieve fire rating. Fire rating shall be as shown on the Drawings or as needed to continue rating of duct or pipe penetration of rated wall, floor, etc.

END OF SECTION

SECTION 23 07 19

HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Related Documents: 2 Drawings and general provisions of the Subcontract apply to this Section.

1. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:

1. Piping insulation.
2. Jackets and accessories.

C. Related Sections:

1. Division 01 Section "Quality Requirements."
2. Division 01 Section "Product Requirements."
3. Division 09 Section "Painting" for painting insulation jacket".
4. Division 23 Section "Identification for HVAC Piping and Equipment".

1.2 REFERENCES

A. General:

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.
3. Refer to Division 01 for the list of applicable requirements.
4. Refer to Division 23 Section "Common Results for HVAC" for codes and standards, and other general requirements.

B. ASTM International:

1. ASTM-B-209 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
2. ASTM-C-195 Standard Specification for Mineral Fiber Thermal Insulating Cement
3. ASTM C 196 Standard Specification for Expanded or Exfoliated Vermiculite Thermal Insulating Cement
4. ASTM-C-449 Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
5. ASTM-C-533 Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
6. ASTM C534 / C534M Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
7. ASTM-C-547 Standard Specification for Mineral Fiber Pipe Insulation

8. ASTM-C-552 Standard Specification for Cellular Glass Thermal Insulation
9. ASTM C553 Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
10. ASTM-C-578 Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation
11. ASTM-C-610 Standard Specification for Molded Expanded Perlite Block and Pipe Thermal Insulation
12. ASTM-E-84 Standard Test Method for Surface Burning Characteristics of Building Material.
13. ASTM C 450 Standard Practice for Fabrication of Thermal Insulating Fitting Covers for NPS Piping, and Vessel Lagging
14. ASTM C 921 Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation
15. ASTM B 209 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
16. ASTM A666 Standard Specification for Annealed or Cold-Worked Austenitic Stainless-Steel Sheet, Strip, Plate, and Flat Bar

C. Code of Federal Regulations 20-CFR-1910.7 Definitions and Requirements for A Nationally Recognized Testing Laboratory (NRTL)

D. National Fire Protection Association NFPA-90A & NFPA-255 Surface Burning Characteristics of Building Materials

E. Underwriters Laboratories UL-723 Surface Burning Characteristics of Building Materials

1.3 SUBMITTALS

A. Submit under provisions of Division 23 Section "Common Results for HVAC, Review of Materials and Division 01 Section "General Requirements."

B. Contractor shall submit the product description, list of materials and thickness for each service, and at each location.

1.4 QUALITY ASSURANCE

A. LEED Submittals:

1. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.

B. Contractor shall assure applicator is a company specializing in piping insulation application with at least 3-years relevant experience.

C. Fire Hazard: Provide insulation, jackets, facings adhesives and accessories acceptable to the State Fire Marshal and NPS AHJ meeting the requirements of NFPA 90A. Meet the following hazard classifications stated in accordance with U.L. Test Method of Fire Hazard Classifications of Building Materials, No. 723:

1. Flame-spread: Maximum 25.
2. Fuel Contributed: Maximum 50.
3. Smoke Developed: Maximum 50.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Mineral-Fiber Insulation: Glass fibers bonded with a thermosetting resin complying with the following:
   1. Preformed Pipe Insulation: Comply with ASTM C 547, Type I, with factory-applied, all-purpose, vapor-retardant jacket.
   2. Blanket Insulation: Comply with ASTM C553, Type II, without facing.
   3. Fire-Resistant Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
      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).
   4. Vapor-Retarder Mastics: Fire and water-resistant. Comply with MIL-C 19565C, Type II.
   5. Mineral-Fiber Insulating Cements: Comply with ASTM C 195.
   6. Expanded or Exfoliated Vermiculite Insulating Cements: Comply with ASTM C 196.
   7. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.

B. Cellular-Glass Insulation: Inorganic, foamed or cellulated glass, annealed, rigid, hermetically sealed cells, incombustible.
   1. Preformed Pipe Insulation, without Jacket: Comply with ASTM C 552, Type II, Class I.
   2. Preformed Pipe Insulation, with Jacket: Comply with ASTM C 552, Type II, Class 2.
   3. Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.
      a. 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).

C. Prefabricated Thermal Insulating Fitting Covers: Comply with ASTM C 450 for dimensions used in performing insulation to cover valves, elbows, tees, and flanges.

D. Elastomeric Cellular Thermal Insulation: Closed cell, fiber-free elastomeric foam, mold resistant, formaldehyde-free, low VOC and non-particulating.
   1. Sheets: Comply with ASTM C 534, Type II – Sheet Grade 1, ASTM E84, NFPA 255, UL 723, NFPA 90A, 90B.
   2. For above ground installation only.
   3. For outdoor installation, a weather – resistant protective finish shall be provided per manufacturer's recommendation.

2.2 FIELD-APPLIED JACKETS

A. General: ASTM C 921, Type I, unless otherwise indicated.

B. Foil and Paper Jacket: Not acceptable.

C. PVC Jacket: High-impact, ultraviolet-resistant PVC; 20 mils thick; roll stock ready for shop or field cutting and forming.

1. Adhesive: Compatible with PVC jacket and recommended by insulation material manufacturer.
   a. 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).
2. PVC Jacket Color: White
3. PVC Jacket Color: Color-code piping jacket as determined by existing conditions.
4. Not to be used for outdoors.

D. Heavy PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 30-mil (0.75 mm) thick, high-impact, ultraviolet-resistant PVC.

1. Shapes: 45 and 90-degree, short and long-radius elbows, tees, valves, flanges, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories for the disabled.
2. Adhesive: Compatible with PVC jacket and recommended by insulation material manufacturer.
   a. 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. Not to be used for outdoors.

E. Aluminum Jacket: Aluminum roll stock, ready for shop or field cutting and forming to indicated sizes. Comply with ASTM B 209 (ASTM B 209M), 3003 alloy, H-14 temper.

1. Finish and Thickness: Smooth finish, 0.010 (0.25 mm) inch thick.
2. Moisture Barrier: 1-mil thick, heat-bonded polyethylene and kraft paper.
3. Elbows: preformed 45 and 90-degree, short and long-radius elbows; same material, finish, and thickness as jacket.
4. Acceptable for outdoor installation.

2.3 ACCESSORIES AND ATTACHMENTS

A. Bands: stainless steel ASTM A666, Type 304, 3/4 inch (20 mm) wide; 0.02 inch (0.050 mm) thick.

2.4 VAPOR RETARDANTS

A. Mastics: Use materials compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.

2.5 SEALANTS

A. Joint sealants, PVC and metal jacket flashing sealants: For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

3.2 PREPARATION

A. Install materials after piping has been tested and approved.

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

3.3 GENERAL APPLICATION REQUIREMENTS.

A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of ducts and fittings.

B. Refer to schedules at the end of this Section for material, form, jacket, and thickness required for each piping system insulation requirements.

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

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

E. Apply 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. Seal joints and seams with vapor-retardant mastic on insulation indicated to receive a vapor retardant.

H. Keep insulation materials dry during application and finishing.

I. Apply insulation with tight longitudinal seams and end joints. Bond the seams and joints with adhesive recommended by the insulation material manufacturer.

J. Apply insulation with the least number of joints practical.

K. Apply insulation over fittings, valves, and specialties, with continuous thermal and vapor-retardant integrity, unless otherwise indicated. Refer to special instruction for applying insulation over fittings, valves, and specialties.

L. Hangers and Anchors: Where vapor retardant is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retardant mastic.

1. Apply insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor retardants are indicated, extend insulation on anchor legs at least 12 inches (300 mm) from point of attachment to pipe and taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retardant integrity.
3. Install insert materials and apply insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by the insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect the jacket from tear or puncture by the hanger, support, and shield.

M. Insulation Terminations: For insulation where vapor retardants are indicated, taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retardant integrity.

N. Apply adhesives and mastics at the manufacturer's recommended coverage rate.

O. Apply insulation with integral jackets as follows:

1. Pull jacket tight and smooth.
2. Circumferential Joints: Cover with 3 inches (75 mm) wide strips of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip and spaced 4-inches o.c.
3. Longitudinal Seams: Overlap jacket seams at least 1 1/2 inches (38 mm). Apply 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.
4. Exception: Do not staple longitudinal laps on insulation having a vapor retardant.
5. Vapor-retardant mastics: Where vapor retardants are indicated, apply mastic on seams and joints and at ends adjacent to flanges, unions, valves, and fittings.
6. At penetrations in jackets for thermometers and pressure gauges, fill and seal voids with vapor-retardant mastic.

P. Roof Penetrations: Apply insulation for interior applications to a point even with top of roof flashing.

1. Seal penetrations with vapor-retardant mastic.
2. Apply insulation for exterior applications tightly joined to interior insulation ends.
3. Extend metal jacket for exterior insulation occurring outside of roof flashing at least 2-inches below the top of the roof flashing.
4. Seal sheet metal jacket to roof flashing with vapor-retardant mastic.

Q. Exterior Wall Penetrations: For penetration of below-grade exterior walls, terminate insulation flush with mechanical sleeve seal. Seal terminations with vapor-retardant mastic.

R. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and floors.

S. Fire-Rated Wall and Partition Penetrations: Apply insulation continuously through penetrations of fire-rated walls and partitions.

1. Firestopping and fire-resistive joint sealers are specified in Division 07 "Penetration Firestopping".
2. Floor Penetrations: Apply insulation continuously through floor assembly.
3. For insulation with vapor retardants, seal insulation with vapor-retardant mastic where floor supports penetrate vapor retardant.

3.4 MINERAL-FIBER INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Secure each layer of preformed pipe insulation to pipe with wire, tape, or bands without deforming insulation materials.
2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic. Apply vapor retarder to ends of insulation at intervals of 15 to 20-feet (4.5 to 6 m) to form a vapor retarder between pipe insulation segments.
3. For insulation with factory-applied jackets, secure laps with outward clinches staples at 6 inches o.c.
4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.

B. Apply Insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the 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. Apply canvas jacket material with manufacturer's recommended adhesive, overlapping seams at least 1 inch (25 mm), and seal joints with vapor-retarder mastic.

C. Apply insulation to fittings and elbows as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When premolded insulation elbows and fittings are not available, apply mitered sections of pipe insulation, or glass-fiber blanket insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire, tape, or bands.
3. Cover fittings with heavy PVC covers. Overlap PVC covers on pipe insulation jackets at least 1 inch (25 mm) at each end. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

D. Apply insulation to valves and specialties as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When premolded insulation sections are not available, apply glass-fiber blanket insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to strainer basket without disturbing insulation.
3. Apply insulation to flanges as specified for flange insulation application.
4. Use preformed heavy PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.
5. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.5 CELLULAR-GLASS INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Secure each layer of insulation to pipe with bands without deforming insulation.
2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic.
3. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6-inches o.c.
4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.

B. Apply insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of the same thickness as pipe insulation
4. Apply insulation to fittings and elbows as follows:
5. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instruction.
6. When premolded sections of insulation are not available, apply mitered sections of cellular-glass insulation. Secure insulation materials with bands.
7. Cover fittings with heavy PVC fitting covers. Overlap PVC covers on pipe insulation jackets as least 1 inch (25 mm) at each end. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

C. Apply insulation to valves and specialties as follows:

1. Apply premolded segments of cellular-glass insulation or glass-fiber blanket insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to strainer basket without disturbing insulation.
2. Apply insulation to flanges as specified for flange insulation application.
3. Use preformed heavy PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.
4. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.6 PREFORMED ELASTOMERIC CELLULAR THERMAL INSULATION APPLICAION

A. Apply insulation to straight pipes and tubes as follows:

1. Install pipe insulation by slitting tubular sections and applying them onto pipes. Seams and butt joints shall be adhered and sealed using Armaflex 520 adhesive.
2. All edges shall be clean-cut. Rough or jagged edges shall not be permitted.

B. Apply insulation to valves, flanges and fittings as follows:

1. Insulate with the same insulation thickness as the adjacent piping. Seams and butt joints shall be adhered and sealed with Armaflex 520 adhesive.
2. All edges shall be clean-cut. Rough or jagged edges shall not be permitted.

C. Outdoor insulation shall be protected as follows:

1. Furnish aluminum jacket and aluminum fitting covers.
2. All jackets shall have the seams located below the horizontal plane of the pipes but not at the bottom of the pipe.

D. Indoor insulation shall be protected as follows:

1. Furnish PVC jacket and PVC aluminum fitting covers.
2. All jackets shall have the seams located below the horizontal plane of the pipes but not at the bottom of pipe.

3.7 FIELD-APPLIED JACKET APPLICATION

A. Apply PVC jacket where indicated, with 1 inch (25 mm) overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

B. Apply metal jacket where indicated, with 2-inch (50 mm) 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 band 12 inches (300 mm) o.c. and at end joints.

C. Insulation and jacket for cold pipes shall include wicks to direct possible condensation to outside the jacket. The product shall be Knauf PermaWick or equal.

D. Indoor, Concealed Applications: Insulated pipes conveying fluids above or below ambient temperature shall have standard jackets, with or without vapor barrier, factory-applied or field-applied. Insulate fittings, joints and valves with insulation of like material and thickness as adjoining pipe, and finish with glass cloth and adhesive. PVC jackets shall be used.

E. Indoor, Exposed Applications: For pipe exposed in mechanical equipment rooms or in finished spaces, insulate as for concealed applications. Finish with canvas jacket; size for finish painting. PVC jackets shall be used.

F. Exterior Applications: Provide vapor-barrier jackets. Cover with aluminum jackets with seams located below the horizontal plane of the horizontal piping route. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and cover with aluminum jackets.

G. Buried Piping: Provide factory-fabricated assembly with inner all-purpose service jacket with self-sealing lap, and asphalt-impregnated open-mesh glass fabric, with 0.001-inch-thick aluminum foil sandwiched between three layers of bituminous compound; outer surface faced with a polyester film.

3.8 FINISHES

A. Paint insulation as specified in Division 09 Section "Painting".

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

3.9 PIPING SYSTEM APPLICATIONS

A. Insulation materials and thicknesses are specified in schedules at the end of this Section.

B. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment.

1. Flexible connectors.
2. Vibration control devices.
3. Fire-suppression piping.
4. Drainage piping located in crawl spaces, unless otherwise indicated.
5. Below-grade piping, unless otherwise indicated.
6. Chrome-plated pipes and fittings, unless potential for personal injury.
7. Air chambers, unions, strainers, check valves, plug valves, and flow regulators.

3.10 INSULATION APPLICATION SCHEDULE, GENERAL.

A. Refer to insulation application schedules for required insulation materials, vapor retarders, and field-applied jackets.

B. Application schedules identify piping system and indicate pipe size ranges and material, thickness, and jacket requirements.

3.11 INTERIOR INSULATION APPLICATION SCHEDULE

A. Service: Domestic and Industrial hot water.

1. Operating Temperature: 60 to 140 deg F (15.6 to 60 deg C).
2. Insulation Material: Mineral-fiber
3. Insulation Thickness: Apply the following insulation thicknesses:
   a. Copper Pipe, Up to 2 inches (50.8 mm): 1 inch (25 mm) Insulation
4. Field-Applied Jacket: PVC
5. Vapor Retarder Required: Yes
6. Finish: As specified in Paragraph 3.8.

B. Service: Chilled-water supply and return.

1. Operating Temperature: 35 to 75 deg F (2 to 24 deg C).

2. Insulation Material: Mineral-fiber or expanded closed-cell cellular.
3. Insulation Thickness: Apply the following insulation thicknesses:
   a. Steel Pipe, All sizes: 1 inch (25 mm) Insulation
   b. Copper All sizes: 1 inch (25 mm) Insulation
4. Field-Applied Jacket: PVC
5. Vapor Retarder Required: Yes
6. Finish: As specified in Paragraph 3.8.

C. Service: Heating hot-water supply and return.

1. Operating Temperature: 100 to 200 deg F (38 to 93 deg C).
2. Insulation Material: Mineral-fiber
3. Insulation Thickness: Apply the following insulation thicknesses:
   a. Steel Pipe, Up to 2 inches (50.8 mm): 1 inch (25 mm) Insulation
   b. Copper Pipe, Up to 2 inches (50.8 mm): 1 inch (25 mm) Insulation
   c. Steel Pipe, 2-1/4 inches (57.2 mm) to 6 inches (152.4 mm): 1-1/2-inch (38 mm) Insulation
   d. Copper Pipe, 2-1/4 inches (57.2 mm) to 6 inches (152.4 mm): 1-1/2-inch (38 mm) Insulation
4. Field-Applied Jacket: PVC
5. Vapor Retarder Required: Yes
6. Finish: As specified in Paragraph 3.8.

D. Service: Steam and Condensate:

1. Operating Temperature: 450 deg F (232 deg C) and lower
2. Insulation Material: Mineral-fiber or Calcium Silicate
3. Insulation Thickness: Apply the following insulation thicknesses:
   a. Steel Pipe, Steam Up to 2 inches (50.8 mm): 1-1/2-inch (38 mm) Insulation
   b. Steel Pipe, Steam 2 1/4 inches (57.2 mm) to 4 inches (101.6 mm): 3 inches (75 mm) Insulation
   c. Steel Pipe, Condensate Up to 2 inches (50.8 mm) : 1-1/2-inch (38 mm) Insulation
4. Field-Applied Jacket: Aluminum
5. Vapor Retarder Required: No
6. Finish: As specified in Paragraph 3.8.

E. Service: Process Cold Water - (Industrial)**:**

1. Operating Temperature: 30 deg F (1.1 deg C)
2. Insulation Material: Mineral-fiber or closed-cell cellular.
3. Insulation Thickness: Apply the following insulation thicknesses:
   a. Copper Pipe, All Sizes: 1 inch (25 mm) Insulation
4. Field-Applied Jacket: PVC
5. Vapor Retarder Required: Yes
6. Finish: As specified in Paragraph 3.8.

3.12 EXTERIOR INSULATION APPLICATION SCHEDULE

A. This application schedule is for aboveground insulation outside the building.

B. Service: Domestic, industrial and DI Water.

1. Operating Temperature: 60 to 140 deg F (15 to 60 deg C).

2. Insulation Material: Mineral-fiber
3. Insulation Thickness: Apply the following insulation thicknesses:
   a. Copper pipe, All sizes: 1 inch (25 mm) Insulation
   b. Polypropylene Pipe 1 inch (25 mm) Insulation
4. Field-Applied Jacket: Aluminum for outdoor
5. Vapor Retarder Required: Yes
6. Finish: As specified in Paragraph 3.8.

C. Service: Chilled-water supply and return.

1. Operating Temperature: 35 to 75 deg F (2 to 24 deg C).
2. Insulation Material: Mineral-fiber or closed-cell cellular.
3. Insulation Thickness: Apply the following insulation thicknesses:
   a. Steel pipe, All sizes: 1-1/2-inch (38 mm) Insulation, 1” for cellular
   b. Copper Pipe, All sizes: 1-1/2-inch (38 mm) Insulation, 1” for cellular
4. Field-Applied Jacket: Aluminum for outdoor, PVC for indoor
5. Vapor Retarder Required: Yes
6. Finish: As specified in Paragraph 3.8.

D. Service: Heating hot-water supply and return.

1. Operating Temperature: 100 to 220 deg F (38 to 104 deg C)
2. Insulation Material: Mineral Fiber
3. Insulation Thickness: Apply the following insulation thicknesses:
   a. Steel Pipe, All sizes: 1-1/2-inch (38 mm) Insulation
   b. Copper Pipe, All sizes: 1-1/2-inch (38 mm) Insulation
4. Field-Applied Jacket: Aluminum for outdoor, PVC for outdoor
5. Vapor Retarder Required: Yes
6. Finish: As specified in Paragraph 3.8.

E. Service: Steam and condensate.

1. Operating Temperature: 450 deg F (232 deg C) and lower.
2. Insulation Material: Mineral Fiber
3. Insulation Thickness: Apply the following insulation thicknesses:
   a. Steel Pipe, Steam Up to 2 inches (50.8 mm): 2-1/2-inch (63 mm) Insulation.
   b. Steel Pipe, Steam 2-1/4-inches (57.2 mm) to 8 inches (203.2 mm): 3-1/2-inch (89 mm) Insulation.
   c. Steel Pipe, Condensate Up to 2 inches (50.8 mm): 1-1/2-inch (38 mm) Insulation.
   d. Steel Pipe, Condensate 2-1/4-inches (57.2 mm) to 8 inches (203.2 mm): 2 inches (50.8 mm) Insulation.
4. Field-Applied Jacket: Aluminum for outdoor, PVC for indoor.
5. Vapor Retarder Required: Yes
6. Finish: As specified in Paragraph 3.8.

3.13 ALTERNATE INSULATION APPLICATION

A. Preformed elastomeric cellular insulation may be used as an alternative to the materials in Sections 3.11 and 3.12.

END OF SECTION

SECTION 23 08 00

COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Related Documents:

1. Drawings and general provisions of the contract apply to this Section.
2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:

1. General requirements that apply to implementation of commissioning of HVAC systems, assemblies and components.

C. Related Sections:

1. Division 01 Section
2. Division 23 HVAC Sections.

1.2 REFERENCES

A. General:

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.
3. Refer to Division 23 Section "Common Results for HVAC" for codes and standards, and other general requirements.

1.3 DESCRIPTION

A. The purpose of commission is to ensure that work has been completed as specified and that systems are functioning in the manner as described in Division 23 Section for HVAC" and specified system operating criteria. It will assist operating staff training and familiarization with new systems. It will serve as a tool to reduce post-occupancy critical systems operational difficulty or failure. It will, also, be used to develop test protocol and record the associated test data in an effort to advance the building systems from a state of substantial completion to a full dynamic operation.

B. Commission will commence after preliminary punch list items are completed by Contractors.

C. The steps associated with commissioning are outlined below:

1. Step One - Installation Verification
2. Step Two - System Start-Up.
3. Step Three – Functional Performance Testing.

D. Operational staff training is essential to the commission process and will run concurrently with steps one through three.

E. The Commissioning Team will include representatives of the Government, Construction and Installing Contractors, Test and Balance Contractor, FMCS Contractor and Construction Contractor's Commissioning Agent. Equipment manufacturer's representatives will be present for start-up as specified in the equipment specification sections and for equipment training.

1.4 SYSTEMS TO BE COMMISSIONED

A. Commissioning will be performed on the following systems:

1. Facility Monitoring and Control System (FMCS)
2. Central Supply and Return Air Systems.
3. Air Terminals.
4. Chilled Water System.
5. Heater Water System
6. Humidification system

1.5 SUBMITTALS

A. Submit under provisions of Section 01 33 23 – "Submittal Procedures."

B. Commissioning Plan as prepared by the prime Contractor or his Commissioning Agent.

C. Prime Contractors or his Commissioning Agent shall provide Functional Performance Tests (FPT) procedures for the above listed systems. Prime Contractors or his Commissioning Agent shall provide system narrative descriptions as part of the FPT procedures.

PART 2 - PRODUCTS

2.1 COMMISSIONING PLAN

A. The commissioning plan shall outline the organization, scheduling, team members, and documentation pertaining to the overall commissioning process.

2.2 NARRATIVE DESCRIPTIONS

A. A narrative description of the design intents of the systems and their intended modes of sequences of operation.

2.3 FUNCTIONAL PERFORMANCE TESTS (FPT) PROCEDURES

A. The FPT procedures at the minimum shall consist of the following sections:

1. Narrative Description:
   a. This section provides a narrative description of the design intents of the systems and their intended modes of sequences of operation.
2. Testing Prerequisites:
   a. This section contains verification that primary mechanical, electrical, and controls systems that support or interact with the system that the FPT is prepared against are completed, tested and operational.
3. Installation Verification:
   a. This section contains verification that the system installation is completed and is ready for commissioning.
4. Commencement of Functional Performance Testing:
   a. This section records the date and time of the start of system commissioning.
5. System Condition Prior to Staring Performance Testing:
   a. This section records the current set points and parameters of the system at the start of commissioning.
6. Functional Performance Test:
   a. This section shall provide the following:
      1) Sequential steps required to set parameters and conditions required to test component and functions throughout intended ranges of operation.
      2) Full range of checks and tests carried out to determine if electric and pneumatic connections, components, subsystems, systems and interfaces between systems function in accordance with the contract documents and design intents.
      3) All modes and sequences of control operations, interlocks and conditional control responses and specified responses to abnormal emergency conditions.
7. End of Functional Performance Test:
   a. This section records the date and time of the end of system commissioning.
8. Field Notes:
   a. This section records notes or remarks during system commissioning.
9. List systems modifications, not required by the Contract Documents, but provided by the Contractor. List other questions regarding such system modifications.
10. List problems discovered during Commissioning that were corrected.
11. List problems discovered during Commissioning that were not corrected.
12. List recommended party that should take action on these problems.

PART 3 - EXECUTION

3.1 GENERAL

A. The Contractors shall be responsible for performing procedures presented in specification and contract drawings as detailed in the Functional Performance Tests (FPT). Members of the designated Commissioning Team shall witness various portions of the commissioning process. Responsibilities for these activities are listed in the following paragraphs. Commissioning Team members shall sign-off on appropriate sections after verifying installation, operation, or documentation. Final sign-off shall be by the Owner and Commissioning Agent.

B. Any test ports, gauges, test equipment, etc., needed to accomplish the functional performance tests shall be provided by Contractors.

C. Contractors shall provide to the Commissioning Team documentation of calibration of controls. Documentation shall include dates, setpoints, calibration coefficients, control loop verification, and other data required to verify system check-out. Documentation shall be dated and initialed by field engineer or technician performing the work.

3.2 OPERATIONAL STAFF TRAINING

A. System narrative descriptions will be prepared by the Commission Agent and supported by flow diagrams, one-line diagrams, and appropriate specification sections for major systems to be commissioned. The Commission Agent will coordinate "system description" meetings with members of facility management and maintenance department groups to review system description documentation. The meetings will provide an overview of major system features, components, and arrangements.

B. The Contractor and associated manufacturer's representatives shall provide required training to operational staff after the system description meetings have occurred. The Contractor training sessions shall provide a more detailed analogy of systems operation and maintenance.

3.3 INSTRUMENTATION

A. Instrumentation will be provided by the Contractor. Instruments used for measurements shall be accurate. Calibration histories for each instrument shall be available for examination. Calibration and maintenance of instruments shall be in accordance with the requirements of NEBB or AABC Standards.

B. Application of instruments and accuracy of measurements shall be in accordance with NEBB or AABC Standards.

3.4 DOCUMENTATION

A. The installing Contractor shall be responsible for collection of pertinent data during system start-up and functional performance testing. The Contractor shall submit to the Commissioning Agent documentation of tests performed prior to and after system start-up. Documentation shall also include start-up procedures as approved by Commissioning Team.

B. Documentation is to be typewritten on 8-1/2 by 11 inches (200 by 280 mm) paper and inserted in a 2 inches (50 mm) to 3 inches (75 mm) thick three ring binder. Indicate the project name, number, volume number, and volume title on the end panel of each binder.

C. Provide a title sheet for each volume and list the following:

1. Volume Title and Section Name and Number requiring this submittal.
2. Project name, project number, and address.
3. Contractor name, address, and phone number.
4. Name, title, signature, and date of person making the submittal.
5. Name of Owner, a blank line for signature, and the date of person accepting the submittal.
6. Name, address, and phone number of Commission Agent; a blank line for signature; and date of person accepting the submittal.

D. Provide a Table of Contents for multiple submittals. List each submittal and page number. Number each page, centered on the bottom in sequential numerical order. Provide tabs for multiple submittals in a single binder.

3.5 STEP ONE - INSTALLATION VERIFICATION

A. General Commissioning responsibilities:

1. Before system start-up begins, the Commission Team shall conduct a final installation verification audit. The Contractor shall be responsible for completion of work including change orders and punch list items to the Owner satisfaction. The audit shall include, but not be limited to, checking of:
   a. Piping specialties including balance, control, and isolation valves.
   b. Ductwork specialty items including turning devices, balance, fire, smoke, control dampers, and access doors.
   c. Control sensor types and location.
   d. Identification of piping, valves, equipment, controls, etc.
   e. Major equipment, pumps, valves, starters, gauges, thermometers, etc.
   f. Documentation of prestart-up tests performed, including manufacturer's factory tests.
2. If work is found to be incomplete, incorrect, or non-functional, the Contractor shall correct the deficiency before system start-up work proceeds.

3.6 STEP TWO - SYSTEM START-UP

A. General Commissioning Responsibilities:

1. A start-up plan shall be developed and submitted by the installing Contractor. Start-up plan to include the following:
   a. Flushing and cleaning of pipe.
   b. Filters, strainers, and screens.
   c. Valve/damper positions.
   d. Electrical tests.
   e. Pressure tests.
   f. Safeties.
   g. Chemical treatment.
   h. Manufacturer's tests.
2. The start-up plan will be reviewed and a prestart-up inspection performed by designated members of the Commissioning Team. The installing Contractor shall commence with system start-up after approval has been given to start-up plan and the prestart-up inspection is completed. Designated members of the Commissioning Team shall witness system start-up and list system and equipment deficiencies noted during start-up. The Contractor shall take corrective action on system deficiencies noted and demonstrate to the Commissioning Team members suitable system operation.
3. Designated systems requiring test and balance work shall have this activity commence after systems have successfully completed start-up. System and equipment deficiencies observed during this activity is to be noted and corrected.

3.7 STEP THREE - FUNCTIONAL PERFORMANCE TESTING

A. General Commissioning Responsibilities:

1. Functional Performance Testing begins after operational testing, adjusting, and balancing of the systems have been completed by the Contractors; and the System Description and Hands-on Training sessions have been completed.
2. The objective of the Functional Performance Testing is to advance the building systems from a state of substantial completion to full dynamic operation in accordance with the specified design requirements and design intent.
3. Attaining this object will be accomplished by developing individual systems testing protocols which, when implemented by the Contractor, will allow the Commissioning Team to observe, evaluate, identify deficiencies, recommend modifications, tune, and document the systems and systems equipment performance over a range of load and functional levels.
4. Functional Performance tests for the systems to be commissioned are defined in the Commissioning Plan. These tests are intended to be conclusive but may require minor modifications as system operation dictates.

END OF SECTION

SECTION 23 09 13

INSTRUMENTATION & CONTROL DEVICES FOR HVAC

PART 1 – GENERAL

1.1 SECTION INCLUDES

A. Electronic Sensors, Switches, Relays, and Indicating Devices

1.2 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Automatic Dampers

B. Thermostats

C. DDC Components

1.3 RELATED SECTIONS

A. Section 01 00 00

B. Section 23 08 00 – Commissioning of HVAC

1.4 SYSTEM DESCRIPTION

A. Provide control system components consisting of thermostats, temperature sensors, pressure sensors, relays, dampers, and operators, indicating devices, and other apparatus and accessories required to operate mechanical systems and perform functions specified.

B. Provide guidance for selection of control devices. Selections shall be based on actual system design parameters methods of selection. Building Automation Systems (BAS) Contractor is responsible for the selection of dampers, control devices and actuators.

C. Provide materials and labor necessary to connect factory-supplied control components to existing control systems.

D. Unless specified otherwise, provide fully proportional components.

E. Provide power supplies and interconnecting wire and conduit.

1.5 SUBMITTALS

A. Comply with the following specific requirements:

1. Provide device model numbers, duct sizes, damper sizes, flow rates, velocities, calculated pressure drops, leakage rates, torque requirements, actuator model number, actuator torque capacities, and pilot positioner locations.
2. Select dampers to meet their intended service with respect to maximum approach velocities and maximum pressure differential.
3. Operation and Maintenance manuals shall be organized by specification number and shall have a table of contents and tabs for each piece of equipment or system. In addition to requirements listed in Section 01 78 23 - Operation and Maintenance Data, Operation and Maintenance manuals shall also include:
   a. Copies of all shop drawings in both paper and electronic format. Electronic drawings shall be provided on CD-ROM in the AutoCAD format listed in Section 01 77 00 Closeout Procedures Manufacturer's operation and maintenance instructions. Include parts lists of all items or equipment with exploded view of components with part numbers. Designate the specific model when several options are shown. Include CD-ROM if available.
   b. Product data sheets, engineering data and manufacturer's installation instructions on each control system component. Include sizing criteria and calculations.
   c. Contact information on local parts suppliers and service companies.
   d. Composite Electrical Diagrams.
   e. Actual location of control components, including panels, thermostats, and sensors. Include revised shop drawings to reflect actual installation and operating sequences.
   f. Factory and field calibration and commissioning records.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three years' experience.

B. Installer: Company specializing in applying the work of this section with minimum three years' experience. Installers must be factory certified by the control system manufacturer.

C. BAS Contractors are limited to firms regularly employing a minimum of 5 full-time service people within 100 miles of the job site.

1.7 WARRANTY

A. General: Provide a one-year warranty on all materials and labor upon substantial completion.

PART 2 – PRODUCTS

2.1 ELECTRONIC SENSORS, SWITCHES, RELAYS AND INDICATING DEVICES

A. Temperature Sensors

1. General
   a. Sensors shall be 1000-ohm Platinum RTDs with the following minimum performance:
      (1) Temperature Coefficient of Resistivity (TCR) of .00385 ohm/ohm/°C for platinum RTD's.
      (2) Accuracy of ±0.1% at 32 degrees F (Class B) for platinum RTDs.
      (3) Operating range of 0 to 99% Relative Humidity non-condensing.
   b. Thermistors are acceptable downstream of reheat coils and where it's the manufacturer's only native option.
2. Duct Mounted Sensors
   a. For averaging service, provide 1000-ohm RTD sensing element. Sensing element shall have a minimum of 1 foot of sensor length for each 2 square feet of duct or coil area. Sensor shall be arranged evenly across the duct or coil such that no point in the duct or coil is more than 1 foot away from the sensor.
   b. Install stainless steel flanges where elements penetrate ducts. Support elements with appropriate clips on coil faces, or 1/2" conduit in open ducts and plenums.
3. Space Temperature Sensors and Thermostats
   a. Electronic thermostats shall be used in conjunction with DDC controllers.
   b. Each thermostat shall incorporate an accessible setpoint adjustment feature.
   c. Each thermostat must digitally display the current setpoint and temperature.
4. Outdoor Air Temperature shall be a 1000 Ohm Platinum RTD sensor, preferably located on the north side of the building and shaded with sun shield. Sensor shall be located at least six feet above grade away from window wells and exhaust openings. (ACI 1K-2w-o-sun or equivalent)
5. Static Pressure Instruments
   a. Air
      (1) 100 percent solid state device, temperature compensated, suitable for pressures of 200 percent rated range with averaging to stabilize output, accuracy of ±1 percent, and a 4-20 mA output.
      (2) For duct-mounted application, install a manufactured static sensing probe per manufacturer's recommendations.
      (3) SETRA Model MRG with display, ACI DLP for low pressure application.
      (4) SETRA Model MRG for high pressure application.
      (5) SETRA Model 269 low Differential pressure transducer for control and monitoring in laboratories, and other critical environments.
6. Differential Pressure Instruments
   a. Air
      (1) 100 percent solid state device, temperature compensated, suitable for pressures of 200 percent rated range with averaging to stabilize output, accuracy of ±1 percent, and a 4-20 mA output.
      (2) SETRA Model MRG series with display or ACI Model: A/DLP-001-W-U-D-A-3 Range: 0-1 in WC, A/DLP-010-W-U-D-A-3 Range: 0-10 in WC
   b. BAS Contractor shall provide transmitter for each filter bank.
      (1) The static sensor tip shall be a minimum of 3 inches from the inside wall of the duct.

B. Flammable Gas Detection

1. Flammable gas sensors shall use an infrared dual wavelength beam. The unit shall be NFPA 72 compliant and meet FM Approval 6320 for combustible gas detector performance.
2. Sensor accuracy shall be ±1% for the range of 0-50%LEL and ±2% for the range of 51-100%LEL. Sensor life expectancy at a minimum of 5 years.
3. Unit shall provide an integral scrolling LED display to allow field calibration and diagnostic messages to be displayed. A 4-20 ma output and 3 relays shall be provided. The relays shall provide warning, alarm and fault indication to the DDC control system. The 4-20 ma output shall provide an output for the range of 0-100%LEL. The unit shall provide integral or remote sensor mounting to the transmitter.
4. The unit shall be a Sierra Monitor Corporation Model 5100-2B-IT

C. Level Instrumentation

D. Power Supplies and Noise Suppression Devices

1. 24 Volt DC Power Supply
   a. Size Power supply a minimum of 33 percent larger than the total connected load to allow for expansion. Fuse the supply circuit at no more than 150 percent of full load capacity of the power supply. Fuse shall be Class CC, or equivalent. Fuse holder shall be Bussmann Model CHCC or equivalent, DIN Rail mounted.
   b. The output of the Power supply shall provide short-circuit protection.
2. Power Conditioners
   a. All microprocessor-based controllers shall be powered from a 120 VAC circuit protected by a noise suppression device. The device shall provide a line regulation of +/- 1% and have a noise attenuation of 40 dB. The audible noise valve shall be less than 65 dBA. Provide overload capacity of 165 percent of rated current. Output harmonic distortion shall be less than 3 percent of RMS content.
   b. Sola CVS Power Conditioner – Transformer shall be sized based on a load but no greater than 150% of the connected load 23 -22- 112 -2 (120 VA), 23-23-125-8 (250 VA) or 23-23-150-8 (500 VA)
   c. The Line side of the conditioner shall be protected by a Class RK1 fuse, Bussmann model LPN or equivalent, sized per Power Conditioner manufacturers requirements. The Load side of the conditioner shall be protected by a Class CC fuse, or equivalent. Load side fuse holder shall be Bussmann Model CHCC or equivalent, DIN Rail mounted. Maximum load side fuse size shall be 7 amperes.

E. Relays and Switches

1. Mount all relays and power supplies on DIN Rails in a NEMA 1 enclosure beside the DDC panel or in the controlled device and clearly label their functions. A NEMA 12 enclosure is required for outdoor or wet applications.
2. High or Low Air Pressure Safety Switch: Differential pressure switch with double-pole, double-throw snap switch and enclosure.
   a. Rated for pressure specified in sequence of control for fan system. (–5.5-to-5.5-inch WC. for most AHUs)
   b. Electrical rating shall be 15 amps at 120-480 volts.
   c. Setpoint adjustment shall be screw type located inside enclosure.

d. Provide optional manual reset for overpressure protection with all tubing, brackets, and adapters.
e. Device shall be mounted in a locked control panel.

3. Coordinate voltage and ampacity of all contacts, relays, and terminal connections of equipment being monitored or controlled. Voltage and ampacity shall be compatible with equipment voltage and be rated for fully ampacity of wiring or overcurrent protection of circuit controlled.

F. Circuit Protection

1. Unless specified otherwise, all fuses shall be Class CC, or equivalent. Fuse holders shall be Bussmann Model CHCC or equivalent, DIN Rail Mounted. Maximum size shall not exceed maximum capacity of conductor, or 7 Amps, whichever is less.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify that systems are ready to receive work. Beginning of installation means installer accepts existing conditions.

B. Verify that all components are installed properly and calibrated to the proper operating range.

3.2 INSTALLATION – GENERAL

A. Install all components as specified by manufacturer.

B. All components shall be installed in a neat workmanlike manner.

C. All wiring shall be labeled on both ends as shown on as-built drawings.

3.3 COMMISSIONING

A. The instrumentation and controls devices shall be commissioned prior to start-up. See the related commissioning sections.

B. Provide two seasonal system functional checkouts including seasonal changes (winter and summer modes).

END OF SECTION

SECTION 23 09 23

DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC

PART 1 - GENERAL

1.1 DESCRIPTION

A. Furnishing and installing all control hardware and software necessary for a complete DDC control system as specified.

B. Furnish all modules, temperature sensors, flow sensors, humidity sensors, control valves, control valve actuators, dampers, damper actuators and any other items necessary for a complete system and sequence of control.

C. Coordinate the installation of automatic control valves, dry wells for fluid temperature sensors, dampers and actuators with the mechanical contractor to assure all work required for a complete system.

1.2 QUALITY ASSURANCE

A. Provide control work by a single company with licensed journeymen specialists in the type of work required, so that only one supplier is responsible for all control work for the project.

B. Provide coordination with other contractors and subcontractors for work required by other trades for control work accomplishment.

1.3 SUBMITTALS

A. In diagrams, show complete piping or ductwork system schematics with DDC, electrical and pneumatic control devices, tubing and wiring superimposed.

B. Completely identify all control devices with manufacturer's type, number, and functional description.

C. Uniquely identify all control tubing, wire and conduit on the drawings with a logical numbering system.

D. Show all electric and hydronic connections of the control system to equipment furnished by others, complete to terminal points specifically identified with manufacturer's terminal designation.

E. In booklet form, provide a bill of material and catalog data on all control device types, including control operation description, technical parameters and connection identifications. Describe the complete sequence of operation containing all information necessary for clarity and understanding of device function and system sequence of operation.

F. Furnish a trunk cable schematic showing the local area network drawings.

G. Furnish a list of connected data points, including connected control unit and input device.

H. In booklet form, provide catalog data on all description, technical parameters and connection identifications. Describe the complete sequence of operation containing all information necessary for clarity and understanding of device function and system sequence of operation.

1.4 OPERATING AND MAINTENANCE DATA:

A. O&M Manuals shall be in a separate three ring binder.

B. Include a complete set of control Shop Drawings indicating as built and operating changes.

C. Include operating and maintenance data on all equipment requiring periodic or incidental services or adjustment. Include a summary schedule for all maintenance tasks. Describe troubleshooting procedures for anticipated problems.

D. Controls Systems Commissioning:

1. Submit a complete, dated, and an initialed record of all system adjustment for components of the control system.
2. Indicate deviations from the specified temperatures, pressures, flows, setpoints, etc.
3. Include a copy of the completed commissioning worksheets in each copy of the Operating and Maintenance Data.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS AND SYSTEMS

A. Contractor shall maintain toll-free technical support phone line or accept collect phone calls during warranty period.

B. Contractor shall provide service within 24 hours.

C. Contractor service and installation technicians shall be technically proficient in both control systems and mechanical service.

D. Variable Frequency Drives, lighting systems or power monitoring systems shall use either Modbus or BACnet software protocols for integration to the DDC system.

E. Utilize BACnet software protocol for integration to this DDC system.

2.2 CONTROL WIRING / COORDINATION WITH LINE VOLTAGE CONTROL

A. Provide control wiring to all control modules, sensors, pilot duty control relays and actuators required to provide the project sequences of operation.

B. Provide control interface to boilers, chillers, pumps and fans. This shall include pilot duty relays where interface to line voltage switching devices is required.

C. All control wiring exposed in occupied areas to be in conduit.

D. Provide all control system related conduit within mechanical room or at equipment locations unless specifically shown to be in other divisions work.

E. Provide exposed plenum rated cabling will be acceptable above accessible ceilings. Electrical Contractor shall provide all required conduit, contactors, magnetic starters and motor control centers required for operation of mechanical systems except where specifically noted to be provided by equipment manufacturer.

F. Control wiring in non-accessible ceilings, walls or floors shall be in conduit.

G. All wiring not in conduit or control cabinets shall be rated for plenum installation.

H. Communication wiring shall be run in data cable tray whenever possible.

I. Provide conduit where required between the zone temperature sensor locations and the zone equipment. Provide all wiring / conduit in the base bid necessary for a complete operating control system.

2.3 AUTOMATION SYSTEM / DDC CONTROL DEVICES

A. System Server: Software shall be maintained on an online server. Specifications for this server will be provided to the owner prior to installation. The contractor shall maintain this server and provide all supporting labor and maintenance of this service.

B. The 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.

C. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.

D. BACnet Compatibility: The system shall be fully native BACnet at the time of installation. The system shall use BACnet as the native communication protocol between distributed controllers communicating on the controller network (i.e. Field Bus) and must, as a minimum, support the following Objects and Application Services (Conformance Class 3):

E. Distributed Control

1. System shall observe the concept of distributed control.
2. All modules shall have “stand alone” capability and shall maintain operator setpoints without connection to primary controllers or central station equipment.
3. Modules shall be located at each operating equipment location such that individual systems or zones shall remain functional without communication to other systems on the network.

4. Equipment operating logic, schedules and current trends shall reside in control modules serving each system.
5. Use of global modules required to maintain programming, schedules or current trend data are not acceptable.

F. Ethernet Gateway Routers

1. System shall include an Ethernet Router/Gateway between the control module network and owners Ethernet.
2. Gateway shall route BACnet communications between the control module network and the owners IP network. If the system is not to be connected to the customer's Ethernet the gateway shall be capable of connection via a web browser on the local host server.

G. Controllers / Control Modules

1. Each controller shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each controller shall be a microprocessor-based, multi-tasking, real-time digital control processor. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.
2. Controllers shall include required inputs and outputs to meet sequence of operation and points list. Digital outputs shall be dry contact relays and analog outputs shall be industry standard 0- 10 vdc, 2-10 vdc or 4-20 milli-amp. Modules shall be fully programmable.
3. Controllers shall have battery backup capable of maintaining all programs, setpoints, schedules and trend information for a minimum of 7 days.
4. All schedules and current trends shall be maintained in the individual controllers. The controllers shall be capable of maintaining sufficient trend samples to report 24 hours of trend history in 5-minute increments for each input or output.
5. Controllers shall communicate via BACnet over Arcnet at a speed of 156kbaud for increased system response. The control module network can be slowed down to support MS/TP (76.8 kbaud) if needed for interface to other BACnet devices.

H. Temperature Sensors

1. Wall mounted zone temperature sensors shall be 10 k ohm thermistor.
2. Zone sensors in primary occupied areas other than restrooms, hallways or storage rooms shall have a slider type set point adjustment to allow the occupants to raise or lower the set point within operator defined parameters.
3. Additionally, sensors in these primary areas shall have a push button to return the system to normal occupancy set points for an operator defined period. Exception will be common areas. Gymnasium sensors shall also include a key access override feature.
4. General building wall sensors will be:
   a. RS Plus – Temperature only with slider type temperature adjustment and occupancy override button.
   b. ZS Plus – Temperature and CO2 with slider type temperature adjustment, occupancy override button and both temperature and CO2 control through a single control point.
5. All other temperature sensors shall be industry standard thermistor or 4-20 milli-amp. Immersion sensors shall be mounted in a blind well for future serviceability.

I. Valve and Damper Actuators

1. Actuators shall be manufactured by Belimo.
2. Torque shall be rated for required load.
3. Modulated actuator input shall be industry standard 0-10 vdc, 2-10 vdc, 4-20 milli-amp, floating motor (tri-state), or pulse width modulation.
4. Two or three position operation is not acceptable for economizers, VAV dampers, multi-zone dampers, valves or any other application specifying modulated operation.

2.4 AUTOMATION SYSTEM SOFTWARE

A. All operating program and site-specific software shall be furnished to the owner on CD ROM disks. The software package shall include all required and necessary programming, graphics, and database software components. It shall support unlimited users with no annual license fees required.

B. Multiple Operating Platforms - The front-end server software furnished as a part of the DDC system shall be capable of operating on multiple operating systems such as Microsoft Windows, Linux, or Sun Solaris.

C. Graphical Programming

1. The system shall be programmed using a graphical programming language for ease of operator understanding.
2. Operating sequences and logic flow shall be assembled in a schematic format using standardized blocks representing inputs, outputs and logical functions such as set points, switches, limits, relays, PIDs etc. The programming software shall be furnished within this scope of work.
3. Full simulation capability shall be provided with the graphic programming. User shall be able to fully simulate the constructed sequence on screen before the sequences are downloaded into the controllers. The system shall also include the ability to simulate multiple graphic programs communicating with each other on a simulated network.

D. Graphical Interface Software

1. System and Equipment Graphic User Interface
   a. The operators interface software shall be graphics based and display in 256 colors at a minimum 1024 x 768-pixel resolution. Graphics display screens shall include a system level graphic of either a map of facilities or an elevation of the building, a graphic of each building floor plan and graphics for each operating system or unit within each building. Entry to the zone and equipment level interface graphics shall be through area maps and/or floor plans to facilitate user orientation. Additionally, the system hierarchy shall be displayed in a fashion similar to Windows Explorer to enable the user to navigate to any graphical screen in the system by expanding building levels or floor levels and selecting a particular zone or system. Graphics shall be accessed by using a mouse or other pointer device. The system shall provide a visual indication of which building, floor and zone the user is accessing at any time. System shall be capable of changing all parameters and schedules, as well as downloading operating software from the same Graphical User Interface software program as that used for viewing system operation.

b. Thermal graphic floor plans shall display each temperature zone in a color appropriate to current space temperature conditions. The system shall display in 8 separate colors the following conditions: High or low temperature alarm, temperature at set point, cooling call, heating call, more than 2° above set point, more than 2° below set point, unoccupied between set points and no communication. Floor plans shall also include color graphic indicators for non-zone-specific mechanical equipment operation showing On/Off and Alarm Conditions. Status indication colors shall be updated dynamically as conditions change.

c. Mechanical equipment pictorial graphics shall be displayed by the use of point-and-shoot selection using a mouse or other pointer device. Graphics shall be provided for all mechanical equipment and devices controlled by the DDC system. These graphics shall provide a current status of all I/O points being controlled and applicable to each piece of equipment including analog readouts in appropriate engineering units at appropriate locations on the graphic representation.

2. Software Graphic Programming Live User Interface

a. The system shall be able to display the graphic displays of system programming, operating logic and logic flow with real time conditions displayed at each input, output and logical function. This display will allow the operator to observe each step of a control logic process and facilitate system software troubleshooting.

b. Operator shall have the ability to select any MircoBlock in the graphical program to change parameters including the ability to lock values.

E. Facility Management and Energy Management Functions

1. The software capability noted below is a minimum requirement.

2. Scheduling.

a. The DDC system shall have the ability to schedule each individual zone, each building or floor or the entire network of buildings for any user with a single entry.

b. Additionally, the operator shall have the capability of assembling groups of zones, buildings or floors for single entry programming, e.g. several offices may be grouped for scheduling of Saturday operations.

c. Available schedule types shall include normal operation, unoccupied operation, setback override and holidays.

d. For maximum flexibility, schedules shall reside in the local control modules. Dated schedules shall be self-managing and automatically deleted after execution.

3. Demand Control – Provide one of the two following capabilities (a or b).

a. The system shall have the ability to receive an analog or digital input of electrical usage/demand through any open input on a general-purpose module. This capability shall be provided without additional hardware except the single input point and digital or analog devices required to read electrical demand levels.

b. The system shall include required demand control hardware and software for monitoring electrical usage and controlling demand. Demand control shall be achieved by adjusting zone temperature set points as electrical demand thresholds are reached. Zone setpoint offset shall be individually adjustable to allow prioritization of zone comfort conditions. Multiple demand level threshold parameters shall be available to allow more aggressive control as building demand rises. Additionally, the demand control strategy shall automatically adjust the demand level thresholds based on ambient temperature to meet peak space conditioning requirements and minimize peak demand during mild temperature months.

c. The system shall be capable of rotating greater or lower demand levels every 10 minutes to alternate zones throughout the facility to minimize long term set point offset.

4. Interactive Operations - The system shall have the ability to send run requests, heating requests and cooling requests from one module to another for the purpose of optimizing run operations of central plant equipment. Additionally, the system shall be capable of limiting operation of various equipment if another mechanical point elsewhere in the system allows that operation.
   a. E.g. a boiler loop circulating pump shall run only when requested by a zone requiring heating operation and will shut down during hours that zone demand is satisfied.
5. Enterprise Integration - The system shall be capable of exchanging web services (via XML/SOAP) information with other Enterprise servers for the purpose of optimizing system operation, e.g. obtaining NOAA Weather Service for optimizing night purge operation, or for the purpose of providing information to other Enterprise servers to optimize other building information systems, e.g. providing maintenance notifications to an Enterprise based facilities maintenance software.
   a. The software to enable this interface shall be provided and fully operational within the scope of this project.

      Or
   b. The Enterprise integration software is to be included within the scope of this project; however, the front-end operating system shall be capable of the addition of this capability without changes to the front end software or server.
6. Energy Reporting Tools.
   a. *Energy Reports*. System shall include an easily configured energy reporting tool that provides the capabilities described in this section.
   b. The energy reporting tool shall be accessible through the same user interface (Web browser or operator workstation software) as is used to manage the BAS.
   c. The energy reporting tool shall be preconfigured by the Contractor to gather and store energy demand and consumption data from each energy source that provides metered data to the BAS. Meter data shall be stored at 5-minute intervals. This data shall be maintained in an industry standard SQL database for a period of not less than five years.
   d. The energy reporting tool shall allow the operator to select an energy source and a time period of interest (day, week, month, year, or date range) and shall provide options to view the data in a table, line graph, bar graph, or pie chart. The tool shall also allow the operator to select two or more data sources and display a comparison of the energy used over this period in any of the listed graph formats, or to total the energy used by the selected sources and display that data in the supported formats.
   e. The energy reporting tool shall allow the operator to select an energy source and two time periods of interest (day, week, month, year, or date range) and display a graph that compares the energy use over the two time periods in any of the graph formats listed in the previous paragraph. The tool shall also allow the operator to select multiple energy sources and display a graph that compares the total energy used by these sources over the two time periods.

f. The energy reporting tool shall allow the operator to easily generate the previously described graphs "on the fly," and shall provide an option to store the report format so the operator can select that format to regenerate the graph at a future date. The tool shall also allow the user to schedule these reports to run on a recurring basis using relative time periods, such as automatically generating a consumption report on the first Monday of each month showing consumption over the previous month. Automatically generated reports shall be archived on the server in a common industry format such as Adobe PDF or Microsoft Excel with copies e-mailed to a user editable list of recipients.
g. The energy reporting tool shall be capable of collecting and displaying data from the following types of meters:
    - Electricity
    - Steam (humidity)
    - Natural Gas
    - Dehumidification
    - Heating and cooling degree days. (May be calculated from sensor data rather than metered.)
h. The user shall have the option of using kW (kWh) or Btu/hr (Btu) as the units for demand and consumption reports. Multiples of these units (MWH, kBtu, etc.) shall be used as appropriate. All selected sources shall be automatically converted to the selected units. The user shall similarly have the option of entering facility area and occupancy hours and creating reports that are normalized on an area basis, an annual use basis, or an occupied hour basis.
i. The user shall have the option of entering benchmark data for an individual facility or a group of facilities.
j. The user shall have the option of displaying any or all of the following data on any chart, line, or bar graph generated by the energy reporting tool:
k. Low / High / Average value of the metered value being displayed.
l. Heating and/or Cooling Degree Days for the time period(s) being displayed.
m. The Environmental Index for the facilities and time periods being displayed.
    - *Environmental Index*. System shall monitor all occupied zones and compile an index that provides a numerical indication of the environmental comfort within the zone. As a minimum, this indication shall be based upon the deviation of the zone temperature from the heating or cooling setpoint. If humidity is being measured within the zone, then the environmental index shall be adjusted to reflect a lower comfort level for high or low humidity levels. Similarly, if carbon dioxide levels are being measured as an indication of ventilation effectiveness, then the environmental index shall be adjusted to indicate degraded comfort at high carbon dioxide levels.
    - Other adjustments may be made to the environmental index based upon additional measurements. The system shall maintain a trend of the environmental index for each zone in the trend log. The system shall also compute an average comfort index for every building included in this contract and maintain trend logs of these building environmental indices. Similarly, the system shall compute the percentage of occupied time that comfortable conditions were maintained within the zones. Through the UI the user shall be able to add a weighting factor to adjust the contribution of each zone to the average index based upon the floor area of the zone, importance of the zone, or other static criteria.

7. Alarms, Trends and Reports
   a. System and Temperature Alarms - The system shall have the capability of monitoring conditions throughout the system and sending alarms or messages to an e-mail address, local PC or printer or to remote PC's, printers or to dial-up pagers. Alarms and messages shall be able to be prioritized for various levels of reporting and action. The operator shall have the ability to customize alarm text and messages.
   b. Trends - The system shall be capable of trending any input or output, or any logical point within the graphic program. There shall be no limitation to the number of points that can be trended at any particular time. Modules shall store in live memory 288 trend samples points for each trended item. The interval between trend samples shall be adjustable from 1 second to 24 hours. Trends from one or more modules shall be able to be simultaneously displayed on a single trend graph. Operator shall be able to "window" any segment of a trend to enlarge the view by dragging a mouse to form the "window". The system shall also have the ability of automatically downloading trend information from any module to the server or other computer connected to the network for historical trend storage. This trend information shall be able to be displayed on the trend graph along with live current trends in seamless fashion. Trend data collection requiring the use of a locally connected PC for data storage is unacceptable.
   c. Reports - The system shall be capable of generating reports of equipment run times, all trended points, temperature conditions, electric demand and usage and alarms or messages. The system shall also have the ability of automatically downloading report information from any module to the server or other computer connected to the network. The operator shall have the ability to create custom reports and logging formats.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Single source responsibility of supplier shall be the complete installation and proper operation of the building automation system and control system and shall include debugging and proper calibration of each component in the entire system.

B. Provide all controllers to accomplish the control sequences specified herein.

C. Provide / coordinate the installation of; sensors, pipe wells, relays and any other devices and materials required to accomplish the functions described herein.

D. Identification - Provide nameplates identifying all switches, lights and starters, and each control device where the control function is not readily apparent.

3.2 SEQUENCES OF OPERATION

A. Energy Management System Point Schedule: Provide monitoring and control functions as listed herein for each piece of equipment listed below. Provide a point list that includes each hard wired, calculated and/or resettable point.

B. Distributed Control – The control system shall observe the concept of distributed control. Modules shall be located at each operating equipment location such that individual systems or zones shall remain functional without communication to other systems on the network.

C. Energy Compliance:

1. Provide 365-day, 24 hour occupancy scheduling.
2. Provide sensors and/or software routines to operate the fan coil units to maintain the minimum night low limit temperature for that system. Operate the fan coil, boiler, pumps, coil valves, etc. as required. Outside air damper to remain closed on night low limit heating.
3. When controlling both heating and cooling (mechanical), provide a 5-degree deadband in which the heating energy provided to the zone is reduced to a minimum.
4. Provide optimum start controls to enable a morning warm-up cycle capable of varying the unit start time to meet occupied setpoint at scheduled time of occupancy.
5. Close outside air dampers as appropriate to the equipment when the units are off and during the warm-up period.

D. Fan Coil Units (Central Station Air Handling Units) /Heat Pumps.

1. Refer to the plans for control drawings.

E. Electric heaters

1. See plans for control drawings.

F. Humidifier

1. See plans for control drawings.

3.3 FIELD QUALITY CONTROL

A. Startup: Implement a logical step-by-step startup and checkout of the control system. In addition, startup assistance and coordination shall be provided during startup of the mechanical equipment. Startup shall be considered complete after the entire system is operating properly.

B. Self-commission all hardware and software provided for the project.

C. Completed field commissioning sheets shall be included with the final “as-built” O&M manuals. These sheets shall include validation check fields for all physical and LAN inputs and outputs and graphics for each operating unit or system within the facility. Each system and point shall be listed, using logical names for future reference by the owner.

D. Commissioning shall include calibration and verification of operation of each I/O and graphic field. Functional commissioning of software programming to meet sequences of operation as submitted and approved shall be verified on the field commissioning sheets.

E. At the completion of the job, in the presence of an Owner's representative, thoroughly check out the entire control system by simulating each control function and determine that the system performs in accordance with the Contract Specifications.

3.4 INSTRUCTION OF OWNER PERSONNEL

A. Provide complete list of system generated messages for system operation, including alarm messages.

B. Modify error message wording as required by the Facility's personnel.

C. Locate all control components for Operating Engineer.

D. The Contractor will videotape the course for the Government for future use/training sessions. Submit an agenda listing topics to be covered during the training along with any literature to be used. Submit information to the Contracting Officer for review/revision one month prior to project substantial completion and scheduling of the training course.

3.5 TRAINING AND TECHNICAL SUPPORT

A. Provide: 4 hours of training on the specific building controls

B. Training shall be oriented to make the owner proficient in the day-to-day use and operation of the DDC system. Additionally, the training shall include information specifically focused on showing the owner’s representative’s methods for troubleshooting the mechanical systems using the DDC system.

C. The contractor shall provide unlimited phone technical support to the owner’s representative during the one-year warranty period. If the technical support location of the contractor is outside of the toll-free calling area for the customer, the contractor shall have a toll free number or accept collect calls for the purpose of providing technical support.

D. In addition to required technical support and training Contractor shall make available access to factory approved training classes.

E. Classes shall be scheduled multiple times during the first year to allow flexibility for Owner’s representative to attend. Tuition for these classes shall be included within the scope of this project. If course locations are more than 200 miles from the project site, cost of transportation, lodging and meals shall be included within the scope of this project.

3.6 RECORD DRAWINGS

A. Provide complete and accurate record drawings noting all deviations from the information furnished in the original submittals.

END OF SECTION

SECTION 23 11 23

FACILITY NATURAL GAS PIPING

PART 1 – GENERAL

1.1 DESCRIPTION

A. Fuel gas systems, including piping, equipment and all necessary accessories as designated in this section.

1.2 RELATED WORK

A. Section 01

B. Section 23

1.3 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications.

B. American Society of Mechanical Engineers (ASME):

B16.3-2019 ..... Malleable Iron Threaded Fittings: Classes 150 and 300
B16.9-2018 ..... Factory Made Wrought Buttwelding Fittings
B16.11-2011 ..... Forged Fittings, Socket-Welding and Threaded
B16.15-2018 ..... Cast Copper Alloy Threaded Fittings: Classes 125 and 250
B16.40-2019 ..... Manually Operated Thermoplastic Gas Shutoffs and Valves in Distribution Systems
B31.8-2018 ..... Gas Transmission and Distribution Piping Systems

C. American Society for Testing and Materials (ASTM):

A47/A47M-2018 ..... Standard Specification for Ferritic Malleable Iron Castings
A53/A53M-2018 ..... Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
A536-2019 ..... Standard Specification for Ductile Iron Castings
A733-2016 ..... Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless-Steel Pipe Nipples
B43-2015 ..... Standard Specification for Seamless Red Brass Pipe, Standard Sizes
B687-2016 ..... Standard Specification for Brass, Copper, and Chromium-Plated Pipe Nipples
D2513-2019 ..... Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings

D2683-2014.....Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
D3261-2016.....Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing

D. American Water Works Association (AWWA):

C203-2015.....Coal-Tar Protective Coatings and Linings for Steel Water Pipes

E. International Code Council (ICC):

IFGC-2018 .....International Fuel Gas Code
IPC-2018 .....International Plumbing Code

F. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS):

SP-72-2010a.....Ball Valves with Flanged or Butt-Welding for General Service
SP-110-2010.....Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

G. NACE International (NACE):

SP0274-2011 .....High-Voltage Electrical Inspection of Pipeline Coatings
SP0490-2007 .....Holiday Detection of Fusion-Bonded Epoxy External Pipeline Coating of 250 to 760 µm (10 to 30 mil)

H. National Fire Protection Association (NFPA):

54-2018.....National Fuel Gas Code

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, Submittal Procedures.

B. Information and material submitted under this section shall be marked “SUBMITTED UNDER SECTION 23 11 23, FACILITY NATURAL-GAS PIPING”, with applicable paragraph identification.

C. Manufacturer's Literature and Data including full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.

1. Pipe & Fittings.
2. Valves.
3. Strainers.
4. All items listed in Part 2 - Products.

D. Detailed shop drawing of clamping device and extensions when required in connection with the waterproofing membrane.

E. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:

1. Include complete list indicating all components of the systems.
2. Include complete diagrams of the internal wiring for each item of equipment.
3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

F. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion.

G. Submit training plans and instructor qualifications in accordance with the requirements of Section.

1.5 AS-BUILT DOCUMENTATION

A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.

B. Submit operation and maintenance data updated to include submittal review comments. Owner approved substitutions and construction revisions shall be in electronic version on CD or DVD inserted into a three-ring binder. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement. Provide record drawings as follows:

1. Red-lined, hand-marked drawings are to be provided, with one paper copy and a scanned PDF version of the hand-marked drawings provided on USB Thumb Drive.

D. The as-built drawings shall indicate the location and type of all lockout/tagout points for all energy sources for all equipment and pumps to include breaker location and numbers, valve tag numbers, etc.

E. Certification documentation shall be provided to the Contracting Officer twenty-one (21) working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results shall contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results shall include all readings, including but not limited to data on device (make, model and performance characteristics), normal pressures, switch ranges, trip points, amp readings, and calibration data to include equipment serial numbers or individual identifications, etc.

1.6 SYSTEM PRESSURE

A. Natural gas systems are designed and materials and equipment selected to prevent failure under gas pressure of 11 psig at downstream side of pressure regulator.

PART 2 - PRODUCTS

2.1 FUEL GAS SERVICE CONNECTIONS TO BUILDING

A. From inside face of exterior wall to a distance of approximately 5 feet outside of building.

B. Pipe: Black steel, ASTM A53/A53M, Schedule 40. Shop-applied pipe coating shall be one of the following types:

1. Coal Tar Enamel Coating: Exterior of pipe and fittings shall be cleaned, primed with Type B primer and coated with hot-applied coal tar enamel with bonded layer of felt wrap in accordance with AWWA C203. Asbestos felt shall not be used; felt material shall be fibrous glass mat in accordance with AWWA C203.

C. Holiday Inspections: Procedure for holiday inspection: Holiday Inspection shall be conducted on all coatings to determine the presence and number of discontinuities in those coatings using a Tinker & Rasor model AP/W Holiday Detector or equal. Holiday inspection shall be performed in a manner spelled out in the Tinker & Rasor operating instructions and at a voltage level recommended by the coating manufacturer or applicable NACE standard such as SP0274 or SP0490 in the case thermosetting epoxy coating. Holiday Detectors shall be calibrated and supplied with a certificate of calibration from the factory.

1. A calibration of the Holiday Detector shall be performed once every 6 months to verify output voltages are true and correct.

D. Steel Fittings:

1. Butt weld fittings, wrought steel, ASME B16.9.
2. Socket weld and threaded fittings forged steel, ASME B16.11.
3. Grooved End: Ductile iron (ASTM A536, Grade 65-45-12), malleable iron (ASTM A47/A47M, Grade 32510), or steel (ASTM A53/A53M, Type F or Type E or S, Grade B).Steel Joints: Welded, ASME B31.8.

2.2 FUEL GAS PIPING ABOVE GROUND

A. Pipe: Black steel, ASTM A53/A53M, Schedule 40.

B. Nipples: Steel, ASTM A733, Schedule 40.

C. Fittings:

1. Sizes 50 mm (2 inch) under ASME B16.3 threaded malleable iron.
2. Over 50 mm (2 inch) and up to 100 mm (4 inch) ASME B16.11 socket welded.
3. Over 100 mm (4 inch) ASME B16.9 butt welded.

D. Joints: Provide welded or threaded joints.

E. Threaded Metallic Joints: Threaded joints in metallic pipe shall have tapered threads evenly cut. Metal screwed pipe joints shall be made leak-tight by applying Rector Seal No. 5 pipe thread sealant to all threaded joints. Care must be taken to prevent the pipe dope compound from getting inside the internal pipeline. Teflon tape type sealant is prohibited.

2.3 VALVES

A. Ball Valve: Bronze body, rated for 1034 kPa at 185 degrees C (150 psig at 365 degrees F), 1723 kPa at 121 degrees C (250 psig at 250 degrees F), reinforced TFE seat, stem seal and thrust washer; end entry, threaded ends, UL-listed for natural or LP gas shut off service when used on those services.

B. Gas Vent Cocks: Type 701: Bronze body, tee handle, rated for 207 kPa at 38 degrees C (30 psig at 100 degrees F), ground plug, rated for tight shut-off on fuel gas service.

2.4 STRAINERS

A. Provide on high pressure side of pressure reducing valves, on inlet side of indicating and control instruments and equipment subject to sediment damage and where shown on drawings. Strainer element shall be removable without disconnection of piping.

B. Gas Lines: "Y" type with removable mesh lined brass strainer sleeve.

C. Body: Smaller than 75 mm (3 inches), brass or bronze; 75 mm (3 inches) and larger, cast iron or semi-steel.

2.5 DIELECTRIC FITTINGS

A. Provide dielectric couplings or unions between ferrous and non-ferrous pipe.

2.6 GAS EQUIPMENT CONNECTORS

A. Flexible connectors with Teflon core, interlocked galvanized steel protective casing, AGA certified design.

2.7 FUEL GAS PIPING BELOW GROUND

A. Thermoplastic (Polyethylene - PE): PE pipe and heat fusion fittings shall conform to ASTM D2513, SDR 11 and manufactured for 861 kPa (125 psig) working pressure. Pipe and fittings shall have heat fusion joints PE pipe and fitting materials for heat fusion shall be compatible to ensure uniform melting and a proper bond.

B. Fittings:

1. Socket Fusion Fittings: ASTM D2683.
2. Butt Fusion Fittings: ASTM D3261, molded and matching pipe dimensions.

C. Risers: Manufacturer's standard anode-less type riser, transition from plastic to steel pipe with fusion bonded epoxy coating. Inlet connection socket or butt weld or swaged gas-tight construction with O-ring seals, metal insert, and protective sleeve. Outlet or above ground connection end shall be threaded or flanged. Riser shall comply with ASTM A53/A53M, Type F and E, Grade A, Schedule 40.

D. Polyethylene ball valves, ASME B16.40 shall be manufactured and rated for underground gas service. Operating pressure to 861 kPa (125 psig) (SDR 9.3). Valve shall be maintenance and corrosion free. Polyethylene valves shall be full port opening type. Valves shall be wrench operated. Wrench operated valves shall have a 50 mm (2 inch) square adaptor securely fastened to the valve stem. Polyethylene valves shall be installed by butt fusion method.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Comply with the ICC IFGC, ICC IPC and the following:

1. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe, shall be reamed to full size after cutting.
2. All pipe runs shall be laid out to avoid interference with other work.
3. Install valves with stem in horizontal position whenever possible. All valves shall be easily accessible.
4. Install union and shut-off valve on pressure piping at connections to equipment.
5. Pipe Hangers, Supports and Accessories:
   a. All piping shall be supported per the ICC IFGC.
   b. Shop Painting and Plating: Hangers, supports, rods, inserts and accessories used for Pipe supports shall be shop coated with red lead or zinc Chromate primer paint. Electroplated copper hanger rods, hangers and accessories may be used with copper tubing.

c. Floor, Wall and Ceiling Plates, Supports, Hangers:
   1) Solid or split un-plated cast iron, chrome plated in finished areas.
   2) All plates shall be provided with set screws.
   3) Pipe Hangers: Height adjustable clevis type.
   4) Adjustable Floor Rests and Base Flanges: Steel.
   5) Concrete Inserts: "Universal" or continuous slotted type.
   6) Hanger Rods: Mild, low carbon steel, fully threaded or Threaded at each end with two removable nuts at each end for positioning rod and hanger and locking each in place.
   7) Riser Clamps: Malleable iron or steel.
   8) Rollers: Cast iron.
   9) Self-drilling type expansion shields shall be "Phillips" type, with case hardened steel expander plugs.
   10) Miscellaneous Materials: As specified, required, directed or as noted on the drawings for proper installation of hangers, supports and accessories.

6. Install cast chrome plated escutcheon with set screw at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.
7. Penetrations:
   a. Fire Stopping: Where pipes pass through fire partitions, fire walls, smoke partitions, or floors, install a fire stop that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING. Completely fill and seal clearances between piping and openings with the fire stopping materials.
   b. Waterproofing: At floor penetrations, completely seal clearances around the pipe and make watertight with sealant as specified in Section 07 90 00, JOINT SEALANTS.

B. Fuel gas piping shall conform to the following:

1. Entire fuel gas piping installation shall be in accordance with requirements of NFPA 54.
2. Provide fuel gas piping with plugged drip pockets at low points.
3. Seismic Data: Refer to Section 23 05 48 - Vibration Seismic Controls HVAC Piping Equip Install automatic shutoff valve (earthquake valve) on discharge side of meter. Valve shall positively shut off supply of gas in case of pressure failure, remain shut off until manually reopened, and be provided with outside adjustment for reset.

C. If an installation is unsatisfactory to the Owner, the Contractor shall correct the installation at no additional cost or time.

3.2 CLEANING OF SYSTEM AFTER INSTALLATION

A. Clean all piping systems to remove all dirt, coatings and debris.

3.3 TESTS

A. General: Test system either in its entirety or in sections after system is installed or cleaned.

B. Test shall be made in accordance with Section 406 of the International Fuel Gas Code. The system shall be tested at a minimum of 1.5 times maximum working pressure, but not less than 3 psig (21 kPa) gauge).

C. System Purging: After completing pressure tests, and before testing a gas-contaminated line, purge line with nitrogen at junction with main line to remove all air and gas. Clear completed line by attaching a test pilot fixture at capped stub-in line at building location and let gas flow until test pilot ignites. Procedures shall conform to NFPA 54 and ASME B31.8.

3.4 STARTUP AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.

B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.

END OF SECTION

SECTION 23 21 13

HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes pipe and fitting materials and joining methods for the following:

1. Hot-water heating piping

2. Chilled water piping

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Chemical treatment.
2. Temperature Treatment.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Welding certificates.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

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

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

1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type.

B. 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; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.

C. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

D. Exterior below ground piping shell be High Density Polyethylene (HDPE) with the properties as listed below.

1. Pipe and fittings are manufactured from polyethylene and fabricated to Standard Dimension Ratio (SDR) wall thickness.
   a. HDPE carrier pipe materials & properties:
   b. Std. Spec. for Polyethylene Plastic Pipe (SDR-PR) based on OD.ASTM F-714
   c. Resin Type III, Grade P34, Cat. 5, CL C ASTM D-3350
   d. Long Term Hydrostatic Strength 1600 psi ASTM D-2837
   e. Std. PE for Water Distribution 4”-63” AWWA C-906
2. Insulation: The insulation shall be a foamed in place closed cell polyurethane which completely fills the annular space between the carrier pipe and the exterior casing. The insulation shall have the following physical properties:
   a. Minimum Density (lb. /cu. ft.) 2.0 ASTM D-1621
   b. 90-95 % Closed Cell ASTM D-2856
   c. “K” Factor BTU/Hr. sq. ft. °F/in . . . . 147 ASTM C-177
   d. Maximum operating temperature shall not exceed 75° F.
   e.
3. Exterior Casing: The casing shall be High Density Polyethylene (HDPE) with the following properties:
   a. Resin Type III, Grade P34 ASTM D-3350
   b. Tensile Yield Strength 3300 psi ASTM D-638
   c. Ultimate Elongation 850% (min) ASTM D-638
   d. Tangent Flexural Modules 175,000 psi ASTM D-790
4. Sub-Assemblies: All fittings shall be HDPE, factory insulated and fusion welded to the HDPE service pipe and sealed to the outer jacket. Field installed fittings are insulated and sealed with Tricon supplied insulation kits.
5. Field Joints: After thermal butt fusion welding and hydrostatic testing of the carrier pipe, HDPE jacketed straight field joints shall be insulated with polyurethane foam half-shells to the thickness specified, and sealed water-tight with a heat-shrink sleeve.

2.3 JOINING MATERIALS

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

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.
   a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
   b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

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

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

D. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 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. Description:
   a. Standard: ASSE 1079.
   b. Pressure Rating: 250 psig.
   c. End Connections: Solder-joint copper alloy and threaded ferrous.

2.5 BYPASS CHEMICAL FEEDER

A. Description: Welded steel construction; 125-psig working pressure; 5-gal. capacity; with fill funnel and inlet, outlet, and drain valves.

1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Chilled-water cooling piping, aboveground, NPS 1 and smaller, shall be any of the following:
   1. Schedule 40, Grade B, Type 96 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

B. Chilled-water cooling piping, aboveground, NPS 3/4 and larger, shall be any of the following:
   1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

3.2 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

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

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20) 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 branch connections to mains using mechanically formed tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install valves according to Section 23 05 23 "General-Duty Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 (DN 65) and larger, at final connections of equipment and elsewhere as indicated.

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

T. Comply with requirements in Section 23 05 53 "Identification for HVAC Piping and Equipment" for identifying piping.

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

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

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

3.3 DIELECTRIC FITTING INSTALLATION

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

B. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric unions.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flanges.

3.4 HANGERS AND SUPPORTS

A. Comply with requirements in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.

B. Comply with requirements in Section 23 05 48 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4 (DN 20): Maximum span, 7 feet.
2. NPS 1 (DN 25): Maximum span, 7 feet.
3. NPS 1-1/2 (DN 40): Maximum span, 9 feet.
4. NPS 2 (DN 50): Maximum span, 10 feet.
5. NPS 2-1/2 (DN 65): Maximum span, 11 feet.
6. NPS 3 (DN 80) and Larger: Maximum span, 12 feet.

E. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4 (DN 20): Maximum span, 5 feet; minimum rod size, 1/4 inch.
2. NPS 1 (DN 25): Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/4 (DN 32:)Maximum span, 7 feet; minimum rod size, 3/8 inch.
4. NPS 1-1/2 (DN 40): Maximum span, 8 feet; minimum rod size, 3/8 inch.
5. NPS 2 (DN 50): Maximum span, 8 feet; minimum rod size, 3/8 inch.
6. NPS 2-1/2 (DN 65): Maximum span, 9 feet; minimum rod size, 3/8 inch.
7. NPS 3 (DN 80) and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.

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

3.5 PIPE JOINT CONSTRUCTION

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

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

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

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

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

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

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

3.6 HDPE PIPING INSTALLATION:

A. No Piping shall be installed in standing water. Trenches shall be maintained dry until final field closure is complete. The installing contractor shall handle the piping system in accordance with the directions furnished by the manufacturer and as approved by the Contracting Officer. The carrier piping shall be hydrostatically tested to 1-1/2 times the operating pressure, or as specified in the contract documents. The test shall be maintained for a minimum time of 1 hour. EXERCISE DUE CARE IN INSTALLING AND TESTING THE PIPING SYSTEM.

B. Backfill: A 4-inch layer of sand or fine gravel shall be placed and tamped in the trench to provide stable and uniform bedding for the piping system. Once the system is in place, the trenches shall be carefully backfilled and hand tamped in 6” layers until a cover of at least 24” from the top of the pipe has been achieved. The first 12” of backfill shall be sand or fine gravel less than ½” in diameter. The remainder of the backfill shall be void of rocks, frozen earth and foreign material over 2” in diameter. The trench shall be compacted to 95% compaction.

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 ports for pressure gages and thermometers at coil inlet and outlet connections.

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.

B. Install bypass chemical feeders in each hydronic system where indicated.

1. Install in upright position with top of funnel not more than 48 inches above the floor.
2. Install feeder in minimum NPS 3/4 (DN 20) bypass line, from main with full-size, full-port, ball valve in the main between bypass connections.
3. Install NPS 3/4 (DN 20) pipe from chemical feeder drain to nearest equipment drain and include a full-size, full-port, ball valve.

C. Add initial chemical treatment and maintain existing water quality for the first 3 months of operation.

END OF SECTION

SECTION 23 21 16

HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Hydronic specialty valves.
2. Air-control devices.
3. Strainers.
4. Connectors.

B. Related Requirements:

1. Section 23 05 23 - General Duty Valves for HVAC Piping for Specification and Installation Requirements for Valves Common to most piping systems.
2. Section 23 09 23 – Direct Digital Control System for HVAC.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product:

1. Include construction details and material descriptions for hydronic piping specialties.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

1.4 CLOSEOUT SUBMITTALS

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

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.6 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

B. Safety Valves and Pressure Vessels: Shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 HYDRONIC SPECIALTY VALVES

A. Bronze or Brass, Calibrated-Orifice, Balancing Valves:
   1. Body: Bronze or brass, ball or plug type with calibrated orifice or venturi.
   2. Ball: Brass or stainless steel.
   3. Plug: Resin.
   4. Seat: PTFE.
   5. End Connections: Threaded or socket.
   6. Pressure Gage Connections: Integral seals for portable differential pressure meter.
   7. Handle Style: Lever, with memory stop to retain set position.
   8. CWP Rating: Minimum 125 psig (860 kPa).
   9. Maximum Operating Temperature: 250 deg F (121 deg C).

B. Automatic Flow-Control Valves:
   1. Body: Brass or ferrous metal.
   2. Flow Control Assembly: Mesurflo® elastomeric diaphragm and polyphenylsulfone orifice plate, within 2- to 80-psig differential pressure operating ranges. The corrosion-resistant, tamper-proof, self-cleaning, and removable flow control assembly device shall be warranted for the life of the HVAC system in which it was originally installed, provided only water-based hydronic fluids are used at usual HVAC temperatures and installed according to product installation and operation specifications.
   3. Combination Assemblies: Include bronze or brass-alloy ball valve.
   4. Identification Tag: Marked with zone identification, valve number, and flow rate.
   5. Size: Same as pipe in which installed.
   6. Performance: Maintain constant flow at a minimum of plus or minus 10 percent, of system pressure fluctuations.
   7. Minimum CWP Rating: 400 psig.
   8. Maximum Operating Temperature: 225 deg F.

2.2 AIR-CONTROL DEVICES

A. Manual Air Vents:
   1. Body: Bronze or brass.
   2. Internal Parts: Nonferrous.
   3. Operator: Wrench or thumbscrew.
   4. Inlet Connection: NPS 1/2 (DN 15).
   5. Discharge Connection: NPS 1/8 (DN 6).
   6. CWP Rating: 150 psig.
   7. Maximum Operating Temperature: 225 deg F.

B. Automatic Air Vents:
   1. Body: Bronze or cast iron.
   2. Internal Parts: Nonferrous.
   3. Operator: Noncorrosive metal float.
   4. Inlet Connection: NPS 1/2 (DN 15).
   5. Discharge Connection: NPS 1/4 (DN 8).
   6. CWP Rating: 150 psig.
   7. Maximum Operating Temperature: 240 deg F.

2.3 STRAINERS

A. Y-Pattern Strainers:
   1. Body: Brass or ASTM A 126, Class B, with bolted cover and bottom drain connection.
   2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
   3. Strainer Screen: Stainless-steel, 20-mesh strainer, or perforated stainless-steel basket.
   4. CWP Rating: 125 psig.

2.4 CONNECTORS

A. Spherical, Rubber, Flexible Connectors:

   1. Body: Fiber-reinforced rubber body.
   2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
   3. Performance: Capable of misalignment.
   4. CWP Rating: 150 psig (1035 kPa).
   5. Maximum Operating Temperature: 250 deg F (121 deg C).

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.

B. Install automatic flow control valves at each branch connection to return main.

C. Install automatic flow control 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; 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.

3.2 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

END OF SECTION

SECTION 23 21 23

HYDRONIC PUMPS

PART 1 – GENERAL

1.1 DESCRIPTION

A. Capacity: Liters per second (L/s) (Gallons per minute (gpm) of the fluid pumped. Hydronic pumps for Heating, Ventilating and Air Conditioning.

B. Definitions:

1. Capacity: Liters per second (L/s) (Gallons per minute (gpm) of the fluid pumped.
2. Head: Total dynamic head in kPa (feet) of the fluid pumped.
3. Flat head-capacity curve: Where the shutoff head is less than 1.16 times the head at the best efficiency point.

C. A complete listing of common acronyms and abbreviations are included in Section 23 05 00 – Common Work Results for HVAC.

1.2 RELATED WORK

A. Section 01 33 2 – Submittal Procedures.

B. Section 01 91 13 – General Commissioning Requirements.

C. Section 23 05 00 – Common Work Results for HVAC.

D. Section 23 05 48 – Vibration & Seismic Controls for HVAC Piping & Equipment.

E. Section 23 05 93 – Testing, Adjusting, & Balancing.

F. Section 23 08 00 – Commissioning of HVAC Systems.

G. Section 23 21 13 – Hydronic Piping.

1.3 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standard will govern.

B. American Society of Mechanical Engineers (ASME):

1. B16.1-2015 Cast Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250

C. American Society for Testing and Materials (ASTM):

1. A48/48M – 2003(R2016) Standard Specification for Gray Iron Castings
2. B62-2017 – Standard Specification for Composition Bronze or Ounce Metal Castings

1.4 SUBMITTALS

A. Submittals, including the number of required copies, shall be submitted in accordance with Section 01 33 23 - Submittal Procedures.

B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 23 21 23 - HYDRONIC PUMPS" with applicable paragraph identification.

C. Manufacturer's Literature and Data including the following: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.

1. Pumps and accessories.
2. Motors and drives.
3. Variable speed motor controllers.

D. Characteristic Curves: Head-capacity, efficiency-capacity, brake horsepower-capacity, and NPSHR-capacity for each pump and for combined pumps in parallel or series service. Identify pump and show fluid pumped, specific gravity, pump speed and curves plotted from zero flow to maximum for the impeller being furnished and at least the maximum diameter impeller that can be used with the casing.

E. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:

1. Include complete list indicating all components of the systems.
2. Include complete diagrams of the internal wiring for each item of equipment.
3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

F. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00 – Commissioning of HVAC Systems.

G. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00 – Commissioning of HVAC Systems.

1.5 QUALITY ASSURANCE

A. Design Criteria:

1. Pumps design and manufacturer shall conform to Hydraulic Institute Standards.
2. Pump sizes, capacities, pressures, operating characteristics and efficiency shall be as scheduled.

3. Head-capacity curves shall slope up to maximum head at shut-off. Curves shall be relatively flat for closed systems. Select pumps near the midrange of the curve, so the design capacity falls to the left of the best efficiency point, to allow a cushion for the usual drift to the right in operation, without approaching the pump curve end point and possible cavitation and unstable operation. Select pumps for open systems so that required net positive suction head (NPSHR) does not exceed the net positive head available (NPSHA).
4. Pump Driver: Furnish with pump. Size shall be non-overloading at any point on the head-capacity curve, including in a parallel or series pumping installation with one pump in operation.
5. Provide all pumps with motors, impellers, drive assemblies, bearings, coupling guard and other accessories specified. Statically and dynamically balance all rotating parts.
6. Furnish each pump and motor with a nameplate giving the manufacturers name, serial number of pump, capacity in gpm and head in feet at design condition, horsepower, voltage, frequency, speed and full load current and motor efficiency.
7. Test all pumps before shipment. The manufacturer shall certify all pump ratings.
8. After completion of balancing, provide replacement of impellers or trim impellers to provide specified flow at actual pumping head, as installed.

B. Allowable Vibration Tolerance for Pump Units: Section 23 05 48, Vibration & Seismic Controls for HVAC Piping & Equipment.

1.6 AS-BUILT DOCUMENTATION

A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.

B. Submit operation and maintenance data updated to include submittal review comments, approved substitutions and construction revisions shall be in electronic version on USB inserted into a three ring binder. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement. Provide record drawings as follows:

1. Red-lined, hand-marked drawings are to be provided, with one paper copy and a scanned PDF version of the hand-marked drawings provided on USB.
2. As indicated in Division 01.

D. The as-built drawings shall indicate the location and type of all lockout/tagout points for all energy sources for all equipment and pumps to include breaker location and numbers, valve tag numbers, etc. Coordinate lockout/tagout procedures and practices with local Park requirements.

E. Certification documentation shall be provided to Contracting Officer twenty-one (21) working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results shall contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results shall include all readings, including but not limited to data on device (make, model and performance characteristics), normal pressures, switch ranges, trip points, amp readings, and calibration data to include equipment serial numbers or individual identifications, etc.

1.7 SPARE MATERIALS

A. Furnish one spare seal and casing gasket for each pump to the Contracting Officer.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Hydronic pumps used for heating and air conditioning applications are defined by the type of impeller, number of impellers, type of casing, method of connection to the driver, and mounting position. Provide centrifugal water pumps of the types split coupled end-suction pump w/ NEMA standard m fittings. Use an electric motor driving unit for each pump as indicated and specified.

1. Selection Criteria Select pumps at a point within the maximum efficiency for a given impeller casing combination. Deviations within 3 percent of maximum efficiency are permissible, provided the lesser efficiency is not less than the scheduled efficiency in the construction design documents. Pumps having impeller diameters larger or smaller than manufacturer's published maximum and minimum impeller diameters for a given impeller casing combination will be rejected. Pump performance data, as shown in performance curves, must be based on factory tests using precision instrumentation and exacting procedures as detailed in HI ANSI/HI 14.6.
2. System Coordination Submit drawings containing complete wiring and piping schematic diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Show the proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation. Provide a complete listing of equipment, materials and miscellaneous components including mechanical seals, bearings, and couplings.
3. Safety Requirements Fully enclose or guard couplings, projecting set-screws, keys, and other rotating parts, that pose an entangling hazards.

2.2 MATERIALS AND EQUIPMENT

A. Nameplates Securely affix a standard nameplate to pumps and motors in a conspicuous place showing the manufacturer's name, address, type or style, model, serial number, and catalog number. In addition, for each pump show the capacity in L/second gpm at rated speed in rpm and total head in mm feet of water. For each electric motor show at least the minimum information required by NEMA MG 1. Show such other information as the manufacturer may consider necessary to complete identification on the nameplate. Pumps must be listed and labeled by UL, and comply with UL 778 for pumps not using universal motors rated more than 250 volts such as circulating pumps.

B. Framed Instructions Submit proposed diagrams, instructions, and other sheets, prior to posting. Post approved wiring and control diagrams showing the complete layout of the entire system, including equipment, piping valves, and control sequence, framed under glass or in approved laminated plastic, where directed. Provide condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system, framed as specified above for the wiring and control diagrams, and posted beside the diagrams. Post the framed instructions before acceptance testing of the systems.

C. Pump Characteristic

1. Construct hydronic water pumps in accordance with HI 1.1-1.2 and HI ANSI/HI 2.1-2.2. The pumps must be capable of discharging quantities at total discharge heads measured at the discharge flange, between the following limits: Operate pumps at optimum efficiencies to produce the most economical pumping system under the conditions encountered. Pumps must furnish not less than 150 percent of rated capacity at a total discharge head of not less than 65 percent of total rated head. The shutoff total head must not be greater than 120 percent of total rated head. Operate pumps at specified system fluid temperatures without vapor binding and cavitation. Operate pumps to HI ANSI/HI 9.6.3 standard for Preferred Operating Region (POR).
2. Pump Drivers: Provide electric motors as indicated for each pump.
3. Equipment Data: Submit manufacturer's descriptive data and technical literature, performance charts and curves for all impeller sizes for a given casing, catalog cuts, and installation instructions. Provide spare parts data for each different item of material and equipment specified, after approval of the detail drawings and not later than 2 months prior to the date of beneficial occupancy. Include a complete list of parts and supplies, with current unit prices and local source of supply with contact information. Submit catalog information, certified pumps curves, rated capacities, final impeller dimensions, and accessories provided for the product indicated. Indicate operating point of each pump on curves. Furnish pump curves for each pump and combination of pumps designed to operate in parallel. The pump curve must show as a minimum; bhp, flow, total dynamic head, efficiency, NPSH, impeller diameter and system curve (individually and in combination for each pump operating in a parallel application). Select pumps operating in parallel operation to cross the system curve when operating individually.

2.3 HYDRONIC PUMPS

A. Provide centrifugal, single-stage type, designed for HVAC service in the following configurations:

1. Configuration Pump No. End Suction P-1A P-1B,1-BP Base-Mounted, Horizontally
2. Configuration Pump No. End Suction P-2A P-2B,2-BP Base-Mounted, Horizontally
3. In line pump No. In line P-3, P-4.
4. The three piece pump must be composed of three separable components a motor, bearing assembly, and cast iron (wet end). The motor shaft must be connected to the pump shaft via a replaceable flexible coupler

B. Provide pumps with capacities as indicated, suitable for 200 degrees F operation working pressure per engineering and design plans. The pump must be single stage, The pump must have a solid steel shaft with a coupler between the pump and motor shafts. For non-stainless-steel shafts, employ a non-ferrous shaft sleeve to completely cover the wetted area under the seal.

1. Bearing The bearing assembly must house maintenance-free permanently lubricated bearings.
2. Seal Assembly Equip the pump with an internal self-flushing mechanical seal assembly. Seal assembly must have Buna bellows and seat gasket, stainless steel spring, and be of a carbon ceramic design with the carbon face rotating against a stationary ceramic face.
3. Impeller Provide impeller of cast bronze or brass material. Impeller must be hydraulically and dynamically balanced to HI 9.6.4 balance grade G6.3, keyed to the shaft and secured by a locking capscrew or nut.
4. Volute Pump volute must be of cast iron. The connection style on cast iron pumps must be flanged. SECTION 23 21 23
5. Motor Mount To ensure alignment, mount the motor to the bearing assembly via a bolted motor bracket assembly. Use a replaceable resilient rubber motor mount to assist in aligning the motor shaft with the pump shaft.
6. Motors NEMA MG 1; premium efficiency; non-overloading at any point on the pump curve; maintenance free with permanently lubricated bearings; and resilient mounted for smaller sizes, rigid mounted otherwise.

PART 3 - EXECUTION

3.1 INSTALLATION

A. If an installation is unsatisfactory to the Contracting Officer, the Contractor shall correct the installation at no additional cost or time to the Government.

B. Follow manufacturer's written instructions for pump mounting and startup. Access/Service space around pumps shall not be less than minimum space recommended by pumps manufacturer.

C. Provide drains for bases and seals for base mounted pumps, piped to and discharging into floor drains.

D. Coordinate location of thermometer and pressure gauges as per Section 23 21 13, Hydronic Piping.

3.2 STARTUP AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.

B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.

C. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with Contracting Officer and Commissioning Agent. Provide a minimum notice of ten (10) working days prior to startup and testing.

D. Verify that the piping system has been flushed, cleaned and filled.

E. Lubricate pumps before startup.

F. Prime the pump, vent all air from the casing and verify that the rotation is correct. To avoid damage to mechanical seals, never start or run the pump in dry condition.

G. Verify that correct size heaters-motor over-load devices are installed for each pump controller unit.

H. Field modifications to the bearings and or impeller (including trimming) are prohibited. If the pump does not meet the specified vibration tolerance send the pump back to the manufacturer for a replacement pump. All modifications to the pump shall be performed at the factory.

I. Ensure the disposable strainer is free of debris prior to testing and balancing of the hydronic system.

J. After several days of operation, replace the disposable startup strainer with a regular strainer in the suction diffuser.

3.3 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, Commissioning of HVAC Systems.

B. Components provided under this section of the specification will be tested as part of a larger system.

3.4 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for 4 hours to instruct each personnel responsible in operation and maintenance of the system.

B. Submit training plans and instructor qualifications to the Contracting Officer in accordance with the requirements of Section 23 08 00, Commissioning of HVAC Systems.

END OF SECTION

SECTION 23 25 00

HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies cleaning and treatment of circulating HVAC water systems, including the following.

1. Cleaning compounds.
2. Chemical treatment for closed loop chilled water transfer systems.
3. Glycol-water chilled transfer systems.

1.2 RELATED WORK

A. Section 01 33 23, Submittal Procedures.

B. Section 23 05 00, Common Work Results for HVAC.

C. Section 23 09 23, Direct-Digital Control Systems for HVAC.

D. Section 23 21 13, Hydronic Piping.

1.3 QUALITY ASSURANCE

A. Refer to paragraph, “Quality Assurance” in Section 23 05 00 - Common Work Results for HVAC.

B. Technical Services: Provide the services of an experienced water treatment chemical engineer or technical representative to direct flushing, cleaning, pre-treatment, training, debugging, and acceptance testing operations; direct and perform chemical limit control during construction period and monitor systems for a period of 12 months after acceptance, including not less than 6 service calls and written status reports. Emergency calls are not included. During this period. These tests shall be conducted in a certified laboratory and not by a technician in the field. Minimum service during construction/start-up shall be 6 hours.

C. Chemicals: Chemicals shall be non-toxic approved by local authorities and meeting applicable EPA requirements.

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 23 – Submittal Procedures.

B. Manufacturer's Literature and Data including:

1. Cleaning compounds and recommended procedures for their use.

2. Chemical treatment for closed systems, including installation and operating instructions.
3. Chemical treatment for open loop systems, including installation and operating instructions.
4. Glycol-water system materials, equipment, and installation.

C. Water analysis verification.

D. Materials Safety Data Sheet for all proposed chemical compounds, based on U.S. Department of Labor Form No. L5B-005-4.

E. Maintenance and operating instructions.

1.5 APPLICABLE PUBLICATIONS

A. The publication listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

B. National Fire Protection Association (NFPA):

1. 70-2020 - National Electric Code (NEC)

C. American Society for Testing and Materials (ASTM):

1. F441/F441M-20 - Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80

PART 2 - PRODUCTS

2.1 CLEANING COMPOUNDS

A. Alkaline phosphate or non-phosphate detergent/surfactant/specific to remove organic soil, hydrocarbons, flux, pipe mill varnish, pipe compounds, iron oxide, and like deleterious substances, with or without inhibitor, suitable for system wetted metals without deleterious effects.

B. All chemicals to be acceptable for discharge to sanitary sewer.

C. Refer to Section 23 21 13 – “Hydronic Piping” for flushing and cleaning procedures.

2.2 CHEMICAL TREATMENT FOR CLOSED LOOP SYSTEMS

A. Inhibitor: Provide sodium nitrite/borate, molybdate-based inhibitor or other approved compound suitable for make-up quality and make-up rate and which will cause or enhance bacteria/corrosion problems or mechanical seal failure due to excessive total dissolved solids. Shot feed manually. Maintain inhibitor residual as determined by water treatment laboratory, taking into consideration residual and temperature effect on pump mechanical seals.

B. pH Control: Inhibitor formulation shall include adequate buffer to maintain pH range of 8.0 to 10.5.

C. Performance: Protect various wetted, coupled, materials of construction including ferrous, and red and yellow metals. Maintain system essentially free of scale, corrosion, and fouling. Corrosion rate of following metals shall not exceed specified mills per year penetration; ferrous, 0-2; brass, 0-1; copper, 0-1. Inhibitor shall be stable at equipment skin surface temperatures and bulk water temperatures of not less than 121 degrees C (250 degrees F) and 52 degrees C (125 degrees Fahrenheit) respectively. Heat exchanger fouling and capacity reduction shall not exceed that allowed by fouling factor 0.0005.

D. Pot Feeder: By-pass type, complete with necessary shut off valves, drain and air release valves, and system connections, for introducing chemicals into system, cast iron or steel tank with funnel or large opening on top for easy chemical addition. Feeders shall be 18.9 L (five gallon) minimum capacity at 860 kPa (125 psig) minimum working pressure.

E. Side stream Water Filter for Closed Loop Systems: Stainless steel housing, and polypropylene filter media with polypropylene, stainless steel core. Filter media shall be compatible with antifreeze and water treatment chemicals used in the system. Replaceable filter cartridges for sediment removal service with minimum 20 micrometer particulate at 98 percent efficiency for approximately five (5) percent of system design flow rate. Filter cartridge shall have a maximum pressure drop of 13.8 kPa (2 psig) at design flow rate when clean, and maximum pressure drop of 172 kPa (25 psig) when dirty. A constant flow rate valve shall be provided in the piping to the filter. Inlet and outlet pressure gauges shall be provided to monitor filter condition.

2.4 GLYCOL-WATER SYSTEM

A. Propylene glycol shall be inhibited with 1.75 percent dipotassium phosphate. Do not use automotive anti-freeze because the inhibitors used are not needed and can cause sludge precipitate that interferes with heat transfer.

B. Provide required amount of glycol to obtain the percent by volume for glycol-water systems as follows and to provide one-half tank reserve supply: 25 percent for run-around coil systems chilled water system/hydronic system.

C. Pot Feeder Make-up Unit: Bypass type for chemical treatment, schedule 3.5 mm (10 gauge) heads, 20 mm (3/4-inch) system connections and large neck opening for chemical addition. Feeders shall be 19 Liters (5 gallon) minimum size.

D. Glycol-Water Make-up System:

1. Glycol-Water storage tank: Self-supporting polyethylene, minimum 90 mil thickness, with removable cover or black steel with 90 mil polyethylene insert. Capacity shall be 213 L (55 gallons), with approximate diameter of 584 mm (23 inches) and height of 914 mm (36 inches). Reinforced threaded pipe connections shall be provided for all connections. Provide identification for tank showing name of the contents.

2. Glycol-Water make-up pump: Bronze fitted, self-priming, high head type suitable for pumping a 33 percent to 50 percent glycol-water solution in intermittent service. The pump shall be provided with a mechanical shaft seal and be flange connected to a 1750 rpm NEMA type C motor. The pump capacity shall be 11 L/m (3 gpm), 345 kPa (50 psig) discharge pressure with a suction lift capability of 127 mm (5 inches) of mercury, with a 2.5 kW (1/3 horsepower) drip-proof motor. The pump may be a "gear-within-a-gear" positive displacement type with built-in relief valve set for 296 kPa (43 psig), or the pump may be a regenerative turbine type providing self-priming with built-in or external relief valve set for design head of the pump.
3. Back pressure regulating valve: Spring loaded, diaphragm actuated type with bronze or steel body, stainless steel trim with capacity to relieve 100 percent of pump flow with an allowable rise in the regulated pressure of 69 kPa (10 psig) above the set point. Set point shall be 103 kPa (15 psig) above system PRV setting.
4. Low water level control: Steel or plastic float housing, stainless steel or plastic float, positive snap-acting SPST switch mechanism, rated 10 amps-120-volt AC, in General Purpose (NEMA 1) enclosure. The control shall be rated for pressures to 1034 kPa (150 psig) and make alarm circuit on low water level. The alarm circuit shall be wired to an alarm light on the nearest local Temperature Control panel (LTCP). Provide remote output relay to indicate alarm condition at the Building Control System specified under Section 23 09 23 - Direct-Digital Control System for HVAC.

2.5 EQUIPMENT AND MATERIALS IDENTIFICATION

A. Refer to Section 23 05 00 - Common Work Results for HVAC.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Delivery and Storage: Deliver all chemicals in manufacturer's sealed shipping containers. Store in designated space and protect from deleterious exposure and hazardous spills.

B. Install equipment furnished by the chemical treatment supplier and charge systems according to the manufacturer's instructions and as directed by the Technical Representative.

C. Refer to Section 23 21 13 - Hydronic Piping for chemical treatment piping, installed as follows:

1. Provide a bypass line around water meters and bleed off piping assembly. Provide ball valves to allow for bypassing, isolation, and servicing of components.
2. Bleed off water piping with bleed off piping assembly shall be piped from pressure side of circulating water piping to a convenient drain. Bleed off connection to main circulating water piping shall be upstream of chemical injection nozzles.
3. Provide piping for the flow assembly piping to the main control panel and accessories.
   a. The inlet piping shall connect to the discharge side of the circulating water pump.
   b. The outlet piping shall connect to the water piping serving the cooling tower downstream of the heat source.
   c. Provide inlet Y-strainer and ball valves to isolate and service main control panel and accessories.

4. Install injection nozzles with corporation stops in the water piping serving the cooling tower downstream of the heat source.
5. Provide piping for corrosion monitor rack per manufacturer’s installation instructions. Provide ball valves to isolate and service rack.
6. Provide piping for erosion chemical feeder per manufacturer’s installation instructions. Provide ball valves to isolate and service feeder.
7. Provide installation supervision, start-up and operating instruction by manufacturer's technical representative.

D. Before adding cleaning chemical to the closed system, all air handling coils, and fan coil units should be isolated by closing the inlet and outlet valves and opening the bypass valves. This is done to prevent dirt and solids from lodging the coils.

E. Do not valve in or operate system pumps until after system has been cleaned.

F. After chemical cleaning is satisfactorily completed, open the inlet and outlet valves to each coil and close the by-pass valves. Also, clean all strainers.

G. Perform tests and report results in accordance with Section 01 77 00 – Closeout Procedures.

H. After cleaning is complete, and water PH is acceptable to manufacturer of water treatment chemical, add manufacturer-recommended amount of chemicals to systems.

I. Instruct personnel in system maintenance and operation in accordance with Section 01 91 13, General Commissioning Requirements.

END OF SECTION

SECTION 23 31 00

HVAC DUCTS & CASINGS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Ductwork and accessories for HVAC including supply air, return air, outside air, exhaust, roof hoods, goosenecks, and relief systems.

B. A complete listing of common acronyms and abbreviations are included in Section 23 05 00, COMMON WORK RESULTS FOR HVAC.

C. Definitions:

1. SMACNA Standards as used in this specification means the HVAC Duct Construction Standards, Metal and Flexible.
2. Seal or Sealing: Use of liquid or mastic sealant, with or without compatible tape overlay, or gasketing of flanged joints, to keep air leakage at duct joints, seams, and connections to an acceptable minimum.
3. Duct Pressure Classification: SMACNA HVAC Duct Construction Standards, Metal and Flexible.
4. Exposed Duct: Exposed to view in a finished room.

5. Exterior Duct: Exposed to the elements.

1.2 RELATED WORK

A. Section 01 33 23 - Submittal Procedures.

B. Section 01 42 00 - References.

C. Section 01 91 13 - General Commissioning Requirements.

D. Section 23 05 00 - Common Work Results for HVAC.

E. Section 23 05 48 - Vibration and Seismic Control for HVAC.

F. Section 23 05 93 - Testing, Adjusting, and Balancing.

G. Section 23 07 13, Duct Insulation.

H. Section 23 09 23 - Direct-Digital Control System for HVAC.

I. Section 23 34 23 - HVAC Power Ventilators.

J. Section 23 36 16 - Variable Air Volume Units.

1.3 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

B. Air Movement and Control Association (AMCA):512-2009 - AMCA Listing Label Program

C. American Society of Civil Engineers (ASCE): ASCE/SEI 7-2010 - Minimum Design Loads for Buildings and Other Structures

D. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE):

1. 62.1-2016 - Ventilation for Acceptable Indoor Air Quality
2. 90.1-2013 - Energy Standard for Buildings Except Low-Rise Residential Buildings

E. American Society for Testing and Materials (ASTM):

1. A653/A653M-2015e1 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
2. B209-2014 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
3. C916-2014 - Standard Specification for Adhesives for Duct Thermal Insulation
4. C1071-2012 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
5. E84-2015b - Standard Test Method for Surface Burning Characteristics of Building Materials

F. Environmental Protection Agency (EPA): CFR 40, PART 59, Subpart D, EPA Method 24

G. National Fire Protection Association (NFPA):

1. 90A-2015 - Standard for the Installation of Air Conditioning and Ventilating Systems
2. 90B-2015 - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems

H. North American Insulation Manufacturers Association (NAIMA):

1. AH124-2002 - Fibrous Glass Duct Liner Standard, 3rd Edition

I. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

1. HVAC Duct Construction Standards, Metal and Flexible
2. HVAC Air Duct Leakage Test Manual
3. IAQ Guidelines for Occupied Buildings Under Construction

J. Underwriters Laboratories, Inc. (UL):

1. 33-2010 - Standard for Heat Responsive Links for Fire-Protection Service
2. 181 - Standard for Factory-Made Air Ducts and Connectors
3. 555 - Standard for Fire Dampers
4. 555S - Standard for Smoke Dampers

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23 – Submittal Procedures.

B. Information and material submitted under this section shall be marked “Submitted Under Section 23 31 00, HVAC Ducts and Casings”, with applicable paragraph identification.

C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.

1. Rectangular ducts:
   a. Schedules of duct systems, materials, and selected SMACNA construction alternatives for joints, sealing, gage, and reinforcement.
   b. Duct liner.
   c. Sealants and gaskets.
   d. Access doors.
2. Round Ducts:
   a. Manufacturer's details for duct fittings and joints.
   b. Duct liner.
   c. Sealants and gaskets.
   d. Access sections.
   e. Installation instructions.
3. Volume dampers, control dampers, and back draft dampers.
4. Hanger attachments.
5. Fire dampers, fire doors, and smoke dampers with installation instructions.
6. Turning Vanes.
7. Sound attenuators, including pressure drop and acoustic performance.
8. Flexible ducts and clamps, with manufacturer's installation instructions.
9. Flexible connections.
10. Instrument test fittings.
11. Details and design analysis of alternate or optional duct systems.

D. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:

1. Include complete list indicating all components of the systems.
2. Include complete diagrams of the internal wiring for each item of equipment.
3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

E. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion.

F. Submit training plans and instructor qualifications.

1.5 QUALITY ASSURANCE

A. Refer to paragraph, QUALITY ASSURANCE, in Section 23 05 00, Common Work Results for HVAC.

B. Fire Safety Code: Comply with NFPA 90A.

C. Duct System Construction and Installation: Referenced SMACNA Standards are the minimum acceptable quality.

D. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

E. Duct Sealing, Air Leakage Criteria, and Air Leakage Tests: Ducts shall be sealed as per duct sealing requirements of SMACNA Standards for duct pressure classes shown on the drawings.

F. Duct accessories exposed to the air stream, such as dampers of all types (except smoke dampers) and access openings, shall be of the same material as the duct or provide at least the same level of corrosion resistance.

G. ASHRAE Compliance: Applicable requirements in ASHRAE 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

H. Sealants and Adhesives: Comply with NFPA 90A and with ASTM C916.

1. 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).

1.6 AS-BUILT DOCUMENTATION

A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.

B. Submit operation and maintenance data updated to include submittal review comments, substitutions and construction revisions shall be in electronic version on USB inserted into a three ring binder. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. As-built drawings are to be provided, and a copy of them in Auto-CAD version 2021 provided on USB. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement.

D. Certification documentation shall be provided to Contracting Officer 10 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and certification that all results of tests were within limits specified.

PART 2 - PRODUCTS

2.1 DUCT MATERIALS AND SEALANTS

A. General: Except for systems specified otherwise, construct ducts and accessories of galvanized sheet steel, ASTM A653/A653M, coating G90; or, aluminum sheet, ASTM B209, alloy 1100, 3003, or 5052.

B. Joint Sealing:

1. Sealant: Elastomeric compound, gun or brush grade, maximum 25 flame spread and 50 smoke developed (dry state) compounded specifically for sealing ductwork as recommended by the manufacturer. Generally provide liquid sealant, with or without compatible tape, for low clearance slip joints and heavy, permanently elastic, mastic type where clearances are larger. Oil base caulking and glazing compounds are not acceptable because they do not retain elasticity and bond.
2. Tape: Use only tape specifically designated by the sealant manufacturer and apply only over wet sealant. Pressure sensitive tape shall not be used except as designated by sealant manufacturer.
3. Gaskets for Flanged Joints: Soft neoprene.

C. Approved factory made joints such as DUCTMATE SYSTEM may be used.

2.2 DUCT CONSTRUCTION AND INSTALLATION

A. Follow SMACNA HVAC Duct Construction Standards.

B. Duct Pressure Class: 500 Pa (2 inch WG)

C. Seal Class: As shown on the drawings and in accordance with SMACNA Standards.

D. Round Ducts: Furnish duct and fittings made by the same manufacturer to ensure good fit of joints. When submitted and approved in advance, round ducting, with size converted on the basis of equal pressure drop may be furnished in lieu of rectangular duct design shown on the drawings.

1. Elbows: Diameters 150 mm through 200 mm (6 through 8 inches) shall be two sections die stamped; all others shall be gored construction, maximum 18 degree angle, with all seams continuously welded or standing seam. Coat galvanized areas of fittings damaged by welding with corrosion resistant aluminum paint or galvanized repair compound.
2. Provide bell mouth, conical tees or taps, laterals, reducers, and other low loss fittings as shown in SMACNA HVAC Duct Construction Standards.

E. Volume Dampers: Single blade, opposed blade, or multi-blade type as detailed in SMACNA Standards.

F. Duct Hangers and Supports: Refer to SMACNA Standards. Do not use trapeze hangers for round duct.

2.3 DUCT LINER (THE FIRST 10 ON EITHER SIDE OF ANY FAN OR WHERE INDICATED ON DRAWINGS)

A. Duct sizes shown on drawings for lined duct are clear opening inside lining.

B. Rectangular Duct Liner: ASTM C1071, Type I (flexible), or Type II (board), 25 mm (one inch) minimum thickness, applied with mechanical fasteners and 100 percent coverage of adhesive in conformance with SMACNA HVAC Duct Construction Standards.

2.4 DUCT ACCESS DOORS, PANELS AND SECTIONS

A. Install access doors with swing against duct static pressure.

B. Provide access doors, sized and located for maintenance work, in the following locations:

1. Upstream and downstream of each duct mounted coil.
2. Each fire damper (for link service), smoke damper, and automatic control damper.
3. Each duct mounted smoke detector.
4. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
5. Upstream //and downstream// from turning vanes.
6. Upstream or downstream from duct silencers.
7. Control devices requiring inspection.

C. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2 (7-2M), "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:
   a. Double wall, rectangular.
   b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
   c. Hinges and Latches: 25 by 25 mm (1 by 1 inch) butt or piano hinge and cam latches.
   d. Fabricate doors airtight and suitable for duct pressure class.
2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:
   a. Access Doors Less Than 300 mm (12 inches) Square: No hinges and two sash locks.
   b. Access Doors up to 450 mm (18 inches) Square: Continuous and two sash locks.
   c. Access Doors up to 600 by 1200 mm (24 by 48 inches): Continuous and two compression latches.

D. Access Doors Greater Than 600 by 1200 mm (24 by 48 inches): Continuous and two compression latches with outside and inside handles, labeled according to UL 1978 by an NRTL.

E. Panel and Frame: Minimum thickness 1.1 mm (0.045 inch) stainless steel.

F. Fasteners: Stainless steel. Panel fasteners shall not penetrate duct wall.

G. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 1,093 degrees C (2,000 degrees F).

H. Minimum Pressure Rating: 2,500 Pa (10 inch WG), positive or negative.

I. Openings shall be as large as feasible in small ducts, 300 mm by 300 mm (12 inch by 12 inch) minimum where possible. Access sections in insulated ducts shall be double-wall, insulated.

1. Refer to SMACNA HVAC Duct Construction Standards.

2.5 FIRE DAMPERS

A. Type: Static and dynamic; rated and labeled according to UL 555 by an NRTL.

B. Closing rating in ducts up to 1 kPa (4 inch WG) static pressure class and minimum 10 m/s (2,000 fpm) velocity

C. Mounting Orientation: Vertical or horizontal as indicated.

D. Galvanized steel, interlocking blade type, UL listing and label, 1-1/2 hour rating, 74 degrees C (165 degrees F) fusible link, 100 percent free opening with no part of the blade stack or damper frame in the air stream.

E. Fire dampers shall be galvanized steel.

1. The damper frame may be of design and length as to function as the mounting sleeve, thus eliminating the need for a separate sleeve, as allowed by UL 555. Otherwise provide sleeves and mounting angles, minimum 1.9 mm (14 gage), required to provide installation equivalent to the damper manufacturer's UL test installation.
2. Submit manufacturer's installation instructions conforming to UL 555 rating test.

2.6 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Description: Gravity balanced.

B. Maximum Air Velocity: 10 m/s (2,000 fpm).

C. Maximum System Pressure: 0.5 kPa (2 inch WG).

D. Frame: Hat-shaped, 2.4 mm (0.094 inch) thick, galvanized sheet steel, with welded corners or mechanically attached.

E. Blades: Multiple single-piece blades, center pivoted maximum 150 mm (6 inch) width, 1.2 mm (0.047 inch) thick aluminum sheet with sealed edges.

F. Blade Action: Parallel.

G. Blade Seals: Neoprene, mechanically locked.

H. Blade Axles:

1. Material: Aluminum.
2. Diameter: 5 mm (3/160 inch).

I. Tie Bars and Brackets: Aluminum.

J. Return Spring: Adjustable tension.

K. Bearings: synthetic pivot bushings.

L. 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: 1.0 mm (20 gage) minimum.
   b. Sleeve Length: 150 mm (6 inches) minimum.
6. Screen Mounting: Rear mounted.
7. Screen Material: Aluminum.
8. Screen Type: Bird.
9. 90 degree stops.

2.7 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Standard leakage rating, with linkage outside airstream.
2. Suitable for horizontal or vertical applications.
3. Frames:
   a. Frame: Hat-shaped, 2.4 mm (3/32 inch) thick, galvanized sheet .
   b. Mitered and welded corners.
   c. Flanges for attaching to walls and flangeless frames for installing in ducts.
4. Blades:
   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Stainless-steel, 1.62 mm (0.064 inch) thick.
5. Blade Axles: Stainless steel.
6. Bearings:
   a. Oil-impregnated bronze.
   b. Dampers in ducts with pressure classes of 750 Pa (3 inch WG) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
7. Tie Bars and Brackets: Galvanized steel.

B. Standard, Aluminum, Manual Volume Dampers:

1. Standard leakage rating, with linkage outside airstream.
2. Suitable for horizontal or vertical applications.
3. Frames: Hat-shaped, 2.5 mm (0.10 inch) thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.

4. Blades:
    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Stiffen damper blades for stability.
    d. Roll-Formed Aluminum Blades: 2.5 mm (0.10 inch) thick aluminum sheet.
    e. Extruded-Aluminum Blades: 1.3 mm (0.050 inch) thick extruded aluminum.
5. Blade Axles: Stainless steel.
6. Bearings:
    a. Oil-impregnated bronze
    b. Dampers in ducts with pressure classes of 750 Pa (3 inch WG) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
7. Tie Bars and Brackets: Aluminum.

2.8 CONTROL DAMPERS

A. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.

B. Frames:

1. Angle shaped.
2. 2.4 mm (0.094 inch) thick, galvanized sheet steel.
3. Mitered and welded corners.

C. Blades:

1. Multiple blade with maximum blade width of 200 mm (8 inches).
2. Opposed-blade design.
3. Aluminum.
4. 1.9 mm (0.0747 inch) thick dual skin.
5. Blade Edging: Closed-cell neoprene.
6. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.

D. Blade Axles: 15 mm (1/2 inch) diameter; nonferrous metal; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.

1. Operating Temperature Range: From minus 40 to plus 93 degrees C (minus 40 to plus 200 degrees F).

E. Bearings:

1. Oil-impregnated bronze.
2. Dampers in ducts with pressure classes of 750 Pa (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.

2.9 FLEXIBLE AIR DUCT

A. General: Factory fabricated, complying with NFPA 90A for connectors not passing through floors or buildings. Flexible ducts shall not penetrate any fire or smoke barrier which is required to have a fire resistance rating of one hour or more. Flexible duct length shall not exceed 1.5 m (5 feet). Provide insulated flexible air duct connectors in supply air duct systems and elsewhere as shown.

B. Flexible ducts shall be listed by Underwriters Laboratories, Inc., complying with UL 181. Ducts greater than 200 mm (8 inches) in diameter shall be Class 1. Ducts 200 mm (8 inches) in diameter and smaller may be Class 1 or Class 2.

C. Insulated Flexible Air Duct: Factory made including mineral fiber insulation with maximum C factor of 0.25 at 24 degrees C (75 degrees F) mean temperature, encased with a low permeability moisture barrier outer jacket, having a puncture resistance of not less than 50 Beach Units. Acoustic insertion loss shall not be less than 3 dB per 300 mm (1 foot) of straight duct, at 500 Hz, based on 150 mm (6 inch) duct, of 750 m/min (2,500 fpm).

D. Application Criteria:

1. Temperature range: minus 18 to 93 degrees C (0 to 200 degrees F) internal.
2. Maximum working velocity: 1,200 m/min (4000 fpm).
3. Minimum working pressure: 2,500 Pa (10 inch WG) positive, 500 Pa (2 inch WG) negative.

E. Duct Clamps: 100 percent nylon strap, 80 kg (175 pounds) minimum loop tensile strength manufactured for this purpose or stainless steel strap with cadmium plated worm gear tightening device. Apply clamps with sealant and as approved for UL 181, Class 1 installation.

2.10 FLEXIBLE CONNECTIONS

A. Where duct connections are made to fans and air handling units, install a non-combustible flexible connection of 822 g (29 ounce) neoprene coated fiberglass fabric, approximately 150 mm (6 inches) wide.

B. Coatings and Adhesives: Comply with UL 181, Class 1. For connections exposed to sun and weather provide Hypalon coating in lieu of neoprene. Burning characteristics shall conform to NFPA 90A.

1. Tensile Strength: 84 N/mm (480 lbf/inch) in the warp and 63 N/mm (360 lbf/inch) in the filling.
2. Service Temperature: Minus 40 to plus 93 degrees C (Minus 40 to plus 200 degrees F)

C. Securely fasten flexible connections to round ducts with stainless steel or zinc-coated iron draw bands with worm gear fastener. For rectangular connections, crimp fabric to sheet metal and fasten sheet metal to ducts by screws 50 mm (2 inches) on center. Fabric shall not be stressed other than by air pressure. Allow at least 25 mm (one inch) slack to ensure that no vibration is transmitted.

2.11 TURNING VANES

A. 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.

B. 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."

C. Vane Construction: Double wall.

D. Vane Construction: Single wall for ducts up to 1200 mm (48 inches) wide and double wall for larger dimensions.

2.12 SOUND ATTENUATING UNITS

A. Casing, not less than 1.0 mm (20 gage) galvanized sheet steel, or 1.3 mm (18 gage) aluminum fitted with suitable flanges to make clean airtight connections to ductwork. Sound-absorbent material faced with glass fiber cloth and covered with not less than 0.6 mm (24 gage) or heavier galvanized perforated sheet steel, or 0.85 mm (22 gage) or heavier perforated aluminum. Perforations shall not exceed 4 mm (5/32 inch) diameter, approximately 25 percent free area. Sound absorbent material shall be long glass fiber acoustic blanket meeting requirements of NFPA 90A.

B. Entire unit shall be completely air tight and free of vibration and buckling at internal static pressures up to 2000 Pa (8 inch WG) at operating velocities.

C. Pressure drop through each unit: Not to exceed indicated value at design air quantities indicated.

D. Submit complete independent laboratory test data showing pressure drop and acoustical performance.

E. Cap open ends of attenuators at factory with plastic, heavy duty paper, cardboard, or other appropriate material to prevent entrance of dirt, water, or any other foreign matter to inside of attenuator. Caps shall not be removed until attenuator is installed in duct system.

2.13 FIRESTOPPING MATERIAL

A. Refer to Section 07 84 00 – Firestopping.

2.14 SEISMIC RESTRAINT FOR DUCTWORK

A. Refer to Section 23 05 48 – Vibration and Seismic Controls for HVAC.

2.15 THERMOMETER (AIR)

A. Refer to Section 23 09 23 - Direct-Digital Control System for HVAC.

2.16 INSTRUMENT TEST FITTINGS

A. Manufactured type with a minimum 50 mm (2 inch) length for insulated duct, and a minimum 25 mm (1 inch) length for duct not insulated. Test hole shall have a flat gasket for rectangular ducts and a concave gasket for round ducts at the base, and a screw cap to prevent air leakage.

B. Provide instrument test holes at each duct mounted temperature sensor or transmitter, and at entering and leaving side of each heating coil, cooling coil, and heat recovery unit.

PART 3 - EXECUTION

3.1 INSTALLATION

A. If an installation is unsatisfactory to the Contracting Officer, the Contractor shall correct the installation at no additional cost or time to the Government.

B. Comply with provisions of Section 23 05 00, Common Work Results for HVAC, particularly regarding coordination with other trades and work in existing buildings.

C. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and aluminum accessories in aluminum ducts.

D. Install backdraft control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan, unless otherwise indicated.

E. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

F. Access Door Sizes:

1. One-Hand or Inspection Access: 200 mm by 125 mm (8 inches by 5 inches).
2. Two-Hand Access: 300 mm by 150 mm (12 inches by 6 inches).
3. Head and Hand Access: 450 mm by 250 mm (18 inches by 10 inches).
4. Head and Shoulders Access: 533 mm by 356 mm (21 inches by 14 inches).
5. Body Access: 635 mm by 356 mm (25 inches by 14 inches).
6. Body plus Ladder Access: 635 mm by 432 mm (25 inches by 17 inches).

G. Label access doors according to Section 23 05 53 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

H. Install ducts with fewest possible joints.

I. Install factory- or shop-fabricated fittings for changes in direction, size, shape, and for branch connections.

J. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

K. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

L. Install ducts with a clearance of 25 mm (1 inch), plus allowance for insulation thickness.

M. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

N. 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 40 mm (1-1/2 inches).

O. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA IAQ Guidelines for Occupied Buildings Under Construction, Appendix G, "Duct Cleanliness for New Construction Guidelines."//

P. Fabricate and install ductwork and accessories in accordance with referenced SMACNA Standards:

1. Drawings show the general layout of ductwork and accessories but do not show all required fittings and offsets that may be necessary to connect ducts to equipment, boxes, diffusers, grilles, etc., and to coordinate with other trades. Fabricate ductwork based on field measurements. Provide all necessary fittings and offsets at no additional cost to the government. Coordinate with other trades for space available and relative location of HVAC equipment and accessories on ceiling grid. Duct sizes on the drawings are inside dimensions which shall be altered by Contractor to other dimensions with the same air handling characteristics where necessary to avoid interferences and clearance difficulties.
2. Provide duct transitions, offsets and connections to dampers, coils, and other equipment in accordance with SMACNA HVAC Duct Construction Standards. Provide streamliner when an obstruction cannot be avoided and must be taken in by a duct. Repair galvanized areas with galvanizing repair compound.
3. Provide bolted construction and tie-rod reinforcement in accordance with SMACNA HVAC Duct Construction Standards.

Q. Install duct hangers and supports in accordance with SMACNA HVAC Duct Construction Standards.

R. Install fire dampers and smoke dampers in accordance with the manufacturer's instructions to conform to the installation used for the rating test.

S. Seal openings around duct penetrations of floors and fire rated partitions with fire stop material as required by NFPA 90A.

T. Flexible duct installation: Refer to SMACNA HVAC Duct Construction Standards. Ducts shall be continuous, single pieces not over 1.5 m (5 feet) long, as straight and short as feasible, adequately supported. Centerline radius of bends shall be not less than 2 duct diameters. Make connections with clamps as recommended by SMACNA Standards. Clamp per SMACNA Standards with one clamp on the core duct and one on the insulation jacket. Flexible ducts shall not penetrate floors, or any chase or partition designated as a fire or smoke barrier, including corridor partitions fire rated 1-hour or 2-hour. Support flexible ducts per SMACNA HVAC Duct Construction Standards.

U. Control Damper Installation:

1. Provide necessary blank-off plates required to install dampers that are smaller than duct size. Provide necessary transitions required to install dampers larger than duct size.
2. Install all damper control/adjustment devices on stand-offs to allow complete coverage of insulation.

V. Air Flow Measuring Devices (AFMD): Install units with minimum straight run distances, upstream and downstream as recommended by the manufacturer.//

W. Low Pressure Duct Liner: Install in accordance with SMACNA HVAC Duct Construction Standards.

X. Protection and Cleaning: Adequately protect equipment and materials against physical damage. Place equipment in first-class operating condition, or return to source of supply for repair or replacement, as determined by Contracting Officer. Protect equipment and ducts during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting. When new ducts are connected to existing ductwork, clean both new and existing ductwork by mopping and vacuum cleaning inside and outside before operation.

3.2 DUCT LEAKAGE TESTS AND REPAIR

A. Leak testing company shall be independent of the sheet metal company employed by General Contractor.

B. Ductwork leak test shall be performed for the entire air distribution supply, return, exhaust system section-by-section including fans, coils, and filter section designated as static pressure class 750 Pa (3 inch WG) and above. All supply ductwork less than 500 Pa (2 inch WG) shall also be tested where there is no air terminal unit employed in the system.

C. Test procedure, apparatus, and report shall conform to SMACNA HVAC Air Duct Leakage Test Manual. The maximum leakage rate allowed is 4 percent of the design air flow rate.

D. All ductwork shall be leak tested first before enclosed in a shaft or covered in other inaccessible areas.

E. All tests shall be performed in the presence of the Contracting Officer and the Test and Balance agency. The Test and Balance agency shall measure and record duct leakage and report to the Contracting Officer and identify leakage source with excessive leakage.

F. If any portion of the duct system tested fails to meet the permissible leakage level, rectify sealing of ductwork to bring it into compliance and retest until acceptable leakage is demonstrated to the Contracting Officer.

G. All tests and necessary repairs shall be completed prior to insulation or concealment of ductwork.

H. Make sure all openings used for testing flow and temperatures by TAB contractor are sealed properly.

3.3 TESTING, ADJUSTING, AND BALANCING

A. Refer to Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

3.4 STARTUP AND TESTING

A. Make tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.

B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.

C. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the Contracting Officer and Commissioning Agent. Provide a minimum notice of 10 working days prior to startup and testing.

3.5 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, Commissioning of HVAC Systems.

B. Components provided under this section of the specification will be tested as part of a larger system.

3.6 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer's technical representative for 4 hours to instruct each NPS personnel responsible in the operation and maintenance of units.

B. Submit training plans and instructor qualifications to the Contracting Officer in accordance with the requirements of Section 23 08 00, Commissioning of HVAC Systems.

END OF SECTION

SECTION 23 31 13

METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Duct liner.
5. Sealants and gaskets.
6. Hangers and supports.
7. Seismic-restraint devices.

B. Related Sections:

1. Section 23 05 93 - "Testing, Adjusting, & Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 23 31 13.19 - "Metal Duct Fittings" for factory- and field-fabricated fittings for mechanical equipment.
3. Section 23 33 00 - "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. 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"

1. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

1.4 SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Factory-built Ducts.
3. Duct materials.
4. Sealants and gaskets.
5. Hangers and Supports.
6. Seismic-restraint devices.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. 1Penetrations 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, seismic restraints, and vibration isolation.

C. Delegated-Design Submittal:
1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

D. 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.

E. Welding certificates.

F. Field quality-control reports.

1.5 QUALITY ASSURANCE

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

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. See "Static-Pressure Classes" and "Leakage and Seal Classes" articles in the Evaluations for discussion on fabrication.

B. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) 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."

D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," 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. 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 2, "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 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," 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 (1,524 mm) in Diameter: Flanged.

B. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," 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 (2,286 mm) in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "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."

2.3 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: G60 (Z180).
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.4 DUCT LINER

A. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

1. 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.
2. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
   a. 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).

B. Natural-Fiber Duct Liner: 85 percent cotton, 10 percent borate, and 5 percent poly-binding fibers, treated with a microbial growth inhibitor and complying with NFPA 90A or NFPA 90B.

1. Maximum Thermal Conductivity: [0.24 Btu x in./h x sq. ft. x deg F (0.034 W/m x K)] at 75 deg F (24 deg C) mean temperature when tested according to ASTM C 518.
2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to ASTM E 84; certified by an NRTL.
3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
   a. 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).

C. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

D. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-19, "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 (12.7 m/s).
7. Secure liner with mechanical fasteners 4 inches (100 mm) from corners and at intervals not exceeding 12 inches (300 mm) transversely; at 3 inches (75 mm) from transverse joints and at intervals not exceeding 18 inches (450 mm) longitudinally.

8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
   a. Fan discharges.
   b. Intervals of lined duct preceding unlined duct.
   c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm (12.7 m/s) or where indicated.
9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.
   a. Sheet Metal Inner Duct Perforations: 3/32-inch (2.4-mm) diameter, with an overall open area of 23 percent.
10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.5 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: 3 inches (76 mm).
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
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).

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
8. Service: Indoor or outdoor.

9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. For indoor applications, 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).
9. VOC: Maximum 395 g/L.
10. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive or negative.
11. Service: Indoor or outdoor.
12. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. For indoor applications, 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).

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

G. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa) and shall be rated for 10-inch wg (2500-Pa) 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.

2.6 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1 (Table 4-1M), "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."

C. Steel Cables for Galvanized-Steel Ducts: 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. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

2.7 SEISMIC-RESTRAINT DEVICES

A. 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 4 times the maximum seismic forces to which they will be subjected.

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

C. Restraint Cables: ASTM A 603, galvanized-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

D. Hanger Rod Stiffener: Reinforcing steel angle clamped to hanger rod.

E. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches (38 mm).

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 23 33 00 - "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class C.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class B.
6. Unconditioned Space, Exhaust Ducts: Seal Class C.
7. Unconditioned Space, Return-Air Ducts: Seal Class B.
8. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class C.
9. Conditioned Space, Exhaust Ducts: Seal Class B.
10. Conditioned Space, Return-Air Ducts: Seal Class C.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "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 (100 mm) thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) 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 4-1 (Table 4-1M), "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches (610 mm) of each elbow and within 48 inches (1200 mm) of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at maximum intervals of 16 feet (5 m).

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 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."

1. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
2. Brace a change of direction longer than 12 feet (3.7 m).

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

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

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.

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

G. Drilling for and Setting Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Contracting Officer 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. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.6 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 23 33 00 - "Air Duct Accessories."

C. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:
   a. Supply Ducts with a Pressure Class of 2-Inch wg (500 Pa) or Higher: Test representative duct sections totaling no less than 100 percent of total installed duct area for each designated pressure class.
   b. Return Ducts with a Pressure Class of 2-Inch wg (500 Pa) or Higher: Test representative duct sections totaling no less than 100 percent of total installed duct area for each designated pressure class.
   c. Exhaust Ducts with a Pressure Class of 2-Inch wg (500 Pa) or Higher: Test representative duct sections totaling no less than 100 percent of total installed duct area for each designated pressure class.
   d. Outdoor Air Ducts with a Pressure Class of 2-Inch wg (500 Pa) or Higher: Test representative duct sections totaling no less than 100 percent of total installed duct area for each designated pressure class.
3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
6. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
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.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.9 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 23 33 00 - "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.10 START UP

A. Air Balance: Comply with requirements in Section 23 05 93 - "Testing, Adjusting, & Balancing for HVAC."

3.11 DUCT SCHEDULE

A. Transfer Air and Exhaust Ducts:

1. Ducts Connected to Exhaust Fans:
   a. Pressure Class: Positive or negative 2-inch wg (500 Pa).
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 12.
   d. SMACNA Leakage Class for Round and Flat Oval: 6.

B. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.

C. Liner:

1. Supply Air Ducts: Flexible elastomeric or Natural fiber, 1 inch (25 mm) thick.
2. Return Air Ducts: Flexible elastomeric or Natural fiber, 1 inch (25 mm) thick.

D. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
   a. Velocity 1000 fpm (5 m/s) or Lower:
      1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
      2) Mitered Type RE 4 without vanes.
   b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s):
      1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
      2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
      3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "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 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "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 1,000 fpm (5 m/s) or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
      2) Velocity 1,000 to 1500 fpm (5 to 7.6 m/s): 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
      3) Radius-to Diameter Ratio: 1.5.
   b. Round Elbows, 12 Inches (305 mm) and Smaller in Diameter: Stamped or pleated.
   c. Round Elbows, 14 Inches (356 mm) and Larger in Diameter: Standing seam.

E. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."
   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 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees." Saddle taps are permitted in existing duct.
   a. Velocity 1,000 fpm (5 m/s) or Lower: 90-degree tap.
   b. Velocity 1,000 to 1,500 fpm (5 to 7.6 m/s): Conical tap.

END OF SECTION

SECTION 23 31 13.19

METAL DUCT FITTINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Related Documents:

1. Drawings and general provisions of the Subcontract apply to this Section.
2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:

1. Volume-control dampers
2. Fire dampers
3. Combination fire and smoke dampers
4. Smoke dampers
5. Backdraft dampers
6. Air-turning devices
7. Flexible duct connections
8. Duct access doors
9. Duct test holes.

C. Related Sections:

1. Division 01 Section "Construction Waste Management & Disposal".
2. Division 23 Section "Vibration & Seismic Controls for HVAC Piping & Equipment".
3. Division 23 Section "Metal Ducts".

1.2 REFERENCES

A. General:

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.
3. Refer to Division 23 Section "Common Results for HVAC" for codes and standards, and other general requirements.

B. Code of Federal Regulation (CFR):

1. 29 CFR 1910.7 Definitions and Requirements for a Nationally Recognized Testing Laboratory (NRTL)

C. National Fire Protection Association (NFPA):

1. NFPA 90A Installation of Air Conditioning and Ventilating Systems

D. Sheet Metal and Air Conditioning Subcontractors National Association (SMACNA)

1. SMACNA HVAC Duct Construction Standards

E. Underwriters Laboratories Inc. (UL):

1. UL 33 Heat Responsive Links for Fire-Protection Service

F. UL 555 Fire Dampers

1.3 SUBMITTALS

A. Submit under provisions of Division 23 Section "Common Results for HVAC, Review of Materials and Division 01 Section "General Requirements."

B. Shop Drawings: For shop-fabricated assemblies indicated, including volume-control dampers duct access doors duct test holes.

C. Product Data: Provide product data for hardware used and include manufacturer's installation instructions for fire dampers.

1.4 ENVIRONMENTAL GUIDELINES

A. Comply with Division 01 Section "Construction Waste Management".

B. Minimize the use of virgin material and waste during construction. Use low-VOC mastics.

PART 2 - PRODUCTS

2.1 VOLUME-CONTROL DAMPER FABRICATION

A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards, and as indicated on the Drawings.

B. Fabricate splitter dampers of material same gauge as duct to 24-inch (600-mm) size in either direction, and two gauges heavier for sizes over 24 inches (600 mm).

C. Fabricate splitter dampers of double-thickness sheet metal to streamline shape. Secure blade with continuous hinge or rod. Operate with at least 1/4-inch (6-mm) diameter rod in self-aligning, universal-joint-action flanged bushing with set screw.

D. Fabricate single-blade dampers for duct sizes to 9-1/2 x 30 inches (240 x 760 mm)

E. Fabricate multi-blade damper of opposed-blade pattern with maximum blade sizes 12 x 72 inches (300 x 1,830 mm). Assemble center- and edge-crimped blades in prime-coated or galvanized channel frame with suitable hardware.

F. Except in round ductwork 12 inches (300 mm) and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon or sintered-bronze bearings.

G. Provide locking, indicating-quadrant regulators on single- and multi-blade dampers.

H. On insulated ducts, mount quadrant regulators on stand-off mounting brackets, bases, or adapters.

2.2 FIRE DAMPER FABRICATION

A. Fabricate in accordance with NFPA 90A and UL 555 or comparable standard from a nationally recognized testing laboratory (NRTL) recognized under 29 CFR 1910.7, and as indicated on the drawings.

B. All fire dampers shall bear the label of the NRTL.

C. Fabricate curtain-type dampers of galvanized steel with interlocking blades. Provide stainless-steel closure springs and latches for horizontal installations. Configure with blades out of airstream except for low-pressure ducts up to 12 inches (300 mm) in height.

1. Recycled Content for galvanized steel products: 28 percent minimum total recycled content containing a minimum of 16 percent post-consumer steel.

D. Fabricate multiple-blade fire dampers with 16-gauge (1.5-mm) galvanized-steel frame and blades, oil-impregnated bronze or stainless-steel sleeve bearings and plated steel axles, 1/8- x 1/2-inch (3-x 13-mm) plated-steel concealed linkage, stainless-steel closure spring, blade stops, and lock.

1. Recycled Content for galvanized steel products: 28 percent minimum total recycled content containing a minimum of 16 percent post-consumer steel.

E. Provide fusible links that separate at 212°F (100°C); UL 33 or comparable NRTL standard. Provide adjustable link straps for combination fire/balancing dampers.

2.3 COMBINATION FIRE AND SMOKE DAMPER FABRICATION

A. Fabricate in accordance with NFPA 90A, and UL 555 or comparable standard from any NRTL, and as indicated on the drawings.

B. Combination fire and smoke dampers shall be listed and labeled by any NRTL.

C. Provide factory sleeve for each damper. Install damper operator on exterior of sleeve and link to damper operating shaft.

D. Fabricate with multiple blades using 16-gauge (1.5-mm) galvanized-steel frame and blades, oil-impregnated bronze or stainless-steel sleeve bearings and plated-steel axles, stainless-steel jamb seals, 1/8- x 1/2-inch (3- x 13-mm) plated-steel concealed linkage, stainless-steel closure spring, blade stops and lock, and 1/2-inch (13-mm) actuator shaft.

1. Recycled Content for galvanized steel products: 28 percent minimum total recycled content containing a minimum of 16 percent post-consumer steel.

E. Provide operators that are spring-return electric type suitable to operate on 120 Vac, 60 Hz. Operators shall be listed and labeled by any NRTL. [Provide end switches to indicate damper position.]

2.4 SMOKE DAMPER FABRICATION

A. Fabricate in accordance with NFPA 90A, and UL 555 or comparable standard from any NRTL, and as indicated on the drawings.

B. Smoke dampers shall be listed and labeled by any NRTL.

C. Normally-Closed Smoke-Vent Dampers: Curtain type, opening by gravity upon actuation of electro-thermal link, flexible stainless-steel blade edge seals to provide constant sealing pressure.

D. Normally-Open Smoke Damper: Curtain type, closing upon actuation of electro-thermal link, flexible stainless-steel blade edge seals to provide constant sealing pressure, stainless-steel springs with locking devices to ensure positive closure for units mounted horizontally.

E. Motorized Smoke Dampers: Curtain type, normally open with power on, close automatically when power is interrupted; damper and damper operator shall be listed and labeled by any NRTL.

F. Electro-Thermal Link: Fusible link that melts when subject to local heat of 165°F (74°C)and from external electrical impulse; listed and labeled by any NRTL.

2.5 BACKDRAFT DAMPERS

A. Gravity backdraft dampers, size 18 x 18 inches (450 x 450 mm) or smaller, provided with air-moving equipment, may be air-moving equipment manufacturer’s standard construction.

B. Fabricate multi-blade, parallel-action, gravity-balanced backdraft dampers of 16-gauge (1.5-mm) galvanized steel or extruded aluminum, with [center-pivoted] blades of 6 inch (150 mm) maximum width, with felt- or flexible-vinyl-sealed edges, linked together in rattle-free manner with 90 degree stop, steel ball bearings, and plated-steel pivot pin; adjustment device shall permit setting for varying differential static pressure; 2”, or equal. Adjust linkages for smooth and coordinated operation of all blade and sections. Linkages shall be visible outside of the air stream.

1. Recycled Content for galvanized steel products: 28 percent minimum total recycled content containing a minimum of 16 percent post-consumer steel.

2.6 AIR-TURNING DEVICES

A. Multi-blade device with radius blades attached to pivoting frame and bracket, steel or aluminum construction, with push-pull operator strap or ceiling-mounted rotary operator knob Barber-Coleman, Titus, Krueger, or equal.

2.7 FLEXIBLE DUCT CONNECTIONS

A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards, and as indicated on the drawings.

B. Material shall be neoprene-coated, woven glass-fiber fabric in accordance with NFPA 90A, minimum density 3 inches (75 mm) wide, crimped into metal edging strip, and listed or labeled as fire-retardant by any NRTL.

C. Leaded-vinyl sheet, at least 0.87 lb/sq ft 10-dB attenuation in 10- to 10,000-Hz frequency range.

2.8 DUCT ACCESS DOORS

A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards and as indicated on the drawings.

B. Review locations prior to fabrication.

C. Fabricate rigid and close-fitting doors of galvanized steel with sealing gaskets and quick-fastening locking devices. For insulated ductwork, install at least 1-inch (25-mm) thick insulation with sheet metal cover.

D. Access doors smaller than 12-inches (300-mm) square may be secured with sash locks.

E. Provide two hinges and two sash locks for sizes up to 18-inches (450-mm) square, three hinges and two compression latches with outside and inside handles for sizes up to 24 by 48 inches (600 by 1 220 mm). Provide an additional hinge for larger sizes.

F. Access doors with sheet-metal screw fasteners are not acceptable.

2.9 DUCT TEST HOLE FABRICATION

A. Cut or drill temporary test holes in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

B. Permanent test holes shall be factory-fabricated, air-tight flanged fittings with screw cap. Provide extended-neck fittings to clear insulation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install accessories in accordance with manufacturer's instructions.

B. Provide balancing dampers at points on low-pressure supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Use splitter dampers only where indicated on the drawings.

C. Provide balancing dampers on medium- and high-pressure systems where indicated.

D. Provide fire dampers at locations indicated, where ducts and outlets pass through fire-rated components [, and where required by authorities having jurisdiction]. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion-resistant springs, bearings, bushings, and hinges.

E. Provide backdraft dampers on exhaust fans or exhaust ducts nearest to outside, and where indicated on the drawings.

F. Provide flexible connections immediately adjacent to equipment in ducts associated with fans and motorized equipment.

G. Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, and elsewhere as indicated on the drawings. Provide at least 8- x 8-inch (200- x 200-mm) size for hand access, 18- x 18-inch (450- x 450-mm) size for shoulder access, unless noted otherwise.

H. Provide duct test holes where indicated on the drawings and required for testing and balancing.

3.2 WASTE MANAGEMENT

A. Conform with Division 01 Section "Construction Waste Management".

B. Collect off cuts and scrap and place them in designated areas for recycling.

C. Separate all other materials, including packaging and banding, in accordance with the Waste Management Plan and place them in designated areas for recycling.

END OF SECTION

SECTION 23 33 00

AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Manual volume dampers.
3. Flange connectors.
4. Turning vanes.
5. Flexible connectors.
6. Flexible ducts.
7. Duct accessory hardware.

B. Related Sections:

1. Section 23 34 23 - "HVAC Power Ventilators".

1.3 SUBMITTALS

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

B. LEED Submittal:

1. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."

C. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

a. Special fittings.
b. Manual volume damper installations.
c. Control damper installations.

d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
e. Wiring Diagrams: For power, signal, and control wiring.

D. 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.

E. Source quality-control reports.

F. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with AMCA 500-D testing for damper rating.

1.5 EXTRA MATERIALS

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

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G60 (Z180).
2. Exposed-Surface Finish: Mill phosphatized.

C. Aluminum Sheets: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B 221 (ASTM B 221M), Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.2 MANUAL VOLUME DAMPERS

A. Low-Leakage, Steel, Manual Volume Dampers:

1. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
2. Suitable for horizontal or vertical applications.
3. Frames:
   a. Angle shaped.
   b. Galvanized -steel channels, 0.064 inch (1.62 mm) thick.
   c. Mitered and welded corners.
   d. Flanges for attaching to walls and flangeless frames for installing in ducts.
4. Blades:
   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Galvanized, roll-formed steel, 0.064 inch (1.62 mm) thick.
5. Blade Axles: Galvanized steel.
6. Bearings:
   a. Molded synthetic.
   b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
7. Blade Seals: Neoprene.
8. Jamb Seals: Cambered aluminum.
9. Tie Bars and Brackets: Galvanized steel.
10. Accessories:
    a. Include locking device to hold single-blade dampers in a fixed position without vibration.

B. Jackshaft:

1. Size: 1-inch (25-mm) diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

C. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- (2.4-mm-) thick zinc-plated steel, and a 3/4-inch (19-mm) hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.3 FLANGE CONNECTORS

A. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

B. Material: Galvanized steel.

C. Gage and Shape: Match connecting ductwork.

2.4 TURNING VANES

A. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

B. 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.

C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."

D. Vane Construction: Single wall for ducts up to 48 inches (1,200 mm) wide and double wall for larger dimensions.

2.5 FLEXIBLE CONNECTORS

A. Materials: Flame-retardant or noncombustible fabrics.

B. Coatings and Adhesives: Comply with UL 181, Class 1.

C. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches (89 mm) wide attached to 2 strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Provide metal compatible with connected ducts.

D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

E. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd. (810 g/sq. m).
2. Minimum Tensile Strength: 500 lbf/inch (88 N/mm) in the warp and 440 lbf/inch (77 N/mm) in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F (Minus 45 to plus 121 deg C).

F. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.

1. Minimum Weight: 16 oz./sq. yd. (542 g/sq. m).
2. Tensile Strength: 285 lbf/inch (50 N/mm) in the warp and 185 lbf/inch (32 N/mm) in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).

G. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.

1. Minimum Weight: 14 oz./sq. yd. (474 g/sq. m).
2. Tensile Strength: 450 lbf/inch (79 N/mm) in the warp and 340 lbf/inch (60 N/mm) in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).

H. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch (6-mm) movement at start and stop.

2.6 FLEXIBLE DUCTS

A. Insulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.

1. Pressure Rating: 4-inch wg (1000 Pa) positive and 0.5-inch wg (125 Pa) negative.
2. Maximum Air Velocity: 4,000 fpm (20 m/s).
3. Temperature Range: Minus 20 to plus 175 deg F (Minus 29 to plus 79 deg C).
4. Insulation R-Value: Comply with ASHRAE/IESNA 90.1.

B. Flexible Duct Connectors:

1. Clamps: Nylon strap in sizes 3 through 18 inches (75 through 460 mm), to suit duct size.
2. Non-Clamp Connectors: Adhesive plus sheet metal screws.

2.7 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 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.

D. Set dampers to fully open position before testing, adjusting, and balancing.

E. Install test holes at fan inlets and outlets and elsewhere as indicated.

F. Install flexible connectors to connect ducts to equipment.

G. Connect diffusers to ducts directly or with maximum 60-inch (1,500-mm) lengths of flexible duct clamped or strapped in place.

H. Connect flexible ducts to metal ducts with draw bands.

I. Install duct test holes where required for testing and balancing purposes.

J. 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 (6-mm) 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

SECTION 23 34 23

HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Ceiling-mounting ventilators.

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on actual Project site elevations.

B. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material thickness and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.
6. Roof curbs.
7. Fan speed controllers.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.
2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
3. 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. Coordination Drawings: Reflected ceiling 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. 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.

D. Field quality-control test reports.

E. 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, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

D. UL Standard: Power ventilators shall comply with UL 705.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.7 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 - PRODUCTS

2.1 CEILING-MOUNTING VENTILATORS

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.

C. Description: Centrifugal fans designed for installation in ceiling or wall or for concealed in-line applications.

D. Housing: Steel, lined with acoustical insulation.

E. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.

F. Grille: Plastic, louvered grille with flange on intake and thumbscrew attachment to fan housing.

G. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

H. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
3. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
4. Motion Sensor: Motion detector with adjustable shutoff timer.
5. Ceiling Radiation Damper: Fire-rated assembly with ceramic blanket, stainless-steel springs, and fusible link.
6. Filter: Washable aluminum to fit between fan and grille.
7. Isolation: Rubber-in-shear vibration isolators.
8. Manufacturer's standard roof jack or wall cap, and transition fittings.

I. Capacities and Characteristics:

1. Refer to Schedules.

2.2 MOTORS

A. Comply with requirements in Division 23 Section 23 05 13 - "Common Motor Requirements for HVAC Equipment."

B. Enclosure Type: Totally enclosed, fan cooled.

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, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

C. Install units with clearances for service and maintenance.

D. Label units according to requirements specified in Section 23 05 53 - "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 23 33 00 - "Air Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

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

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

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.

4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control 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.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Refer to Section 23 05 93 - "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

END OF SECTION

SECTION 23 36 16

VARIABLE AIR VOLUME UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The other Contract Documents complement the requirements of this Section.

B. The General requirements apply to the work of this Section.

1.2 SCOPE

A. Provide material, equipment, labor, and supervision necessary to install Variable Air Volume Terminal Units as required by the Drawings and this Section.

1.3 STANDARDS

A. All lining materials shall meet the requirements of NFPA 90A, UL 181 and ASTM C655.

B. Provide proof of compliance with performance specifications, for air pressure drop and flow and radiated/discharge sound power levels, by manufacturers published certified data derived from tests conforming to ARI 880.

C. Use electrical components listed by Underwriters Laboratories for their intended use.

1.4 QUALIFICATIONS

A. Arrangement, capacity, performance, and type as scheduled and/or indicated on the Drawings and specified herein.

B. Provide certification of equipment in accordance with ARI 880 for air and acoustical performance.

1. All units shall meet or exceed specified acoustical parameters.

1.5 SUBMITTALS

A. Submit product information on terminal units including physical dimensions, heaters, air performance, acoustical data, access/maintenance requirements, support locations, wiring diagrams, and similar data.

B. Provide certified sound performance data for each terminal unit (and silencers, if necessary) at the scheduled operating conditions with 1.5" of inlet static pressure (corrected for silencer pressure drop).

1. Provide pressure drop data for each terminal unit at the scheduled conditions.

1.6 COMMISSIONING

A. Commissioning of a system or systems specified in this section is part of the construction process.

B. Documentation and testing of these systems, as well as training of the Owner’s operation and maintenance personnel, is required in cooperation with the Owner's Representative and the Commissioning Authority.

C. Project Closeout is dependent on successful completion of all commissioning procedures, documentation, and issue closure.

1. Refer to Section 01 77 00 - Closeout Procedures, for substantial completion details.

D. Refer to Section 01 91 13, General Commissioning Requirements, for detailed commissioning requirements.

PART 2 - EQUIPMENT

2.1 GENERAL

A. Acceptable Manufacturers

1. Variable Air Volume Terminal Units by Trane, Envirotech, Aneomostat, Titus, or Carrier are acceptable.

B. Use variable air-volume terminal units of size, capacity, and style shown on the drawings.

1. Use casing constructed of not less than welded 22-gauge galvanized steel.
   a. Leakage rate shall not exceed 4% of the design airflow at 3" water gauge.
2. The interior surface of the casing shall be acoustically and thermally lined with 1" thick, 1.0 lb/cu ft density glass-fiber insulation (minimum R-value 3.85) with a high density facing covered with a 26 gauge galvanized steel inner liner isolating the fiberglass from the airstream. Cut edges of insulation shall be covered by metal flanges.
   a. Insulation shall be UL listed, and meet NFPA 90A, UL 181 requirements and bacteriological standard ASTM C655.
3. Provide units with a cylindrical, cast-aluminum airflow control device, or damper assembly with internal or external actuator.
   a. Verify control requirement with Control Subcontractor.
   b. Leak rate shall be 4 percent or less at 3.0' WG.

c. Provide a pressure independent 16 point airflow sensor (8 points on the high side and 8 points on the low side) and calibration chart on unit. Damper assembly shall maintain airflow to within ± 5% of rated unit airflow with 1.5 diameters of straight duct upstream of the unit.
d. Flow sensor transducer shall not be integral to the unit.
e. Flow coefficient calibration data shall be provided for each terminal unit at or near the unit inlet.
f. Flow sensor pressure transducer shall be pressure tested, with air, prior to field installation.

4. The Owner's Authorized Control Representative shall provide any VAV-box terminal unit controls consisting of the volume control external (only) actuator and the microprocessor based volume controller.
   a. The control representative will ship control components and a typical wiring diagram to the terminal box manufacturer for factory installation (field installation is not acceptable).
   b. The control representative for each box shall identify the components.
   c. The terminal box manufacturer shall factory mount the components on the terminal box and complete all interconnecting wiring between the controller, actuator, and hydronic heating valve to allow for a single point power connection to the terminal box disconnect.
   d. Provide a fuse-type overprotection device for the control circuit.
   e. The terminal box manufacturer is solely responsible for proper integration of owner furnished control components and the terminal box operation.
5. Provide factory wired electric heaters as specified in schedule, UL listed resistance open-type element of nickel-chromium.
   a. Provide with airflow switch, disc-type automatic thermal primary safety device, and manual reset thermal secondary device.
   b. Provide with ceramic insulators, interlocking door handle disconnect, and magnetic contractors.
   c. Provide electric heaters listed for use with a circuit breaker protection.
6. Provide disconnect and transformer for control voltage circuit on VAV boxes without electric heat.
7. For units with internal actuators, provide a removable access panel in the bottom of each VAV unit for access to the actuator.
   a. Provide fully gasketed access doors not exceeding the specified casing leakage rates.
8. All VAV terminal box units shall meet the following levels of radiated and discharge noise without any credit for environmental adjustment, space effect, sound division, end reflection, or similar elements external to the terminal box.
   a. Noise levels shall be measure at inlet static pressures of 1.5" W.G.
   b. Radiated Noise

i)	Octave Band	2	3	4	5	6	7
ii)	Frequency	63	125	250	500	1000	2000
iii)	dB	76	69	62	57	56	55

   c. Discharge Noise

i)	Octave Band	2	3	4	5	6	7
ii)	Frequency	63	125	250	500	1000	2000
iii)	dB	70	65	61	75	71	66

d. A maximum variance of +1db is allowed in each octave band and 2db in any octave band.
e. The Manufacturer may opt to install a pre-manufactured duct type silencer mounted on the box discharge to obtain the listed discharge noise levels.
   i) Provide copy of calculations, including the effect of silencer generated noise levels, indicating the net discharge noise levels and compliance with the above requirements.
   ii) Base the performance for silencers upon independent testing performed in accordance with ASTM E477.
   iii) Add additional pressure drop associated with the silencer to the inlet static pressure requirements in determining discharge and radiated noise levels.
f. Noise levels listed are for internally lined boxes without foil facing.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide ceiling access doors or locate units above easily removable ceiling components.

1. Locate bottom of unit not more than 18" above finished ceilings.
2. Design and installation work shall be coordinated to avoid location of VAV units above the ceiling mounted light fixtures.
3. Support units individually from structure.
4. Do not support from adjacent ductwork.

C. Connect to ductwork using rigid duct at inlet and outlet.

1. Provide a minimum of 5 straight duct diameters upstream of the terminal box inlet and a minimum of 10' of duct downstream of the terminal box prior to the first air device connection.

D. Locate and install units ensuring the minimum service area clearance meets NEC requirements.

1. Keep building structural components, any piping (including sprinklers), any ductwork, and equipment out of the service clearance area.
2. Advise other trades of encroachment violations and have offending items relocated or with the Contracting Officer’s approval relocate terminal box to correct nonconforming conditions at no additional cost to the Owner.

3.2 FUNCTIONAL PERFORMANCE TESTING

A. System Functional Performance Testing is part of the Commissioning Process.

1. The Contractor shall perform the Functional Performance Testing and the Commissioning Authority shall witness and document the test.
2. Refer to Section 01 91 13, General Commissioning Requirements, for functional performance tests and commissioning requirements.

B. Systems Readiness Checklists shall be completed and submitted for each piece of equipment included in this section.

C. Perform the functional performance testing of HVAC pumps as part of the Chilled Water System Functional Performance testing.

3.3 DEMONSTRATION AND TRAINING

A. Training of the Government's operation and maintenance personnel is required in cooperation with the Contracting Officer's Representative.
1. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems.
2. Schedule the instruction in coordination with the Contracting Officer's Representative after submission and approval of formal training plans.
3. Refer to Section 01 91 13, General Commissioning Requirements, for further contractor training requirements

B. Perform demonstration and training for all equipment covered by this section and installed in this project.

END OF SECTION

SECTION 23 37 00

AIR OUTLETS & INLETS

PART 1 - GENERAL

1.1 SUMMARY

A. Related Documents:

1. Drawings and general provisions of the Subcontract apply to this Section.
2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:

1. Diffusers.
2. Grilles and registers.
3. Outside louvers.
4. Door grilles.
5. Diffuser boots.
6. Roof hoods.
7. Goosenecks.

C. Related Sections:

1. Division 23 Section "Testing, Adjusting, & Balancing for HVAC".

1.2 REFERENCES

A. General:

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.
3. Refer to Division 23 Section "Common Results for HVAC" for codes and standards, and other general requirements.

B. Air Diffuser Council (ADC):

1. ADC Applicable Standards.

C. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)

1. ASHRAE 52 ..... Method of Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter

D. National Fire Protection Association (NFPA):

1. NFPA 90A ..... Installation of Air Conditioning and Ventilating Systems
2. NFPA 90B ..... Installation of Warm Air Heating and Air Conditioning Systems

1.3 SUBMITTALS

A. Submit under provisions of Division 23 Section "Common Results for HVAC, Review of Materials

B. Shop Drawings:

1. Check location of outlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.
2. Review requirements of outlets as to size, finish, and type of mounting prior to submitting shop drawings and schedules of outlets.

C. Product Data: Cover each item, together with schedule of outlets, and manufacturer's installation instructions.

1.4 QUALITY ASSURANCE

A. Make airflow tests and sound-level measurements in accordance with applicable ADC equipment test codes and ASHRAE standards.

B. Manufacturer shall certify cataloged performance and ensure correct application of air-outlet types.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Krueger,

B. Titus,

C. Approved equal.

2.2 APPLICATION

A. Rate units in accordance with ADC standards.

B. Base air outlet application on space noise level throw noted on the drawings.

C. Provide supply outlets with sponge-rubber seal around edge.

D. Provide baffles to direct air away from walls, columns, or other obstructions within radius of diffuser operation.

E. Provide plaster frame for diffusers located in plaster surfaces.

F. Provide anti-smudge frames or plaques on diffusers located in rough textured surfaces such as an acoustical plaster.

2.3 SUPPLY GRILLES

A. For sidewall supply grilles, provide streamlined and individually adjustable blades, depth of which exceeds 3/4-inch (19-mm) maximum spacing. Provide spring tension or other device to set blades. Provide units with vertical face, double-deflection bar-style grilles.

B. Provide 1-1/4 inch (32-mm) margin frame with countersunk screw holes.

C. Fabricate of steel with 20-gauge (0.9-mm) or heavier frames and 22-gauge (0.8-mm) or heavier blades, steel and aluminum with 20-gauge (0.9-mm) or heavier frame, or aluminum extrusions.

D. Provide grilles with integral, gang-operated opposed-blade dampers with removable key operator, operable from face.

E. Finish in factory baked-enamel

2.4 LOUVERED SUPPLY GRILLES

A. For ceiling supply grilles, provide streamlined and individually adjustable curved blades to discharge air along face of grille. Units shall have one and two way deflection.

B. Provide 1-1/4 inch (32-mm) margin frame with countersunk screw holes.

C. Fabricate of aluminum extrusions.

D. Provide grilles with integral, gang-operated opposed-blade dampers with removable key operator, operable from face.

E. Finish in factory clear-lacquer

2.5 LINEAR SUPPLY GRILLES

A. Linear supply grilles shall have streamlined blades with 15-degree deflection, 1/8

B. Fabricate of aluminum extrusions.

C. Provide 1-1/4 inch (32-mm) margin frame extra heavy for floor mounting, with countersunk screw holes.

D. Provide grilles with integral gang-operated opposed-blade damper with removable key operator, operable from face in areas were the ceiling is a hard lid and the access to the duct is impractical.

E. Provide mounting frame suitable for casting in concrete floor.

2.6 RETURN AND EXHAUST GRILLES

A. For sidewall and ceiling exhaust grilles, provide streamlined blades, depth of which exceeds 3/4-inch (19-mm) spacing. Provide spring tension or other device to set blades. Provide units with vertical face.

B. Provide 1-1/4 inch (32-mm) margin frame with countersunk screw holes.

C. Fabricate of steel with 20-gauge (0.9-mm) or heavier frames and 22-gauge (0.8-mm) or heavier blades, steel and aluminum with 20-gauge (0.9-mm) or heavier frame, or aluminum extrusions.

D. Provide exhaust grilles, where not individually connected to exhaust fans, with integral, gang-operated opposed-blade dampers with removable key operator, operable from face.

E. Finish in factory baked-enamel.

2.7 GRID CORE RETURN AND EXHAUST GRILLES

A. Fabricate fixed grilles of 1/2-inch (13-mm) louvers.

B. Provide lay-in frame for suspended grid ceilings.

C. Fabricate of aluminum.

D. Provide exhaust grilles, where not individually connected to exhaust fans, with integral, gang-operated opposed-blade dampers with removable key operator, operable from face.

2.8 LINEAR RETURN OR EXHAUST GRILLES

A. Linear return of exhaust grilles shall have streamlined blades with 0-degee centers.

B. Provide 1-1/4 inch (32-mm) margin frame extra heavy for floor mounting, with countersunk screw holes.

C. Fabricate of steel with 20-gauge (0.9-mm) or heavier frames and 22-gauge (0.8-mm) or heavier blades, steel and aluminum with 20-gauge (0.9-mm) or heavier frame, or aluminum extrusions.

D. Provide exhaust grilles, where not individually connected to exhaust fans, with integral, gang-operated opposed-blade dampers with removable key operator, operable from face.

E. Provide mounting frame for casting in concrete floor.

2.9 OUTSIDE LOUVERS

A. Provide louvers 6 inches (150 mm) deep with blades on 45-degree slope [with center baffle and return bend,] heavy channel frame, bird screen with 1/2-inch (13-mm) square mesh for exhaust and 3/4 inch (19 mm) for intake.

B. Fabricate of 16-gauge (1.5-mm) galvanized steel and provide welded assembly.

C. Finish in factory baked-enamel finish.

D. Fabricate louvered penthouses with mitered corners and reinforce with structural angles.

2.10 ROOF HOODS

A. For air-inlet or exhaust hoods, provide removable hood, curb flange, and bird screen with 1/2-inch (13-mm) square mesh for exhaust and 3/4 inch (19 mm) for intake.

B. Fabricate of galvanized steel, 16-gauge (1.5-mm) or heavier base and 20-gauge (0.9-mm) hood, or aluminum 16 gauge (1.5 mm) or heavier and 18-gauge (1.2-mm) hood. Provide suitable reinforcing to hood.

C. Mount unit on at least 12-inch (300-mm) high curb base with insulation between duct and curb.

D. Finish in factory baked-enamel.

E. Make hood outlet area minimum of twice throat area.

2.11 GOOSENECKS

A. Fabricate goosenecks of 18-gauge (1.2-mm) or heavier galvanized steel.

B. Mount on at least 12-inch (300-mm) high curb base where size exceeds 9 inches (225 mm).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install items in accordance with manufacturers’ printed instructions.

B. Paint interior of ductwork matt-black where it is visible behind air outlets.

END OF SECTION

SECTION 23 51 23

GAS VENTS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. For Category II, IV Gas Fired Appliances:

1. Listed Single Wall Polypropylene Vent. (Z-DENS Single Wall) (Z-DENS Cascade)
2. Listed Concentric Polypropylene Vent / Air. (Z-DENS Concentric)
3. Listed Flexible Polypropylene Liner. (Z-DENS Flexible)

1.2 RELATED SECTIONS

A. Section 23 52 16 - Condensing Boilers.

1.3 REFERENCES

A. American National Standards Institute (ANSI): USA.

1. ANSI Z223.1/NFPA-54 - National Fuel Gas Code.

B. BOCA National Mechanical Code.

C. CSA Group (CSA): Canada.

1. CSA B149.1 - Natural Gas and Propane Installation Code.

D. National Fire Protection Association (NFPA):

1. NFPA-54 - National Fuel Gas Code.

E. Standard Mechanical Code.

F. Underwriters Laboratories (UL):

1. UL 1738 - Venting Systems for Gas-Burning Appliances, Categories II, III, and IV.
2. ULC S636 - Standard for Type BH Gas Venting Systems.

G. Uniform Mechanical Code.

1.4 SUBMITTALS

A. Submit under provisions of Section 01 33 23 - Submittal Procedures.

B. Product Data:

1. Layout drawings and sizing calculations if applicable.
2. Manufacturer's data sheets on each product to be used.
3. Preparation instructions and recommendations.
4. Storage and handling requirements and recommendations.
5. Typical installation methods.
6. Product warranty.

C. Verification Samples: Two representative units of each type, size, pattern, and color.

D. Shop Drawings: Include details of materials, construction, and finish. Include relationship with adjacent construction.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section with a minimum of five years documented experience.

B. Installer Qualifications: Company specializing in performing Work of this section with minimum two years documented experience with projects of similar scope and complexity.

C. Source Limitations: Provide each type of product from a single manufacturing source to ensure uniformity.

D. Mock-Up: Construct a mock-up with actual materials in sufficient time for Architect's review and to not delay construction progress. Locate mock-up as acceptable to Architect and provide temporary foundations and support.

1. Intent of mock-up is to demonstrate quality of workmanship and visual appearance.
2. If mock-up is not acceptable, rebuild mock-up until satisfactory results are achieved.
3. Retain mock-up during construction as a standard for comparison with completed work.
4. Do not alter or remove mock-up until work is completed or removal is authorized.

1.6 PRE-INSTALLATION CONFERENCE

A. Convene a conference approximately two weeks before scheduled commencement of the Work. Attendees shall include Architect, Contractor and trades involved. Agenda shall include schedule, responsibilities, critical path items and approvals.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store and handle in strict compliance with manufacturer's written instructions and recommendations.

B. Protect from damage due to weather, excessive temperature, and construction operations.

1.8 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 recommended limits.

1.9 WARRANTY

A. Manufacturer's standard limited warranty unless indicated otherwise.

1. The manufacturer shall warrant the Vent System against defects in material and workmanship for a period of 10 years from the date of the installation. Any portion of the vent repaired or replaced under the warranty shall be warranted for the remainder of the original warranty period.

PART 2 PRODUCTS

2.1 LISTED SINGLE WALL POLYPROPYLENE VENT

A. Listed Single Wall Polypropylene Vent for Category II, IV Gas Fired Appliances.

1. Basis of Design: Z-DENS Single Wall manufactured by Z-Flex U.S. or Flexmaster Canada.
2. Codes and Applicable Standards Compliance:
   a. Listed to ULC-S636 Vent Standards.
   b. Installed in accordance with all applicable local, state, and national and provincial codes, ordinances, regulations, and laws such as:
      1) National Fuel Gas Code.
      2) ANSI Z223.1/NFPA-54 (USA).
      3) Natural Gas and Propane Installation Code, B149.1 (Canada).
      4) BOCA National Mechanical Code.
      5) Standard Mechanical Code.
      6) Uniform Mechanical Code where applicable.
3. Factory built single wall vent engineered for use with category II, and IV gas fired appliances or as specified by the gas fired appliance manufacturer.
4. Construction: Fire retardant polypropylene.
   a. Wall Thicknesses:
      1) Pipe O.D.: 2.36 inches (60 mm).
         a) Wall Thickness: 0.07 to 0.09 inches (1.8 to 2.2 mm).
      2) Pipe O.D.: 3.15 inches (80 mm).
         a) Wall Thickness: 0.08 to 0.09 inches (2.0 to 2.4 mm).
      3) Pipe O.D.: 4.33 inches (110 mm).
         a) Wall Thickness: 0.10 to 0.12 inches (2.6 to 3.0 mm).
      4) Pipe O.D.: 4.92 inches (125 mm).
         a) Wall Thickness: 0.12 to 0.15 inches (3.1 to 3.7 mm).
      5) Pipe O.D.: 6.30 inches (160 mm).
         a) Wall Thickness: 0.15 to 0.18 inches (3.9 to 4.5 mm).
      6) Pipe O.D.: 7.87 inches (200 mm).
         a) Wall Thickness: 0.19 to 0.21 inches (4.9 to 5.3 mm).

5. Vents include factory installed Double Fail-Safe gasket in the female end of vent yielding an air and watertight joint when the overlapping male/female ends are assembled per the vent manufacturer's instructions.
6. Single wall vent shall be compatible with flexible and concentric vents with an adapter all from the same vent manufacturer.
7. Maximum Intertek rated vent gas temperature shall not exceed 230 degrees F (110 degrees C).
8. Vent shall be Intertek rated for a maximum pressure of 20 inches (508 mm) w.c. The vent system is to be continuous from the appliance's flue outlet to the vent termination outside the building. Components located outdoors must be UV rated.
    a. Systems components such as vent supports, roof or wall penetrations, terminations, connectors and drain fittings shall be Intertek listed and supplied by the same vent manufacturer.
9. Vent components in direct contact with products of combustion must include a Intertek label.

2.2 LISTED CONCENTRIC POLYPROPYLENE VENT / AIR

A. Listed Concentric Polypropylene Vent / Air for Category, II, IV Gas Fired Appliances.

1. Basis of Design: Z-DENS Concentric manufactured by Z-Flex U.S. or Flexmaster Canada.
2. Codes and Applicable Standards Compliance:
    a. Listed to ULC-S636 Vent Standards.
    b. Installed in accordance with all applicable local, state, and national and provincial codes, ordinances, regulations, and laws such as
        1) National Fuel Gas Code.
        2) ANSI Z223.1/NFPA-54 (USA).
        3) Natural Gas and Propane Installation Code, B149.1 (Canada).
        4) BOCA National Mechanical Code.
        5) Standard Mechanical Code.
        6) Uniform Mechanical Code where applicable.
3. Factory built concentric vent / air engineered for use with category II, IV gas fired appliances or as specified by the gas fired appliance manufacturer.
4. Construction: Inner vent fire retardant polypropylene.
    a. Wall Thicknesses:
        1) Pipe O.D.: 2.36 inches (60 mm).
            a) Wall Thickness: 0.07 to 0.09 inches (1.8 to 2.2 mm).
        2) Pipe O.D.: 3.15 inches (80 mm).
            a) Wall Thickness: 0.08 to 0.09 inches (2.0 to 2.4 mm).
        3) Pipe O.D.: 4.33 inches (110 mm).
            a) Wall Thickness: 0.10 to 0.12 inches (2.6 to 3.0 mm).
5. Inner vent shall include factory installed Double Fail-Safe gasket in the female end of vent yielding an air and watertight joint when the overlapping male/female ends are assembled per the vent manufacturer's instructions.
6. Outer Air Wall:
    a. Powdered coated galvanized steel or aluminum.
    b. Incorporate an overlapping joint closure system which is secured together with provided screws.

7. Concentric Vent / Air: To be compatible with single wall vent with an adaptor all from the same vent manufacturer.
8. Maximum Intertek rated vent gas temperature shall not exceed 230 degrees F (110 degrees C).
9. Vent shall be Intertek rated for a maximum pressure of 20 inches (508 mm) w.c.
10. The vent system is to be continuous from the appliance's flue outlet to the vent termination outside the building.
    a. Systems components such as vent supports, roof or wall penetrations, terminations, connectors and drain fittings shall be Intertek listed and supplied by the same vent manufacturer.
11. Concentric components in direct contact with products of combustion must include a Intertek label.

2.3 LISTED FLEXIBLE POLYPROPYLENE LINER

A. Listed Flexible Polypropylene Liner for Category II, IV Gas Fired Appliances.

1. Basis of Design: Z-DENS Flexible manufactured by Z-Flex U.S. or Flexmaster Canada.
2. Codes and Applicable Standards Compliance:
    a. Listed to ULC-S636 Vent Standards.
    b. Installed in accordance with all applicable local, state, and national and provincial codes, ordinances, regulations, and laws such as:
        1) National Fuel Gas Code.
        2) ANSI Z223.1/NFPA-54 (USA).
        3) Natural Gas and Propane Installation Code, B149.1 (Canada).
        4) BOCA National Mechanical Code.
        5) Standard Mechanical Code.
        6) Uniform Mechanical Code where applicable.
3. Factory built flexible liner shall be engineered for use with category II, IV gas fired appliances or as specified by the gas fired appliance manufacturer.
4. Flexible liner to be constructed of fire-retardant polypropylene.
5. Flexible liner coupling and flexible adaptors shall include a factory installed Double Fail Safe fluoroelastomer (FKM) gasket yielding an air and watertight joint when assembled per the vent manufacturer's instructions.
6. Flexible liner shall be compatible with single wall and concentric vents with an adapter all from the same vent manufacturer.
7. Maximum Intertek rated vent gas temperature shall not exceed 230 degrees F (110 degrees C).
8. Vent shall be Intertek rated for a maximum pressure of 20 inches (508 mm) w.c.
9. The vent system shall be continuous from the appliance's flue outlet to the vent termination outside the building. Components located outdoors must be UV rated.
    a. All systems components such as vent supports, roof or wall penetrations, terminations, appliance connectors and drain fittings shall be Intertek listed and supplied by the same vent manufacturer.
10. Vent components in direct contact with products of combustion must include a Intertek label.

PART 3 EXECUTION

3.1 EXAMINATION

A. Do not begin installation until the substrates have been properly constructed and prepared.

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

3.2 PREPARATION

A. Clean surfaces thoroughly prior to installation.

B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

3.3 INSTALLATION

A. Install in accordance with manufacturer's instructions, approved submittals, and in proper relationship with adjacent construction.

1. Vent System Layout:
   a. Vent System and Breachings: Clean inspect and repair if necessary before connecting to appliance.
   b. Maintain air space clearances to combustibles as specified by the manufacturer.
   c. Design and install in compliance with manufacturer's installation instructions including vent category, vent diameter, maximum equivalent length and/or allowable vent pressures, number of elbows, condensate drains, terminations, slope, clearances, support, etc.
   d. Conform to manufacturer's installation instructions, its UL/cUL listing and state/local codes.
2. Mechanical Equipment:
   a. Support any dampers or fans installed in the vent system to prevent any twisting or movement of vent system from fan torque or vibration.

3.4 CLEANING AND PROTECTION

A. Clean products in accordance with the manufacturer’s recommendations.

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

END OF SECTION

SECTION 23 52 16

CONDENSING BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This section includes packages, factory-fabricated and assembled, gas-fired, fire-tube and/or water-tube condensing boilers, trim, and accessories for generating hot water.

1.3 SUBMITTALS

A. Product Data: Include performance data, operating characteristics, furnished specialties and accessories.

1. Prior to flue vent installation, engineered calculations and drawings must be submitted to Architect/Engineer to thoroughly demonstrate that size and configuration conform to recommended size, length, and footprint for each submitted boiler.

B. Efficiency Curves: At a minimum submit efficiency curves for 100%, 50% and 10% input firing rates at incoming water temperature ranging from 80 degrees F to 160 degrees F.

C. Pressure Drop Curve: Submit pressure drop curve for each boiler size at the specific flow rate.

1. If submitted material is different from that of the design basis, boiler manufacture shall incur all costs associated with reselection of necessary pumps. Possible difference includes, but are not limited to, the pump type, pump pad and size, electrical characteristics, and piping changes.

D. Shop drawings: For boilers, boiler trim and accessories include:

1. Plans, elevation, sections, details, and attachment to other work
2. Wiring diagrams for power, signal, and control wiring.

E. Source Quality Control Test Reports: Reports shall be included in materials.

F. Field Quality Control Test Reports: Reports shall be included in materials.

G. Operation and Maintenance Data: Date to be included in boiler emergency, operation, and maintenance manuals.

H. Warranty: Standard warranty specified in this section.

I. Other Information Submittals:

1. ASME Stamp Certification and Report: Submit “H” stamp certificate of authorization, as required by authorities have jurisdiction and document hydronic testing of piping external to boiler.

1.4 QUALITY ASSURANCE

A. Electrical components, Devices and Accessories: Boilers must be listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction and marked for intended use.

B. I=B=R Performance Compliance: Condensing boilers must be rated in accordance with applicable federal testing methods and verified by AHRI as capable of achieving the energy efficiency and performance ratings as tested within prescribed tolerances.

C. ASME Compliance: Condensing boilers must be constructed in accordance with ASME Boiler and Pressure Vessel Code, Section IV “Heating Boilers.”

D. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to “Gas and Oil Fired Boilers – Minimum Efficiency Requirements.”

E. UL Compliance: Boilers must be tested for compliance with UL 795, “Commerical-Industrial Gas Heating Equipment.” Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction such as ETL.

F. NOx Emission Standards: When installed and operated in accordance with manufactures instructions, the boiler shall comply with the NOx emission standards outlined in South Coast Air Quality Management District (SCAQMD), Rule 1146.1; and the Texas Commission on Environmental Quality (TCEQ), Title 30, Chapter 117, and Rule 117.465 or the NOx emission referenced by the manufacturer for the specific boiler model.

1.5 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.6 WARRANTY

A. Standard Warranty: Boilers shall include manufactures standard form in which manufacture agrees to repair or replace (FOB) components of boilers that fail in materials or workmanship within specified warranty period.

1. Warranty period for Fire-Tube and/or Water-Tube Condensing Boilers
   a. The pressure vessel/heat exchanger shall carry a 10-year from date of shipment, non-prorated, limited warranty against any failure due to condensate corrosion, thermal stress, mechanical defects, or workmanship.
   b. All other components, with the exception of the igniter, flame detector and O2 sensor where applicable are conditionally guaranteed against any failure for 18 months from shipment. Local Sales Representative shall include warranty services labor for the duration of the 18-month warranty period. Extended warranty terms shall be offered by the manufacture prior to equipment purchase.

PART 2 - PRODUCTS

2.1 MANUFACTURES

A. Aerco Benchmark

B. Lochinvar Crest

C. Riello Array

2.2 CONSTRUCTION – FIRETUBE BOILERS

A. Description: Boiler shall be either natural gas, propane, or dual fuel fired, fully condensing, fire tube design. Power burner shall have full modulation, discharge into a positive or negative pressure vent and the minimum firing rate shall not exceed the following per size range:

1. Input: 750-1000 MBTU/hr: 50,000 BTU/hr input minimum
2. Input: 1,500 MBTU/hr: 75,000 BTU/hr input minimum
3. Input: 2,000 MBTU/hr: 100,000 BTU/hr input minimum
4. Input: 2,500 MBTU/hr: 167,000 BTU/hr input minimum
5. Input: 3,000 MBTU/hr: 200,000 BTU/hr input minimum
6. Input: 5,000-6,000 MBTU/hr: 400,000 BTU/hr input minimum

B. Boilers that have an input greater that what is specified above at minimum fire will not be considered. Boiler efficiency shall increase with decreasing load (output), while maintaining setpoint. Boiler shall be factory-fabricated, factory-assembled, and factory-tested, fire-tube condensing boiler with heat exchanger sealed pressure-tight, built on a steel base, including insulated jacket, flue-gas vent, combustion-air intake connections, water supply, return and condensate drain connections, and controls.

C. Heat Exchanger: The heat exchanger shall be constructed of 439 stainless steel fire tubes and tube sheets, with a one-pass combustion gas flow design. The fire tubes shall be ½” or 5/8” OD with no less than 0.049” wall thickness. The upper and lower stainless steel tube sheet shall be no less than 0.25” thick. The pressure vessel/heat exchanger shall be welded construction. The heat exchanger shall be ASME stamped for a working pressure not less than 150 psig. Access to the tube sheets and heat exchanger shall be available by burner and exhaust manifold removal. Minimum access opening shall be no less that 8-inches diameter. C. Pressure Vessel: The boiler water pressure drop shall not exceed the following per size:

1. 750-1,000 MBTU/hr: 3 psig @ 100 gpm
2. 1,500-2,000 MBTU/hr: 3 psig @ 170 gpm
3. 2,500 MBTU/hr: 3 psig @ 218 gpm
4. 3,000 MBTU/hr: 3 psig @ 261 gpm
5. 5,000/6,000 MBTU/hr: 4 psig @ 500 gpm

D. The boiler water shall be 3-inch (750-1,000 MBTU/hr), 4-inch (1,500-3,000 MBTU/hr), or 6-inch (5,000-6,000 MBTU/hr) flanged 150-pound; ANSI rated. The pressure vessel shall be constructed of ASME SA53 carbon steel, with a 0.25-inch-thick wall and 0.50 inch thick upper head. Inspection openings in the pressure vessel shall be in accordance with ASME Section IV pressure vessel code. The boiler shall be designed so that the thermal efficiency increases as the boiler firing rate decreases.

E. Modulating Air/Fuel Valve and Burner: the boiler burner shall be capable of high turndown ratio of the firing rate without loss of combustion efficiency or staging of gas valves. The burner shall not operate above 7.5% oxygen level or 55% excess air. The burner shall produce less than 20 ppm of NOx, under standard calibration, corrected to 3% excess oxygen when firing on natural gas. The burner shall be metal-fiber mesh covering a stainless-steel body with spark or proven pilot ignition and flame rectification. All burner material exposed to the combustion zone shall be of stainless-steel construction. There shall be no moving parts within the burner itself. A modulating air/fuel valve shall meter the air and fuel input. The modulating motor must be linked to both the gas valve body and air valve body with a single linkage. The linkage shall not require any field adjustment. A variable speed cast aluminum pre-mix blower shall be used the optimum mixing of air and fuel between the air/fuel valve and the burner.

F. Dual Fuel Capacity: If dual fuel is required (natural gas/propane), the boiler shall include a combustion system with dual fuel capability. The dual fuel unit shall be capable of operating on both natural gas and propane. The boiler efficiency and turndown shall remain unchanged regardless of fuel source. The dual fuel system shall incorporate independent natural gas and propane gas trains and a fuel selector switch. This switching mechanism shall be such that it shall not be possible to flow both fuels simultaneously. The unit shall be calibrated to run on both fuel sources at start-up. No additional re-calibration shall be required when switching between fuel sources for a period of one year from the initial calibration.

G. Exhaust Manifold: The exhaust manifold shall be of corrosion resistant cast aluminum or 316 stainless steel with the following diameter flue connections:

1. 750-1,500 MBTU/hr: 6-inch
2. 2,000-3,000 MBTU/hr: 8-inch
3. 5,000 MBTU/hr: 12-inch or 14-inch
4. 6,000 MBTU/hr: 12-inch (<20 ppm NOx) or 14-inch (<9 ppm NOx)
5. The exhaust manifold shall have a collecting reservoir and a gravity drain for the elimination of condensation.

H. Blower: the boiler shall include a variable-speed, DC centrifugal fan to operate during the burner firing sequence and pre-purge the combustion chamber.

I. Motors: Blower motors shall comply with requirements specified in Division 23 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 a motor to operate in the service factor range above 1.0.

J. Ignition: Ignition shall be via spark or proven pilot ignition with 100 percent main-valve shutoff and electronic flame supervision.

K. The boiler shall be designed such that the combustion air is drawn from the inside of the boiler enclosure, decoupling it from the combustion air supply and preheating the air to increase efficiency.

L. The boiler shall incorporate an air filter to filter the combustion air prior to it entering the blower assembly.

M. Enclosure: The plastic and sheet metal enclosure shall be fully removable, allowing for easy access during servicing. Main access panels shall be removable without the need for tools.

2.3 CONTROLS – FIRETUBE BOILERS

A. Refer to Division 23, Section "Instrumentation and Control Devices for HVAC."

B. The entire boiler control system shall be Underwriters Laboratories recognized.

C. The control panel shall consist of individual circuit boards using state-of-the-art surface-mount technology in a single enclosure. Each board shall be individually field replaceable without requiring special software programs or interfacing with a PC.

D. The combustion safeguard/flame monitoring system shall use spark or proven pilot ignition and a rectification type flame sensor.

E. The control panel hardware shall support RS-485 remote communications.

F. The controls shall annunciate boiler and sensor status and include extensive self-diagnostic capabilities that incorporate a minimum of eight separate status messages and 52 separate fault messages.

G. The control panel shall incorporate three self-governing features designed to enhance operation in external control modes. When operating by an external control signal, the control panel can work to eliminate nuisance faults such as over-temperature, resulting from improper external signal or loss of external signal. These features include:

1. Setpoint High Limit: Setpoint high limit allows for a selectable maximum boiler outlet temperature and acts as temperature limiting governor. Setpoint limit is based on a PID function that automatically limits firing rate to maintain outlet temperature within a 0-to-10-degree selectable band from the desired maximum boiler outlet temperature.
2. Setpoint low limit: Allow for a selectable minimum operating temperature.
3. Failsafe Mode: Failsafe mode allows the boiler to switch its mode to operate from an internal setpoint if its external control signal is lost, rather than shut off. This is a selectable mode, enabling the control can to shut off the unit upon loss of external signal, if so desired.

H. The boiler control system shall incorporate the following additional features for enhanced external system interface.

1. Outside Air Reset Control with optional sensor.
2. Analog input for set point control (0-5 vdc or 1-5 vdc) (0-20 ma or 4-20 ma)
3. Auxiliary start delay timer
4. Remote interlock circuit
5. Delayed interlock circuit
6. Fault relay for remote fault alarm

I. Each boiler shall include an electric, single-seated combination safety shutoff valve/regulator with proof of closure switch in its gas train. Each boiler shall incorporate dual over-temperature protection with manual reset, in accordance with ASME Section IV and CSD-1.

J. Each boiler shall have integrated software capable of multi-unit sequencing with lead-lag functionality and parallel operation. The system will incorporate the following capabilities:

1. Efficiently sequence 2 to 8 units on the same system to meet load requirement.
2. Integrated control and wiring for seamless installation of optional isolation valve. When valves are utilized, the system shall operate one motorized valve per unit as an element of load sequencing. Valves shall close with decreased load as units turn off, with all opening under no-load condition.
3. Automatically rotate lead/lag amongst the units on the chain and monitor run hours per unit and balance load in an effort to equalize unit run hours.
4. Option to manually designate lead and last boiler.
5. Designated master control, used to display and adjust key system parameters.
6. Automatic bump-less transfer of master function to next unit on the chain in case of designated master unit failure (with optional network header sensor); master/slave status should be shown on the individual unit displays.

2.4 CONSTRUCTION – WATERTUBE BLOILERS

A. Description: Boiler shall be either natural gas or propane fired, fully condensing, water tube design. Power burner shall have full modulation, discharge into a positive or negative pressure vent and the minimum firing rate shall not exceed the following per size range:

1. Input: 1,000 MBTU/hr: 100,000 BTU/hr input minimum
2. Input: 1,500 MBTU/hr: 100,000 BTU/hr input minimum
3. Input: 2,000 MBTU/hr: 100,000 BTU/hr input minimum
4. Input: 3,000 MBTU/hr: 100,000 BTU/hr input minimum
5. Input: 4,000 MBTU/hr: 100,000 BTU/hr input minimum

B. Boilers that have an input greater that what is specified above at minimum fire will not be considered. Boiler efficiency shall increase with decreasing load (output), while maintaining setpoint. Boiler shall be factory-fabricated, factory- assembled and factory- tested, water-tube condensing boiler with heat exchangers sealed pressure-tight, built on a steel base, including insulated jacket, flue-gas vent, combustion-air intake connections, water supply, return and condensate drain connections, and controls.

C. Heat Exchangers: Each boiler shall consist of multiple, individual stainless-steel (AISI 316L) water tube heat exchangers. Each heat exchanger shall be 500,000 BTU/hr input each and shall be independent of one another. The heat exchangers shall be of a dual helical coil design which consists of a single continuous tube, connected only at the ends. Coils with multiple tubes or multiple connections to a common manifold will not be accepted. The heat exchanger shall have a water-backed reservoir on each end of the helical coils. Such reservoirs shall allow expansion and contraction of the coil with minimal mechanical stress. The water tube shall have a minimum equivalent diameter of 1-inch. To reduce the possibility of internal scaling, the helical coil shall have a water velocity of at least 1.8 ft/s. The heat exchangers shall be built and tested in accordance with ASME Section IV and have a MAWP of 80 psi. the heat exchangers shall be of welded construction, no gaskets. Each heat exchanger shall provide 43sf.ft/500,000 BTU/hr of heating surface and shall be individually replaceable without isolating the entire boiler.

D. Combustion Chamber: The combustion chamber shall be 316L or 316Ti stainless- steel. Carbon steel combustion changers will not be accepted. A window view port shall be provided for visual inspection fo the boiler combustion during firing.

E. Pumps: Each module shall have its own internal wet rotor circulation pump. The onboard boiler control panel shall stage these pumps with the modules as described below in lead/lag staging. Each module shall also have its own flow meter to monitor the status of its pump. Boilers requiring singular, or externally mounted primary pumps will not be accepted.

F. Gas Trains: The main boiler gas train shall incorporate a low and high gas pressure switch. Each individual heat exchanger (module) shall have its own zero governing, dual safety shut off gas valve. Each module shall also have its own manual gas shut off valves upstream and downstream of the automatic gas valve.

G. Burners: The burners shall be of a premix design with a stainless-steel knitted metal fiber mesh. Ceramic or non-metallic burners will not be accepted. Each burner shall operate with a 5:1 turndown, per module in a fully modulating fashion. Stepped or staged modulation will not be accepted.

H. Emissions: The burners shall not produce more that .04% of carbon monoxide at all firing rates. The burner shall be certified for NOx readings of <9ppm corrected to 3% oxygen.

I. Ignition: Ignition shall be via direct spark with 100 percent main-valve shutoff and electronic flame supervision.

J. The boiler shall be designed such that the combustion air is drawn from the inside of the boiler enclosure, decoupling it from the combustion air supply and preheating the air to increase efficiency.

K. Enclosure: The sheet metal enclosure shall be fully removable, allowing for easy access during servicing. Main access panels shall be removable without the need for tools.

2.5 CONTROLS – WATERTUBE BOILERS

A. Refer to Division 23, Section " Instrumentation and Control of HVAC."

B. The entire boiler control system shall be UL or ETL recognized.

C. The control panel shall consist of individual circuit boards. Each board shall be individually field replaceable without requiring special software programs or interfacing with a PC.

D. The combustion safeguard/flame monitoring system shall use spark ignition. The spark igniter shall also double as the rectification-type flame sensor.

E. The control panel hardware shall support the RS-485 remote communications.

F. Each module shall have its own flame safeguard/controller to allow for shutdown of an individual module without shutting down the entire boiler.

G. The boiler shall incorporate a service display for service personnel (password protected). And a 7" color touchscreen for the general boiler operator. Each shall provide full diagnostics including real time data logging, error history and current operating status/data. Both the service display and the touchscreen are intended for annunciation purposes only and shall not be control devices. In the event of failure, the boiler shall operate without the service panel or touchscreen in place.

H. The boiler control system shall incorporate the following additional features for enhanced external system interface:

1. Outside Air Reset Control with sensor installed
2. Analog input for set point control (0-10vdc)
3. Air damper control
4. Enable/Disable
5. Fault relay for remote fault alarm
6. System/Secondary pump control
7. Individual flow monitoring and pump control per module

I. Each boiler shall have integrated software capable of multi-unit sequencing with lead-lag functionality and parallel operation. The system will incorporate the following capabilities:

1. Efficiently sequence 2 to 8 boilers (2-64 modules) on the same system to meet load requirements.
2. Automatically rotate lead/lag amongst the boilers on the chain and the modules within the boilers.
3. Designated master control, used to display and adjust key system parameters
4. Failsafe/Emergency Mode to allow for standalone boiler operation in the event of communication failure or system sensor failure.
5. Automatic set point calculation to maintain secondary loop temperature without prematurely staging modules and with varying flows

2.6 ELECTRICAL POWER

A. Controllers, Electrical Devices and Wiring: Electrical devices and connections are specified in Division 26 sections.

1. Single-point Field Power Connections: Factory-installed and factory-wired switches, motor controllers, transformers and other electrical devices shall provide a single-point power connection to the boiler.

2.7 VENTING

A. The exhaust vent must be UL listed for use with Category II, III, and IV appliances and compatible with operating temperatures up to 230 degrees F, condensing flue gas service. UL-listed vents of Polypropylene and A1 29-4C stainless steel must be used with boilers.

B. The minimum exhaust vent duct size for each boiler is six-inch (750-1,500 MBTU/hr), 8-inch (2,000-3,000 MBTU/hr), 10-inch (4,000 MBTU/hr) or 12-inch (5,000-6,000 MBTU/hr) diameter.

C. Combustion-Air Intake: Boilers shall be capable of drawing combustion air from the outdoors via a metal or PVC duct connected between the boiler and the outdoors.

D. The minimum ducted combustion air duct size for each boiler is six-inch (750-1500 MBTU/hr), 8-inch (2,000 to 3,000 MBTU/hr), 10-inch (4,000 MBTU/hr) or 12-inch (5,000 to 6,000 MBTU/hr), or 14-inch (5,000 to 6,000 MBTU/hr) diameter.

E. Common vent and common combustion air must be an available option for boiler installation. Consult manufacturer for common vent and combustion air sizing.

F. Follow guidelines specified in manufacturer's venting guide.

2.8 SOURCE QUAILTY CONTROL

A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions and carbon monoxide in flue gas, and to achieve combustion efficiency. Perform hydrostatic testing.

B. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.

1. If boilers are not factory assembled and fire-tested, the local vendor is responsible for all field assembly and testing.

C. Allow owner access to source quality-control testing of boilers. Notify Architect 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before boiler installation examine roughing-in for concrete equipment bases, anchor-bolt sizes, locations, piping, and electrical connections to verify actual locations, sizes and other conditions affecting boiler performance, maintenance and operations.

1. Final boiler locations indicated on drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

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

3.2 INSTALLATION

A. Install boilers level on concrete bases. Concrete bas is specified in Division 23 Section "Common Worl Results for HVAC," and concrete material and installation requirements are specified in Division 03. The rear of each boiler shall be flush with the concrete base "housekeeping pad" to insure proper gravity drainage of condensate.

B. Install gas-fired boilers according to NFPA 54.

C. Assemble and install boiler trim per manufactures recommendations.

D. Install electrical devices furnished with boiler but not specified to be factory mounted.

E. Install control wiring to field-mounted electrical devices.

F. Install a condensate neutralizer manufactured by BKI Industries or equivalent for each boiler. Condensate drain piping shall be of PVC/CPVC or stainless- steel material. Unions shall be installed upstream and downstream of condensate neutralizer to allow for ease of maintenance.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to boiler to permit service and maintenance.

C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

D. Connect gas piping to boiler gas-train inlet with unions. Piping shall be at least full size of gas train connection. Provide a reducer if required. An appropriate shutoff valve shall be installed at each boiler and shall be operable without the use of ladders, steps or tools.

E. Connect hot water piping to supply and return boiler connection with shutoff valve and union or flange at each connection.

F. Install piping from safety relief valves to nearest floor drain.

G. Boiler Venting:

1. Install venting using the vent manufacturers appliance adaptor for the specific boiler model being installed. Modifications to universal adaptors or standard vent lengths will not be accepted.
2. Connect venting full size to boiler connections. (Comply with requirements in Division 23 Section "Breechings, Chimneys and Stacks.")

H. Ground equipment according to Division 23 Section "Grounding and Bonding for Electrical Systems."

I. Connect wiring according to Division 23 Section "Low-Voltage Electrical Power Conductors & Cables."

J. When installed, Enable/Disable relay(s) shall be accessible without removing the boilers sheet metal or using ladders. The relay(s) shall incorporate HOA switched and indicator lights.

K. Emergency Power Off (EPO) switches shall be installed at each exit point of the room where the boiler is being installed. RGe EPO switched/relays shall break line/control power to the boilers internal controllers to prohibit the gas valves from being energized.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

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

B. Tests and Inspections

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Perform hydrostatic test. Repair leaks and retest until no leaks exist.
3. Start units to confirm proper motor rotation and unit operations. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment
   a. Check and adjust initial operating set point and high-and low-limit safety set points of fuel supply, water level and water temperature.
   b. Set field-adjustable switched and circuit-breaker trip ranges as indicated. C. Remove and replace malfunctioning units and retest as specified above.

C. Occupancy Adjustments: When requested within 2 months of date of Substantial Completion, provide on-site assistance adjusting system to suit actual occupied conditions. Provide up to two visits to project during other than normal occupancy hours for this purpose. E. Performance Tests:

1. The boiler manufacture is expected to provide partial load thermal efficiency curves. These thermal efficiency curves must include at least three separate curves at various BTU input levels. It these curves are not available; it is the responsibility of the boiler manufacturer to complete the following performance tests:
   a. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
   b. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
   c. Perform field performance tests to determine capacity and efficiency of boilers
      1) Test for full capacity
      2) Test for boiler efficiency at (low fire, 20, 40, 60 80, 100, 80, 60, 40, and 20)percent of capacity. Determine efficiency at each test point. F. Repeat test until results comply with requirements indicated.

D. Provide analysis equipment required to determine performance.

E. Provide temporary equipment and system modifications necessary to dissipate the heat produced during test if building systems are not adequate.

F. Notify architect in advance of test dates.

G. Document test results in a report and submit to Contracting Officer for Engineer's review.

END OF SECTION

SECTION 23 64 16.13

AIR-COOLED CENTRIFUGAL WATER CHILLERS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements"

1.2 DESCRIPTION OF WORK

A. Work Included: Provide water-cooled centrifugal water chillers and components as shown, scheduled, and indicated on the Drawings, including but not limited to:

1. Chiller package.
2. Charge of refrigerant and oil.
3. Controls and control connections.
4. Chilled water connections.
5. Condenser water connections.
6. Starters.
7. Electrical power connections.

1.3 QUALITY ASSURANCE

A. Manufacturers: the design shown on the drawings is based upon products of the manufacturer scheduled. Equipment manufactured by Train, Carrier, McQuay, or York will be acceptable if it meets the scheduled capacities and complies with these specifications. If equipment manufactured by a manufacturer other than that scheduled is utilized, then the Mechanical Contractor shall be responsible for coordinating with the General Contractor and all affected Subcontractors to insure proper provisions for installation of the furnished unit. This coordination shall include, but is not limited to, the following:

1. Structural supports for units.
2. Piping size and location.
3. Electrical power requirement and wire, conduit, and overcurrent protection sizes.
4. The Mechanical Contractor shall be responsible for all costs incurred by the General Contractor,
5. Subcontractors and Consultants to modify the building provisions to accept the furnished units.

B. Standards: Products shall be designed, tested, rated, and installed in compliance with the following standards, as applicable.

1. ANSI/ASHRAE STANDARD 15-1978 Safety Code for Mechanical Refrigeration.

2. ANSI/ASHRAE 90A Energy Conservation in New Building Design.
3. ANSI/ASME SEC VIII Boiler and Pressure Vessel Code.
4. ANSI/ASME B31.S-1983 ASME Code for Pressure Piping and Refrigeration Piping.
5. ANSI/UL 465 Central Cooling Air Conditioners.
6. UL 984 Safety Standards for Hermetic Motor Compressors.
7. ARI STANDARD 550-90 Centrifugal or Rotary Water Chilling Packages.
8. AFBMA 9 Load Ratings and Fatigue Life for Ball Bearings. Bearings must have life of not less than 200,000 hours. Ratings and Certifications: Products shall be rated and certified in accordance with the following:
   a. Conform to ARI Standard 550-90 code for rating and testing of centrifugal chillers.
   b. Conform to ANSI/UL 465 for construction of centrifugal chillers [and provide UL label].
   c. Conform to ANSI/ASME Section VIII Boiler and Pressure Vessel Code for construction and testing of centrifugal chillers.
   d. Conform to ANSI/ASHRAE Standard 15-1978 code for construction and operation of centrifugal chillers. Unit shall bear the ARI certification label for centrifugal water-cooled chillers as applicable.
   e. Factory Performance Testing: One chiller of each size specified for the project shall be factory performance tested under full load conditions in an ARI-certified test facility. The manufacturer shall supply a certified test report to confirm performance as specified. Proper ARI certification documents for the test loop shall be made available upon request from the manufacturer. The performance test shall be conducted in accordance with ARI Standard 550-90 procedures and tolerances. The performance test shall be run with clean tubes in accordance with ARI 550-90 to include the following:
      1) A downward temperature adjustment per Section A7.3 shall be made to the design leaving evaporator water temperature to adjust from the design fouling to the clean tube condition.
      2) An upward temperature adjustment per Section A7.3 shall be made to the design entering condenser water temperature to adjust from the design fouling to the clean tube condition.
      3) Factory performance testing shall include integrated part load value (IPLV) testing. Test reports provided with O&M Manuals shall include raw data used in IPLV calculations. The factory test instrumentation shall be per ARI Standard 550, and the calibration of all instrumentation shall be traceable to the National Institute of Standards and Technology.

C. Warranty:

1. Provide five-year warranty for chillers including coverage for compressor, compressor motor evaporator condenser complete chiller package gear box refrigerant metering system as manufactured and delivered to site including materials and labor.

D. Maintenance Service:

1. Provide service and maintenance of chillers for period of one years from Date of Substantial Completion. Manufacturer shall have local stock of parts for centrifugal chillers proposed. Manufacturer shall have local service organization which shall have been established for at least 5 years.

1.4 SUBMITTALS

A. Shop drawing submittals shall include, but not be limited to, the following:

1. Drawings indicating components, assembly, dimensions, weights, and loadings, required clearances, and location and size of field connections. Indicate equipment, piping and connections, valves, strainers, and thermostatic valves required for complete system.
2. Submit product data indicating rated capacities, weights, specialties and accessories, electrical requirements and wiring diagrams.
3. Written description of equipment functions and normal operating characteristics.
4. Written operating instructions including check-out, adjustment, start-up, routine and normal operations, regulations and controls, and shutdown for emergency.
5. Written instructions for installation and assembly, where required, including assembly drawings showing matchmarking of field-assembled components.
6. Chiller starter cut sheets with components, features, options, and wiring clearly indicated.
7. Wiring diagrams showing power and control wiring for chiller components, safety devices, and controls, clearly indicating both factory and field wiring.
8. Written listing of limiting conditions of chiller including minimum permissible temperatures, minimum voltages, maximum and minimum permitted ambient conditions, maximum permitted chilled-water-entering temperature, recommended thermal shock, and change-over temperatures.
9. Performance certifications and certified reports.
10. Warranties and guarantees.

1.5 HANDLING

A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

B. Protect units from physical damage. Leave factory shipping covers in place until installation.

PART 2 - PRODUCTS

2.1 CHILLER MATERIALS AND COMPONENTS

A. General: Provide chiller manufacturer's standard materials and components as indicated by his published product information, designed, and constructed as recommended by the manufacturer and as required for a complete chiller installation as specified herein.

B. Selection: Each chiller shall allow for a water side fouling factor of 0.00025 in the evaporator tubes and 0.001in the condenser tubes. Evaporator and condenser water pressure drops shall not exceed those scheduled on the Drawings. The total kW power consumption of the units shall not exceed the scheduled kW on the Drawings and will be factory verified in the chiller capacity test specified. Chillers shall be rated in accordance with the latest edition of ARI Standard 550-90 and shall conform to ASHRAE/ANSI 15-1978 Safety Codes. Refrigerants: Chillers shall be provided for use with R-134a.

C. Efficiency: Chiller full load efficiency shall be equal to or greater than that scheduled.

D. Chillers: Shall consist of, but not be limited to, a complete system with compressor, motor, evaporator, condenser, lubrication system, purge system or pump-out unit, economizer or sub-cooler, capacity controller, instrument and control panel, unit mounted motor starter, factory-installed insulation and other items as specified herein or required.

2.2 COMPRESSORS AND MOTORS

A. Compressors: Shall be direct drive or gear driven, single or multistage centrifugal type. Capacity control shall be provided by fully modulating variable inlet guide vanes and shall allow capacity modulation from 100% of scheduled capacity to 15% of scheduled capacity at scheduled design conditions and with condenser water temperatures down to 45°F, without hot gas bypass. Guide vanes shall be controlled by an externally mounted electric operator in response to the refrigeration load on the evaporator. Impellers shall be high strength aluminum alloy and shall be directly connected to the motor shaft or gear driven. Compressor bearings shall be hydrodynamic sleeve type or tapered roller bearings. Sleeve bearings shall be either aluminum insert or steel backed Babbitt.

B. Tapered roller bearings shall be stainless steel. The entire motor/compressor assembly shall be statically and dynamically balanced and tested at 25% overspeed. The motor/compressor assembly on direct driven units or motor/gearbox/compressor assembly on gear driven units shall be balanced to a maximum vibration amplitude of one mil as measured on the motor/compressor housing. All compressor casings shall be cast iron and shall be proof-tested at 1.5 times the maximum working pressure and leak-tested with refrigerant trace gas.

C. Transmissions: If the compressor requires a speed-increasing transmission, it shall be hermetically sealed with the motor/compressor. The transmission shall be self-aligning with a parallel double helical gear arrangement having a minimum service factor of 1.2. If the thrust of the gears is counteracted by the design residual thrust of the impellers, single helix gear design will be acceptable.

D. Each assembled compressor motor (transmission) shall be run-tested at the factory. At any bearing, neither the horizontal nor vertical vibration shall exceed 1.0 mil. Prior to installation, the manufacturer shall provide certified test results.

E. Motors: Shall be hermetically sealed low-slip squirrel cage induction motors designed and guaranteed for continuous operation at nameplate rating. Motors shall be cooled with liquid or suction refrigerant circulated directly over the starter windings and between the rotor and starter. All motor windings shall be designed for operation in a refrigerant atmosphere. The motor shall be suitable for SCR controlled solid-state or Star-Delta reduced voltage starting at the voltage scheduled on the drawings. Motor winding temperature sensors, interlocked for unit shutdown, shall be provided for each phase.

F. Lubrication: Force-feed lubrication shall be provided by a direct drive, positive displacement oil pump which shall provide positive lubrication to all bearings at all times. Power for the oil pump shall be supplied through the control power transformer/source. A lubrication oil filter with a differential pressure gauge shall be provided. A low voltage-density oil heater shall maintain oil temperature at a level to minimize its affinity for refrigerant. Power for the oil heater shall be supplied from a separate control power circuit and wired through the unit control panel. An integral or independent oil cooling system shall be provided. An interlock shall be provided to prevent motor starting unless oil pressure is established.

2.3 VESSELS AND ACCESSORIES

A. Evaporator and Condenser Vessels: Heat exchangers shall be of a shell and tube type designed in accordance with ANSI/ASHRAE 15-1978 Safety Code for Mechanical Refrigeration and ASME Code for Unfired Pressure Vessels and shall be appropriately stamped where required by ASME Code. The refrigerant side shall be proof tested 1.5 times the maximum design working pressure. The waterside working pressure shall be 150 psi and shall be tested at 1.5 times design working pressure.

B. Heat exchangers shall include water side taps for vent and drain connections as required. Waterside pressure drop shall not exceed scheduled values. Water side heads shall be removable to allow direct access to all tubes. Provide flanged connections with ANSI 125 pounds drilling for all heat exchanger supply and return piping.

C. Evaporator: The evaporator shell shall be formed of carbon steel plate and shall incorporate a carbon rupture disc. The evaporator relief shall be piped through the building roof in conformance with applicable codes or as shown in the drawings. The chiller manufacturer shall be responsible for sizing the relief piping. End and intermediate tube sheets shall be carbon steel and shall be drilled for tube installation. Tube sheets shall be welded to the vessel shell and be fully self-supporting. Tubes shall be externally finned nominal 0.028" wall copper tubing mechanically expanded into the tube sheets. Tubes shall be individually cleanable and replaceable. Mesh screen eliminators shall be installed along the entire length of the evaporator to prevent liquid refrigerant carry over into the compressor. Liquid refrigerant entering the evaporator shall be distributed uniformly along its entire length without direct impingement of high velocity refrigerant on tubes. For standard water selections, minimum allowable refrigerant temperatures shall be 32°F at the design conditions scheduled with a minimum water side tube temperature of 33.5°F. The refrigerant side of the evaporator shall be vacuum and pressure leak tested with refrigerant trace gas. The evaporator shall be tested as specified hereinabove for Evaporator and Condenser Vessels. Provide a site glass at each evaporator, located such that the proper refrigerant change is near the center of the glass with the unit off.

D. Refrigerant Flow Control: Shall be by means of a positive metering device and the chiller shall be capable of starting and operating with entering condenser water at 65°F. Adjustable or float type refrigerant metering devices and thermal expansion valves shall be inspected and adjusted by the manufacturer annually for the first 5 years of operation to assure equivalent reliability to a fixed orifice system.

E. Condenser: The condenser shell and tube sheets shall be formed of carbon steel plate. Condenser tubes shall be externally finned, internally smooth nominal 0.028" wall copper and shall be mechanically expanded into the tube sheets and shall be compatible with the Brush Cleaning System specified elsewhere in these specifications.

F. Tubes shall be cleanable and replaceable. The condenser shall be tested as specified hereinabove for the Evaporator and for Evaporator and Condenser Vessels.

G. Economizer: An economizer may be incorporated to help maintain the correct differential between condensing and evaporator pressures over the entire range of loading. All units utilizing subcooling must be provided with a thermometer well to monitor the amount of subcooling.

H. Purge System: An automatic high efficiency purge system shall be provided on low pressure refrigerant (R-34A, etc.) units to remove any non-condensables and water vapor present in the refrigerant. At standard operating conditions and with a condensing refrigerant temperature of 80°F, the purge discharge shall be better than one pound of non-condensable per pound of refrigerant. The purge system shall include a purge compressor, controls, sight glass oil level indicator, electrically heated oil separator, sectionalized drum permitting separation of non-condensable gases and water from the discharge of the compressor purge, a means of return refrigerant to the condenser and drawing off of non-condensables and solenoid valves to automatically isolate the purge system from the refrigerant circuit when the purge compressor is not in operation. A purge pressure gauge, a number of starts counter, and an hour meter shall be included on the purge system. Pump-out Unit: An automatic pump-out unit and storage vessel shall be factory installed on all high-pressure refrigerant R134A etc.) units or the unit shall be capable of storing and isolating the entire refrigerant charge in the unit condenser vessel. Unit shall be factory installed and piped and shall be furnished prewired with all necessary controls, transfer pump, condensing unit and tank constructed in accordance with ASME Code for unfired pressure vessels bearing the National Board stamp. Pump-out systems shall be supplied and warranted by the centrifugal machine manufacturer. Pump-outs shall comply with the following:

1. Pump-out tank(s) with ASME stamp capable of holding refrigerant charge when 80% full at 90°F.
2. Separate charging connections for liquid and gas refrigerant.
3. Piping and valves between pump-out and chiller to be supplied and installed by installing contractor. Contractor shall provide all piping, electrical equipment, and wiring required.
4. Refrigerant piping shall be Type K hard-drawn copper with wrought copper fittings. Valves shall be pack-less type suitable for refrigerant use.
5. Recycle/Recovery Unit: The manufacturer shall provide a portable Recycle/Recovery System. The system shall be modular allowing a single operator to transport, unload and install the system without requiring hoists, cranes, etc. the system shall include modular storage tanks, portable evacuation pump, heater, pump high pressure control, water cooled condenser, and pump starter. The system shall be compatible with R-134a and shall have a storage capacity of 1000 lbs. The system shall include 25 ft. of self-sealing refrigerant hoses.

2.4 ACCESSORIES

A. Vibration Isolation: Vibration isolation shall be provided at all supports points. Refer to Section 23 05 48, "Vibration Isolation", for requirements.

B. Refrigerant and Oil Charge: All chillers shall be provided with a full charge of refrigerant and oil.

C. Refrigerant and oil charge shall be checked prior to startup. All or any part of the refrigerant or oil that may be lost during startup or the warranty period, shall be replaced by the chiller manufacturer at no additional cost to the Owner.

1. Thermometer Wells and Site Glasses: Thermometer wells shall be provided to measure liquid refrigerant condensing and evaporating temperature and for all safety controls. Site glasses shall be provided for monitoring refrigerant and oil charge level, compressor rotation and the purge condenser drum.

2. Differential Pressure Sensors: Provide Orange Research, Inc. or approved equal differential pressure sensors with pressure switches and direct reading differential pressure gauges factory-installed to read across each heat exchanger. Differential pressure gauges shall be factory-mounted in the face of the chiller control panel and the pressure switches shall be factory-interlocked with the chiller controls to provide heat exchanger water flow verification. Sensors shall be similar to Series 1516 with 3-1/2" gauge readout, two reed switches and 316 stainless steel construction. Gauge range shall be adequate to monitor pressure drop from clean tubes to 0.0001 fouled tubes plus a 25% safety margin. Gauges shall be calibrated with water and shall be liquid filled to prevent pointer pulsation.

2.5 CONTROLS

A. General: The chiller(s) shall be controlled by a stand-alone Direct Digital Control (DDC) System. The controller shall provide chiller capacity control in response to the leaving chilled water temperature.

B. Control Panel: The chiller control panel shall provide control of chiller operation and monitoring of chiller sensors, actuators, relays, and switches.

C. Safeties: The chiller control panel shall monitor such safeties as motor starting and running current, motor winding temperature (hermetic motors only), time between compressor/motor starts, low chilled water temperature, high condenser refrigerant pressure, low evaporator refrigerant pressure, high discharge pressure, evaporator and condenser water flows, low oil flow/pressure, and proper operation of unit controls and sensors.

D. Gauges: The chiller control panel is to be provided with the following system pressure information:

1. Evaporator refrigerant pressure.
2. Condenser refrigerant pressure.
3. Oil pressure.
4. Purge drum pressure.

E. Meters: The chiller control panel is to be provided with a starts counter and running time meter.

F. Indicator/Displays: The front of the chiller control panel shall be capable of displaying the following:

1. Entering and leaving evaporator water temperature.
2. Entering and leaving condenser water temperature.
3. Chilled water setpoint.
4. Electrical current limit set point.
5. Chiller operating mode.
6. Chiller diagnostic codes and operating messages.

G. Protection: The chiller control panel shall provide evaporator freeze protection and low limit control.

H. This control shall be used to avoid low evaporator refrigerant temperature trip-outs during critical periods of chiller operation. The control shall take progressively more aggressive load limiting action in response to the severity of the rate of change and the actual value of the evaporator refrigerant temperature. A diagnostic code/message, reflecting the operating status, shall be automatically displayed at the front panel whenever this control is in effect.

I. Control Interface Outputs: The chiller control panel shall provide a relay output to start the condenser water pump and/or enable the cooling tower temperature controls.

J. Alarm Outputs: The chiller control panel shall provide an alarm relay output that shall energize whenever a fault requiring manual reset is detected by the panel.

K. Condenser Limit Control: The chiller control panel shall provide condenser limit control to include a pressure transducer and interconnecting piping and wiring. This control shall be used to avoid high condenser refrigerant pressure trip-outs during critical periods of chiller operation. The control shall take progressively more aggressive load limiting action in response to the severity of the rate of change and actual value of the condenser refrigerant pressure. A diagnostic code/message, reflecting the operating status, shall be automatically displayed at the front panel whenever this control mode is in effect.

L. Low Temperature Startup: Include necessary controls to allow the water chilling unit to start with a condenser water temperature of 45°F (7.2°C) and operate continuously at 65°F (18.3°C) condenser water temperature. Single stage units or 2-stage units with inlet vanes in front of only one stage of compression, may utilize automatic hot gas bypass to allow operation at reduced load.

M. Chilled Water Temperature Reset: The chiller control panel shall provide leaving chilled water temperature reset based upon return water temperature or ambient temperature.

N. Chilled Water Temperature Reset: The unit control panel shall provide leaving chilled water temperature reset based upon a pulse width modulated (PWM), SCR controlled solid state or 4-20ma or 0-10 VOLTS DIRECT CURRENT signal from a building automation system.

2.6 600 VOLT STARTERS

A. General: Each chiller motor shall be provided with a unit mounted free-standing SCR controlled solid state or starter. Motor starter shall have NEMA 1A gasketed enclosure. Unit mounted starters shall be fully wired and tested such that only external power and control wiring connections are required in the field. Enclosure shall be constructed of 12-gauge steel minimum with the exception of doors which shall be code gauge steel minimum. Unit mounted enclosures shall have ventilating louvers or water-cooled heat sinks.

B. Each door or enclosure more than 48" high shall have three-point vault type latches with pad-lockable handles and gasketing.

C. Connections: Motor starters shall include incoming line provisions for the number and size copper cables shown in the Drawings. Incoming line lugs shall be copper compression type. Connection directly to the contactors is not permissible.

D. Contactors: Star delta starter contactors shall be sized properly, per the NEMA requirements, to the chiller full load and locked rotor currents. Contactors shall have double break main contacts with weld resistant silver cadmium faces. Auxiliary interlocks that interface with the control panel shall have low resistance palladium silver contacts.

E. Control Accessories: Each motor starter shall include a control power transformer with fused primary and secondary. Current transformers of the proper size, ratio and burden capacity shall be provided to provide a signal to the control panel and optional devices. Control relays shall be provided within the motor starter to interface with the control panel.

F. Starter Wiring: Power wiring within the starter shall be Type MTW copper stranded 90°C. Power wire bends shall show no evidence of nicking or insulation degradation. Control wire shall be Type MTW copper stranded 90°C, 14 gauge minimum.

G. Motor Protection: Starter shall include motor protection system incorporating electronic three phase overloads and current transformers. The electronic motor protection system shall monitor and protect against the following conditions:

1. Three phase overload protection.
2. Overload protection during start-up.
3. Phase imbalance.
4. Phase loss.
5. Phase reversal.
6. Low voltage.

H. Distribution fault protection consisting of 3-phase, current sensing devices that monitor the status of the current. Distribution faults of 1-1/2 electrical cycle durations shall be detected, and the compressor motor shall be disconnected within six electrical cycles.

I. A lockout transition safety circuit shall be provided to prevent damage from prolonged energization due to malfunction of the transition contractor. Malfunction shall cause the machine to be shut down and the "starter circuit fault" indicator to be displayed. The overload system shall be coordination with the current control system to provide fail-safe circuitry. A single adjustment shall be used to set all three overloads.

J. The motor protection system can, at the manufacturer's option, be furnished as part of the chiller control panel.

K. Ambient Temperature: The starter shall be able to operate in temperatures up to 120°F.

L. Additional Features: The following starter features shall be provided:

M. Disconnect: A non-fused disconnect switch shall be provided.

N. Ammeters and Voltmeters: Three ammeters shall be provided, one per phase. Ammeters shall be calibrated so the inrush current can be indicated. Three voltmeters shall be provided, each reading a phase-to-phase voltage.

O. UL Approval: Starters shall be Underwriters' Laboratories, Inc. approved.

P. Capacitors: Power Factor Correction Capacitors shall be provided to correct to 93.5-95.5% at full load conditions (free standing starters only).

PART 3 – EXECUTION

3.1 INSTALLATION

A. General: Install chillers, including components and controls required for chiller operation, in accordance with chiller manufacturer's instructions.

B. Location: Locate chiller in general position indicated in relation to other work. Position chiller with sufficient clearance for normal service and maintenance, including clearance for cleaning and replacement of tubes and motor.

C. Components: Install auxiliary piping, solenoid valves, shutoff valves, water strainers and controls for accessory systems, including but not limited to, oil cooler, compressor motor cooler, and purge and transfer system. Comply with manufacturer's instructions.

D. Interlock: Interlock flow switches with chiller controls in accordance with the manufacturer's instructions, except as otherwise indicated.

E. Supervision: The unit manufacturer shall supervise the installation and final checkout of the electrical interlock control wiring and review the location of the flow switches so that they perform the safety function without faulty operation or excessive vibration of the sensor.

F. Finish: Paint damaged and abraded factory finish with touch-up paint matching factory finish.

3.2 RELATED WORK

A. General: Provide work related to and connected to chiller work and required for a complete chiller installation, including, but not limited to:

1. Piping connections including provisions for disconnecting and servicing of chiller and cleaning/ replacing of tubes.

B. Relief pipe from chiller relief opening to the outside, including a dirt trap and flexible connection. Size relief piping as recommended by the manufacturer. Tapping in condenser lines for acid cleaning. Isolation of chilled water and condenser water piping connections to chiller. Balancing valves in water piping for balancing system operations. Pipe strainers to protect chiller components and controls including pumps, automatic modulating valves, and pneumatic controls.

C. Pipe support and bracing, adequately separated from chiller work in a manner preventing transfer of pipe stresses to chiller components.

D. Flow switches or pressure differential switches, properly installed in a horizontal run of the chilled water piping and condenser water piping near the chiller.

E. Connecting all miscellaneous piping including oil cooler and auxiliary water piping.

F. Vibration and noise isolation as specified in Section 23 05 48.

G. Ambient room conditions, including additional cooling, if required, for open drive motors.

H. Wiring of flow switches or pressure differential switches for chiller interlock.

I. Electrical wiring by Division 26 to compressor motor controller with interconnecting wiring to chiller control panel and unit motors, as required.

J. Electrical wiring by Division 26 to oil pump/starter, refrigeration transfer compressor/starter and controls, if required.

K. The unit control circuit shall be arranged so that on start-up, the chilled water pump, condenser water pump and oil pump shall start first and the compressor motor shall start after operation conditions have been satisfied. On shutdown, the compressor motor shall stop first and the chilled water pump, condenser water pump and oil pump shall stop after a suitable time-delay period.

L. Prestart-up: Complete the preparation and review the report on related work prior to chiller start up; do not start chiller until inadequacies have been corrected in a manner acceptable to the chiller Installer.

3.3 START-UP SERVICES

A. Manufacturer Supervision: A factory-trained technical service representative of the manufacturer shall supervise the field-assembly (if any), installation and startup of each chiller, for a minimum of five working days, plus one additional day for each chiller unit in excess of one unit. Prepare manufacturer's written report/log of the installation and startup, signed by the service representative and the Owner.

B. Representative shall supervise leak testing, evacuation, dehydration, vacuum pumping, charging, lubrication, including the filling of reservoirs and confirm that lubricant is of the quantity and type as instructed by the manufacturer.

C. Representative shall instruct the Owner's operating personnel in the operation and service of the units for a period of one week, based on a 40-hour week, excluding nights, weekends, and travel time to and from the Project.

D. Sustained Operation: Do not place chiller in sustained operation prior to initial balancing of the mechanical systems affected by chiller operation. Refer to requirements of Section 23 05 93, "Testing, Adjusting, and Balancing for HVAC".

E. Cooperation: Cooperate with other trades and installers of other work during the testing, adjusting, balancing, and start-up of mechanical systems.

3.4 TESTING

A. General: Except as otherwise indicated, test chiller in accordance with ARI Standard 550-90.

B. Pressure Test: Conduct a standing pressure test on the refrigerant circuit for a period of 12 hours using nitrogen without exceeding test pressure recommended by the manufacturer. Conduct a standing vacuum test on the vessel equal to 1 mm Hg absolute for a 24-hour period. Refrigerant shall be charged, through filter dryers, to a recommended level. Machine shipped pre-charged need not comply with this requirement unless the factory pre-charge or holding charge is lost during shipment or prior to start up, in which case the Contractor shall test as indicated. Perform all tests and start up in such a manner as not to introduce moisture into the machine. Flush system as required to remove non condensables.

C. Oil Samples: Obtain oil samples from each compressor at start up, label, and send one sample in a clean, clear, suitable container with screw cap to the Engineer's office. [Send one sample in a suitable container to Analysts Services, Inc., 12715 Royal Drive, Stafford, Texas.] This sample will provide a base reference for all samples taken during the warranty period. At the end of the next two 30-day periods, samples as above shall be taken and distributed. If no recommendations are made by the Engineer or Analysts Services, Inc., samples shall then be taken at 60-day intervals and distributed as above. This testing program shall provide a minimum of eight samples of two each during the warranty period. Test shall include Karl Fisher Titration Test. If a problem is indicated at any time during this process, the Contractor shall take whatever steps necessary to ascertain the cause of any oil contamination. Any remedial measures shall be performed at no additional expense to the Government.

D. The Contractor may at any time submit additional samples to the compressor manufacturer for analysis and a factory-recommended procedure to be followed. All remedial measures shall be reviewed by the Engineer before beginning any work.

END OF SECTION

SECTION 23 73 00

INDOOR CENTRAL-STATION AIR HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Related Documents:

1. Drawings and general provisions of the Subcontract apply to this Section.
2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:

1. Packaged air-handling unit.
2. Cast-in-place concrete.

C. Related Sections:

1. Section 23 05 48 - “Vibration & Seismic Controls for HVAC Piping & Equipment”
2. Section 23 07 13 - "Duct Insulation".
3. Section 23 31 13 - "Metal Ducts".
4. Section 23 05 93 - "Testing, Adjusting, & Balancing".

1.2 REFERENCES

A. General:

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.
3. Refer to Division 01 Section "General Requirements" for the list of applicable regulatory requirements.
4. Refer to Section 23 05 00 - "Common Work Results for HVAC" for codes and standards, and other general requirements.

B. Code of Federal Regulations 29 CFR 1910.7 Definitions and Requirements for a Nationally Recognized Testing Laboratory (NRTL)

C. Air Conditioning and Refrigeration Institute ARI 430 Central-Station Air-Handling Units

D. Air Movement and Control Association, Inc. (AMCA)

E. American Society of Heating, Refrigerating, and Air-Conditioning Engineers ASHRAE 52 Method of Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.

F. Underwriters Laboratories, Inc. UL 900 Test Performance of Air Filter Units

1.3 DEFINITIONS

A. DB = dry bulb

B. WB = wet bulb

C. wg = water gauge

D. cfm = cubic feet per minute

E. gpm = gallons per minute

F. L/s = liters per second

1.4 SUBMITTALS

A. Submit under provisions of Section 23 05 00 - "Common Results for HVAC."

B. Product Data:

1. Curves showing fan performance with system operating-point plotted on curves
2. Manufacturer's installation instructions

1.5 QUALITY ASSURANCE

A. Unit performance shall be certified in accordance with ARI 430.

B. Provide fans bearing AMCA-certified rating seal.

C. Provide filter media with UL 900 class 1 rating or comparable standard and rating by a nationally recognized testing laboratory (NRTL) recognized under 29 CFR 1910.7.

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

E. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Carrier, Daikin, Pace, Trane.

2.2 OVERALL UNIT

A. Provide blow-through type air-handling unit of unitary design suitable for medium-pressure operation.

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

C. Components: Provide supply-fan section plus accessories, including heating coil, mixing-box section, filter section, face and bypass-damper section, cooling-coil section, return fan and humidifier.

D. Performance: See Schedule on the Drawings.

2.3 CASING

A. Mount equipment and support exterior steel panels from structural-steel frame. Reinforce panels. Provide 10 gauge (3.3 mm) galvanized steel base frame under entire unit.

B. Provide hinged double wall access doors with multiple panels for access to sections and components requiring servicing. Minimum access-door size unit full height x 18 inches (450 mm). Provide continuous gasket seals and inward opening door for positive pressure location, outward opening door for negative pressure. Handles shall be quarter-turn type, operated internally and external to the unit.

C. Provide double-wall unit construction. Exterior panel shall be minimum 18 gauge (1.2 mm) galvanized steel. Interior panel shall be 20 gauge (0.9 mm) galvanized steel except where identified for acoustical purposes, the interior panel shall be 18 gauge (1.2 mm) perforated galvanized steel or aluminum. Construct coil section so that coils can be removed without affecting the casing structure.

D. Provide bolted connections between individual modules with closed cell foam gasketing the full perimeter of the unit connection.

E. Unit drain pan shall be a sloped, double-walled insulated drain pan leading to a single drain connection on one side of the unit. Drain pan shall be stainless steel.

F. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

G. Inspection and Access Panels and Access Doors:

1. Panel and Door Fabrication: Formed and reinforced, single- or double-wall and insulated panels of same materials and thicknesses as casing.
2. Inspection and Access Panels:
   a. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
   b. Gasket: Neoprene, applied around entire perimeters of panel frames.
   c. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.

3. Access Doors:
   a. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
   b. Gasket: Neoprene, applied around entire perimeters of panel frames.

H. Condensate Drain Pans:

1. Fabricated with one percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
   a. Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1-2004.
   b. Condensate Drain Pan: Stainless steel formed with pitch and drain connections complying with ASHRAE 62.1-2004.

2.4 INSULATION

A. Insulate unit casing with 2-inch (50-mm) thick, neoprene-faced, 1-1/2 lb/cu ft (24 kg/m3) density fiberglass insulation.

B. Insulate the fan section, face and bypass-damper section, filter section, mixing section, coil section.

C. Secure insulation to single-walled casing with adhesive and weld-pins with fasteners. Protect exposed edges with mastic coating and sheet metal nosings.

2.5 FAN, DRIVE, AND MOTOR SECTION

A. Plug unhoused centrifugal type with multi-blade wheel statically and dynamically balanced. Refer to Section 23 34 23 - "HVAC Power Ventilators" for construction.

B. Provide self-aligning ball bearings. Extend lubrication fittings to exterior of fan casing.

C. Provide variable sheaves for motors rated 15 hp (11 kW) and smaller, and fixed sheaves for motors rated 20 hp (15 kW) and larger.

D. Provide ECM motor capable of variable flow operations.

E. Mount fan and motor on a structural steel frame which is separated from the casing frame. Fan unit shall be isolated from casing with spring vibration isolators and integral seismic restraints. Refer to Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for vibration isolation requirements.

2.6 FACE AND BYPASS DAMPERS

A. Provide opposed-blade type steel airfoil dampers mounted on steel rods supported in stainless steel bearings. Provide neoprene blade seals. Damper leakage shall not exceed 7 cfm/sq ft at 1.0 inch wg (35 L/s/m2 at 250 Pa).

B. Make face-damper area equal to coil size.

2.7 FILTERS

A. Each filter module shall be constructed to house the filter type specified in part B below and as noted on the drawings. Modules shall have side service access doors for replacement of filter media.

B. Provide 2 inch (50 mm) deep cartridge filter with 2 inch (50 mm) prefilter. Cartridge filter shall have 90 percent efficiency as determined in accordance with ASHRAE 52. Filter media shall be SYN-PAC-R media, a synthetic material that is moisture and mold resistant.

2.8 MIXING BOX

A. Provide casing module with two sets of parallel-blade, galvanized-steel dampers mounted on steel shafts supported in stainless steel-bearings. Arrange dampers for mixing of air streams. Provide neoprene blade seals. Damper leakages shall not exceed 7 cfm/sq ft at 1.0 inch wg (35 L/s/m2 at 250 Pa).

2.9 COILS

A. General Requirements for Coil Section:

1. Comply with ARI 410.

B. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).

C. Enclose coils in coil section with headers and U-bends fully contained within the casing.

2.10 CONTROLS

A. Fixed Minimum Outdoor-Air Damper:

1. Outdoor-Airflow Monitor: Accuracy maximum plus or minus 5 percent within 15 and 100 percent of total outdoor air. Monitor microprocessor shall adjust for temperature, and output shall range from 2- to 10-V dc

B. Interface Requirements for HVAC Instrumentation and Control System:

1. Monitoring constant and variable motor loads.
2. Monitoring variable-frequency drive operation.
3. Monitoring cooling load.
4. Monitoring economizer cycles.
5. Monitoring air-distribution static pressure and ventilation air volume.

PART 3 - EXECUTION

3.1 ASSEMBLY

A. Assemble units by bolting sections together to make single unit with full perimeter gasket seal.

3.2 INSTALLATION

A. Install items in accordance with manufacturer's instructions.

B. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

3.3 AIR-HANDLING UNIT SCHEDULE

A. See Drawings.

END OF SECTION

SECTION 23 84 16.00 20

MECHANICAL DEHUMIDIFICATION UNITS

PART 1 - GENERAL

1.1 REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

1. AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)
2. ANSI/ASHRAE 15 & 34 (2010; Addenda a, b, c, d, e, f, g, h, and i)
3. ANSI/ASHRAE Standard 15-Safety
4. Standard for Refrigeration Systems and ANSI/ASHRAE Standard 34-Designation and Safety Classification of Refrigerants.
5. ASHRAE 84 (2008) Method of Testing Air-to-Air Heat Exchangers.
6. NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)
7. NFPA 70 (2011) National Electrical Code
8. NFPA 90A (2009; Errata 09-1) Standard for the Installation of Air Conditioning and Ventilating Systems.

1.2 SUBMITTALS

A. Unit shall be a factory fabricated and tested assembly for air-to-air energy recovery by transfer of sensible heat from exhaust air to supply air stream. Device performance shall be according to ASHRAE 84. Device shall deliver energy transfer effectiveness of not less than 85 percent with cross contamination not in excess of 0.1percent of exhaust airflow rate at system design differential pressure. Exchange media shall be chemically inert, moisture resistant, fire-retardant, laminated, nonmetallic material which complies with NFPA 90A. Exhaust and supply stream shall be isolated by seals which are static, field adjustable, and replaceable. Chain drive mechanisms shall be fitted with ratcheting torque limiter or slip-clutch protective device. Enclosure shall include maintenance access provisions. Recovery control and rotational failure provisions shall be as indicated.

B. Heat Pipe

1. Device shall be a factory fabricated, assembled, and tested, counterflow arrangement, air-to-air heat exchanger for transfer of sensible heat between exhaust and supply airstreams. Device shall deliver an energy transfer effectiveness not less than that indicated without cross-contamination. Heat exchanger tube core shall be (15 mm) 1/2-inch nominal diameter, seamless aluminum, or copper tube with extended surfaces, utilizing wrought aluminum Alloy 3003 or Alloy 5052, temper to suit. Maximum fins per unit length and number of tube rows shall be as indicated. Tubes shall be fitted with internal capillary wick, filled with an ANSI/ASHRAE 15 & 34, Group 1 refrigerant working fluid, selected for system design temperature range, and hermetically sealed. Heat exchanger frame shall be constructed of not less than (1.6 mm) 16 gage galvanized steel intermediate tube supports, and flange connections. Tube end-covers and a partition

of galvanized steel to separate exhaust and supply air streams without cross-contamination shall be provided. A drain pan constructed of welded Type 300 series stainless shall be provided. Heat recovery regulation shall be provided by system face and bypass dampers and related control system as indicated interfacing with manufacturer's standard tilt-control mechanism for summer/winter operation, regulating the supply air temperature and frost prevention on weather face of exhaust side at temperature indicated. Coil shall be fitted with pleated flexible connectors.

C. Desiccant Wheel

1. Supply and regeneration airstreams shall be counterflow. The dehumidifier shall be a rotary type designed for continuous operation. The wheel structure shall be of the extended surface type in the axial flow direction and the geometry shall provide for laminar flow over the operating range for minimum air pressure differentials. The dehumidifier shall be complete with a drive system utilizing a fractional-horsepower electric motor and speed reducer assembly driving the rotor. A slack-side tensioner shall be included for automatic take-up for belt-driven wheels. The desiccant material shall be an adsorbing type. The desiccant material shall be applied to the wheel such that the entire surface is active as a desiccant and the desiccant material does not degrade or detach from the surface of the wheel. The wheel shall be fitted with full-face, low-friction contact seals on both sides to prevent cross leakage. The rotary structure shall have underheat, overheat and rotation fault circuitry. The wheel assembly shall be warranted for a minimum of 5 years.

PART 2 – PRODUCTS – Not Used.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install desiccant dehumidification equipment as indicated and in accordance with the manufacturer's instructions. Provide clearance for inspection, repair, replacement, and service. Electrical work shall conform with NFPA 70 and Division 26, "Electrical". Provide overload protection in the operating disconnect switches and magnetic starters. Locate outside air intake at a minimum of (8 meters) 25 feet from industrial stacks, bathroom vents, and sanitary risers. Prevailing wind direction shall not be used as justification for placing air intake closer than 8 meters 25 feet of exhaust stacks. Install assembled units on vibration isolators. Bolt sections together in high pressure units. Pipe drain pan to nearest floor drain.

3.2 FIELD QUALITY CONTROL

A. Schedule and administer specified tests. Provide personnel, instruments, and equipment for such tests. Correct defects and repeat the respective inspection and tests. Give the Contracting Officer ample notice of the dates and times scheduled for tests and trial operations. Conduct inspection and testing in the presence of the Contracting Officer. Inspection Prior to initial operation, inspect equipment installation for conformance with drawings and specifications.

B. Preliminary Tests

1. For each item of air handling and distribution equipment and its components, perform an operational test for a minimum period of 4 hours.

C. Testing and Balancing

1. After preliminary tests, perform air handling and distribution equipment tests adjustment, and balancing in accordance with Section 23 05 93 – Testing, Adjusting, & Balancing.

3.3 FIELD TRAINING

A. The contractor shall conduct a training course for operating and maintenance personnel as designated by the Contracting Officer. Training shall be provided for a period of 4 hours of normal working time and shall start after the system is functionally complete but prior to the performance of tests. The field instruction shall cover all of the items contained in the approved Operating and Maintenance Instructions.

END OF SECTION

DIVISION 26

ELECTRICAL

SECTION 26 00 00

ELECTRICAL GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section applies to all sections of Division 26.

B. Furnish and install electrical wiring, systems, equipment, and accessories per the specifications and drawings. Capacities and ratings of motors, transformers, cable, switchboards, switchgear, panelboards, motor control centers, generators, automatic transfer switches, and other items and arrangements for the specified items are shown on drawings.

C. Wiring ampacities specified or shown on the drawings are based on copper conductors, with the conduit and raceways accordingly sized. Aluminum conductors are prohibited.

1.2 MINIMUM REQUIREMENTS

A. References to the International Building Code (IBC), National Electrical Code (NEC), Underwriters Laboratories, Inc. (UL), and National Fire Protection Association (NFPA) are minimum installation requirement standards.

B. Drawings and other specification sections shall govern in those instances where requirements are greater than those specified in the above standards.

1.3 TEST STANDARDS

A. All materials and equipment shall be listed, labeled, or certified by a nationally recognized testing laboratory to meet Underwriters Laboratories, Inc., standards where test standards have been established. Equipment and materials which are not covered by UL Standards will be accepted provided equipment and material are listed, labeled, certified, or otherwise determined to meet the safety requirements of a nationally recognized testing laboratory. Equipment of a class that no nationally recognized testing laboratory accepts, certifies, lists, labels, or determines to be safe, will be considered if inspected or tested following national industrial standards, such as NEMA, or ANSI. Evidence of compliance shall include certified test reports and definitive shop drawings.

B. Definitions:

1. Listed: Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with the evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that the equipment, material, or services either meets appropriate designated standards or has been tested and found suitable for a specified purpose.

2. Labeled: Equipment or materials to which has been attached a label, symbol, or another identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.
3. Certified: Equipment or product which:
   a. Has been tested and found by a nationally recognized testing laboratory to meet nationally recognized standards or to be safe for use in a specified manner.
   b. Production of equipment or product is periodically inspected by a nationally recognized testing laboratory.
   c. Bears a label, tag, or another record of certification.
4. Nationally recognized testing laboratory: A laboratory, which is approved, following OSHA regulations, by the Secretary of Labor.

1.4 QUALIFICATIONS (PRODUCTS AND SERVICES)

A. Manufacturer’s Qualifications: The manufacturer shall regularly and presently produce, as one of the manufacturer's principal products, the equipment, and material specified for this project, and shall have manufactured the item for at least 3 years.

B. Product Qualification:

1. The manufacturer's product shall have been in satisfactory operation, on three installations of similar size and type as this project, for approximately 3 years.
2. The Government reserves the right to require the Contractor to submit a list of installations where the products have been in operation before approval.

C. Service Qualifications: There shall be a permanent service organization maintained or trained by the manufacturer which will render satisfactory service to this installation within four hours of receipt of notification that service is needed. Submit name and address of service organizations.

1.5 APPLICABLE PUBLICATIONS

A. Applicable publications listed in all Sections of Division 26 are the latest issue unless otherwise noted.

1.6 MANUFACTURED PRODUCTS

A. Materials and equipment furnished shall be of current production by manufacturers regularly engaged in the manufacture of such items, for which replacement parts shall be available.

B. When more than one unit of the same class or type of equipment is required, such units shall be the product of a single manufacturer.

C. Equipment Assemblies and Components:

1. Components of an assembled unit need not be products of the same manufacturer.

2. Manufacturers of equipment assemblies, which include components made by others, shall assume complete responsibility for the final assembled unit.
3. Components shall be compatible with each other and with the total assembly for the intended service.
4. Similar constituent parts shall be the product of a single manufacturer.

D. Factory wiring shall be identified on the equipment being furnished and on all wiring diagrams.

E. When Factory Testing Is Specified:

1. The Government shall have the option of witnessing factory tests. The contractor shall notify the Contracting Officer through the Contracting Officer's Representative (COR) a minimum of 15 working days before the manufacturers make the factory tests.
2. Four copies of certified test reports containing all test data shall be furnished to the Contracting Officer or COR before final inspection and not more than 90 days after completion of the tests.
3. When equipment fails to meet factory test and re-inspection is required, the Contractor shall be liable for all additional expenses, including expenses of the Government.

1.7 EQUIPMENT REQUIREMENTS

A. Where variations from the contract requirements are requested, the connecting work and related components shall include, but not be limited to additions or changes to branch circuits, circuit protective devices, conduits, wire, feeders, controls, panels, and installation methods.

1.8 EQUIPMENT PROTECTION

A. Equipment and materials shall be protected during shipment and storage against physical damage, vermin, dirt, corrosive substances, fumes, moisture, cold, and rain.

1. Store equipment indoors in a clean dry space with a uniform temperature to prevent condensation. Equipment shall include but not be limited to switchgear, switchboards, panelboards, transformers, motor control centers, motor controllers, uninterruptible power systems, enclosures, controllers, circuit protective devices, cables, wire, light fixtures, electronic equipment, and accessories.
2. During installation, equipment shall be protected against entry of foreign matter; and be vacuum cleaned both inside and outside before testing and operating. Compressed air shall not be used to clean equipment. Remove loose packing and flammable materials from inside equipment.
3. Damaged equipment shall be, as determined by the Contracting Officer or the Contracting Officer's Representative (COR) placed in first-class operating condition or be returned to the source of supply for repair or replacement.
4. Painted surfaces shall be protected with factory-installed removable heavy kraft paper, sheet vinyl, or equal.
5. Damaged paint on equipment and materials shall be refinished with the same quality of paint and workmanship as used by the manufacturer so repaired areas are not obvious.

1.9 WORK PERFORMANCE

A. All electrical work must comply with the requirements of NFPA 70 (NEC), NFPA 70B, NFPA 70E, OSHA Part 1910 subpart J, OSHA Part 1910 subpart S, and OSHA Part 1910 subpart K in addition to other references required by the contract.

B. All electrical work shall be performed by, or under the direct supervision of an electrician licensed in the State of South Carolina.

C. Job site safety and worker safety are the responsibility of the Contractor.

D. Electrical work shall be accomplished with all affected circuits or equipment de-energized. When an electrical outage cannot be accomplished in this manner for the required work, the following requirements are mandatory:

1. Electricians must use full protective equipment (i.e., certified and tested insulating material to cover exposed energized electrical components, certified and tested insulated tools, etc.) while working on energized systems following NFPA 70E.
2. Electricians must wear personal protective equipment while working on energized systems following NFPA 70E.
3. Work on energized circuits or equipment cannot begin until prior written approval is obtained from the Contracting Officer or COR.

E. New work shall be installed and connected to existing work neatly, safely, and professionally. Disturbed or damaged work shall be replaced or repaired to its prior conditions.

F. Coordinate location of equipment and conduit with other trades to minimize interferences.

1.10 EQUIPMENT INSTALLATION AND REQUIREMENTS

A. Equipment location shall be as close as practical to locations shown on the drawings.

B. Working spaces shall not be less than specified in the NEC for all voltages specified.

C. Inaccessible Equipment:

1. Where the Government determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, the equipment shall be removed and reinstalled as directed at no additional cost to the Government.
2. "Conveniently accessible" is defined as being capable of being reached quickly for operation, maintenance, or inspections without the use of ladders, or without climbing or crawling under or over obstacles such as, but not limited to, motors, pumps, belt guards, transformers, piping, ductwork, conduit, and raceways.

1.11 EQUIPMENT IDENTIFICATION

A. In addition to the requirements of the NEC, install an identification sign which indicates information required for use and maintenance of items such as switchboards and switchgear, panelboards, cabinets, motor controllers (starters), fused and unfused safety switches, automatic transfer switches, separately enclosed circuit breakers, individual breakers and controllers in switchboards, switchgear and motor control assemblies, control devices and other significant equipment.

B. Nameplates for Normal Power System equipment shall be laminated black phenolic resin with a white core with engraved lettering. Nameplates for Essential Electrical System (EES) equipment, as defined in the NEC, shall be laminated red phenolic resin with a white core with engraved lettering. Lettering shall be a minimum of 1/2 inch (12mm) high. Nameplates shall indicate equipment designation, rated bus amperage, voltage, number of phases, number of wires, and type of EES power branch as applicable. Secure nameplates with screws.

C. Install adhesive arc flash warning labels on all equipment as required by NFPA 70E. The label shall indicate the arc hazard boundary (inches), working distance (inches), arc flash incident energy at the working distance (calories/cm2), required PPE category, and description including the glove rating, voltage rating of the equipment, limited approach distance (inches), restricted approach distance (inches), prohibited approach distance (inches), equipment/bus name, date prepared, and manufacturer name and address.

1.12 SUBMITTALS

A. Submit per Section 01 33 23, “Submittal Procedures.”

B. The Government's approval shall be obtained for all equipment and material before delivery to the job site. Delivery, storage, or installation of equipment or material which has not had prior approval will not be permitted at the job site.

C. All submittals shall include adequate descriptive literature, catalog cuts, shop drawings, and other data necessary for the Government to ascertain that the proposed equipment and materials comply with specification requirements. Catalog cuts submitted for approval shall be legible and identify the equipment being submitted.

D. Submittals for individual systems and equipment assemblies that consist of more than one item or component shall be made for the system or assembly as a whole. Partial submittals will not be considered for approval.

1. Mark the submittals, "SUBMITTED UNDER SECTION_____".
2. Submittals shall be marked to show specification references including the section and paragraph numbers.
3. Submit each section separately.

E. The submittals shall include the following:

1. Information that confirms compliance with contract requirements. Include the manufacturer's name, model or catalog numbers, catalog information, technical datasheets, shop drawings, pictures, nameplate data, and test reports as required.
2. Elementary and interconnection wiring diagrams for communication and signal systems, control systems, and equipment assemblies. All terminal points and wiring shall be identified on wiring diagrams.
3. The parts list shall include those replacement parts recommended by the equipment manufacturer.

F. Manuals: Submit per Section 01 78 23, “Operation & Maintenance Data.”

1. Maintenance and Operation Manuals: Submit as required for systems and equipment specified in the technical sections. Furnish four copies, bound in hardback binders, (manufacturer's standard binders) or an approved equivalent. Furnish one complete manual as specified in the technical section but no case later than before performance of systems or equipment test and furnish the remaining manuals before contract completion.
2. Inscribe the following identification on the cover: the words "MAINTENANCE AND OPERATION MANUAL," the name and location of the system, equipment, building, name of Contractor, and contract number. Include in the manual the names, addresses, and telephone numbers of each subcontractor installing the system or equipment and the local representatives for the system or equipment.
3. Provide a "Table of Contents" and assemble the manual to conform to the table of contents, with tab sheets placed before instructions covering the subject. The instructions shall be legible and easily read, with large sheets of drawings folded in.
4. The manuals shall include:
   a. Internal and interconnecting wiring and control diagrams with data to explain detailed operation and control of the equipment.
   b. A control sequence describing start-up, operation, and shutdown.
   c. Description of the function of each principal item of equipment.
   d. Installation instructions.
   e. Safety precautions for operation and maintenance.
   f. Diagrams and illustrations.
   g. Periodic maintenance and testing procedures and frequencies, including replacement parts numbers and replacement frequencies.
   h. Performance data.
   i. Pictorial "exploded" parts list with part numbers. Emphasis shall be placed on the use of special tools and instruments. The list shall indicate sources of supply, recommended spare parts, and the name of servicing organization.
   j. List of factory-approved or qualified permanent servicing organizations for equipment repair and periodic testing and maintenance, including addresses and factory certification qualifications.

G. Approvals will be based on the complete submission of manuals together with shop drawings.

H. After approval and before installation, furnish the Contracting Officer or COR with one sample of each of the following:

1. A 300 mm (12 inches) length of each type and size of wire and cable along with the tag from the coils of reels from which the samples were taken.
2. Each type of conduit coupling, bushing, and termination fitting.
3. Conduit hangers, clamps, and supports.
4. Duct sealing compound.
5. Each type of receptacle, toggle switch, occupancy sensor, outlet box, manual motor starter, device wall plate, engraved nameplate, wire and cable splicing and terminating material, and branch circuit single pole molded case circuit breaker.

1.13 SINGULAR NUMBER

A. Where any device or part of the equipment is referred to in these specifications in the singular number (e.g., "the switch"), this reference shall be deemed to apply to as many such devices as are required to complete the installation as shown on the drawings.

END OF SECTION

SECTION 26 05 00

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 – GENERAL

1.1 SUMMARY

A. Related Documents:

1. Drawings and general provisions of the Subcontract apply to this Section.
2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:

1. The contractor shall furnish services, skilled labor, apparatus, and materials required for the complete installation as shown and within the intent of the drawings and these Specifications.
2. Work includes, but is not limited to, the following and shall be completed per the project construction drawings and specifications:

C. Related Sections:

1. Division 01 Section "Submittal Procedures."
2. This section applies to Division 26 Sections.

1.2 REFERENCES

A. General:

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.
3. Refer to Division 01 Section "General Requirements" for the list of applicable regulatory requirements.

B. ANSI/NFPA 70 - National Electrical Code.

C. ANSI - American National Standards Institute

D. Illuminating Engineering Society of North America (IES)

E. 2017 LBNL Facilities Department Lateral Force Design Criteria.

F. 2023 NFPA 70 - National Electrical Code

G. 2017 IEEE, National Electrical Safety Code (NESC)

H. NFPA – National Fire Protection Association

I. 2021 Standard for Electrical Safety in the Workplace (NFPA 70E)

J. NETA ATS 2021 - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

K. UL – Underwriter's Laboratories

1.3 SUBMITTALS

A. Submit under provisions of Division 01 Section 01 33 23 "Submittal Procedures." Drawings and Specifications and as required by other sections of the Specifications.

B. Shop Drawings: The Subcontractor shall submit for approval Shop Drawings prepared following Division 01 Section 01 33 23 "Submittal Procedures," and as required by other sections of the Specifications.

1.4 QUALITY ASSURANCE

A. Quality Control: Refer to Division 01 Section 01 40 00 , "Quality Requirements".

B. If the Drawings or Specifications may not appear clear or definite, the Subcontractor shall request the Project Manager through the 'Request for Information' (RFI) process for an interpretation and decision of same and shall have such questions decided before proceeding with the Work.

C. Manufacturer's Directions: Follow the manufacturer's directions covering points not shown on the drawings or specified herein. Manufacturers' directions do not take precedence over drawings and Specifications. Where these conflict with the Drawings and Specifications, notify the Project Manager for clarification before installing the work.

D. Protection of Equipment:

1. Care shall be exercised during construction to avoid damage or disfigurement. Equipment shall be protected from dust and moisture before and during construction. The Subcontractor is cautioned that concrete finishing, painting, etc. in electrical rooms shall not proceed if unprotected equipment is installed.
2. Where required or directed, construct temporary protection for equipment and installations to protect the same from dust and debris caused by construction.
3. All protection shall be substantially constructed with the use of clean canvas, heavy plastic, Visqueen, and plywood as required, and made tight and dustproof as directed.
4. The Subcontractor shall repair by spray or brush painting, after properly preparing the surface, scratches or defects in the finish of the equipment. Only identical paint furnished by the equipment manufacturer shall be used for such purposes.
5. Failure of the Subcontractor to protect the equipment as outlined herein shall be grounds for rejection of the equipment and its installation.

E. Cleaning: Refer to Division 01 Section 01 73 40, “Execution,” and 01 74 19, “Construction Waste Management & Disposal.”

F. Qualifications and License Requirements:

1. Prime, Sub, or Sub-Sub contractor performing electrical construction work on the project shall have a C-10 Electrical Construction License from the State of South Carolina, USA.
2. The subcontractor performing electrical construction work shall provide details of the project experience addresses and references with names and phone numbers.
3. Certified electricians shall have evidence of certification in their possession at all times. Non-certified personnel shall perform electrical work under the continuous supervision of a certified electrician.

G. Materials and Equipment: Materials and equipment shall be new. Materials and equipment for which tests have been established by Underwriter's Laboratories, Inc. shall be approved by that body and shall bear its label of approval, or the label of an OSHA-approved nationally recognized testing laboratory [NRTL].

1. All equipment shall bear a label or listing by Underwriter's Laboratories, Inc. or NRTL.
2. Unless otherwise approved by the Contracting Officer, the materials to be furnished under this Specification shall be the standard products of manufacturers regularly engaged in the production of such equipment equal to or superior to the material specified and shall be the manufacturer's latest standard design that complies with the Specification requirements.

H. Approval of Materials:

1. A complete list of materials and equipment proposed shall be submitted to the Project Manager for approval. The list shall include for each item: the manufacturer, the manufacturer's catalog number, type or class, the rating, capacity, size, etc.
2. The Subcontractor shall submit a brochure containing catalog cuts or drawings and data for, but not limited to, the following items:
3. Before installation of the equipment, the Subcontractor shall submit for approval detailed construction drawings for each item of fabricated equipment required for the electrical installation. Drawings shall be to scale and fully dimensioned and shall provide sufficient detail to clearly indicate the arrangement of equipment and its components.
4. Installation of approved substituted equipment is the Subcontractor's responsibility and changes required to work included under other divisions for installations of approved substituted equipment must be made to the satisfaction of the Contracting Officer and without change in the contract price. Approval by the Contracting Officer of substituted equipment and/or dimension drawings does not waive these requirements.

1.5 EXISTING CONDITIONS

A. The Subcontractor shall examine the site and become familiar with conditions that may affect the work covered by this division of the Specifications to obtain a conclusive bid. Failure to do so shall not lessen the subcontractor's responsibility or entitle him to additional compensation for work not included in the bid.

B. The electrical prime, sub, or sub-sub-contractor shall list separately in the bid quote exceptions taken from the construction documents and specifications. If none are specified in the bid quote, it shall be understood that the prime, sub, or sub-sub-contractor shall comply with the requirements of the construction documents and specifications in their entirety.

1.6 COORDINATION

A. Refer to Division 01 Section 01 73 40 Paragaph 3.2 “Coordination with Utility Service Providers.”

1.7 MAINTENANCE

A. Maintenance and Operating Instructions:

1. See Division 01 Section 01 78 23 “Operation & Maintenance Data.”
2. At the time of occupancy, arrange for manufacturer's representatives to instruct building, operating, and maintenance personnel in the use of equipment requiring operating and maintenance. Arrange for personnel to be instructed at one time. Pay the costs for such service.
3. Maintenance and operating instructions and training for equipment will be provided by the equipment vendor. The Subcontractor shall be responsible for all other equipment.

1.8 WARRANTY

A. Refer to individual Division 26 specification sections.

PART 2 – PRODUCTS

2.1 GENERAL

A. In addition to the material and equipment specified, the Subcontractor shall also provide incidental materials required to affect a complete installation. Such incidental materials include solders, tapes, caulking, mastics, gaskets, and similar items that are approved for the purpose.

B. Materials and equipment shall be uniform throughout the installation. Equipment of the same type shall be of the same manufacturer. Materials and equipment shall be new. Materials and equipment for which tests have been established by the Underwriter's Laboratories, Inc. shall have been approved by that body, or an equivalent testing firm (see Paragraph 1.4.C) and shall bear its label of approval.

PART 3 – EXECUTION

3.1 TESTS

A. Upon completion of the electrical construction work, perform tests and provide test reports as specified in this and other sections.

B. Tests shall be made in the presence of the Contracting Officer or designated representative. The application or interruption of power shall be programmed and directed by the Contracting Officer.

C. The Subcontractor shall submit to the Project Manager 3 copies of test results, certified in writing, witnessed, signed, and dated, immediately upon completion of work. Unsatisfactory conditions revealed by these test results, or unsatisfactory methods of tests and/or testing apparatus and instruments, shall be corrected by the Subcontractor to the satisfaction of the Contracting Officer.

D. The Contracting Officer reserves the right to require that the Subcontractor perform and repeat tests that are deemed necessary to complete or check the tests or the certified records of the Subcontractor at any time during the work. The Subcontractor shall correct the unsatisfactory portion of his work that is revealed by the tests or that may be due to progressive deterioration during this period unless the item in question was a direct specification.

3.2 EQUIPMENT IDENTIFICATION

A. Transformers: Transformers shall be identified by one-inch-high white stenciled-on characters giving bank number and circuit feeding the transformer in agreement with the Drawings.

B. Panelboards: Panelboards shall be identified by circuit number, voltage, phase, and wire as shown on drawings or specified elsewhere in these Specifications.

C. Schedules: Panelboards shall be furnished with a complete 8-1/2" x 11" typewritten schedule mounted on the inside of the inner door. If field changes are necessary, new schedules shall be provided by the Subcontractor. Forms will be provided by the Project Manager.

D. Receptacles and Light Switches: Receptacles and light switches shall be identified by a circuit number as indicated on the drawings with 1/4 inches (6 mm) high white characters on 1/2 inch (12 mm) wide dark contrasting stick-on embossing tape placed directly above the device.

E. Equipment: Properly identify circuit breakers and other devices on switchboards, motor disconnect switches, starters, time clocks, and other apparatus used for the operation of, or control of circuits, appliances, or equipment utilizing a 3/32-inch-thick black laminated phenolic nameplate with a white core. For switchboards and panelboards, fed by standby or emergency power sources, use a 3/32-inch-thick yellow laminated phenolic nameplate with a black core. Engrave characters a minimum of 1/2 inch size for device numbers, except that transformer bank identification, shall use a minimum size of 1-1/2-inch character height and 15kV switchgear shall use 1-inch character height, Helvetica style font. Attach nameplates with No. 4-36 RH nickel-plated brass machine screws.

F. Conductors: The main incoming power will be delivered to the building site with the A phase, B phase, C phase, and Neutral phase (if applicable) cables positively identified. The phase sequence rotation shall be A-B-C clockwise.

1. Conductors shall be identified using plastic or metal labels, factory-colored wires, or by using color bands or tape intended for the purpose and approved for wet, outdoor applications at terminations, junctions, and wherever the conductors are accessible in pull boxes. Conductors are not color-coded, but identified as "A Phase", "B Phase", and "C Phase".
2. Feeder circuit cables shall be identified with embossed metal or plastic labels with 1/2" characters permanently attached to the feeder circuit cables. Feeder circuits shall be identified with the circuit number per the drawings.
3. Branch circuit identification shall be by use of wrap-around labels such as manufactured by Brady, Thomas, and Betts, or equal. Labels shall be placed on conductors at outlets (switch, receptacle, fixture, etc.), panelboards, junction boxes, relays, disconnect switches, motor starters, and controls. Branch circuit conductors shall be identified with the circuit number.

3.3 NOISE AND VIBRATION

A. The Subcontractor shall cooperate in reducing objectionable noise or vibration. If noise or vibration is a result of improper material or installation, these conditions shall be corrected at no cost to the National Park Service.

3.4 GENERAL INSTALLATION METHODS

A. Carpentry, Cutting, Patching, and Core Drilling:

1. Provide carpentry, cutting, patching, and core drilling required for installation of material and equipment specified in the scope of work.
2. Do not cut, core, or drill structural members without the written consent of the Contracting Officer.
3. Seismic Mounting: Electrical material and equipment, including floor-mounted equipment, suspended raceways, and light fixtures, shall be installed with bracing, cabling, or anchoring to comply with the latest edition of the CBC and Standard and Division 01 Section “Lateral Force Provisions.”

B. Waterproof Construction:

1. Maintain waterproof integrity of penetrations of materials intended to be waterproof. Provide flashings at exterior roof penetrations. Caulk penetrations of foundation walls and floors are watertight. Provide membrane clamps at penetrations of waterproof membranes.
2. Provide waterproof NEMA 3R enclosures for equipment or devices mounted outside or otherwise exposed to the weather.

C. Painting of Electrical Equipment and Hardware:

1. Provide moisture-resistant paint for exterior painting.
2. Colors shall be as shown on the drawings unless specified.

3. Refer to individual Sections and Construction Drawings for painting requirements of electrical equipment.
4. Exposed conduits, raceways, and gutters inside and outside the building shall be painted to match the wall color.

D. Equipment Concrete Pads:

1. Equipment located on concrete floors inside the building or on grade outside the building shall be mounted on a concrete base. The concrete base shall be four inches high and shall extend six inches beyond the edge of the equipment base unless indicated otherwise on drawings.
2. Coordinate concrete bases: Concrete bases indicated on Architectural or Structural drawings are specified in other Divisions. Concrete bases not on Architectural or Structural drawings are the requirements of this Division.

E. Seismic Anchorage:

1. Seismic anchorage of electrical equipment shall be following. See Section 26 05 48, "Vibration & Seismic Requirements for Electrical."

F. Demolition and Removal:

1. Refer to construction documents for demolition and removal details.
2. Contracting Officer approval shall be obtained before disposal of electrical equipment and materials.
3. Disconnected wiring shall be removed from raceway systems, panels, enclosures pull boxes, junction boxes, etc. irrespective of whether the removal is specified in the construction documents or not. The empty raceway systems shall be tagged spare on both ends of each termination.

END OF SECTION

SECTION 26 05 19

LOW VOLTAGE ELECTRICAL POWER CONDUCTORS & CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.
3. Sleeves and sleeve seals for cables.

1.3 DEFINITIONS

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

B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

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

B. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

1.6 COORDINATION

A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

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

1. Alcan Products Corporation; Alcan Cable Division.
2. American Insulated Wire Corp.; a Leviton Company.
3. General Cable Corporation.
4. Senator Wire & Cable Company.
5. Southwire Company.
6. Honeywell.

B. Copper Conductors: Comply with NEMA WC 70.

C. Conductor Insulation: Comply with NEMA WC 70 for Types THW, THHN-THWN and XHHW.

2.2 CONNECTORS AND SPLICES

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

1. AFC Cable Systems, Inc.
2. Hubbell Power Systems, Inc.
3. O-Z/Gedney; EGS Electrical Group LLC.
4. 3M; Electrical Products Division.
5. Tyco Electronics Corp.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SLEEVES FOR CABLES

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 water stop, unless otherwise indicated.

2.4 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.

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: Stainless steel. Include two for each sealing element.
3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

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 MULTI-CONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN-THWN, single conductors in raceway.

B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN-THWN, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

E. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway. Type THWN-XHHW for underground.

F. Class 1 Control Circuits: Type THHN-THWN, in raceway.

G. Class 2 Control Circuits: Type THHN-THWN, in raceway.

H. Phone wire, Cat 6 (min.), weatherproof suitable for direct burial.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. 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.

B. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.

C. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

D. Support cables according to Division 26 Section "Hangers & Supports for Electrical Systems."

E. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

F. Neutral conductors shall be installed in accordance with the National Electric Code (NEC). Separate neutral conductors are required for all 120V circuits. Multiple individual 120V circuits **may not** be ganged under a common handle tie (multi-phase breaker) to reduce the quantity of neutral conductors.

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than un-spliced conductors.

1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.5 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of penetration.

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. Rectangular Sleeve Minimum Metal Thickness:

1. For sleeve rectangle perimeter less than 50” and no side greater than 16”, thickness shall be 0.052 inch.
2. For sleeve rectangle perimeter equal to, or greater than, 50” and one or more sides equal to, or greater than, 16”, thickness shall be 0.138 inch.

E. 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.

F. Size pipe sleeves to provide 1/4” annular clear space between sleeve and cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.

G. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

H. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.

I. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1” annular clear space between pipe and sleeve for installing mechanical sleeve seals.

J. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1” annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.6 SLEEVE-SEAL INSTALLATION

A. Install to seal underground exterior-wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.7 INSPECTION AND TESTS

A. Tests shall be made in the presence of the NPS Contracting Officer or the designated representative.

B. The electrical installation shall be inspected and tested to ensure safety for operating personnel and conformity to Code authorities and subcontract documents. Field tests shall be performed in conformance with the National Electrical Testing Association (NETA) Standards.

C. Measure and record insulation resistance of all power, lighting and control wiring installed by or altered by the Subcontractor including insulation resistance of all equipment, supplied by either the University or the Subcontractor. The Subcontractor shall not be responsible for defective insulation in equipment that has been supplied by to the Subcontractor unless such damage is due to negligence or incorrect handling or installation workmanship of the Subcontractor.

1. The insulation resistance of each main feeder conductor and phase-to-ground shall be measured. For circuits rated less than 600 volts, the resistance shall not be less than one mega-ohm.
2. Systems rated above 240 volts shall be tested with a 1000-volt Megohmmeter. Main feeders for 240 volts and below shall be tested with a 500-volt Megohmmeter. The D.C. potential shall be applied for 30 seconds.

D. Measure ground grid ground resistance using a ground fall of potential meter as described in IEEE Standards 81. Report the results in writing to NPS Contracting Officer for acceptance/approval.

E. Using a calibrated torque wrench, test and record values at all feeder terminations.

F. The Subcontractor shall submit to the contracting officer 5 copies of test results, certified in writing, witnessed, signed and dated, immediately upon completion of work for review and acceptance by the NPS. An unsatisfactory condition revealed by these test results, or unsatisfactory methods of tests and/or testing apparatus and instruments, shall be brought to the attention of the Contracting Officer. Corrections by the Subcontractor shall be validated by re-tests to the satisfaction of the Contracting Officer.

G. The Contracting Officer reserves the right to require that the Subcontractor perform and repeat tests that are deemed necessary to complete or check the tests or the certified records of the Subcontractor at any time during the course of the work. The Subcontractor shall correct any unsatisfactory portion of his work that is revealed by the tests or that may be due to progressive deterioration during this period, unless the item in question was a direct specification.

END OF SECTION

SECTION 26 05 23

CONTROL VOLTAGE ELECTRICAL CABLES

PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes:

1. Low-voltage control cabling.
2. Control-circuit conductors.
3. Identification products.

B. Related Sections:

1. The Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the CONTRACTOR and its Sub-Contractors to review all sections to ensure a complete and coordinated project.

C. Cabinets and enclosures to house electrical controls, instruments, terminal blocks, and similar equipment.

1.2 DEFINITIONS

A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.

1.3 SUBMITTALS

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

B. Field quality-control reports.

C. Maintenance data.

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.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Inspect cables upon receipt at the Project site.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

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

1. Belden.
2. Carol.
3. Or approved equal.

2.2 LOW-VOLTAGE CABLES

A. Analog type control circuits shall be wired with Multi-Conductor – Shielded Twisted Pair cable.

1. One pair, twisted, No. 18 AWG, stranded tinned-copper conductors
2. 300V minimum operating voltage
3. Overall Shield with No. 20 AWG stranded tinned copper drain wire.
4. PVC jacket.
5. Outdoor rated.

2.3 CONTROL-CIRCUIT CONDUCTORS

A. Class 1, 2, and 3 Control Circuits: Stranded copper, Type THHN-THWN, in raceway, complying with UL 83.

2.4 IDENTIFICATION PRODUCTS

A. Manufacturers: Subject to compliance with requirements.

1. Brady Corporation.
2. Kroy LLC.
3. Panduit Corp.
4. Or approved equal.

B. Comply with requirements in Division 26 Section 26 05 53, "Identification for Electrical Systems."

PART 3 – EXECUTION

3.1 INSTALLATION OF PATHWAYS

A. Comply with NEC for pull-box sizing and length of conduit and number of bends between pull points.

B. Comply with requirements in Division 26 Section 26 05 33, “Raceways & Boxes for Electrical Systems,” for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or modified in this Section.

1. Flexible conduit shall be metallic liquid tight only and shall not be used for lengths over 5ft.

C. Pathway Installation in Equipment Rooms:

1. Install cable trays to route cables if conduits cannot be located in these positions.
2. Extend conduits 3 inches above the finished floor.
3. Install metal conduits with grounding bushings and connect with grounding conductor to the grounding system.

3.2 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1 and NFPA 70.

B. General Requirements for Cabling:

1. All cabling and wiring shall be in conduit as required by code.
2. Cables may not be spliced.
3. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
4. Conduit will be supported at least every ten (10) feet and within three (3) feet of junction boxes and terminations.
5. Bundle, lace, and train conductors to terminal points without exceeding the manufacturer's limitations on bending radii.
6. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard the cable if damaged during installation and replace it with a new cable.
7. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
8. Pulling Cable: Per manufacturer’s recommendations.
9. Secure: Fasten securely in place with hardware specifically designed and installed to not damage cables.

C. Installation of Control-Circuit Conductors:

1. Install wiring in raceways. Comply with requirements specified in Division 26 Section 26 05 33 “Raceways & Boxes for Electrical Systems.”

D. Separation from EMI Sources:

1. Provide separation of control conductors and data communications cable from potential EMI sources including electrical power lines and equipment.

E. Separate Power circuits from Control circuits

1. Power circuits and Control circuits shall be run in separate conduits.

3.3 CONTROL-CIRCUIT CONDUCTORS

A. Minimum Conductor Sizes:

1. Class 1 remote-control and signal circuits, No 14 AWG.
2. Class 2 low-energy, remote-control, and signal circuits, No. 16 AWG.
3. Class 3 low-energy, remote-control, alarm, and signal circuits, No 18 AWG.

3.4 IDENTIFICATION

A. Identify all field-installed control wiring, and cabling according. Comply with requirements for identification specified in Division 26 Section 26 05 53, “Identification for Electrical Systems.”

1. Identify cable and conductor source and wire label per Process Control Panel Shop Drawings.

B. Identify data and communications system components, wiring, and cabling according to TIA-606-A; label printers shall use label stocks, laminating adhesives, and inks complying with UL 969.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Visually inspect cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments and inspect cabling connections to confirm compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination, but not after cross-connection.
   a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in its "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in its "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by the test equipment manufacturer for channel or link test configuration.

B. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide or transfer the data from the instrument to the computer, save as text files, print, and submit.

C. End-to-end cabling will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION

SECTION 26 05 26

GROUNDING & BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes methods and materials for grounding systems and equipment.

1.3 SUBMITTALS

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

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 the 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 600V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Conductor: Sized as indicated on drawings, stranded copper conductor.
5. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) 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 2 bolts.

1. Pipe Connectors: Clamp type, sized for the pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by the kit manufacturer for materials being joined and installation conditions.

2.3 GROUNDING SYSTEM DEVICES

A. Ground Rods: Copper-clad, Zinc-coated Stainless steel, sectional type; 5/8” x 96”.

B. Ground Rod Connectors: Accessible; Burndy, Copperweld, or equal.

C. Cable Connectors: Accessible; O.Z./Gedney, Burndy, or equal.

D. Ground Rod and Cable Connectors: Not Accessible; Cadweld, Thermoweld, or equal.

E. Grounding Bushings: O.Z. Type BL, Burndy, or equal.

F. Pipe Connectors: O.Z. Type ABG, Burndy, or equal.

G. Enclosure Connectors: O.Z. Type QG or KG, Burndy, or equal.

H. Feedthrough Lug: Burndy Type Q2B, O.Z./Gedney, or equal.

I. Concrete Ground Box: Brooks Concrete Products 3-RT, or equal.

J. Copper Mechanical Grounding Connector for Copper Cable to Flat Bus Bar: Burndy Type KC Servit Post, or equal.

K. Rebar connector (ground clamp); Burndy GB series ground bar connector. Burndy, or equal.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 18 AWG and smaller, and stranded conductors for No. 16 AWG and larger, unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, No. 6 AWG minimum.

1. Bury at least 24” (600 mm) 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.
4. Connections to Structural Steel: Welded connectors.

3.2 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

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” (50 mm) 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 2 rods spaced at least 1 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 the 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.
3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

D. Grounding Electrode System: All ground electrodes as identified below that are present at each building or structure shall be bonded together to form a grounding electrode system per NEC Article 250.52:

1. Metal Underground Water Pipe.
2. Metal and Ground Support Structures

3. Concrete Encased Electrodes
4. Grounding Rings
5. Rod and Pipe Electrodes
6. Other Listed Electrodes
7. Plate Electrodes
8. Other Local Metal Underground Systems or Structures

3.3 TESTING

A. Testing: Perform the following field quality-control testing:

1. After installing grounding system but before permanent electrical circuitry has been energized, test for compliance with requirements.
2. Test completed grounding system at each location where a maximum ground-resistance level is indicated and at service disconnect enclosure grounding terminal. Measure ground resistance not less than 2 full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests, by the fall-of-potential method according to IEEE 81. Drive additional rods if the reading is greater than 25 Ohms.

END OF SECTION

SECTION 26 05 29

HANGERS & SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Hangers and supports for electrical equipment and systems.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. IMC: Intermediate metal conduit.

C. RMC: Rigid metal conduit.

1.4 PERFORMANCE REQUIREMENTS

A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

1.5 SUBMITTALS

A. Submit as required under provisions of Division 26 Section 26 00 00 “Electrical General Requirements.” and as required by other sections of the Specifications.

B. Product Data: For the following:

1. Steel slotted support systems.
2. Nonmetallic slotted support systems.

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.
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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Hilti Inc.
      2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
      3) MKT Fastening, LLC.
      4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc coated or stainless steel, for use in hardened Portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
    a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
        1) Cooper B-Line, Inc.; a division of Cooper Industries.
        2) Empire Tool and Manufacturing Co., Inc.
        3) Hilti Inc.
        4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
        5) MKT Fastening, LLC.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) 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, RMC, EMT, IMC, RMC, and MC (where approved by local jurisdiction) may be supported by openings through structure members, as permitted in NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. 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 (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69 Spring-tension clamps.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

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

B. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 PAINTING

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

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

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

END OF SECTION

SECTION 26 05 33

RACEWAYS & 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. FMC: Flexible metal conduit.

C. IMC: Intermediate metal conduit.

D. LFMC: Liquid-tight flexible metal conduit.

E. LFNC: Liquid-tight flexible nonmetallic conduit.

F. RNC: Rigid nonmetallic conduit.

G. RMC: Rigid metal 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.

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 the intended use.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

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

1. AFC Cable Systems, Inc.
2. Alflex Inc.
3. Allied Tube & Conduit; a Tyco International Ltd. Co.
4. Anamet Electrical, Inc.; Anaconda Metal Hose.
5. Electri-Flex Co.
6. Manhattan/CDT/Cole-Flex.
7. Maverick Tube Corporation.
8. O-Z Gedney; a unit of General Signal.
9. Wheatland Tube Company.

B. Rigid Metal Conduit: ANSI C80.1.

C. Aluminum Rigid Conduit: ANSI C80.5.

D. IMC: ANSI C80.6.

E. EMT: ANSI C80.3.

F. FMC: Zinc-coated steel or aluminum.

G. LFMC: Flexible steel conduit with PVC jacket.

H. RMC: PVC coated.

I. Fittings for Conduit (including all Types and Flexible and Liquid-tight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
2. Fittings for EMT: Steel, set-screw, or compression type.

2.2 NONMETALLIC CONDUIT AND TUBING

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

1. AFC Cable Systems, Inc.
2. Anamet Electrical, Inc.; Anaconda Metal Hose.
3. Arnco Corporation.
4. CANTEX Inc.
5. CertainTeed Corp.; Pipe & Plastics Group.
6. Condux International, Inc.
7. ElecSYS, Inc.
8. Electri-Flex Co.
9. Lamson & Sessions; Carlon Electrical Products.
10. Manhattan/CDT/Cole-Flex.
11. RACO; a Hubbell Company.
12. Thomas & Betts Corporation.

B. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.

C. LFNC: UL 1660.

D. Fittings for RNC: NEMA TC 3; match to conduit or tubing type and material.

E. Fittings for LFNC: UL 514B.

2.3 METAL WIREWAYS

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

1. Cooper B-Line, Inc.
2. Hoffman.
3. Square D; Schneider Electric.

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 a complete system.

D. Wireway Covers: Hinged type or Screw-cover type.

E. Finish: Manufacturer's standard enamel finish.

2.4 BOXES, ENCLOSURES, AND CABINETS

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

1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
2. EGS/Appleton Electric.
3. Erickson Electrical Equipment Company.
4. Hoffman.
5. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
6. O-Z/Gedney; a unit of General Signal.
7. RACO; a Hubbell Company.
8. Robroy Industries, Inc.; Enclosure Division.
9. Scott Fetzer Co.; Adalet Division.
10. Spring City Electrical Manufacturing Company.
11. Thomas & Betts Corporation.
12. Walker Systems, Inc.; Wiremold Company (The).
13. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.

B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, aluminum, Type FD, with gasketed cover.

D. Nonmetallic Outlet and Device Boxes: NEMA OS 2.

E. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

F. For outdoor environments: NEMA 3R

G. For corrosive environments: NEMA 4X.

H. 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: Plastic**,** finished inside with radio-frequency-resistant paint.

I. Cabinets:

1. NEMA 250, Type 1, galvanized-steel box with the removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. A hinged door in the 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.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Indoors: Apply raceway products as specified below, unless otherwise indicated:

1. Exposed Conduit: Rigid metal conduit, IMC.
2. Concealed Conduit: Rigid metal conduit, IMC, EMT.
3. Underground Conduit: Sch 80 -PVC, direct buried.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R, and (if corrosive environment) 4X.
6. Conduit in Hazardous areas: Rigid metal conduit, PVC coated rigid metal conduit.
7. Conduit in Corrosive areas: PVC coated rigid metal conduit.

B. Outdoors: Apply raceway products as specified below, unless otherwise indicated:

1. Exposed Conduit: Rigid metal conduit, IMC.
2. Concealed Conduit, Aboveground: Rigid metal conduit, IMC, EMT.
3. Underground Conduit: Sch 80 -PVC, direct buried.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R, and (if corrosive environment) NEMA Type 4X.
6. Conduit in Hazardous areas: Rigid metal conduit, PVC coated rigid metal conduit.
7. Conduit in corrosive areas: PVC coated rigid metal conduit.

C. Minimum Raceway Size: 3/4-inch (21-mm) trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Metal Conduit: Use threaded rigid metal conduit fittings, unless otherwise indicated.
2. PVC Externally Coated, Rigid Metal Conduits: Use only fittings listed for use with that material. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.

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 inches (150 mm) 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 26 Section "Hangers & 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° 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 1/2 -inch (16-mm) 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 RNC to rigid metal 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. (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of the pull wire.

L. Flexible Conduit Connections: Use a maximum of 72 inches (1830 mm) of flexible conduit for recessed and semi-recessed lighting fixtures**,** equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC in damp or wet locations not subject to severe physical damage.

M. Recessed Boxes in Masonry Walls: Saw-cut opening for the box in the center of the cell of masonry block and install box flush with the surface of the wall.

N. Set metal floor boxes level and flush with the finished floor surface.

O. Set nonmetallic floor boxes level. Trim after installation to fit flush with the finished floor surface.

3.3 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 the manufacturer.
2. Repair damage to PVC or paint finishes with matching touchup coating recommended by the manufacturer.

END OF SECTION

SECTION 26 05 48

VIBRATION AND SEISMIC REQUIREMENTS FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.1 SUMMARY

A. This section includes performance-based design requirements for Seismic Restraints, Equipment Operability Requirements, and Vibration Isolation for electrical systems.

B. Contractor is to engage the services of a Professional Engineer licensed in the State of South Carolina to design necessary seismic restraints as necessary to comply with all applicable National and Local Codes and requirements of Authority Having Jurisdiction.

C. This Section includes requirements for the following materials:

1. Channel support systems
2. Anchorage bushings and washers

D. Related Sections include the following:

1. Division 26 Section "Common Work Results for Electrical" for commonly used electrical supports and installation requirements.

1.2 RELATED DOCUMENTS

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

1.3 DEFINITIONS

A. IBC: International Building Code, latest edition.

B. ICC-ES: ICC-Evaluation Service.

C. ASCE 07 American Society of Civil Engineers.

D. South Carolina Building Code, latest edition.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Design Criteria:

1. Seismic Design Parameters:
   a. Building Occupancy Category: II

b. Site Class: D
c. Mapped Spectral Response Acceleration at Short Period (SS): 1.33
d. Design Spectral Response Acceleration at Short Period (SDS): 1.064
e. Mapped Spectral Response Acceleration at 1-Second Period (S1): 0.391
f. Design Spectral Response Acceleration at 1-Second Period (SD1): 0.521
g. Seismic Design Category: D

1.5 SUBMITTALS

A. Product Data:

1. 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.
2. Electrical equipment manufacturer's special certification requirements per ASCE-07 Section 13.2.2 for structures with a Seismic Design Category C through F containing electrical equipment that must remain operable following the design earthquake. Equipment manufacturer's certification may be submitted with Product Data for the applicable equipment under the appropriate Division 26 specification sections.
   a. Provide manufacturer's certification of operability approved and stamped by a registered professional engineer.
   b. Indicate whether certification is based on shake table testing or experience data.
3. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
4. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads. Bumper restraints or snubbers shall have nominal clearance (air gap) between equipment frame and restraint less than 0.25 inch.

B. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.

C. Welding certificates.

D. Qualification Data: For professional structural engineer to assess.

E. Field quality-control test reports.

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 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 have preapproval by ICC-ES, or preapproval by another agency acceptable to the Contracting Officer, 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 combined shear, compressive and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer in the State of South Carolina.

E. Comply with NFPA 70, latest edition.

PART 2 – PRODUCTS

2.1 SEISMIC-RESTRAINT DEVICES

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

1. Amber/Booth Company, Inc.
2. Cooper B-Line, Inc.; a division of Cooper Industries
3. Hilti Inc.
4. Loos & Co.; Seismic Earthquake Division
5. Mason Industries
6. TOLCO Incorporated; a brand of NIBCO INC.
7. Unistrut; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and application requirements 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. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchors and studs.

E. 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.

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

G. Adhesive Anchor: 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.

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

PART 3 – EXECUTION

3.1 EXAMINATION

A. Design Professional shall obtain equipment Center of Gravity and Weight data from manufacturers for equipment to be secured.

B. Design restraints to comply with critical equipment manufacturers' requirements and to achieve system operability as defined by manufacturer's certification design limits per Section 1.5 subpart A.2.

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

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

3.2 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables 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 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Conduit Support Restraints:

1. Install transverse restraints at both ends if the conduit run is less than 30 feet. Install transverse restraints at both ends and at 90º bends.
2. Install longitudinal restraints at 1 per conduit run.
3. Transverse restraints for 1 support may serve as the longitudinal brace for a perpendicular run if the restraint is within 4 feet of the intersection and the restraint is sized for the larger run.
4. Conduits less than 2.5 inches diameter suspended by individual hanger rods may be excluded from the above requirements.
5. Clevis or trapeze supported conduits suspended by hanger rods where the point of attachment is less than 12 inches in length from the conduit to the structural connection of the clevis or trapeze may be excluded from the above requirements.

B. Equipment Restraints:

1. Install restrained isolators on electrical equipment.
2. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
3. Install seismic-restraint devices using methods approved by an evaluation service member of an agency acceptable to authorities having jurisdiction providing required submittals for component.
4. Equipment weighing less than 50 lbs. may be excluded from the above requirements.

C. 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.

D. 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.

E. 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 pre-stressed 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 runs of raceways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Contractor shall engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
2. Test to 90% of rated proof load of device.

END OF SECTION

SECTION 26 05 53
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and 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. Equipment identification labels.
5. Miscellaneous identification products.

1.3 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

1.4 QUALITY ASSURANCE

A. Comply with ANSI A13.1.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

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 the 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 the location of access panels and doors.

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

PART 2 – PRODUCTS

2.1 CONDUCTOR IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) 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.

2.2 EQUIPMENT IDENTIFICATION LABELS

A. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm).

B. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for the label.

C. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).

D. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).

2.3 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in Division 09 Painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify the identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by the manufacturer of the identification device.

E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

F. 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 (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.

G. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

3.2 IDENTIFICATION SCHEDULE

A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 120V to ground: Identify with the self-adhesive vinyl label. Install labels at 30-foot (10-m) maximum intervals.

B. Provide Arc Flash Hazard warning labels on equipment identified in NEC Art. 110-16.

C. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and hand-holes, use color-coding conductor tape to identify the phase.

1. Color-Coding for Phase Identification, 600 V or Less: Use colors listed below for grounded and ungrounded feeder and branch-circuit conductors.
   a. The 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.
      4) Neutral: White
   c. Colors for 240-V Circuits:
      1) Phase A: Black
      2) Phase B: Red
      3) Neutral: White Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) 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.

D. Power-Circuit Conductor Identification, More than 600 V: For conductors in vaults, pull and junction boxes, manholes, and hand holes, use nonmetallic plastic tag holder with adhesive-backed phase tags, and a separate tag with the circuit designation.

E. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.

F. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.

G. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by the system and circuit designation.
2. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.

H. 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.

I. Equipment Identification Labels: On each unit of equipment, install a unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:
   a. Indoor Equipment: Self-adhesive, engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches high.
   b. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.
2. Equipment to Be Labeled:
   a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be self-adhesive, engraved, laminated acrylic or melamine label.
   b. Enclosures and electrical cabinets.
   c. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
   d. Enclosed controllers.
3. Variable-speed controllers.
4. Pushbutton stations.
   a. Contactors.
   b. Monitoring and control equipment.

END OF SECTION

SECTION 26 27 26

WIRING DEVICES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Snap switches and wall-box dimmers.
3. Cord and plug sets.

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. TVSS: Transient voltage surge suppressor.

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 pre-marking 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 as 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 the intended use.

C. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:

1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
3. Leviton Mfg. Company Inc. (Leviton).
4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

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.

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 the device is tripped.

B. Provide weather resistant devices.

C. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
   a. Cooper; GF20.
   b. Pass & Seymour; 2084.
   c. Leviton.

2.4 TWIST-LOCKING RECEPTACLES

A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, 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; L520R.
   b. Hubbell; HBL2310.
   c. Leviton; 2310.
   d. Pass & Seymour; L520-R.

B. 50 A generator power inlet receptacle. Comply with UL/CSA.

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. Milbank mmtsinlet50
   b. Reliance PB50
   c. Generac 6347
2. NEMA 3R enclosure
3. 50A, 125/250V, 3P4W (2 hot, 1 neutral, 1 gnd) Power Inlet

2.5 WALL PLATES

A. Single and combination types to match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: Smooth, high-impact thermoplastic 0.035-inch

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant, in-use, die-cast aluminum with lockable cover.

2.6 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 the contracting officer unless otherwise indicated or required by NFPA 70 or device listing.

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 the 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 are permitted provided the outlet box is large enough.

D. Device Installation:

1. Replace all devices that have been in temporary use during the 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 the terminal screw.
6. Use a torque screwdriver when 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 down, and on horizontally mounted receptacles to the left.
2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.

H. Adjust locations of floor service outlets and service poles to suit the arrangement of partitions and furnishings.

3.2 IDENTIFICATION

A. Comply with Division 26 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 the face of the plate, and durable wire markers or tags inside outlet boxes.

3.3 FIELD QUALITY CONTROL

A. 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.

END OF SECTION

SECTION 26 28 13

FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600 V-AC and less for use in enclosed switches.
2. Plug-fuse adapters for use in Edison-base, plug-fuse sockets.

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 a list of fuses with adjusted ratings.
   a. For each fuse having adjusted ratings, include the location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
   b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
3. Current-limitation curves for fuses with current-limiting characteristics.
4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of the fuse.
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 & 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 the fuse.
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 a single 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 NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Comply with UL 248-11 for plug fuses.

1.5 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40°F or more than 100°F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.6 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

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. Fuses: One for each size and type.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

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

1. Cooper Bussmann, Inc.
2. Edison Fuse, Inc.
3. Ferraz Shawmut, Inc.
4. Littelfuse, Inc.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

2.3 PLUG FUSES

A. Characteristics: UL 248-11, nonrenewable plug fuses; 125-V-AC.

2.4 PLUG-FUSE ADAPTERS

A. Characteristics: Adapters for using Type S, rejection-base plug fuses in Edison-base fuseholders or sockets; ampere ratings matching fuse ratings; irremovable once installed.

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 the utilization of 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 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing the fuse.

B. Install plug-fuse adapters in Edison-base fuseholders and sockets. Ensure that adapters are irremovable once installed.

3.3 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems" and indicating fuse replacement information on the inside door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION

SECTION 26 28 16

ENCLOSED SWITCHES & CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Non-fusible switches.
3. Receptacle switches.
4. Shunt trip switches.
5. Molded-case circuit breakers (MCCBs).
6. Molded-case switches.
7. Enclosures.

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.4 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 a 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.

C. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation & Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within the same product category, from a single source from a single manufacturer.

B. 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.

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

D. Comply with NFPA 70.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than 6°F and not exceeding 104°F
2. Altitude: Not exceeding 1,000 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 Contracting Officer no fewer than seven days in advance of proposed interruption of electric service.
2. Indicate the method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Contracting Officer's written permission.
4. Comply with NFPA 70E.

1.7 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.8 EXTRA MATERIALS

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

1. Fuses: One for each size and type.
2. Fuse Pullers: One for each size and type.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

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

1. Square D; a brand of Schneider Electric.
2. Eaton;
3. Siemens;
4. General Electric;
5. or approved equal.

B. Type HD, Heavy Duty, Single Throw, 240-V-AC, 800 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with cartridge fuse interiors to accommodate indicated fuses, lockable handle with the capability to accept two padlocks, and interlocked with cover in the closed position.

C. 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 the capability to accept three padlocks, and interlocked with cover in the closed position.

D. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.2 NONFUSIBLE AND MANUAL SWITCHES

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

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

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 the capability to accept three padlocks, and interlocked with cover in the closed position.

C. Type HD, Heavy Duty, Double Pole, Double Throw, 240 V-AC, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, designed for manual transfer of loads from one supply to another, lockable handle with the capability to accept three padlocks, and interlocked with cover in the closed position.

D. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.

2.3 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at the installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R.
3. Wash-Down Areas: NEMA 250, Type 4X.
4. Corrosive or hazardous locations: NEMA 250, Type 4X.
5. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
6. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Non-corrosive Liquids. NEMA 250, Type 12.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting the 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. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration & Seismic Controls for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.

E. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by the manufacturer.

END OF SECTION

SECTION 26 29 23

VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. The section includes separately enclosed, pre-assembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1.3 DEFINITIONS

A. BAS: Building automation system.

B. CE: Conformite Europeene (European Compliance).

C. CPT: Control power transformer.

D. EMI: Electromagnetic interference.

E. IGBT: Insulated-gate bipolar transistor.

F. LAN: Local area network.

G. LED: Light-emitting diode.

H. MCP: Motor-circuit protector.

I. NC: Normally closed.

J. NO: Normally open.

K. OCPD: Overcurrent protective device.

L. PCC: Point of common coupling.

M. PID: Control action, proportional plus integral plus derivative.

N. PWM: Pulse-width modulated.

O. RFI: Radio-frequency interference.

P. TDD: Total demand (harmonic current) distortion.

Q. THD(V): Total harmonic voltage demand.

R. VFC: Variable-frequency motor controller.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: VFCs shall withstand the effects of earthquake motions determined according to local seismic requirements.

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."

1.5 SUBMITTALS

A. Product Data: For each type and rating of VFC indicated. Include features, performance, electrical ratings, operating characteristics, shipping, and operating weights, and furnished specialties and accessories.

B. Shop Drawings: For each VFC indicated. Include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.

1. Show tabulations of installed devices, equipment features, and ratings. Include the following:
   a. Each installed unit's type and details.
   b. Factory-installed devices.
   c. Enclosure types and details.
   d. Nameplate legends.
   e. Short-circuit current (withstand) rating of the enclosed unit.
   f. Features, characteristics, ratings, and factory settings of each VFC and installed devices.
   g. Specified modifications.
2. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring.

C. Product Certificates: For each VFC, from the manufacturer.

D. Source quality-control reports.

E. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation & Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and MCP trip settings.
2. Manufacturer's written instructions for setting field-adjustable overload relays.

3. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
4. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.

F. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.

G. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate the switch settings for motor-running overload protection suit actual motors to be protected.

1.6 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

1.7 DELIVERY, STORAGE, AND HANDLING

A. If stored in space that is not permanently enclosed and air-conditioned, remove loose packing and flammable materials from inside controllers.

1.8 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than 6 deg. F (minus 14 deg. C) and not exceeding 104 deg. F (40 deg. C).
2. Humidity: Less than 95 percent (noncondensing).
3. Altitude: as high as 1,000 feet

B. Product Selection for Restricted Space: Drawings indicate maximum footprint for equipment including clearances between VFCs, and adjacent surfaces and other items.

1.9 COORDINATION

A. Coordinate features of motors, load characteristics, installed units, and accessory devices to be compatible with the following:

1. Torque, speed, and horsepower requirements of the load.
2. Ratings and characteristics of the supply circuit and required control sequence.
3. Ambient and environmental conditions of installation location.

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

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within the specified warranty period.

1. Warranty Period: 3 years from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Basis-of-Design Product: Subject to compliance with requirements provide a comparable product by the following:

1. ABB
2. Allen Bradley
3. Danfoss Inc.; Danfoss Drives Div.
4. Mitsubishi
5. Toshiba

B. General Requirements for VFCs: Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.

C. VFC Description: Variable-frequency power converter (rectifier, dc bus, and IGBT, PWM inverter) factory packaged in a NEMA 1 enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of NEMA MG 1, Design A and Design B motors as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and general-purpose motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

D. Design and Rating: Match load types, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

E. Output Rating: Three-phase; 10 to 60 Hz, with a voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.

F. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFC input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding 5 percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
4. Minimum Efficiency 97 percent at 60 Hz, full load.
5. Ambient Temperature Rating: Not less than 40 deg. F and not exceeding 100 deg. F.
6. Ambient Storage Temperature Rating: Not less than minus 4 deg. F and not exceeding 104 deg. F.
7. Humidity Rating: Less than 95 percent (noncondensing).
8. Altitude Rating: Not exceeding 1,000 feet
9. Vibration Withstand: Comply with IEC 60068-2-6.
10. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
11. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
12. Speed Regulation: Plus or minus 5 percent.
13. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
14. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

G. Inverter Logic: Microprocessor-based, isolated from all power circuits.

H. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.

1. Signal: Electrical.
2. Signal: Pneumatic.

I. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 0.1 to 999.9 seconds.
4. Deceleration: 0.1 to 999.9 seconds.
5. Current Limit: 30 to a minimum of 150 percent of maximum rating.

J. Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors to provide three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
3. Under- and overvoltage trips.
4. Inverter overcurrent trips.
5. VFC and Motor Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor overload alarm and trip; settings selectable via the keypad; NRTL approved.
6. Instantaneous line-to-line and line-to-ground overcurrent trips.
7. Loss-of-phase protection.
8. Reverse-phase protection.

9. Short-circuit protection.
10. Motor overtemperature fault.
11. Automatic Reset/Restart: Attempt three restarts after drive fault or on the return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

K. Power-Interruption Protection: To prevent the motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Auto-speed Search" feature is available and engaged.

L. Bidirectional Auto-speed Search: Capable of starting VFC into rotating loads spinning in either direction and returning the motor to set speed in proper direction, without causing damage to drive, motor, or load.

M. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

N. Motor Temperature Compensation at Slow Speeds: Adjustable current fall back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

2.2 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators displaying the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad, and plain-English language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
   a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.

C. Historical Logging Information and Displays:

1. Real-time clock with current time and date.
2. Running log of total power versus time.

3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

D. Indicating Devices: Digital display mounted flush in VFC door and connected to display VFC parameters including, but not limited to:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (V dc).
9. Setpoint frequency (Hz).
10. Motor output voltage (V ac).

E. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.

1. Number of Loops: 2

F. Ethernet/IP Communication Adaptor:

1. Use Ethernet/IP Communication Adapter.
2. Add I/O cards to the PLC to accommodate hardwired connections.

2.3 ENCLOSURES

A. VFC Enclosures: NEMA 250, to comply with environmental conditions at the installed location.

1. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.
2. Provide in a factory-configured enclosure.

2.4 ACCESSORIES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory-installed in VFC enclosure. All accessories will be factory configured in a factory enclosure:

1. Push Buttons, Pilot Lights, and Selector Switches: Standard-duty, type.
   a. Push Buttons: Shrouded; maintained
   b. Pilot Lights: LED
   c. Selector Switches: Rotary type.
   d. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

B. Phase-Failure, Phase-Reversal, and under-voltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable under-voltage, overvoltage, and time-delay settings.

1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.

C. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250 Type 12 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

D. Spare control-wiring terminal blocks, wired

2.5 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.

B. Test each VFC while connected to [its specified motor] a motor that is comparable to that for which the VFC is rated.

1. Verification of Performance: Rate VFCs according to the operation of functions and features specified.

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

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, Examine VFC before installation. Reject VFCs that are wet, moisture-damaged, or mold damaged.

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

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

D. Prepare a harmonic analysis study and report complying with IEEE 399 and NETA Acceptance Testing Specification.

3.2 INSTALLATION

A. Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Wall-Mounting Controllers: Install VFCs on walls with tops at a uniform height and with disconnect operating handles not higher than 79 inches above finished floor unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall.

C. Seismic Bracing: Comply with requirements specified in Division 26 Section "Vibration & Seismic Controls for Electrical Systems."

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install fuses in each fusible-switch VFC.

F. Install fuses in control circuits if not factory installed. Comply with requirements in Division 26 Section 26 28 13, "Fuses."

G. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

H. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

I. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Division 26 Section 26 05 53, "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each VFC with an engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.4 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices and the facility's central control system. Comply with requirements in Division 26 Section 26 05 19, " Low Voltage Electrical Power Conductors and Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic control devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic control devices that have no safety functions when switches are in manual-control position.
2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.5 FIELD QUALITY CONTROL

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

B. Perform tests and inspections.

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

C. Acceptance Testing Preparation:

1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and the control circuit.
2. Test continuity of each circuit.

D. Tests and Inspections:

1. Inspect VFC, wiring, components, connections, and equipment installation
2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFC locations are within 10 percent of the motor nameplate rated voltages.
5. Test each motor for proper phase rotation.
6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:
   a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each VFC. Remove front panels so joints and connections are accessible to a portable scanner.
   b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each VFC 11 months after the 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.

9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

E. VFCs will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 STARTUP SERVICE

A. Perform startup service.

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

3.7 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

3.8 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to the manufacturer's written instructions until controllers are ready to be energized and placed into service.

B. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.9 DEMONSTRATION

A. Train NPS maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

END OF SECTION