

SECTION 10 44 16 - FIRE EXTINGUISHERS

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 portable, fire extinguishers and mounting brackets for fire extinguishers.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include rating and classification, material descriptions, dimensions of individual components and profiles, and finishes for fire extinguisher and mounting brackets.

1.4 INFORMATIONAL SUBMITTALS

- A. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fire extinguishers to include in maintenance manuals.

1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace fire extinguishers that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

- a. Failure of hydrostatic test according to NFPA 10 when testing interval required by NFPA 10 is within the warranty period.
- b. Faulty operation of valves or release levers.

2. Warranty Period: Six years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. NFPA Compliance: Fabricate and label fire extinguishers to comply with NFPA 10, "Portable Fire Extinguishers."

2.2 PORTABLE, HAND-CARRIED FIRE EXTINGUISHERS

- A. Fire Extinguishers: Type, size, and capacity for each mounting bracket indicated.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Amerex Corporation.
 - b. Buckeye Fire Equipment Company.
 - c. Kidde Residential and Commercial Division.
 - 2. Source Limitations: Obtain fire extinguishers, fire-protection cabinets, and accessories, from single source from single manufacturer.
 - 3. Valves: Manufacturer's standard.
 - 4. Handles and Levers: Manufacturer's standard.
 - 5. Instruction Labels: Include pictorial marking system complying with NFPA 10, Appendix B, and bar coding for documenting fire-extinguisher location, inspections, maintenance, and recharging.
- B. Multipurpose Dry-Chemical Type in Steel Container: UL-rated 4-A:60-B:C, 10-lb nominal capacity, with monoammonium phosphate-based dry chemical in enameled-steel container.

2.3 MOUNTING BRACKETS

- A. Mounting Brackets: Manufacturer's standard galvanized steel, designed to secure fire extinguisher to wall or structure, of sizes required for types and capacities of fire extinguishers indicated, with plated or red baked-enamel finish.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Amerex Corporation.
 - 2. Buckeye Fire Equipment Company.
 - 3. Kidde Residential and Commercial Division.
 - 4. Source Limitations: Obtain mounting brackets and fire extinguishers from single source from single manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine fire extinguishers for proper charging and tagging.
 - 1. Remove and replace damaged, defective, or undercharged fire extinguishers.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. General: Install fire extinguishers and mounting brackets in locations indicated and in compliance with requirements of authorities having jurisdiction.
 - 1. Mounting Brackets: Top of fire extinguisher to be at 42 inches above finished floor.
- B. Mounting Brackets: Fasten mounting brackets to surfaces, square and plumb, at locations indicated.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 11 94 01 - FIBERGLASS TANKS

PART 1 -- GENERAL

1.1 SUMMARY

- A. The work includes furnishing all labor, materials and equipment for the installation of fiberglass fish feeding vessels as shown on the drawings and as specified herein.
- B. Provide the following:
 - 1. Two (2) rectangular vessels; 20'-0" long, 5'-1" wide, 4'-0" deep fiberglass feeding tanks, including removable drain standpipes and screen slots as shown on the Drawings and specified herein. The water depth would be 3 feet with 1-foot of freeboard.

1.2 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Commercial Standards

ASTM C 581	Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass Fiber Reinforced Structures, Intended for Liquid Service
ASTM D 638	Test Method for Tensile Properties of Plastics
ASTM D 695	Test Method for Compressive Properties of Rigid Plastics
ASTM D 790	Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
ASTM D 883	Definitions of Terms Relating to Plastics
ASTM D 2563	Recommended Practice for Classifying Visual Defects in Glass-Reinforced Plastic Laminate Parts
ASTM D 2583	Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor
ASTM D 2584	Test Method for Ignition Loss of Cured Reinforced Resins
ASTM D 3299	Filament-Wound Glass Fiber Reinforced Thermoset Resin Chemical-Resistant Tanks
ASTM D 4097	Contact-Molded Glass-Fiber-Reinforced Thermoset Resin Chemical-Resistant Tanks

- B. When 2 or more of the above regulations are applicable, the more stringent requirement shall be met.

1.3 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.

1. Shop Drawings. Shop drawings and design calculations shall be submitted showing details of construction and layouts for review and acceptance before materials are fabricated.
2. Product Data. Submit manufacturer's printed literature for care and maintenance for review and acceptance, including certification the manufacturer has at least five years of experience in the fabrication and supply of circular dual drain aquaculture tanks of the size specified.
3. CONTRACTOR shall provide color samples of a standard color palette for OWNER selection and approval.
4. Submit final inspection and approval prior to shipment.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. **Delivery of Materials:** Tanks and accessories shall be delivered and placed without damage.

1.5 WARRANTY

- A. **All Components:** The Manufacturer shall furnish to the CONTRACTOR the Manufacturer standard 1-year workmanship warranty, commencing on the date of successful commissioning at the Project by the OWNER, through the CONTRACTOR.

PART 2 -- PRODUCTS

2.1 REQUIREMENTS

- A. Manufacturers' Qualifications

1. Only manufacturers with 5 years or more of proven experience and satisfactory performance in the manufacture of fiberglass reinforced plastic fish tanks.
2. All manufacturers shall be required to submit a complete set of design calculations, material specifications and shop drawings.

- B. Description of Fiberglass Fish Feeding Vessel

1. Provide fiber-reinforced plastic tanks complete and ready for piping hookup and installation in the size indicated in Section 1.1.B.1. The tanks are to be used for the production of fish in water temperatures ranging from 0 to 20 degrees Celsius. The tanks are to be used for an interior, covered application as shown on the Drawings but may be subjected to the maximum ambient temperature range and fluctuations for the geographical location in the event of a facility shut-down.
2. Tanks shall conform to all dimensions and have the features indicated on the Drawings. CONTRACTOR shall verify tank dimensions and resolve any spacing

changes required prior to installation. Units to be provided with reinforcement sufficient to maintain less than 1/2" total deflection at midpoint when filled with water.

3. Tank standpipe opening and screen slots shall be fabricated for use as shown on the Drawings.
4. All tank drain standpipes shall be provided by the tank manufacturer. Standpipes shall seat in a molded PVC pipe coupling where shown in the Drawings to provide watertight seal at base.
6. Each tank shall be provided with screen slots to fit existing fish screens 6'-0 3/8" wide, 4'-4" tall, and 1 1/2" thick.

2.2 WORKMANSHIP

- A. **Visual Defects:** ASTM D 2563 shall be used for quality control of both filament-wound and hand lay-up construction. Acceptance levels shall be as follows:

<u>Process Surface:</u>	<u>Defects:</u>
Blisters	None
Burned Areas	None
Chips	None
Cracks	None
Crazing	None
Dry Spots	None
Entrapped Air	None at surface. If in laminate 1/16-in dia max and 5/sq. in max.
Exposed Glass	None
Exposed Cut Edges	None
Foreign Matter	None
Pits	Max 1/8-in dia X 1/32-in deep, max 10/sq. ft.
Scratches	None (coated)
Surface Porosity	None
Wrinkles	Max deviation 10 percent of wall thickness.
Sharp Discontinuity	None

<u>Non-Process Surface:</u>	<u>Defects:</u>
Blisters	Max 1/4-in X dia 1/16-in high.
Burned Areas	None
Chips	Max 1/4-in with max thickness of 20 percent of wall.
Cracks	None
Crazing	Slight
Dry Spots	Max 2 sq. in/sq. ft
Entrapped Air	1/8-in dia max; no more than 3 percent of area.
Exposed Glass	None
Exposed Cut Edges	None
Foreign Matter	None if it affects the properties of laminate.
Pits	Max 1/8-in dia X 1/16-in deep.
Scratches	None (coated)
Surface Porosity	None
Wrinkles	Max deviation 20 percent of wall thickness, but not exceed 1/8-in.
Sharp Discontinuity	None

- B. If the area fails to meet the requirements of entrapped air or voids in less than 40 percent of the total surface, those areas shall be repaired and re-inspected. If the defective areas exceed 40 percent of the total surface, the entire vessel shall be rejected.
- C. **Shop Inspection:** The OWNER or OWNER Representative shall be permitted access to the manufacturing area during fabrication and shall be notified one week prior to the estimated date of tests and/or inspections. Final inspection and approval shall be obtained prior to shipment unless written waiver is obtained. The shop inspection of the equipment shall include the following:
 - 1. Check for compliance with Drawing dimensions and adherence to construction standards.
 - 2. An acetone wipe test to check surface cure. No surface tackiness is permitted.
 - 3. A Barcol hardness test; at least 90 percent of manufacturer's specified hardness must be attained.
 - 4. Examination of laminated (nozzle) cutouts.
 - 5. A hydrotest of at least 24 hours duration to check for leaks.

2.3 BOLTS, ANCHOR BOLTS, WASHERS, SUPPORTS, AND HOLD DOWN LUGS

- A. The CONTRACTOR shall provide bolts, anchor bolts, nuts, washers, and supports as required for the plastic and fiber glass items in this Section and in accordance with the requirements of the manufacturers of the plastic and fiber glass items. Bolts, anchor bolts, washers, hold down lugs, and supports required in connection with the plastic or fiberglass items shall be of Type 316 stainless steel.

PART 3 -- EXECUTION

3.1 TANK INSTALLATION AND DELIVERY

- A. The fiberglass tank manufacturer shall review and certify in writing that all installation requirements as shown on the plans are in accordance with design character and limitations of the unit.
- B. The tanks shall be covered and protected to prevent damage in shipment and handling. All finished surfaces are to be protected. Tanks shall not be stored in the open at manufacturer's site or at job site. Any damage to the units incurred in transit and unloading shall be the responsibility of the manufacturer. Permits, import requirements, and precautionary measures required for highway transport are the entire responsibility of the manufacturer.
- C. The manufacturer shall be responsible for delivering and supervising the unloading of the units at the hatchery. Visually imperfect units shall be rejected. The manufacturer and CONTRACTOR shall fully cooperate in the unloading and installation of the units at the hatchery.

- D. The manufacturer shall fully cooperate and shall assist the CONTRACTOR with respect to the tank shipping and loading/unloading schedule. The shipping schedule shall conform to the project completion schedule.
- E. The manufacturer shall provide a qualified site representative with the first shipment of units to the project site to insure proper unloading, handling and final installation. The CONTRACTOR shall provide equipment to handle and install the tanks in strict accordance with the manufacturer's instructions.
- F. The manufacturer shall provide a qualified site representative during installation of the units to verify proper installation and grading of the tank bedding material, verify proper tank installation, and connections to the process piping.
- G. The manufacturer shall provide a qualified site representative during start up and commissioning to provide guidance to the CONTRACTOR and to provide training to Hatchery personnel on the correct operation of the tanks including start up procedures, operational procedures, and end of season draining procedures.
- H. All minor defects shall be refinished by the manufacturer prior to completion of the Project and acceptance by the OWNER. The refinished surface shall show no discernible variations in appearance from the surrounding areas.
- I. Prior to shipment, the tanks shall be cleaned to remove any residual parting agent, film or other deleterious material. The units shall be carefully cleaned (per the manufacturer's instructions) prior to completion of the project.
- J. The first tank manufactured shall be inspected by the OWNER and the CONTRACTOR for conformance to drawings and specifications prior to manufacturing remaining order. All subsequent tanks shall be inspected by the CONTRACTOR prior to shipment to the site.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 13 34 19 - PRE-ENGINEERED METAL BUILDING SYSTEMS

PART 1 -- GENERAL

1.1 SUMMARY

- A. The CONTRACTOR shall furnish and install all components, materials and sub-assemblies, and all appurtenant work to construct the pre-engineered metal building (PEMB) system, complete as defined in this specification, and in accordance with the requirements of the Contract Documents.
- B. The CONTRACTOR shall submit documents from the Metal Building System Supplier (MBSS) as identified by this Section to the ENGINEER for approval of the PEMB, prior to the installation of the PEMB.

1.2 WORK INCLUDED

- A. Pre-engineered metal building(s) as shown on Contract Document shall be furnished by the MBSS complete with, but not limited to, the following:
 - 1. Complete engineering design of the building system per the requirements of Part 1.5 below.
 - 2. Primary and secondary steel framing including frames, purlins, girts, and flange bracing.
 - 3. Pre-finished roof and wall cladding, including liner panels if required, and associated trim, mastic, and closures, including gutters and downspouts.
 - 4. Diagonal bracing.
 - 5. Framed openings including overhead and walk door frames.
 - 6. Skylights, translucent panels and other roof and wall opening accessories, including penetration flashing, as shown on the Contract Drawings.
 - 7. Fasteners.
 - 8. Overhead doors and walk doors.
 - 9. Insulation and vapor barriers.
 - 10. All other components and materials as required for a complete and weather tight installation.

1.3 DESCRIPTIONS

- A. **Building Type:** Rigid frame with column and rafter sections of shop welded steel plates; allowed to be tapered unless noted otherwise by the Contract Drawings. The frames shall be:

1. Gable, as shown on the Contract Drawings,
 2. Either clear span or multi-span using interior columns, adopting the configuration shown on the frame sections for each PEMB in the Contract Drawings.
- B. Building Height and Roof Slope:** Either of the following two methods will determine the height of the structure. If case (2) defined below is not explicitly defined on the Contract Drawings or Specifications, then case (1) applies:
1. **Eave Height as shown on Contract Drawings:** The eave height shall be defined as the height corresponding to the top of the purlin cavity at the outside-of-girt location (high side, if the building is monoslope). By this definition the eave height excludes the thickness of the roof panel and is unaffected by eave extensions, per industry standard.
 2. **Eave defined by an Inside Clearance:** If this approach is indicated in either the Contract Drawings or the Specifications, the eave of the building shown on the Contract Drawings will be estimated, with the inside clearance at the Haunch of the lowest Rigid Frame governing.
- C. Column Spacing at Exterior Walls:** As shown on Contract Drawings and compatible with placement of wall openings (walk doors, overhead doors, etc.) and other requirements.

1.4 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

All references listed herein shall be the most current version.

A. Commercial Standards:

AISC	American Institute of Steel Construction, "Specification for Structural Joints Using ASTM A 325 or ASTM A 490 bolts."
AISC 360	American Institute of Steel Construction, "Steel Construction Manual" and "Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings."
AISC 341	American Institute of Steel Construction, "Seismic Provisions for Structural Steel Buildings."
AISI	American Iron and Steel Institute, "Specifications for the Design of Cold Formed Steel Structural Members."
ANSI A 320.9	Voluntary Specifications for Aluminum Prime Windows.
ANSI A 115	Specifications for Door and Frame Preparation for Hardware.
ASTM A 36	Structural Steel
ASTM A 53	Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless

ASTM A 123	Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
ASTM A 307	Carbon Steel Bolts and Studs
ASTM A 325	Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A 500	Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A 501	Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
ASTM A 572	High-Strength Low-Alloy Columbium-Vanadium Structural Steel
ASTM A 653	Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A 792	Steel Sheet, 55% Aluminum-Zinc Alloy-Coated by the Hot-Dip Process.
ASTM A 924	Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM A 992	Steel for Structural Shapes for Use in Building Framing
ASTM A 1008	Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
ASTM A 1008	Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength
ASTM F 1554	Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength
AWS D1.1	American Welding Society: "Structural Welding Code-Steel."
AWS	American Welding Society: "Standard Code for Arc and Gas Welding in Building Construction."
FGMA	Flat Glass Marketing Association, "Glazing Manual."
CBSC	CBC California Building Code
ICC	IBC International Building Code
ICC	IFC International Fire Code

MBMA	Metal Building Manufacturers Association, "Design Practices Manual."
MBMA	Metal Building Manufacturers Association, "Low-Rise Building Systems Manual."
MBMA	Metal Building Manufacturers Association, "Metal Building Systems Manual."
NFPA	National Fire Protection Association
OSHA	OSHA Regulations
SSPC	Structural Steel Painting Council, applicable standards, as referenced herein.
TT-P	Federal Specification, applicable standards, as referenced herein

1.5 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 – Contractor Submittals.

B. **Shop Drawings and Calculations** shall include:

1. Design Calculations and Erection Drawings: The final shop drawing corrected calculations and drawings shall be sealed by a Registered Professional Engineer, licensed to practice in the State which the building is to be constructed, and shall be submitted by the MBSS to the CONTRACTOR & OWNER for their final record and review. If computer programs are utilized in the preparation of calculations, the program's operational premise shall be submitted along with the output data.
2. Shop drawings shall show each type of structural building frame required and its location within the structure. All flange braces required shall be readily identifiable on the shop drawings. All details and other pertinent information required for proper and complete fabrication, assembly and erection of a watertight metal building system shall be provided. Drawings shall show sealant locations.
3. Elevation drawings shall be provided for each of the exterior wall systems, including location of all non-field-located framed openings. Details showing necessary block-outs for the framed openings shall also be provided.
4. Calculations and details of anchorage, including anchor bolt size, grade, location, and embedment length, shall be by the MBSS and shall be submitted for review.
5. Rigid-frame cross-sections shall be provided showing the vertical and horizontal inside clearances.
6. Shop drawings and calculations include the placement and setting details of the cast-in-place anchor bolts, including minimum requirements for bolt material strength, diameter, and projection, the location, magnitude and direction of all loads imposed on the foundation system."

C. **Schedule:** The MBSS shall submit a complete schedule of fabrication and delivery to the site of the pre-engineered building. The CONTRACTOR shall also furnish a schedule detailing sequencing of erection of the pre-engineered building and clearly define the relationship of work of this Section to the overall project schedule.

D. **Material and Color Samples:**

1. Color and texture sample sets shall be submitted by the CONTRACTOR of the full range of alternatives available for selection by the OWNER. The samples shall be clearly marked to show the paint manufacturer's name and product identification.
2. 12-inch square of roof and wall panels, with required finishes.
3. Fasteners for roof and wall panels.
4. Samples of the selected trim color, roof and wall color shall be submitted after color selection.

E. **Erection and Maintenance Manual:** The MBSS's complete building system description, erection manual and maintenance instructions shall be submitted by the CONTRACTOR.

F. **Certificates:**

1. Building engineer & fabricator's certification shall be submitted, prepared and signed by a Registered Professional Engineer licensed to practice in the State which the building is to be constructed, attesting that the building design meets all specified system performance design criteria and the requirements of applicable codes and authorities having jurisdiction at the project site.
2. Documentation shall be submitted by the MBSS and CONTRACTOR confirming that the roof system qualifies for the Underwriters Laboratories Class 90 rating.

1.6 QUALITY ASSURANCE

A. **Design Criteria**

1. **Structural Steel:** For the design of structural steel members, comply with the requirements of the American Institute of Steel Construction (AISC) 360 "Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings" and AISC 341.
2. **Light Gauge Steel:** For the design of light gauge steel members, comply with the requirements of the American Iron and Steel Institutes (AISI) "Specification for the Design of Cold Formed Steel Structural Members" and "Design of Light Gauge Steel Diaphragms".
 - a. For welded procedures, comply with the American Welding Society (AWS) "Standard Code for Arc and Gas Welding in Building Construction".

1.7 SYSTEM PERFORMANCE & DESIGN LOADINGS

A. Notwithstanding any statement in the Contract, the pre-engineered metal buildings shall be designed to satisfy at a minimum the provisions of the California Building Code with

Siskiyou County Amendments. Minimum load criteria shall comply with the requirements of ASCE 7 and the parameters and loads described in the following sections.

B. Risk Category:

1. Risk Category = II

C. Wind Condition Design Loadings:

1. Ultimate Wind Speed, $V_{ult} = 115$ MPH
2. Exposure = C
3. Internal Pressure Coefficient (G) = +/- 0.55 (Partially Enclosed)
4. Topographic Factor, $K_{zt} = 1.00$

D. Seismic Condition Design Loadings:

1. Mapped Spectral Response Acceleration, $S_s = 0.584$
2. Mapped Spectral Response Coefficient, $S_1 = 0.304$
3. Site Class = D
4. Importance Factor, $I_e = 1.00$
5. C_s shall be calculated in accordance with Eqn. 12.8-2.

E. Vertical Live Loads:

1. Purlins and Roof Joists: Design for 20 PSF (live load) uniformly distributed over supported roof area. The live load for these elements shall not be reduced.
2. Primary Framing (Frames): Design for 20 PSF (live load) uniformly distributed over supported roof area, unless permitted to be reduced in accordance with provisions of IBC or ASCE 7.
3. Roof Covering: Design to support either a 20 PSF uniformly distributed load or a 300-lbs. concentrated load over a 1-ft x 1-ft area located at center of maximum roof panel span. The most severe loading condition shall govern the design.
4. Snow Load: 58 psf ground snow (P_g). **Minimum uniform (blanket) roof snow load as defined by the local building official or State shall be designed for, and it is the responsibility of the MBSS to confirm if one exists by contacting the local building official.** Snow drift loads shall be taken into consideration for roof snow load, including those from parapets and roof top obstructions. Sliding snow provisions shall not be used when in conjunction with snow guards designed to prevent snow from sliding.
5. Snow Importance Factor, $I_s = 1.00$

F. Dead Loads:

1. Dead loads for the building shall include the weight of all materials of construction incorporated into the building including fixed service equipment.

G. Collateral Loads:

1. In addition to dead loads, the building shall be designed for a minimum of **3 psf** throughout the roof to account for miscellaneous mechanical and electrical equipment loads. These loads shall be used with gravity load cases, but not used for uplift wind and seismic cases, to produce the worst possible loading scenario.

H. Deflections: Deflection (D) of structural elements and cladding shall not exceed the following, where H is the height from the member to the bottom of the eave, and L is the length of the unsupported clear span of the respective member:

1. Sidesway of Rigid Frames:

- b. Non-Seismic Cases: $D < H/90$, Seismic Cases: $D < H/60$;

- c. Portal Frames/Wind Bents for Wind: $D < H/90$;

2. Sidesway of Braced Frames: $D < H/90$;

3. Vertical Deflection of Rigid Frame Rafters: $D < L/180$;

4. Vertical Deflection of Endwall Rafters:

- a. Wind cases: $D < L/120$;

- b. Live load cases: $D < L/180$;

5. Endwall and Soldier Columns: $D < L/120$;

6. Purlins:

- a. Wind cases: $D < L/120$;

- b. Live load cases (including snow): $D < L/180$

- c. Purlins in eave extensions for both live and wind cases: $D < L/90$.

7. Girts:

- a. Not supporting masonry or concrete walls or glass: $D < L/90$

8. Panels / Cladding: $D < L/90$.

- I. Design temperature differential shall be a minimum of 120 degrees F for thermal expansion and contraction analysis of framing systems. Standing Seam Roof Systems in large roof areas shall have thermal expansion and contraction accounted for in the design.

- J. **Purlin Roll.** Purlins shall be designed to prevent purlin roll resulting from heavy snow loads acting on steep roof pitches with larger sidewall bay spacing.

K. **Girts and Other Secondary Steel Requirements:**

1. Vertical spacing between horizontal girts shall be as determined by system design.
2. MBSS shall design the secondary steel to accommodate all framed openings. Additional strength shall be provided as required for roll-up doors. Additional channels shall be provided for overhead doors to support full vertical travel of overhead doors.

1.8 **PRODUCT DELIVERY, STORAGE, AND HANDLING**

- A. **Delivery of Materials:** Manufactured materials and prefabricated components shall be delivered in original, unbroken packages, containers, or bundles bearing the name of the building engineer & fabricator.
- B. **Storage:** All materials shall be carefully stored in conformance with the building engineer & fabricator's recommendations, on platforms or pallets above grade or on concrete slab, covered with opaque tarpaulins or other approved weather-resistant ventilated covering. Storage shall be in a manner that will prevent damage or marring of finish.
- C. **Trapped Water:** Efforts shall be taken to transport and store structural members in a manner which prevents them from collecting rainwater (ex: uncovered rigid frames on their side). Any additional cost required to remove water from structural members shall be paid by the CONTRACTOR.

1.9 **WARRANTY**

- A. **All Components:** The MBSS shall furnish to the CONTRACTOR the MBSS's standard 1-year workmanship warranty, commencing on the date of acceptance of the Project to the OWNER, through the CONTRACTOR.
- B. **Roof Cladding:** MBSS shall provide standard 10-year paint finish warranty and standard 20-year no-perforation warranty to the OWNER, through the CONTRACTOR.
- C. **Wall Cladding:** MBSS shall provide standard 10-year paint finish warranty to the OWNER, through the CONTRACTOR.

PART 2 -- **PRODUCTS**

2.1 **STRUCTURAL STEEL**

A. **Materials**

1. Structural Plate or Bar Stock: ASTM A572 Gr. 50 or 55.
2. Cold Formed Structural Steel: Minimum yield strength (Fy) of 55,000 PSI.
3. Structural steel angles and misc. plates: ASTM A36 or ASTM A572 Gr. 50.
4. HSS (Square, Rectangular, Round): ASTM A500 Gr. B.
5. Primary Structural Bolts and Nuts: ASTM A325.

6. Secondary Structural Bolts and Nuts: ASTM A325.

B. Primary Structural Steel

1. Columns and Rafters: Fabricated with all necessary holes for attachment of secondary members and flange braces.
2. Rigid Frame End Plates: Factory fabricated for precision for all rafter-to-rafter and/or column-to-rafter connections, complete with connection bolt holes. **Holes in the column base plate that align with cast-in-place anchor rods shall be sized to match the recommended sizes for anchor rod holes in base plates per the AISC Manual of Steel Construction to accommodate concrete construction tolerances.**
3. Base Plates, End Plates, and Stiffeners: Factory welded to primary steel elements.
4. Join flanges and webs of structural members fabricated of plate or bar stock together by continuous automatic submerged arc welding process with all welding performed under the supervision of certified welders in accordance with standard practices of AWS D1.1.
5. Coating:
 - a. **Coating:** All primary structural steel shall be **hot-dipped galvanized** to meet standards, at a minimum, of ASTM A123.
 - b. The steel shall have the necessary surface preparation performed (either at the fabrication shop or the galvanizing facility, or both) to produce a product free of surface discontinuities which would be removed during the SP3 "*Power Cleaning*" definition of surface preparation.
 - c. Steel members shall be fabricated with drain holes and/or details as required by the galvanizer to galvanize the product safely, without incurring **zinc bath explosion**.

C. Secondary Structural Steel:

1. Purlins: Provide Z sections, roll formed, punched for attachment with minimum 1/2-inch diameter bolts. Purlins on roof system shall be spaced at no greater than 5.0 feet on center.
2. Girts: Provide roll formed Z sections; or C sections either roll or break formed, punched for attachment with minimum 1/2-inch diameter bolts.
3. Eave Struts: Cold formed sections with minimum (Fy) 55,000 PSI steel, with vertical web to receive sidewall panels and two 1/2-inch-diameter bolt attachments to rigid frame in factory-punched holes in column or bracket.
4. Roof Struts: Provide as required with attachment to top flange of rigid frame rafters by two of 1/2-inch minimum size diameter bolts at each end of strut.
5. **Base Channel: 14 Gauge.**

6. Flange Braces: Steel angles attached to purlin or girt, to stiffen rigid frame flanges as dictated by the MBSS and noted on final shop drawings.

7. Coating:

- a. Secondary structural steel members (purlins, girts, struts, braces, etc.) shall be coated with **G90 Galvanizing**, meeting ASTM A653.

2.2 EXTERIOR ROOF PANELS

- A. Exterior roof panels shall comply with Section 07 41 16 – Insulated Metal Roof Panels.

2.3 EXTERIOR WALL PANELS

- A. Exterior wall panels shall comply with Section 07 42 13.19 – Exterior Wall Panels

2.4 FLASHING AND TRIM

- A. Flashing and trim shall comply with Section 07 62 00 – Sheet Metal Flashing and Trim

2.5 SNOW GUARDS

- A. Snow guards shall comply with Section 07 72 53 – Snow Guards.

2.6 JOINT SEALANTS

- A. Joint sealants shall comply with Section 07 92 00 – Joint Sealants.

2.7 OVERHEAD COILING DOORS

- A. Overhead coiling doors shall comply with Section 08 33 23 – Overhead Coiling Doors.

2.8 SECTIONAL DOORS

- A. Sectional doors shall comply with Section 08 36 13 – Sectional Doors.

2.9 OTHER WALKDOORS AND FRAMES

- A. Hollow metal doors and frames shall comply with Section 08 11 13 – Hollow Metal Doors and Frames.

2.10 DOOR HARDWARE

- A. Door hardware shall comply with Section 08 71 00 – Door Hardware.

2.11 UNIT SKYLIGHTS

- A. Unit skylights shall comply with Section 08 62 00 – Unit Skylights.

2.12 LOUVERS

- A. Operable wall louvers shall comply with Section 08 91 16 – Operable Wall Louvers.

- B. Fixed louvers shall comply with Section 08 91 19 – Fixed Louvers.

2.13 WIND AND SEISMIC BRACING

- A. Tension-only cable or rod bracing shall be used for lateral wind and seismic bracing. Braces shall be located to avoid framed openings, unless accepted by the OWNER. Braces shall have all necessary connection materials provided.

2.14 ACCEPTABLE METAL BUILDING SYSTEM SUPPLIERS

- A. Subject to compliance with specified requirements, the following are acceptable MBSS suppliers:
 - 1. Evergreen Industrial. Ltd.;
 - 2. American Buildings Company;
 - 3. Or approved equal.

PART 3 -- EXECUTION

3.1 ERECTION

A. General

- 1. **Erector's Qualifications:** The CONTRACTOR shall erect the prefabricated building, or have the erection performed by a Subcontractor under their supervision. The party which erects the PEMB shall have not less than 5 years successful experience in the erection of prefabricated buildings similar to that required for this project.
- 2. Metal building system components shall be installed in strict compliance with the MBSS instructions shown on final shop drawings.
- 3. Handle and store all materials to avoid damage and replace any damaged materials.
- 4. The party which erects the PEMB shall observe and follow recommendations of the Metal Building Manufacturers Association (MBMA) practice and procedures where applicable and the recommendations of the MBSS.
- 5. The party which erects the PEMB shall not field cut or alter primary or secondary structural members without approval from the Engineer of Record.
- 6. A minimum of 1-inch of non-shrink, non-metallic grout shall be provided under each column base plate.

B. Structural Frames

- 1. Structural frames shall be erected true to line, level and plumb, **braced and secured with temporary bracing** in all directions as required.
- 2. Base plates shall be leveled and secured with anchor bolts to a level plane with full bearing on foundation supporting structures. **A minimum of 1-inch grout shall be used under base plates.**

C. Bracing

1. All permanent bracing shall be installed in appropriate roof and sidewall locations as indicated on approved shop drawings. Sidewall knee braces, if knee braces are used, shall be located within 5-feet from the top of the building columns.

D. Framed Openings

1. Securely attach to building structural framing members, square and plumb.

E. Roof and Wall Panels:

1. General

- a. Install roof and canopy panels in such a manner to permit drainage to eaves of building, with panel ends square to eave.
- b. Install wall panels with vertical edges plumb.
- c. Arrange and nest side lap joints away from prevailing winds when possible.
- d. Apply panels and associated items for neat and weather-tight enclosure.
- e. Avoid "panel creep" or application not true to grid lines.
- f. Protect factory finishes from mechanical damage or abrasions.
- g. Install approved type closures to exclude weather.
 - i. Install weather seal under ridge cap. Flash and seal roof panels at eave, gable and perimeter of all openings through roof and elsewhere as required or shown on Contract Drawings.
 - ii. Flash and/or seal wall and liner panels at perimeter of all openings, under eaves and gable trims, along lower panel edges, and elsewhere as required or shown on Contract Drawings, as applicable.
- h. Remove all fastener or cutting shavings from roof and wall as erection is completed.

2. Wall Panels

- a. Align bottoms of panels to proper coverage and fasten with panel manufacturer's recommended and supplied fasteners.
- b. Cut and fasten flashing and trims with approved type fasteners.
- c. Install all fasteners with power tool having adequate torque and proper RPM adjusted to seat fastener without damage to heads, washers or panels.
- d. Install panel side lap away from prevailing wind or view direction when possible, maintaining proper lap without fastener dimpling or excessive overlap.

3. **Accessories:** Install flashings, trim, ridge covers, roof curbs, skylights, pipe flashings, closure strips, roof jacks, gutters, roof drains, Insulation, and other accessories and sheet metal items in accordance with manufacturer's recommendations for positive attachment to building and provide a weathertight mounting.

F. **Overhead Doors:** The doors, tracks, hardware, and accessories shall be installed in accordance with door manufacturer's instructions and as shown on Drawings for fully operational door system. The party installing the overhead doors shall be an authorized distributor of the door manufacturer.

3.2 COATINGS

A. All abrasions, scratches, field welds or other damages in shop-primed or factory-finished painted surfaces shall be touched-up consistent with the quality and coating thickness of original shop primer or factory-finished painting. In the case of hot-dip galvanizing, a similar quality of touch-up galvanizing shall be applied to the aforementioned damages.

B. When paint is used, finish coats shall be provided which are compatible with the metal building engineer & fabricator's prime coat paints.

C. When paint is used, Hardware, accessories and similar items not intended to be finish-painted shall be properly protected during painting operations.

3.3 FIELD QUALITY CONTROL

A. All framing members shall be erected plumb, level or aligned not to exceed a deviation 1:300 (i.e., no more than 1-inch in 25-ft)

B. The ENGINEER shall make at least one (1) on-site inspection during the erection and installation of the building as required ensuring that erection is in accordance with the MBSS's and ENGINEER's foundation design requirements.

C. The CONTRACTOR shall provide written certification that the final installation has been erected in conformance with the MBSS recommendation and meets the requirements of the Specifications.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 13 50 00 – PREDATOR NETTING

PART 1 -- GENERAL

1.1 SUMMARY

- A. The CONTRACTOR shall provide predator netting in conformance with the Contract Drawings.
- B. This specification is based on the 1.5" x 1.5" 380/21ply (US#15) DuraTough netting as manufactured by Pacific Netting Products.

1.2 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals.
- B. **Shop Drawings:** Detailed plans for the fabrication and erection of predator netting shall be submitted for review by the ENGINEER.
- C. **Netting Calculations:** Detailed calculations stamped by a licensed professional engineer showing that the predator netting is capable of withstanding the design loads shall be submitted for review by the ENGINEER.
- D. Product data sheets shall be submitted for review by the ENGINEER.

PART 2 -- PRODUCTS

2.1 Predator Netting

- A. The predator netting shall be comprised of black twisted knotted polyethylene conforming to the following;
 - 1. Mesh size – 1.5" x 1.5"
 - 2. Twine diameter – 1.54 mm
 - 3. Mesh break minimum strength – 100 lbs per ISO 1806
 - 4. Minimum burst strength per square foot – 839 lbs
 - 5. Color – Black
 - 6. Construction – Twisted knotted
 - 7. Finish – UV stabilized and bonded, suitable for outdoor exposure
- B. Design Requirements
 - 1. Roof snow load – 40 psf

2. Design wind speed – 115 mph
3. Mesh size must limit birds from penetrating the netting, namely kingfishers.

PART 3 -- EXECUTION

-- Not used --

- END OF SECTION -

SECTION 13 60 01 – OUTDOOR VAULT TOILETS

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 CONTRACTOR shall furnish and install all components, materials and sub-assemblies, and all appurtenant work to construct the precast outdoor vault toilet, complete as defined in this specification, and in accordance with the requirements of the Contract Documents.

1.3 ACTION SUBMITTALS

- A. Product Data: Submit manufacturer's product data.
- B. Shop Drawings: Submit shop drawings including profiles, accessories, location, adjacent construction interface, and dimensions, stamped by a Licensed Professional Engineer.
- C. Warranty: Submit executed copy of manufacturer's standard warranty.
- D. Calculations: Submit detailed calculations stamped by a Licensed Professional Engineer.

1.4 MANUFACTURER CRITERIA

- A. The manufacturer supplying the requested precast concrete vault toilet facility must meet the following;
 - 1. ISO 9001 certified
 - 2. PCI certified
 - 3. Gunnison style vault toilet by CXT Incorporated, or approved equal

1.5 Warranty

- A. Manufacturer shall provide a one (1) year warranty.

1.6 Design Criteria

- A. The design shall meet all applicable accessibility and building code requirements.
- B. Vault toilet shall be designed to meet the Project general design load criteria on sheet GS001 of the contract drawings, plus the following additional criteria;

1. Sweet Smelling Technology (SST)

- a) Vault building shall incorporate design aspects of SST as outlined by Briar Cook for the U.S. Forest Service
 - b) All wall to floor interior surface seams shall have a minimum 1" radius coving made of high strength grout
 - c) The vault shall have a bottom slope of 1" per foot from under the toilet riser out to the outside cleanout area.
 - d) The vault shall have a 24" diameter (minimum) lightweight manhole cover installed to the rear or side of the building.
 - e) The manhole cover should be raised, with the surrounding concrete sloped away using a minimum slope of 1/2" per foot.
 - f) The depth of the vault shall be no deeper than 4 1/2' to 5'.
 - g) A 12" diameter round pipe shall be installed to vent the vault and the pipe shall be raised a minimum of 3' above the highest point of the roof. Vent pipe shall be straight up from the vault.
 - h) There shall be only one vent opening in the building and it shall be placed only on one side of the building (the side that the wind blows against).
2. All concrete design with a minimum 7/12 roof pitch.
3. Minimum 4" wall, 4 1/2" roof, and 5" floor thickness
4. One-piece floor unit
5. One-piece full length and width vault unit

PART 2 -- PRODUCTS

2.1 Materials

A. Concrete – General

- 1. The concrete mix design shall be designed to ACI 211.1 to produce concrete of good workability.
- 2. Concrete shall contain a minimum of 675 pounds of cementitious material per yard.
- 3. Cement shall be a low alkali type I/II or III conforming to ASTM C-150.
- 4. Coarse aggregates used in the concrete mix design shall conform to ASTM C33 with the designated size of coarse aggregate #67.
- 5. Maximum water/cement ratio shall not exceed .45.

6. Air-entraining admixtures shall conform to ASTM C260. Water reducing admixtures shall conform to ASTM C494, Type A.
7. If Self Compacting Concrete (SCC) is used, it must conform to ASTM C1611.

B. Concrete – Cold Weather

1. Cold weather concrete placement shall be in accordance with ACI 306.
2. Concrete shall not be placed if ambient temperature is expected to be below 35°F during the curing period unless heat is readily available to maintain the temperature of the concrete at least 50°F.
3. Materials containing frost or lumps of frozen materials shall not be used.

C. Concrete – Hot Weather

1. The temperature of the concrete shall not exceed 90°F at the time of placement. When the ambient reaches 90°F the concrete shall be protected with moist covering.

D. Concrete Reinforcement

1. Reinforcing steel shall conform to the requirements of Specification 03 20 00.

E. Caulking, Grout, Adhesive and Sealer

1. Caulking service temperatures from -40°F to +194°F.
2. Interior and exterior joints shall be caulked with a paintable polyurethane sealant.
3. Grout shall be a non-shrink type and shall be painted to match the color of surrounding concrete as nearly as possible.
4. Cement base coating shall be formulated with a very fine aggregate system.

F. Dead Bolt

1. Certified ANSI/BHMA A156.5-2001 Grade 1.
2. Heavy duty tamper resistant.
3. 2¾" backset.
4. U.S. 26D finish.

G. Doors – Steel

1. Doors shall be flush panel type 1¾" thick, minimum 16-gauge galvanized steel, top painted with DTM ALKYD.
2. Door frames shall be knockdown or welded type, single rabbet, minimum 16-gauge prime coated steel top painted with DTM ALKYD, width to suit wall thickness.
3. Three (3) rubber door silencers shall be provided on latch side of frame.

H. Door Hinges

1. Three (3) per door with dull chrome plating 4½" x 4½", adjustable tension, and automatic closing for each door.

I. Doorstop

1. Dome style stop meeting ANSI 156.16.

J. Door Sweep

1. Provided at the bottom of door with an adjustable brush.

K. Double Coat Hook

1. 16-gauge (1.5mm), type 304 stainless steel.
2. Formed construction with a satin finish and $\frac{3}{16}$ " x $\frac{7}{8}$ " nail in anchor.
3. Upper hook shall extend at least 2½" from the wall.
4. Lower hook shall extend at least 1¼" from the wall.

L. Grab Bars

1. 18-gauge, type 304 stainless steel with 1½" clearance.
2. Able to withstand 300-pound top loading.

M. Lockset

1. Meets ANSI A156.2 Series 4000, Grade 1 cylindrical lockset for exterior door.
2. Lever handle both inside and out.
3. Either handle operates latch unless outside handle is locked by inside push-button.
4. Push-button shall automatically release when inside lever handle is turned or door is closed.
5. Emergency slot on exterior so door can be unlocked from the outside with a coin, screwdriver etc.
6. Inside lever always active.
7. U.S. 26D finish.

N. Paint

1. Paints shall not contain more than .06% by weight of lead.
2. Inside concrete surfaces.
 - a) Interior floors – chemical resistant urethane, color gray.

b) Interior walls and ceilings – modified acrylic, water repellent penetrating stain, color white followed by a clear acrylic anti-graffiti sealer.

3. Exterior concrete surfaces.

a) Exterior slab – clear sealer.

b) Exterior walls and roof – water repellent penetrating stain in the same color as the walls or roof followed by a clear acrylic anti-graffiti sealer.

c) Metal surfaces (interior and exterior) - DTM ALKYD or approved equal.

O. Riser

1. Meets ADA standards.

2. Molded one-piece HDPE polyethylene.

3. Smooth surface and high impact resistance at extremely cold temperatures.

P. Sealers and Curing Compounds

1. Curing compounds, if used, shall be colorless, complying with ASTM C309, type I or 1-D.

2. Weatherproofing sealer for exterior of building shall be clear water repellent penetrating sealer.

Q. Signs

1. Signs to have raised pictograms, letters, and braille to meet ADA requirements.

2. Interior to have “No Trash in Vault” sign.

3. All signs shall be inset a minimum of $\frac{3}{4}$ ” into wall with 45-degree bevel.

4. All signs shall be anchored into concrete with $\frac{1}{4}$ ” x $\frac{3}{4}$ ” concrete anchor nails.

R. Toilet Paper Dispenser

1. Constructed of $\frac{1}{4}$ ” thick, type 304 stainless steel.

2. Holds three (3) standard rolls of toilet paper.

3. Fastening system able to withstand 300-pound top loading.

S. Polyethylene Vault Liner

1. Shall consist of a Roto molded 8460 polyethylene.

2. Holds up to 1,000 gallons of waste or 15,000 uses per vault.

3. Minimum thickness 0.10”.

4. Molded dovetail embeds to attach the liner to concrete walls of the vault.
5. Welded two (2) C-channels to attach the liner to the bottom of the vault.

T. Vent Stack

1. Minimum 12" in diameter and a minimum 3' higher than the roof peak.

U. Wall Vent

1. Vent cover shall be 14-gauge, type 304 stainless steel painted with DTM and anchored into the concrete wall with high strength anti-rust tap con fasteners.
2. Vent louver frame and louvers shall be non-vision, 0.1" extruded, aluminum jet coat finish.
3. Vent shall have insect screen.
4. Cover to be recessed a minimum $\frac{3}{4}$ " on exterior walls with a 45-degree bevel. Interior to be flush mounted. Wall vent shall not protrude from the wall.

V. Windows and Vault Cleanout Cover

1. Windows and cleanout cover frames shall be constructed from steel.
2. Window glazing shall be $\frac{3}{16}$ " thick translucent pebble finished mar-resistant Lexan.
3. Plate for vault cleanout cover shall be $\frac{1}{4}$ " thick diamond plate steel.
4. Lid shall be hinged and configured so that it can be locked with a padlock. A gasket shall be provided around the entire perimeter of the lid to provide an airtight seal.
5. Windows shall have $\frac{3}{4}$ " recess with 45-degree bevel.
6. Windows frames shall have vandal resistant fasteners.

W. Bedding Materials

1. Bedding material shall be sand or $\frac{3}{8}$ " minus crushed or screened aggregate.

X. Caulking

1. Caulking between vault and toilet floor shall be 1" x 1" Butyl tape designed specifically to bond precast concrete to precast concrete.

PART 3 -- EXECUTION

3.1 Fabrication

A. Mixing and Delivery of Concrete

1. Mixing and delivery of concrete shall be accordance with ASTM C94, Section 12.6 through 12.9.

B. Placing and Consolidating Concrete

1. Concrete shall be consolidated by the use of mechanical vibrators. Vibration shall be sufficient to accomplish compaction but not to the point that segregation occurs.

C. Finishing Concrete

1. Interior floor and exterior slabs shall be floated and troweled.
2. All exterior building walls and exterior screen walls texturing shall be selected by OWNER.
3. All exterior surface textures of the roof panels shall be selected by the OWNER. The underside of the overhang shall have a smooth finish.

D. Repairs

1. Cracks in concrete components which shall be determined to affect the structural integrity of the building shall be rejected.
2. Small holes, depressions, and air voids shall be patched with a suitable material. The patch shall match the finish and texture of the surrounding surface.
3. Patching shall not be allowed on defective areas if the structural integrity of the building is affected.

E. Curing and Hardening Concrete

1. Concrete surfaces shall not be allowed to dry out from exposure to hot, dry weather during initial curing period.

F. Structural Joints

1. Wall components shall be joined together with two (2) welded plate pairs at each joint.
 - a) Each weld plate shall be 6" long and located one (1) pair in the top quarter and one (1) pair in the bottom quarter of the seam.
 - b) Weld plates shall be anchored into the concrete panel and welded together with a continuous weld.
 - c) Inside seams shall be a paintable caulk.
 - d) Outside seams shall use a caulk in a coordinating building color or clear.
2. Walls and roof shall be joined with weld plates, 3" x 6" at each building corner.
3. The joint between the floor slab and walls shall be joined with a grout mixture on the inside, a matching colored caulk on the outside and two (2) weld plates 6" long per wall.

G. Painting/Staining

1. An appropriate curing time shall be allowed before paint shall be applied to concrete. Some applications may require acid etching. A 30% solution of hydrochloric acid shall be used, flushed with water, and allowed to thoroughly air dry.
2. Painting shall not be done outside in cold, frosty, or damp weather.
3. Painting shall not be done outside in winter unless the temperature is 50°F or higher.
4. Painting shall not be done in dusty areas.

3.2 Testing

- A. Testing shall only be performed by qualified individuals who have been certified ACI Technician Grade 1.
- B. Sampling shall be in accordance with ASTM C172.
- C. The following tests shall be performed on concrete used in the manufacture of vault toilets. All testing shall be performed in a PCI certified laboratory.
 1. Air content – checked per ASTM C231. The air content shall be in the range of 5.0% +/- 1.5%.
 2. Compressive strength– tested to ASTM C39.
 - a) Two cylinders at release (minimum strength of 2500 psi).
 - b) One cylinder at seven (7) days (minimum strength of 4500 psi).
 - c) Two cylinders at 28 days (minimum strength of 5000 psi).
- D. A copy of all test reports shall be available to the OWNER as soon as 28-day test results are available.

3.3 Installation

- A. Excavation and Elevation
 1. Excavation shall be performed in accordance with Section 31 00 00 Earthwork.
 2. Finish floor elevation shall be 4-6" above natural grade measured at the front (entrance) of the exterior slab unless otherwise approved by the OWNER. The back of the building should be slightly higher to allow water to freely drain out of the vault toilet rooms.
- B. Backfill and Compaction
 1. Backfill and compaction shall be performed in accordance with Section 31 00 00 Earthwork.

- END OF SECTION -

SECTION 22 05 00 - PLUMBING, GENERAL

PART 1 -- GENERAL

1.1 SUMMARY

- A. The CONTRACTOR shall provide plumbing piping and specialties, complete and operable, as indicated in accordance with the Contract Documents.

1.2 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with Section 01 33 00 – Contractor Submittals.
- B. Shop Drawings
 - 1. General arrangement drawings of system components
 - 2. Catalog cuts and other manufacturer information for products
- C. Samples: electrically fused test joint for drainage and vent piping

1.3 WORKMANSHIP AND MATERIALS

- A. WORK shall in strict accordance with the Uniform Plumbing Code and codes of the State of California, Siskiyou County, and any other authorities having jurisdiction.
- B. The CONTRACTOR shall have required certifications and shall be thoroughly familiar with the local codes.
- C. The CONTRACTOR shall obtain and pay for necessary permits.
- D. Protection
 - 1. Care shall be taken at all times to protect floors, stairways, and walls during the make-up and installation of piping and equipment.
 - 2. The CONTRACTOR shall remove stains and repair damage before final acceptance of the WORK.
- E. Identifying Marks
 - 1. If the ENGINEER finds materials that have identifying marks removed or lack such marks completely, such items will be rejected until the CONTRACTOR has furnished proof that said items conform to the Specifications.
 - 2. Adequacy and extent of such proof will be determined by the ENGINEER.

PART 2 -- PRODUCTS

2.1 GENERAL

- A. Plumbing piping, fixtures, specialties, and equipment shall be as recommended by the manufacturer for the intended usage.
- B. Floor drains or floor sinks shall be provided for equipment drains.
- C. No equipment drains shall discharge to floor slabs.

2.2 PIPE, FLASHING, DRAINS AND ACCESSORIES

- A. **Plumbing Pipe.** All plumbing piping and fittings shall be in accordance with the Piping Schedule Contract Drawing, and with the respective individual pipe material specifications.
- B. **Flashing**
 - 1. Vent piping passing through the roof shall be flashed.
 - 2. Flashing shall extend a minimum 12 inches from the outer surface of the pipe in each direction.
 - 3. Flashing shall be fabricated from one piece of spun, heavy, 0.064 prime aluminum or 4-pound lead sheet.

2.3 HANGERS, SUPPORTS, AND MISCELLANEOUS METAL WORK

- A. General
 - 1. For utility piping located inside the building, the CONTRACTOR shall provide hangers and supports for vertical, axial, and seismic loads in accordance with the applicable plumbing code.
 - 2. No perforated strap hangers nor wire supports will be permitted.
 - 3. Pipe supports shall be as indicated in Section 40 23 02 – Pipe Supports.
- B. Spacing
 - 1. Pipe support spacing for plumbing pipe shall be as indicated in Section 40 23 02 – Pipe Supports.
 - 2. Copper tube or pipe support spacing shall be not more than 6 feet between supports.
- C. Rod sizes for pipe hangers shall be as recommended by the hanger manufacturer.
- D. Vertical piping shall be supported at the base with fittings made for this purpose or shall be supported from the nearest horizontal member or floor with a riser extension pipe clamp.
- E. Inserts

1. Anchors that are installed into existing concrete shall be **Grinnel Figure 117, Modern Figure 740**, or equal, expansion case inserts.
2. Drill clean holes for the insertion of case and patch concrete around the hole, as required.
3. Continuous-slotted concrete inserts, if used, shall be **Crawford Figure 148, Fee & Mason Figure 9000**, or equal.
4. The CONTRACTOR shall provide secondary angle supports between main inserts to handle the loads which can be properly supported by such arrangement.
5. Concrete inserts shall be as indicated in Section 40 23 02 – Pipe Supports.
6. Inserts shall be galvanized.

2.4 PIPE SLEEVES

- A. Sleeves shall be constructed from Schedule 40 galvanized steel pipe, one size larger than the pipe passing through, or where pipe is insulated, one size larger than the pipe plus insulation.
- B. At exposed wall or ceiling surfaces, install a suitable chromium plated brass wall plate approved by the ENGINEER.

2.5 VALVES

- A. **General.** Ball valves, check valves, globe valves, or angle valves required of the plumbing system design shall be in accordance with the requirements of their respective Specification Section.
 1. Valves shall open by turning counterclockwise and shall be provided with suitable handwheels or nuts as required.
- B. **Hose Bibb Valves**
 1. Interior hose valves shall be provided as indicated.
 2. The hose nipple shall be a female iron pipe thread inlet with hose thread outlet.
 3. Hose bibbs shall be the size shown on the Drawings.
- C. **Isolation Shut-Off, Ball Valves**
 1. Water shutoff valves shall be ball type, except on fixture supply piping where globe style isolation valves shall be used.
 2. Provide isolation shut-off ball valves (NPT ends) on cold water piping at entrances to pipe chases and other inaccessible areas and wherever indicated or required to obtain the maximum efficiency for shut-off control on the water system

3. Shut-off valves shall be placed on hot and cold-water connections to equipment and fixtures.
4. Extra-long barrel stops shall be used where supply piping is concealed behind partitions.
5. Show proposed locations of shut-off valves on the Shop Drawings.

2.6 FLOOR DRAINS IN CONCRETE FLOORS

- A. Floor drains in concrete floors shall be constructed of cast iron, in the sizes indicated, and provided with sediment buckets.
- B. Each floor drain located on an upper floor shall have a clamping collar, with 4-lb sheet lead flashing 12 inches minimum all around.
- C. Where lead flashing does not comply with the Code, use epoxy waterproofing material and submit a Shop Drawing for review.
- D. Manufacturers, or Equal
 1. **Josam Mfg. Co., Series 31120**
 2. **Jay R. Smith Mfg. Co., Fig. 2350**
 3. **Zurn Industries, Inc., Series Z-520-Y**

2.7 CLEANOUTS

- A. Cleanouts shall be heavy plugs with tapered shoulders against caulked lead or heavy brass plugs.
- B. Where underground or concealed, cleanouts shall be brought to floor level and to accessible locations with access covers and frames.
- C. **Manufacturers**, or Equal

Service	Josam Series	J.R. Smith No.	Zurn No.
Exposed Locations	58500-20	4405	Z-1440-A
Underground (finished floors)	56010/30	4143	ZN-1400-2
Walls, Concealed	58790-20	4535	ZN-1445-1-A
Traffic Areas	56070	4240	Z-1420-27

- D. Cleanouts shall have a minimum diameter of 3 inches.
- E. Stack cleanouts shall be installed at the base of each stack.

- F. Cleanouts shall be fabricated from galvanized cast iron with ABS plastic cleanout plugs.

2.8 HOSE BIBBS AND HYDRANTS

- A. Hose bibbs and hydrants in exposed locations subject to freezing shall be the non-freeze type.⁷
- B. Hose bibbs connected to a non-potable water supply shall be provided with plastic or stainless steel warning signs reading "DO NOT DRINK" in clearly legible letters, permanently attached at the hose bibb.
- C. Hose bibbs shall be provided with vacuum breakers as furnished by **Crane Co., American Standard**, or equal.

2.9 WALL-MOUNTED HOSE RACKS

- A. The CONTRACTOR shall provide wall-mounted hose racks at the indicated locations.
- B. Racks shall be of welded steel construction, minimum 8-gauge sheet steel, hot-dip galvanized after fabrication, and shall have a capacity to hold 100 feet of the indicated hose.
- C. Racks located in the open shall be supported from two 2-by-2-by-1/4-inch galvanized steel angle posts set in a concrete base or as indicated.
- D.

2.10 COATING OF PLUMBING MATERIALS

- A. Ferrous metal piping and surfaces, except finished, galvanized, and machined surfaces, shall have surfaces prepared and primed in the shop in accordance with the requirements of Section 09 96 00 – Protective Coatings.
- B. Prime colors shall be compatible with finish coats that are applied in the field.
- C. Self-contained units such as wall-mounted hose racks shall be supplied with factory-applied finish coats of baked enamel.
- D. Field painting shall comply with the requirements of Section 09 96 00.

PART 3 -- EXECUTION

3.1 PREPARATION

- A. The CONTRACTOR shall coordinate the roughing-in process with provisions for wall and floor sleeves, pipe inserts, and cutting of roof and floor penetrations, such that drain lines will have the required invert elevations and slopes.

3.2 OPENINGS

- A. New Construction

1. The CONTRACTOR shall provide necessary openings in walls, floors, and roofs for the passage of piping and plumbing equipment within and into the building.
2. Openings shall be as indicated or as required to provide passage for the plumbing WORK.

B. Existing Construction

1. The CONTRACTOR shall provide openings required in existing walls, floors, and roofs for the passage of piping and plumbing equipment.
2. Openings shall be as indicated or required for passage.
3. Openings shall be cut in a neat and orderly manner, minimizing damage to existing structures.
4. Patching of openings shall match existing construction.
5. The CONTRACTOR shall be responsible for hangers and supporting members installed in existing masonry or structural steel as required for the proper completion of the WORK.

3.3 INSTALLATION AND APPLICATION

- A. The CONTRACTOR shall provide plumbing specialties in accordance with manufacturer's printed instructions.
- B. Pipe shall be arranged in a neat and orderly manner to occupy the minimum amount of space and so that the pipe will not obstruct passageways and movement of building occupants or interfere with normal operation and maintenance of any equipment.
- C. Pipe shall be carefully placed and properly sloped and shall be neatly and firmly supported by hangers or supports.
- D. Piping in buildings shall be as close to the ceilings or walls as possible unless indicated otherwise.
- E. Joints
1. Screwed joints shall be made with joint compound and be tight and leak proof.
 2. Sufficient brass-to-ferrous metal seat unions shall be placed in lines such that any pipe, valve, or piece of equipment may be easily disconnected.
- F. Drainage Lines
1. Drainage lines shall be properly run, trapped, and vented to conform to Code requirements.
 2. Changes in direction shall be made with "Y" branch fittings and shall be of the same size as the pipe.

- 3. Changes in pipe size shall be made with reducing fittings.
 - 4. The minimum depth of cover shall be 3 feet.
 - G. Horizontal soil, drain, and waste pipes shall be provided with a slope of at least 1/4 inch per foot, unless indicated otherwise.
 - H. Floor drains and cleanouts shall be installed such that the tops of the drains are flush with the finished floor.
 - I. Joints in PE pipe shall be installed such that the longitudinal pull out resistance of each joint is at least equal to the tensile strength of the pipe
- 3.4 EQUIPMENT DAMAGE AND REMOVAL
- A. The CONTRACTOR's operations shall be carried out in such a manner as to guard against damage to those portions of the structure and equipment that are to remain in the finished WORK.
 - B. Any damage caused by the CONTRACTOR or Subcontractor through their operations shall be repaired to the satisfaction of the ENGINEER.
- 3.5 TESTING
- A. The CONTRACTOR shall perform such tests as are required by local ordinances and Codes in the presence of a local governing authority inspector to show that piping is tight, leak-free, and otherwise satisfactory, and shall also perform such tests as the ENGINEER may direct to ensure that fixtures and equipment operate properly.
 - B. The CONTRACTOR shall pay the costs to perform such tests and the costs of making changes or repairs until the WORK is acceptable to the governing authorities.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 22 05 48 - VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

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

B. Mechanical systems shall include the following items to the extent required on plans or in other sections of these specifications.

1. All piping systems inside the building.
2. All piping systems exterior to the building.
3. All equipment associated with the above systems.

1.2 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: D.
2. Assigned Seismic Use Group or Building Category as Defined in the IBC: II.
 - a. Component Importance Factor: **1.0**.
 - b. Component Response Modification Factor: **2.5**.
 - c. Component Amplification Factor: **See ASCE 7-16 Table 13.6-1**

3. Design Spectral Response Acceleration at Short Periods (0.2 Second): **0.519g**

4. Design Spectral Response Acceleration at 1-Second Period: **0.405g**

1.3 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.
- B. **Product Data:** For each product indicated.
- C. **Delegated-Design Submittal:** For vibration isolation and seismic-restraint calculations and 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.
- D. The isolator manufacturer shall furnish submittals indicating capacities and sizes of isolators and bases for isolated equipment. Data shall include outside diameter and heights (free, operating, solid) of springs; free and operating heights of neoprene and fiberglass isolators; and loads on each isolator. Calculations and selection data shall include structural consideration, such as floor span, slab on grade, etc.
- E. All calculations and selection shall be based on the actual equipment to be installed whether the equipment is as specified or is a substitute item.
- F. Provide a schedule of equipment being supported listing the specific isolation device proposed for approval. Include the approved schedule with the Operation and Maintenance Manual.
- G. Welding certificates.
- H. **Qualification Data:** For professional engineer.
- I. Field quality-control test reports.

1.4 QUALITY ASSURANCE

- A. Comply with seismic-restraint requirements in the IBC and ASCE 7-16 unless requirements in this Section are more stringent.
- B. **Welding:** Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- C. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproved by ICC-ES, or preapproved 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.

- D. The Contractor shall coordinate with the supplier of vibration isolation equipment to ensure isolators are sized for the actual equipment supplied.
- E. The supplier of equipment specified in this Section shall coordinate with all trades to identify the locations of all required isolation devices.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATION PRODUCTS

- 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. Kindorf.
- 2. Grinnell.
- 3. Elcen.
- 4. Unistrut.
- 5. Kinetics Noise Control.
- 6. Mason Industries.
- 7. Vibration Eliminator Co., Inc.
- 8. Amber Booth

- B. **SUPPORTS**

- 1. Equipment isolator pads shall be Mason type W neoprene waffle pad. Provide an appropriate durometer or equal (hardness) for a recommended loading of 40 to 60 psi. Provide pad with steel backing plate or other options as required for the application.
- 2. Neoprene isolators shall be Mason model ND or equal and shall incorporate completely enclosed metal inserts to permit bolting to the supported unit.
- 3. Spring isolators shall be Mason model SLF or equal. Units to be freestanding, unhoused, laterally stable spring mounts, incorporating leveling bolts and 1/4" thick noise isolation pads. The outside spring diameter shall be equal to or greater than 80% of the designed spring operating height, and the horizontal stiffness shall be at least 80% of the vertical stiffness. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection.

- C. **HANGERS**

- 1. Equipment hanger isolators shall be combination series elastomer spring type, Mason Industries model 30N or equal. Elastomer element shall provide an isolation bushing for the hanger rod. Units shall have stamped or welded housings with a lower hole

large enough to allow 30° movement of the lower rod before contacting the housing. Springs shall be laterally stable and shall have a minimum additional travel to solid equal to 50% of the rated deflection. Elastomer element shall be rated for a minimum of .25" deflection.

2. Hanger isolators for equipment under 75 lbs. shall be Mason Model HD or equal.
3. Isolated ceiling hangers shall include welded steel assemblies designed to be incorporated into the isolated ceiling suspension system specified for this project. Hanger assembly brackets shall be designed to allow a 15 degree off vertical alignment of ht suspension member without making metal-to-metal contact between suspension and hanger assembly members. Isolation hanger load capacities shall be selected by the manufacturer to provide a minimum vertical static deflection of the steel spring element of 1.0 inch and maintain an additional deflection to solid of 0.5 inch. Hanger assemblies shall include a method by which the installing contractor can preload the steel spring element to restrict additional vertical deflection of the steel spring to 1/4" on installation of finish ceiling materials.

2.2 SEISMIC PRODUCTS

A. CABLE SUPPORT ASSEMBLIES

1. Cables and Cable End Connections:
 - a. Manufacturers
 - 1) Kindorf.
 - 2) Grinnell.
 - 3) Elcen.
 - 4) Unistrut.
 - 5) Kinetics Noise Control.
 - 6) Mason Industries.
 - 7) Vibration Eliminator Co., Inc.
 - 8) Amber Booth
 - b. Steel cables sized to resist seismic loads with a minimum safety factor of two and arranged to provide an all directional restraint.
 - c. Cable end connections shall be steel assemblies that swivel to final installation angle. Cable end connections shall utilize two clamping bolts to provide proper angle engagements.
2. Rod Clamps:
 - a. Manufacturers

- 1) Kindorf.
- 2) Grinnell.
- 3) Elcen.
- 4) Unistrut.
- 5) Kinetics Noise Control.
- 6) Mason Industries.
- 7) Vibration Eliminator Co., Inc.
- 8) Amber Booth

b. Clamps designed to secure steel angles to rods.

B. PIPE SUPPORT ASSEMBLIES

1. Manufacturer:
 - a. B-Line
2. Pre-engineering piping seismic restraint system designed to resist seismic loading in any direction.
3. Certified and signed by registered professional structural engineer that details are in accordance with the requirements of the International Building Code for the listed seismic criteria.
4. System shall be a complete seismic system and shall include:
 - a. Installation details and devices for vertical, transverse and longitudinal bracing.
 - b. Attachment details to structure complete with bolt types and sizes.

PART 3 - EXECUTION

3.1 APPLICATIONS

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

3.2 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.

3.3 SEISMIC PROVISION SPECIFIC

1. General:

- a. All in-line equipment shall be braced independently of pipe or ducts.
- b. Welding shall conform to AWS D1.1 and shall use either shielded or submerged arc methods.
- c. When conduit is to be installed, it shall be braced the same as the equivalent weight pipe.
- d. Use either cable or solid bracing for all situations. Do not mix bracing types in the same direction.
- e. Bolt holes shall be 1/8 inch larger than the bolt diameter unless otherwise noted.

2. Piping System

- a. Support and brace piping as specified herein.
 - 1) At the Contractor's option, a pre-engineered support system specified in this section may be utilized. Support and brace piping system in complete accordance with the manufacturer's recommendations.
- b. Brace all pipes 2-1/2 inch and larger.
 - 1) Exceptions:
 - a) Brace all fuel oil, gas piping (including fuel gases, medical gases and compressed air) 1-inch ID and larger.
 - b) Brace all piping in boiler and mechanical equipment rooms 1-1/4" ID and larger.
 - c) Bracing is not required for piping suspended from individual hangers 12 inches or less in length, as measured from the top of the pipe to the bottom of the support where the hanger is attached and where the hanger provides a non-moment generating (swivel) connection to the structure.
- c. Details indicated provide lateral bracing system. A typical vertical support system must also be used. However, where brace occurs, the vertical angle shown may replace a typical vertical support.
- d. Transverse bracings at 40 feet on center maximum.
 - 1) Except gas piping shall be at 20 feet.
 - 2) Except where lesser spacing is indicated in the tables.

- e. Longitudinal bracings at 80 feet on center maximum.
 - 1) Except gas piping shall be at forty feet.
 - 2) Except where lesser spacing is indicated in the tables.
- f. Transverse bracing from one pipe section may also act as longitudinal bracing for the pipe section connected perpendicular to it, if the bracing is installed within 24 inches (610 mm) of the elbow or tee and similar size.
- g. Do not use branch lines to brace main lines.
- h. Provide oversized pipe sleeves through walls or floors to allow for anticipated differential movements.
- i. Provide flexibility in joints where pipes pass through building seismic or expansion joints, or where rigidly supported pipes connect to equipment with vibration isolators.
 - 1) For threaded piping, the flexibility may be provided by the installation of swing joints.
 - 2) For piping with manufactured ball joints, select the length of piping offset using Seismic Drift in place of the expansion given in the joint manufacturer's selection table. Seismic Drift = 0.015 feet per foot of height above the base where seismic separation occurs.
- j. At vertical pipe risers, wherever possible, support the weight of the riser at a point or points above the center of gravity of the riser. Provide lateral guides at the top and bottom of the riser, and at intermediate points not to exceed 30 feet (9.1 m) on center.
- k. Do not fasten one rigid piping system to two dissimilar parts of a building that may respond in a different mode during an earthquake; for example, a wall and a roof.
- l. Piping grouped for support on trapeze-type hangers shall be brazed at the same intervals as determined by the smallest diameter pipe of the group. Hanger rods shall be increased in cross-sectional area proportionate to the increased weight per linear foot of pipe and contents supported at each trapeze hanger. No trapeze-type hanger shall be secured with less than two ½ inch (12.7 mm) bolts.
- m. Bracing rigidly attached to pipe flanges, or similar, shall not be used where it would interfere with thermal expansion of piping.
- n. Spreaders shall be provided between racked or adjacent piping runs to prevent contact during seismic activity whenever pipe or insulated pipe surfaces are less than 4 inches (102 mm) or four times the maximum displacement due to seismic force. Spreaders to be applied at same interval as sway braces. Spreaders shall be applied to surface of bare or insulated hot pipe and over insulation utilizing

high-density inserts and pipe protection shields where vapor-barrier-type insulation is employed.

o. Flexible Couplings or Joints:

- 1) Flexible couplings or joints in building piping shall be provided at bottom of all pipe risers 3-1/2 inches size and larger. Cast-iron waste and vent piping need only comply with these provisions when caulked joints are used. Flexible bell and spigot pipe joints using rubber gaskets or no-hub fittings may be used at each branch adjacent to tees and elbows for underground waste piping inside of building to comply with these requirements.
- 2) All underground piping except heat distribution system, shall have flexible couplings installed adjacent to building as shown. Additional flexible couplings shall be provided as follows:
 - a) On each side of the joints of demarcation between soils having widely differing degrees of consolidation.
 - b) At all points that can be considered to act as anchors.
 - c) On every branch of a tee and each side of an elbow.

- END OF SECTION -

SECTION 23 05 00 - HEATING, VENTILATION, AND AIR CONDITIONING, GENERAL

PART 1 -- GENERAL

1.1 SUMMARY

- A. The CONTRACTOR shall provide heating, ventilating, and air conditioning systems and associated equipment complete with supports, mounting frames, ventilators, ductwork, piping, louvers, panels, filters, grilles, electric drive units and controls, mechanical equipment, electrical work, appurtenances, testing, and balancing, as indicated in accordance with the Contract Documents.
- B. Where a conflict exists between the specifications and or the contract drawings the more stringent of the requirements will apply.
- C. The equipment shall be installed ready for operation.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Codes, as referenced herein, are indicated in Section 01 42 10 – Reference Standards.
- B. The WORK and materials shall be in full accordance with the latest rules and regulations or publications of the state of California, the State Energy Resources Conservation and Development Commission, the State Fire Marshall, the Industrial Safety Orders, the Health and Safety Rules (Air Conditioning systems), the local plumbing code, the local building code, and other local codes.
- C. Nothing in the Contract Documents shall be construed to permit WORK in violation of the above codes, rules and regulations.
- D. In the absence of applicable codes, the installation and workmanship shall follow the standards set by the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).

1.3 CONTRACTOR SUBMITTALS

- A. Equipment submittals
 - 1. At a minimum, the contractor shall provide the ENGINEER a complete submittal package for each piece of equipment, accessory, and controller listed in the mechanical schedule. A complete submittal package will also be provided to the ENGINEER for all supports and hangers that will be used on the project. Reference individual spec sections for specific submittal requirements. All submittals shall be in accordance with the requirements in Section 01 33 00 – Contractor Submittals.
- B. Shop Drawings
 - 1. Submit complete shop drawings and certificates, test reports, affidavits of compliance, for all equipment, ductwork and piping systems, in accordance with the requirements

in Section 01 33 00 – Contractor Submittals, and as indicated in the individual equipment, piping or ductwork Sections.

2. Construction Drawings

- a. The HVAC Drawings define the general layout, configuration, routing, size and the general intent of the design and are not fabrication drawings.
 - b. It shall be the CONTRACTOR's responsibility to develop the Shop Drawings required for the construction of the HVAC system.
3. The Shop Drawings shall include all necessary dimensions and details regarding equipment, pipe and ductwork joints, fittings, valves, appurtenances, design calculations, and material lists.
 4. The submittals shall include detailed layout, spool, or fabrication drawings which shall show all fittings, and supports as necessary to accommodate the equipment as a complete and functional system.

C. Equipment Numbers

1. Equipment is identified by assigned numbers for reference and location purposes in the Contract Documents.
2. Indicate the appropriate equipment numbers on the Shop Drawings and other submittals.

D. Furnish certified fan curves for each fan.

E. Acoustic Louver Certification: The manufacturer shall submit certified data from a laboratory, substantiating the specified performance of the acoustic louvers.

F. Close Out Documents: Operations and Maintenance information will be provided for all equipment and accessories in accordance with the requirements of specification 01 77 00 Project Closeout.

1.4 WARRANTY

- A. Air conditioners, heaters, fans, ventilators, grilles, and the like, that are provided by the CONTRACTOR shall carry the manufacturer's standard warranty.
- B. Warranties shall be furnished to the ENGINEER upon final acceptance of the completed systems by the OWNER.
- C. Refrigerant compressors shall carry a manufacturer's 5-year warranty.
- D. Control System
 1. The temperature and equipment control system shall be warranted free from defects in workmanship and material under normal use and service for a period of one year after acceptance by the ENGINEER.

2. Equipment that proves to be defective in workmanship or material during the warranty period shall be adjusted, repaired, or replaced by the automatic control manufacturer as part of the Contract.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Quality

1. Mechanisms and other parts shall be amply proportioned for the stresses which may occur during operation and for any other stresses which may occur during fabrication and erection.
2. Individual parts furnished which are alike in all units shall be alike in workmanship, design, and materials, and shall be of the manufacturer's top-line, industrial-commercial grade.

B. Supports

1. Equipment and appurtenances shall be firmly anchored or connected to supporting members.
2. Equipment shall be supported on restrained spring-type vibration isolators.
3. Supports as required for the proper installation of the equipment, but not forming an integral part of the building structure, shall be provided unless otherwise indicated.

C. Noise and Vibration Control

1. The system shall be free of objectionable vibrations and noise.
2. Provide flexible connections in ducts and piping connections to fans, compressors, and other vibrating equipment.

2.2 MOTORS

- A. Motors provided with the equipment shall conform to the latest IEEE and NEMA requirements for mechanical and electrical characteristics, including service factors.
- B. Motors shall be in conformance with the requirements of Section 26 05 10 Low-Voltage AC Electric Motors.
- C. Each motor shall bear the manufacturer's nameplate with complete motor data.
- D. Each motor shall be of ample size and construction to continuously carry the loads which might be imposed by the equipment throughout the full range of operation of the equipment.
- E. The maximum motor loading shall be less than or equal to the nameplate horsepower rating, exclusive of the service factor.

2.3 ELECTRICAL WORK

A. General

1. Provide controls, sensors and control panels relating to the HVAC systems, including starters, thermostats, motorized dampers, louver operators and other equipment as indicated.
 2. Provide control wiring of 120-volt and less as indicated in this Section and in conformance the requirements of Section – 26 05 83 Wire & Cable. Provide local power disconnects, where required.
 3. Provide circuit breakers, starters in motor control centers, and 120-, 208-, 240- and 480-volt power feeders from the starters and circuit breakers to the HVAC equipment, as indicated.
- B. Starters, whether as an integral or separate part of the equipment, shall be in accordance with the requirements of Section 26 05 10 – Low-Voltage AC Electric Motors.
- C. Enclosures shall be of the same NEMA class as the electrical equipment in the same area.
- D. Starters shall be of the same manufacturer as the starters indicated under Section 26 05 10 – Low-Voltage AC Electric Motors.
- E. Low-voltage control wiring shall be in accordance with the National Electric Code.
- F. Control wiring for line voltage 120-volt and higher shall be in conformance with the requirements of Section 26 05 83 – Wires and Cables.
- G. Control Panels shall be in conformance with the requirements of Division 26 – Electrical.
- H. Conduit shall be in conformance with the requirements of Section 26 05 33 – Electrical Raceway Systems and Section 26 05 43 – Underground Raceway Systems.

2.4 FLASHING

- A. Equipment that passes through roofs of buildings or structures shall be provided with flashing as indicated.
- B. Flashing shall be in conformance with the requirements of Section 07 62 00 – Sheet Metal Flashing and Trim.

2.5 PIPE AND FITTINGS

- A. Refrigerant piping shall be Type L hard temper copper with cast brass fittings.
- B. Provide a drain at each low point in the piping system.
- C. Copper fittings shall be in conformance with the requirements of Section 23 23 00 – Refrigeration Piping.

- D. Joints in refrigeration piping shall be made with silver solder.

2.6 PIPING AND DUCTWORK INSULATION

- A. Heating piping, refrigerant piping, and supply and outside air ductwork shall be insulated as indicated and as required per state and local codes.
- B. Insulation shall be in conformance with the requirements of Section 23 07 00 – HVAC Insulation.

2.7 WELDING

- A. The welding of black steel or alloy pipe shall be carried out in strict accordance with AWS procedures and the codes and ordinance of the State of California and local codes pertaining to welded steel pipelines.
- B. Welding shall be accomplished by means of the shielded electric arc process and performed by workers who are certified for this WORK.

2.8 HANGERS AND SUPPORTS

- A. Provide all necessary hangers, supports, concrete inserts, anchors and guides for material and equipment to be installed.
- B. No perforated strap hangers and no wire supports will be accepted.
- C. Insulation Allowance
 - 1. Hangers supporting insulated pipe shall be sized to fit the pipe plus the insulation.
 - 2. The insulation at support points shall be provided with a metal shield in order to prevent damage to the insulation.
- D. Anchors and guides shall be constructed of steel, in accordance with approved Shop Drawings, and as indicated.
- E. Pipe hangers used to support uninsulated copper piping shall be copper-plated.
- F. Anchors
 - 1. Anchorages shall be obtained by welding lugs onto the pipe and providing abutting surfaces against the lugs to restrict longitudinal movement.
 - 2. Anchors shall be designed such that the pipe may be removed by removing bolts; no welding of pipe to the anchor will be accepted.
 - 3. bolting materials shall be cadmium-plated.
- G. Guides shall be located not more than 20 feet from each expansion loop or joint.

- H. Horizontal runs of pipe shall be provided with supports spaced such that the sag of the unsupported length will not create any pockets in the piping (weight of fluid included).
- I. Pipe support lengths shall be in conformance with the requirements of Section 40 23 02 – Pipe Supports.
- J. Vertical Piping
 - 1. Vertical piping shall be:
 - a. supported at the base with fittings made for this purpose; or
 - b. supported from the nearest horizontal member or floor with a riser extension pipe clamp.
 - 2. Provide a riser extension clamp at each floor.
- K. Hangers for ductwork and equipment shall be as indicated and in accordance with the guidelines of the Sheet Metal and Air Conditioning Contractors National Association (SMACNA).
- L. Inserts shall be galvanized.

2.9 PIPE SLEEVES

- A. The CONTRACTOR shall examine the Drawings carefully for sleeves that are to be built into the construction and plan the WORK accordingly, such that the sleeves are placed well in advance and care is taken with their location and support until encased.
- B. Sleeves shall be fabricated from standard weight galvanized steel pipe for dry interior installations.
- C. Sleeves for exterior or wet installations shall be fabricated from standard-weight ductile black steel, stainless steel, or standard-weight PVC for pipe temperatures below 120 degrees F.
- D. Sleeves shall be sized one pipe size larger than uninsulated piping and one pipe size larger than piping plus insulation for insulated pipe.
- E. Locations
 - 1. Where pipes pass through floors, sleeves shall extend 3 inches above the finished floor.
 - 2. Where pipes pass through walls, sleeves shall be flush with the wall.

2.10 MOTORIZED DAMPERS

- A. General
 - 1. Provide the motorized opposed blade dampers as indicated.

2. Damper sizes and capacities shall be as indicated on the Drawings.

B. Design and Construction

1. The damper and frames shall be fabricated from aluminum with a minimum thickness of B&S 12-gauge.
2. The aluminum blades shall be provided with interlocking edges, with one center and two edge crimps, and brass bearings.
3. The frame shall be of welded channel construction, and shall be provided with lugs and mounting brackets for damper operators.
4. The dampers shall be provided with felt or rubber seals at their edges in order to minimize air infiltration when closed.

C. Motors

1. Damper motors shall be 120V electric type; with necessary linkages for positioning the damper blades.
2. The motors shall be powered open and spring-closed, unless otherwise indicated.

2.11 BACKDRAFT OR GRAVITY DAMPERS

A. General

1. Provide backdraft dampers on the exhaust fans and ventilators where indicated.
2. Damper sizes and capacities shall be as indicated on the Drawings.

B. Design and Construction

1. The dampers shall be of the multi-blade type, with soft-seating gaskets for minimizing noise and air leakage when closed.
2. Blades shall be constructed of 16-gauge aluminum, and shall be of an air foil design.
3. Frames shall be fabricated from 16-gauge extruded aluminum alloy.
4. The frames shall be totally out of the air stream, and arranged for flange mounting.
5. The dampers shall be designed to operate at 0.05 inch w.g. S.P., or less.
6. Blades shall be individually counterbalanced, and shall be provided with non-ferrous pins turning in nylon bearings.

C. Damper Manufacturers, or Equal

1. **Air Balance, Inc.**

2. Air Dynamic

3. Ruskin

2.12 VOLUME CONTROL DAMPERS (MANUAL AND MOTORIZED)

A. General

1. Provide volume control dampers in accessible locations in branch supply ducts and at each exhaust air opening, in order to properly regulate the volume of air delivered or withdrawn from each inlet and outlet, and as indicated.
2. Damper sizes and capacities shall be as indicated on the Drawings.

B. Construction

1. The volume dampers shall be of the opposed blade type.
2. The dampers shall be constructed of aluminum, of B & S 14-gauge thickness.
3. The dampers shall be suitably reinforced with sturdy control shafts.
4. Ductwork shall be reinforced to double thickness at damper shaft openings.

C. Air Extractor Type

1. The volume control dampers indicated to be of the air extractor type shall be constructed of stainless steel, of 20-gauge for frames and of 24-gauge thickness for blades.

D. No splitter dampers will be accepted.

E. Manual control dampers shall be provided with mechanisms for adjustment and locking into position after being set.

F. Motors

1. Damper motors shall be electric type; with either modulating or 2-position control and necessary linkages.
2. The motors shall be powered open and spring-closed, unless otherwise indicated.

2.13 FIRE DAMPERS

A. General

1. Provide fire dampers in ductwork at floor penetrations and at fire-rated wall penetrations, whether or not indicated.
2. Fire dampers shall be in accordance with the codes of the State of California and the provisions of NFPA Bulletin 90A.

3. Fire dampers shall be of the fusible link type and shall be UL-approved.
- B. The units shall be arranged for horizontal or vertical mounting, and shall be provided with a 165-degree F fusible link.
- C. Provide an end switch on the fire dampers to signal the fire alarm and de-energize fan motors in the event of a fire.
- D. Fire dampers shall be 1-1/2-hour **Ruskin FD35**, or equal.

2.14 REGISTERS, GRILLES AND DIFFUSERS

A. General

1. Provide supply and return registers and grilles, and all supply diffusers as indicated.
 2. The sizes, capacities, and deflection of each unit shall be as indicated on the Drawings.
- B. The finish shall be selected by the architect from the manufacturers standard color selection and will be a baked-on enamel type finish.
- C. Accessory equipment shall be constructed of aluminum, or steel if aluminum is not available, and provided with a baked-on enamel finish with the finish color selected by the architect from the manufacturers standard color selection.
- D. The proper border style shall be selected by the CONTRATOR to suit the installation conditions.
- E. Registers, grilles, and diffusers located in corrosive atmospheres, as indicated, shall be painted with a special protective coating in accordance with the requirements of Section 09 96 00 – Protective Coatings.

2.15 FLAT AIR FILTERS

- A. **General.** Flat air filters used in the fresh air intakes, packaged air conditioning units, and electric heat pumps shall be 2-inch thick, pleated, throw-away type, and provided as an integral part of each unit and filter box.

B. Filter Spares and Supplies

1. Furnish 3 complete spare filter changes for each flat filter in each unit and filter box.
2. Provide one new filter set in each unit and filter box at the time of turning the units over to the OWNER.
3. Filters used in the units and filter boxes during construction are not included in the above supply, and these filters shall be provided as part of the WORK.

- C. **Construction.** The air filters shall be:

1. constructed of an adhesive-coated fiber media;
2. rated at 300-fpm face velocity; and
3. rated at 0.04-inch w.g. initial resistance and 0.50-inch w.g. recommended final resistance.

D. Manufacturers, or Equal.

1. **Airguard Industries**
2. **Farr Co.**
3. **Snyder General Corp.**
4. **Camfil**

E. Filter Racks

1. The filter racks using the above filter shall hold a minimum of 1 panel and have hinged access doors with gaskets on both sides.
2. Filter racks shall be manufactured by the Louver manufacturer and provided as part of a complete system with the louver as noted in the mechanical.

2.16 AIR FILTER GAUGES

A. General

1. Provide air filter gauges on each filter box and filter section for air handling unit packaged air conditioning units.
2. The air filter gauges shall be of the inclined tube manometer type.

B. Construction

1. Provide the gauge complete with:
 - a. an enameled scale with a screw-type zero adjustment;
 - b. a rust-resistant steel frame;
 - c. a 3/16-inch plate glass removable cover;
 - d. oil;
 - e. screened inlet and outlet nozzles;
 - f. a level glass;
 - g. an oil chamber; and

- h. necessary connecting piping and accessories.
- 2. Each gauge shall be 10 inches long with a total scale reading of 1.0 inch water and 0.1-inch scale graduations.
- 3. Accuracy shall be within 0.02 lineal inch at any point on the scale.
- 4. Gauges shall be mounted level and provided with necessary pressure sensing tubing.
- 5. Gauges shall not be mounted on fan housing or casings containing rotating or reciprocating machinery.

C. **Manufacturers**, or Equal:

- 1. **F.W. Dwyer Company**
- 2. **Honeywell, Inc.**

2.17 VIBRATION ISOLATORS

A. General

- 1. Provide vibration control isolation all rotating equipment except electric motors.
- 2. Where rotating units are part of factory-assembled package units, such as a package air handling unit, provide the isolator under the unit casing.

B. Mount floor-mounted or platform-mounted built-up or package air handling units on structural steel or concrete bases with isolator springs and brackets.

C. Springs used in the vibration isolators shall have approximately one inch of deflection under load, and shall have a minimum additional travel of 50 percent between the design height and the solid height.

D. All isolation equipment shall be provided in strict compliance with the manufacturer's recommendations.

E. Pads

- 1. For vibration isolation between HVAC equipment and supports and where indicated, provide 3/4-inch-thick rubber pads for full contact between equipment and support
- 2. The pads shall be **Mason Industries, Super W Pads, Kinetics** or equal.

F. **Equipment Supports (Outdoor Condenser Unit)**

- 1. Provide pre-fabricated equipment support frame for ground mounted equipment.
- 2. Equipment stand to be tubular steel support frame, hot-dip Galvanized.
- 3. Minimum height to unit invert of 12" above FG.

4. Secure Equipment Support Frame with post drilled ½" dia. galvanized steel epoxy adhesive anchors. Install per manufacturers recommendations.
5. **Manufacturers, or Equal**
 - a. **Big Foot System Stand Range**

2.18 TEMPERATURE AND EQUIPMENT CONTROL

A. **General**

1. Design and provide a complete electric-electronic system of automatic temperature control as indicated.
2. The temperature control equipment and devices shall be furnished by **Johnson Controls, Honeywell or approved equal.**

B. **Wiring and Switches**

1. Provide wiring incidental to the temperature control system, including electrical interlock.
2. Furnish detailed wiring diagrams along with necessary supervision.
3. Provide control wiring (line voltage or low voltage) as required to complete the temperature control system (by interconnecting starters, thermostats, PE switches, relays, and like devices) in accordance with the requirements of Division 26 – Electrical.
4. Provide HOA switches in accordance with the requirements of Division 26 – Electrical.
5. Switches shall be UL-listed and of a type to meet the current and voltage requirements of the particular application.

C. **Thermostats**

1. Room thermostats shall be of the digital type, provided with heating and cooling setpoints.
2. Adjustment shall be accomplished by pressing the thermostat UP or DOWN arrows.
3. Comfort Setpoints: adjustable from 40 to 0 degrees F
4. Setback Setpoints: adjustable from 40 to 70 degrees F for heating setback;
5. Automatic Setback Time Period:
 - a. 7-day setback programming;
 - b. up to 2 automatic setback comfort time periods per day;

- c. built-in setback override, adjustable from 10 minutes to 40 hours;
 - d. 7-day electric time clock; and
 - e. heat/cool/fan annunciators to indicate equipment operation and automatic heating/cooling changeover
- 6. The thermostats shall meet the Energy Conservation Standard approval where required by the State having jurisdiction over the Project.
 - 7. Provide an insulating back where exterior wall mounting is indicated.
 - 8. Provide guards for room thermostats installed in areas other than administrative offices or control rooms.

D. Relays

- 1. Provide 2-position relays, capacity relays, sequencing relays, and other controls as necessary in order to provide a properly operating automatic control system.
- 2. Relays shall be UL-listed and of a type to meet the current and voltage requirements of the particular application.

E. Control Panels

- 1. General
 - a. Control panels shall be provided with relays, control switches, transformers, pilot lights, timers, time clocks, step controllers, gages, thermostats (unless otherwise indicated), and other accessories necessary for the particular system.
 - b. The panels shall be of aluminum construction with a baked enamel finish, and shall be provided with a hinged front door and locking handle.
 - c. Manual switches and direct-reading gauges shall be flush-mounted on the front face, and identified by engraved and riveted **Bakelite** or laminated plastic nameplates with white letters on black background.
 - d. Manual switches shall be of heavy-duty, oil-tight construction.
- 2. Wiring
 - a. Control devices shall be prewired internally.
 - b. Wires leaving the panel shall be terminated at separate numbered terminal strips.
 - c. Provide individual connectors for every item of mechanical equipment, integral and remote pilot lights, and other devices described for each panel.

- d. Power and control circuit requirements shall be as indicated on the Electrical Drawings.
 - e. Identify wires by color coding or numerical tags at both ends.
 - f. Wire each control device to the terminal strip without splices.
 - g. Provide integral circuit protection for panel-mounted control devices.
 - h. Wire each panel with a single 20-amp, 120-volt, AC feeder in accordance with the requirements of Division 26 - Electrical.
3. Diagrams
- a. Secure the panel electrical wiring diagrams to the inside of the panel door.

F. Sequence of Operation

1. Electric Unit and Downflow Heater controls
- a. Wall mount space/unit heaters are to be tied into (1) thermostat located a minimum of 5'-0" from the personal door for each building or as is practical. The space temperature for each building shall be maintained at a minimum 40 degrees to prevent freezing conditions inside the building envelope.
 - b. The ceiling/roof mounted downflow electric heater will be tied into (1) thermostat that will be set at 5 degrees above the set point of the wall mount space/unit heaters thermostat.
 - c. During Standby Power Mode and startup of the genset unit the Electric heater time delays shall be staggered with each other and the heaters in the other buildings to prevent overload of standby generator on startup. Coordinate all electric heater time delay relay setups with the electrical contractor.
2. Propeller Exhaust Fan Controls
- a. Wall mounted propeller exhaust fans will be controlled by a ON/OFF switch located near the personal door of each building. When the Propeller exhaust fans are switched ON the motorized backdraft damper at each propeller fan is powered open. The intake air louvers that interlocked with each respective propeller fan as noted in the mechanical schedule are powered open.
 - b. When the propeller fans are switched OFF the fans shall power down. Motorized back draft dampers will power closed. The intake air louvers that are interlocked with each propeller fan will closed.
3. Fresh Air intake Fans
- a. Fresh Air intake fans shall be switched ON once the building wall mounted occupancy sensor is triggered. Fan shall remain ON while the building is

occupied. Upon the occupancy sensor timing out due to not sensing any occupants in the building the fresh air intake fan will be switched OFF.

- b. A barometric relief air damper shall allow excess air pressure to be relieved from the building during operation of the fresh air fan.

4. Electric Radiant Heaters

- 1) Electric radiant heater will be switched ON and OFF by an ON/OFF switch located on the wall of the building.

2.19 ELECTRIC HEATING CABLE

A. **General:**

- 1. self-regulating
- 2. 150 degrees F maintenance temperature
- 3. 120-volt
- 4. 3 watts per ft. output
- 5. twin 16-AWG copper buss wires within insulated jacket

- B. After the pipe has been heat traced, insulate and apply exterior jacketing in accordance with the requirements of Section 23 07 00 – HVAC Insulation.

C. **Manufacturers**, or Equal

- 1. **Chromalox**

2.20 PAINTING

- A. Painting of the equipment and materials shall comply with the requirements of Section 09 96 00 – Protective Coatings.

B. Field Touch-Up Coating Repair

- 1. Touch up factory-coated surfaces that are rusted or scratched.
- 2. Clean finishes to be touched up to bright metal, prime with a corrosion inhibitor, and finish with a coating to match the original finish.

PART 3 -- EXECUTION

3.1 GENERAL

A. Openings - New Construction

1. Provide necessary openings in walls, floors and roofs for the passage of heating and ventilating equipment in the buildings.
2. Openings shall be as indicated or as required to provide passage for heating and ventilating WORK.
3. Provide hanger and support inserts into masonry or structural steel as required for proper completion of the WORK.

B. Openings - Existing Construction

1. Provide openings required in the existing construction for piping and equipment that are not specifically indicated.
2. Openings shall be cut in a neat and orderly manner with as little damage to existing structures as possible.
3. The patching of openings that have been cut shall match the existing construction.
4. Provide hangers and supporting members installed in the existing masonry or structural steel as required for proper completion of the WORK.

3.2 INSTALLATION OF PIPING

A. Drain Piping

1. Valve-Drain Piping
 - a. Provide valve-drain piping where valves are equipped with a drain connection.
 - b. Fabricate piping from Type L copper tube, and solder-joint drainage fittings.
2. Provide piping system and equipment drains fabricated from copper tube with solder-joint fittings, or from black steel piping with fittings as indicated.
3. Install drain piping at the low points of supply and return piping, at abrupt changes in vertical offsets in horizontal runs, and in piping at mechanical equipment including pumps.
4. Extend drain piping to the nearest drain.

B. Bypass Piping

1. Except as otherwise indicated, fabricate and install bypass piping using the same materials and in the same plane as connected piping, but one pipe size smaller or as indicated.
2. Provide a valve in the bypass piping.

3.3 INSTALLATION OF VALVES

1. Set the valves carefully regarding their location with respect to accessibility and the equipment being controlled.
2. Give consideration to the location of valves with respect to the proper drainage of the piping system.
3. Install valves where required for proper operation of piping and equipment, including valves in branch lines necessary to isolate sections of piping.
4. Locate valves to be accessible and such that separate support can be provided where necessary.
5. Install valves with stems pointed up, in the vertical position where possible, but in no case with stems pointed downward.
6. Where insulation is indicated, install extended-stem valves, arranged in the proper manner to receive insulation.
7. Control Valve Installation
 - a. Coordinate valve submittals for type, quantity, size, and piping configuration, in order to ensure compatibility with pipe design.
 - b. Slip-stem control valves shall be installed such that the stem position is not more than 60 degrees from the vertical up position.
 - c. Install ball-type control valves with the stem in the horizontal position.
 - d. Install valves in accordance with the manufacturer's recommendations.
 - e. Install valves such that they are accessible and serviceable, and such that actuators may be serviced and removed without interference from structure or other pipes or equipment.
 - f. Install isolation valves such that the control valve body may be serviced without draining the supply- or return-side piping system.
 - g. Install unions at connections to screw-type control valves.
 - h. Identification Tags
 - 1) Provide tags for control valves, indicating service and number.
 - 2) Tags shall be brass, 1.5 inch in diameter, and with 1/4-inch high letters.
 - 3) Securely fasten tags with chain and hook.
 - 4) Match identification numbers as shown on approved control Shop Drawings.

3.4 BALANCING AND TESTING

A. Balancing Subcontractor

1. After the installation WORK has been completed, the CONTRACTOR shall provide the services of an independent balancing subcontractor who shall perform necessary adjustments of volume dampers, volume controllers, exhaust blowers, exhaust fans, supply blowers, supply and return registers, and heating units. All work shall be in accordance with the requirements of Section 23 05 93 – Testing, Adjusting, and Balancing for HVAC.
2. The balancing subcontractor shall balance the hot water heating system, provide all pressure gauge tappings, and through the use of balancing valves adjust water flows.
3. The balancing subcontractor shall:
 - a. have at least 5 years of balancing experience, and experience in at least 5 projects of the Project type;
 - b. not be associated with any firms doing engineering or construction work in HVAC and/or Plumbing;
 - c. use the balancing methods approved by the Associated Air Balance Council; and,
 - d. send a copy of all correspondence and reports, as they are written, pertaining to this project, directly to the ENGINEER.

B. The CONTRACTOR shall:

1. provide labor, tools, testing equipment and appliances for the necessary testing and adjustment that is required;
2. submit to the ENGINEER an experience resume and project resume for approval of the balancing subcontractor;
3. demonstrate to the OWNER, in an extensive operating test covering every component of the installation, that the entire heating, ventilating and air conditioning system meets the indicated requirements and is ready for continuous, satisfactory operation; and,
4. make repairs and revisions as necessary to make the system operative, as part of the Contract.

3.5 VIBRATION ISOLATORS

- #### A. Install isolation equipment in strict compliance with the manufacturer's recommendations.

3.6 TEMPERATURE AND EQUIPMENT CONTROL

- A. After completion of the installation, use trained personnel to adjust thermostats and sensors in the motors and other provided equipment, and place them in complete operating condition subject to the approval of the ENGINEER.
- B. Instruct the operating personnel in the operation of the control system.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 05 13 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

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

1.2 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals

1.3 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

- A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.
- B. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS

- A. **Duty:** Continuous duty at ambient temperature of 40 deg C and at altitude of 2,000 feet above sea level.
- B. **Capacity and Torque Characteristics:** Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

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

- B. **Efficiency:** Energy efficient, as defined in NEMA MG 1.
- C. **Service Factor:** 1.15.
- D. **Multispeed Motors:** Variable torque.
 - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
 - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. **Rotor:** Random-wound, squirrel cage.
- F. **Bearings:** Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- G. **Temperature Rise:** Match insulation rating.
- H. **Insulation:** Class F.
- I. **Code Letter Designation:**
 - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - 2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
- J. **Enclosure Material:** Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- A. **Motors Used with Reduced-Voltage and Multispeed Controllers:** Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. **Motors Used with Variable Frequency Controllers:**
 - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
 - 2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - 3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.5 SINGLE-PHASE MOTORS

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

1. Permanent-split capacitor.
 2. Split phase.
 3. Capacitor start, inductor run.
 4. Capacitor start, capacitor run.
- B. **Multispeed Motors:** Variable-torque, permanent-split-capacitor type.
- C. **Bearings:** Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. **Motors 1/20 HP and Smaller:** Shaded-pole type.
- E. **Thermal Protection:** Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (NOT USED)

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. **This Section includes Testing, Adjusting, and Balancing (TAB) to produce design objectives for the following:**

1. Air Systems:
 - a. Variable-air-volume systems.
 - b. Ventilation and exhaust systems.
2. HVAC equipment quantitative-performance settings.
3. Verifying that automatic control devices are functioning properly.
4. Reporting results of activities and procedures specified in this Section.

1.2 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.
- B. **Strategies and Procedures Plan:** Within 30 days from CONTRACTOR's Notice to Proceed, submit 2 copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.
- C. **Certified TAB Reports:** Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.
- D. Warranties specified in this Section.

1.3 QUALITY ASSURANCE

- A. **TAB Firm Qualifications:** Engage a TAB firm certified by AABC, NEBB or TABB or approved by the ENGINEER.
1. The CONTRACTOR shall submit the name and credentials of the TAB firm for review and approval within 30 days after signing the construction contract.
 - a. The TAB firm shall provide qualifications of the firm and of both the individual who is to do the test and balance. Provide proof of completed balancing work on at least five projects of similar size and scope, along with a list of references which may verify qualifications.
 - b. Final approval of the TAB firm will be at the ENGINEER's discretion, based on the information submitted.

- B. **Certification of TAB Reports:** Certify TAB field data reports. This certification includes the following:
 - 1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
 - 2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.
- C. **TAB Report Forms:** Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems." or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."

1.4 PROJECT CONDITIONS

- A. **Partial Owner Occupancy:** OWNER may occupy completed areas of building before Substantial Completion. Cooperate with OWNER during TAB operations to minimize conflicts with OWNER's operations.

1.5 COORDINATION

- A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.
- B. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS (NOT USED)

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.
 - 1. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- B. Examine approved submittal data of HVAC systems and equipment.
- C. Examine Project Record Documents described in Division 01 Section "Project Record Documents."
- D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

- E. Examine equipment performance data including fan and pump curves. 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. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.
- F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.
- G. Examine system and equipment test reports.
- H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.
- J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- K. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible, and their controls are connected and functioning.
- L. Examine plenum ceilings used for supply air to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.
- M. Examine strainers for clean screens and proper perforations.
- N. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.
- O. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- P. Examine system pumps to ensure absence of entrained air in the suction piping.
- Q. Examine equipment for installation and for properly operating safety interlocks and controls.
- R. **Examine automatic temperature system components to verify the following:**
 - 1. Dampers, valves, and other controlled devices are operated by the intended controller.

2. Dampers and valves are in the position indicated by the controller.
 3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
 4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
 5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
 6. Sensors are located to sense only the intended conditions.
 7. Sequence of operation for control modes is according to the Contract Documents.
 8. Controller set points are set at indicated values.
 9. Interlocked systems are operating.
 10. Changeover from heating to cooling mode occurs according to indicated values.
- S. 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 strategies and step-by-step procedures.
- B. Complete system readiness checks and prepare system readiness reports. Verify the following:
1. Permanent electrical power wiring is complete.
 2. Hydronic systems are filled, clean, and free of air.
 3. Automatic temperature-control systems are operational.
 4. Equipment and duct access doors are securely closed.
 5. Balance, smoke, and fire dampers are open.
 6. Isolating and balancing valves are open and control valves are operational.
 7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
 8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.
- C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct airflow measurements.
- E. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling unit components.
- L. Check for proper sealing of air duct system.

3.5 PROCEDURES FOR EXHAUST SYSTEMS SYSTEM AND VENTILATION FAN SYSTEMS.

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure fan static pressures to determine actual static pressure as follows:
 - a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
 - b. Measure static pressure directly at the fan outlet or through the flexible connection.
 - c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.
 - d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
 2. Measure static pressure across each component that makes up the system.
 3. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.
 4. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.
 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 will occur. Measure amperage in full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.
- B. Adjust volume dampers to indicated airflows within specified tolerances.
1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.
- C. Measure inlets without making adjustments.
- D. Adjust inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers.
- ### 3.6 PROCEDURES FOR MOTORS
- A. **Motors, 1/2 HP and Larger:** Test at final balanced conditions and record the following data:
1. Manufacturer, model, and serial numbers.
 2. Motor horsepower rating.
 3. Motor rpm.

4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. **Motors Driven by Variable-Frequency Controllers:** Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.7 PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.
- B. Measure entering- and leaving-air temperatures.
- C. Record compressor data.

3.8 PROCEDURES FOR TEMPERATURE MEASUREMENTS

- A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.
- B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.
- C. Measure outside-air, wet- and dry-bulb temperatures.

3.9 TEMPERATURE-CONTROL VERIFICATION

- A. The temperature control system test and report shall be performed by the temperature control contractor.
- B. Verify that controllers are calibrated and commissioned.
- C. Check transmitter and controller locations and note conditions that would adversely affect control functions.
- D. Record controller settings and note variances between set points and actual measurements.
- E. Check the operation of limiting controllers (i.e. high- and low-temperature controllers).
- F. Check free travel and proper operation of control devices such as damper and valve operators.

- G. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.
- H. Check the interaction of electrically operated switch transducers.
- I. Check the interaction of interlock and lockout systems.
- J. Check main control supply-air pressure and observe compressor and dryer operations.
- K. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or non-grounded power supply.
- L. Note operation of electric actuators using spring return for proper fail-safe operations.

3.10 TOLERANCES

- A. **Set HVAC system airflow and water flow rates within the following tolerances:**
 - 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 5 to plus 10 percent.
 - 2. Air Outlets and Inlets: 0 to minus 10 percent.
 - 3. Heating-Water Flow Rate: 0 to minus 10 percent.
 - 4. Cooling-Water Flow Rate: 0 to minus 5 percent.

3.11 FINAL REPORT

- A. **General:** Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.
- B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing ENGINEER.
 - 1. Include a list of instruments used for procedures, along with proof of calibration.
- C. **Final Report Contents:** In addition to certified field report data, include the following:
 - 1. Fan curves.
 - 2. Manufacturers' test data.
 - 3. Field test reports prepared by system and equipment installers.
 - 4. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.
- D. **General Report Data:** In addition to form titles and entries, include the following data in the final report, as applicable:

1. Title page.
2. Name and address of TAB firm.
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 firm 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, type size, and fittings.
14. Notes to explain why certain final data in the body of reports varies from indicated values.
15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outside-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Face and bypass damper settings at coils.
 - e. Fan drive settings including settings and percentage of maximum pitch diameter.
 - f. Inlet vane settings for variable-air-volume systems.

- g. Settings for supply-air, static-pressure controller.
 - h. Other system operating conditions that affect performance.
- E. **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 outside, supply, return, and exhaust airflows.
 - 2. Water and steam flow rates.
 - 3. Duct, outlet, and inlet sizes.
 - 4. Pipe and valve sizes and locations.
 - 5. Terminal units.
 - 6. Balancing stations.
 - 7. Position of balancing devices.

3.12 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional testing and balancing 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 testing, inspecting, and adjusting during near-peak summer and winter conditions.

- END OF SECTION -

SECTION 23 07 00 - HVAC INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Insulation Materials:
 - a. Cellular glass
 - b. Flexible elastomeric
 - c. Mineral fiber
 - d. Polyolefin
2. Fire-rated insulation systems:
3. Insulating cements
4. Adhesives
5. Mastics
6. Sealants
7. Factory-applied jackets
8. Field-applied fabric-reinforcing mesh
9. Field-applied jackets
10. Tapes
11. Securements
12. Corner angles

1.2 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.
- B. **Product Data:** For each type of product indicated.
- C. **Shop Drawings:**
 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.

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

D. Field quality-control reports.

1.3 QUALITY ASSURANCE

- A. **Fire-Test-Response Characteristics:** Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting 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.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in Part 3 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. **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. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Pittsburgh Corning Corporation; Foamglas Super K.
 2. Block Insulation: ASTM C552, Type I.
 3. Special-Shaped Insulation: ASTM C552, Type III.
 4. Board Insulation: ASTM C552, Type IV.
 5. Preformed Pipe Insulation without Jacket: Comply with ASTM C552, Type II, Class 1.
 6. Preformed Pipe Insulation with Factory-Applied [ASJ-SSL]: Comply with ASTM C552, Type II, Class 2.
 7. Factory fabricate shapes according to ASTM C450 and ASTM C585.
- G. **Flexible Elastomeric:** Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, Type I for tubular materials and Type II for sheet materials.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Aeroflex USA Inc.; Aerocel.
 - b. Armacell LLC; AP Armaflex.
- H. **Mineral-Fiber Blanket Insulation:** Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type II and ASTM C1290, Type II with factory-applied vinyl jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. CertainTeed Corp.; Duct Wrap.
 - b. Johns Manville; Microlite.
 - c. Knauf Insulation; Duct Wrap.
 - d. Owens Corning; All-Service Duct Wrap.
- I. **High-Temperature, Mineral-Fiber Blanket Insulation:** Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type V, without factory-applied jacket.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Johns Manville; HTB 23 Spin-Glas.
 - b. Owens Corning; High Temperature Flexible Batt Insulations.
- 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 ASJ. For equipment applications, provide insulation with factory-applied AS. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. CertainTeed Corp.; Commercial Board.
 - b. Fibrex Insulations Inc.; FBX.
 - c. Johns Manville; 800 Series Spin-Glas.
 - d. Knauf Insulation; Insulation Board.
 - e. Owens Corning; Fiberglas 700 Series.
- K. **High-Temperature, Mineral-Fiber Board Insulation:** Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type III, without factory-applied jacket.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Fibrex Insulations Inc.; FBX.
 - b. Johns Manville; 1000 Series Spin-Glas.
 - c. Owens Corning; High Temperature Industrial Board Insulations.
 - d. Rock Wool Manufacturing Company; Delta Board.
 - e. Roxul Inc.; Roxul RW.
 - f. Thermafiber; Thermafiber Industrial Felt.
- L. **Mineral-Fiber, Preformed Pipe Insulation:**
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Fibrex Insulations Inc.; Coreplus 1200.

- b. Johns Manville; Micro-Lok.
 - c. Knauf Insulation; 1000 Pipe Insulation.
 - d. Owens Corning; Fiberglas Pipe Insulation.
2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- M. **Mineral-Fiber, Pipe and Tank Insulation:** Mineral or glass fibers bonded with a thermosetting resin. Semi-rigid 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. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. CertainTeed Corp.; CrimpWrap.
 - b. Johns Manville; Micro-Flex.
 - c. Knauf Insulation; Pipe and Tank Insulation.
 - d. Owens Corning; Fiberglas Pipe and Tank Insulation.
- N. **Polyolefin:** Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C534 or ASTM C1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.
- 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Armacell LLC; Tubolit.
 - b. Nomaco Inc.; IMCOLOCK, IMCOSHEET, NOMALOCK, and NOMAPLY.
 - c. RBX Corporation; Therma-cell.

2.2 INSULATING CEMENTS

- A. **Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement:** Comply with ASTM C449/C449M.
- 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Insulco, Division of MFS, Inc.; SmoothKote.

- b. P. K. Insulation Mfg. Co., Inc.; PK No. 127, and Quik-Cote.
- c. Rock Wool Manufacturing Company; Delta One Shot.

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. **Flexible Elastomeric and Polyolefin Adhesive:** Comply with MIL-A-24179A, Type II, Class I.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Aeroflex USA Inc.; Aero seal.
 - b. Armacell LCC; 520 Adhesive.
 - c. Foster Products Corporation, H.B. Fuller Company; 85-75.
 - d. RBX Corporation; Rubatex Contact Adhesive.
- C. **Mineral-Fiber Adhesive:** Comply with MIL-A-3316C, Class 2, Grade A.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Products, Division of ITW; CP-82.
 - b. Foster Products Corporation, H.B. Fuller Company; 85-20.
- D. **ASJ Adhesive, and FSK and PVDC Jacket Adhesive:** Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Products, Division of ITW; CP-82.
 - b. Foster Products Corporation, H.B. Fuller Company; 85-20.
 - c. ITW TACC, Division of Illinois Tool Works; S-90/80.
 - d. Marathon Industries, Inc.; 225.
 - e. Mon-Eco Industries, Inc.; 22-25.
- E. **PVC Jacket Adhesive:** Compatible with PVC jacket.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

- a. Dow Chemical Company (The); 739, Dow Silicone.
- b. Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
- c. P.I.C. Plastics, Inc.; Welding Adhesive.
- d. Red Devil, Inc.; Celulon Ultra Clear.
- e. Speedline Corporation; Speedline Vinyl Adhesive.

2.4 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
- B. **Breather Mastic:** Water based; suitable for indoor and outdoor use on above ambient services.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Products, Division of ITW; CP-10.
 - b. Foster Products Corporation, H.B. Fuller Company; 35-00.
 - c. ITW TACC, Division of Illinois Tool Works; CB-05/15.
 - d. Marathon Industries, Inc.; 550.
 - e. Mon-Eco Industries, Inc.; 55-50.
 - f. Vimasco Corporation; WC-1/WC-5.

2.5 SEALANTS

A. **Joint Sealants:**

- 1. Joint Sealants for Cellular-Glass Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Products, Division of ITW; CP-76.
 - b. Foster Products Corporation, H.B. Fuller Company; 30-45.
 - c. Pittsburgh Corning Corporation; Pittseal 444.

B. **FSK and Metal Jacket Flashing Sealants:**

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

- a. Childers Products, Division of ITW; CP-76-8.
- b. Foster Products Corporation, H.B. Fuller Company; 95-44.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.

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

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Products, Division of ITW; CP-76.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.

2.6 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM 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.

2.7 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. **PVC 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. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Johns Manville; Zeston.
 - b. P.I.C. Plastics, Inc.; FG Series.
 - c. Proto PVC Corporation; LoSmoke.

- d. Speedline Corporation; SmokeSafe.
 - 2. Adhesive: As recommended by jacket material manufacturer.
 - 3. Color: Color-code jackets based on system.
 - 4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
 - 5. Factory-fabricated tank heads and tank side panels.
- D. **Aluminum Jacket:** Comply with ASTM B209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.
- 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Products, Division of ITW; Metal Jacketing Systems.
 - b. PABCO Metals Corporation; Surefit.
 - c. RPR Products, Inc.; Insul-Mate.
 - 2. Sheet and roll stock ready for shop or field sizing.
 - 3. Finish and thickness are indicated in field-applied jacket schedules.
 - 4. Moisture Barrier for Indoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
 - 5. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
 - 6. Factory-Fabricated Fitting Covers:
 - a. Same material, finish, and thickness as jacket.
 - b. Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - c. Tee covers.
 - d. Flange and union covers.
 - e. End caps.
 - f. Beveled collars.
 - g. Valve covers.

- h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
- E. **Self-Adhesive Outdoor Jacket:** 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with aluminum-foil facing.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Polyguard; Alumaguard 60.
- F. **PVDC Jacket for Indoor Applications:** 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E84.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Dow Chemical Company (The), Saran 540 Vapor Retarder Film.
- G. **PVDC Jacket for Outdoor Applications:** 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E84.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Dow Chemical Company (The), Saran 560 Vapor Retarder Film.
- H. **PVDC-SSL Jacket:** PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

2.8 TAPES

- A. **ASJ Tape:** White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.

- b. Compac Corp.; 104 and 105.
 - c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
 - d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
- B. **FSK Tape:** Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
 - b. Compac Corp.; 110 and 111.
 - c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.
 - d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.
- C. **PVC Tape:** White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.
 - b. Compac Corp.; 130.
 - c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape.
 - d. Venture Tape; 1506 CW NS.
- D. **Aluminum-Foil Tape:** Vapor-retarder tape with acrylic adhesive.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
 - b. Compac Corp.; 120.
 - c. Ideal Tape Co., Inc., an American Biltrite Company; 488 AWF.
 - d. Venture Tape; 3520 CW.
- E. **PVDC Tape for Indoor Applications:** White vapor-retarder PVDC tape with acrylic adhesive.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

- a. Dow Chemical Company (The); Saran 540 Vapor Retarder Tape.
- F. **PVDC Tape for Outdoor Applications:** White vapor-retarder PVDC tape with acrylic adhesive.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Dow Chemical Company (The); Saran 560 Vapor Retarder Tape.

2.9 SECUREMENTS

- A. **Aluminum Bands:** ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020-inch-thick, 3/4-inch wide with wing or closed seal.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Products; Bands.
 - b. PABCO Metals Corporation; Bands.
 - c. RPR Products, Inc.; Bands.
- B. **Insulation Pins and Hangers:**
 - 1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, and securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series T.
 - 2) GEMCO; Perforated Base.
 - 3) Midwest Fasteners, Inc.; Spindle.
 - 2. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, and securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) GEMCO; Nylon Hangers.
 - 2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.

3. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, and securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series TSA.
 - 2) GEMCO; Press and Peel.
 - 3) Midwest Fasteners, Inc.; Self Stick.
 4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
 - a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) AGM Industries, Inc.; RC-150.
 - 2) GEMCO; R-150.
 - 3) Midwest Fasteners, Inc.; WA-150.
 - 4) Nelson Stud Welding; Speed Clips.
 - b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
 5. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
 - a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) GEMCO.
 - 2) Midwest Fasteners, Inc.
- C. **Staples:** Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.
- D. **Wire:** 0.062-inch, stainless steel.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

- a. C & F Wire.
- b. Childers Products.
- c. PABCO Metals Corporation.
- d. RPR Products, Inc.

2.10 CORNER ANGLES

- A. **PVC Corner Angles:** 30-mils-thick, minimum 1 by 1 inch, PVC according to ASTM D1784, Class 16354-C. White or color-coded to match adjacent surface.
- B. **Aluminum Corner Angles:** 0.040-inch-thick, minimum 1 by 1 inch, aluminum according to ASTM B209, Alloy 3003, 3005, 3105 or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 PREPARATION

- A. **Surface Preparation:** Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that applies to insulation.
- C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during application and finishing.

- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. **Install insulation with factory-applied jackets as follows:**
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 - 4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

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

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

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

3.3 PENETRATIONS

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

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

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

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

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

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

E. **Insulation Installation at Fire-Rated Wall and Partition Penetrations:** Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

1. Comply with requirements in Division 07 Section "Penetration Firestopping" Firestopping and fire-resistive joint sealers.

F. **Insulation Installation at Floor Penetrations:**

1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.

2. Pipe: Install insulation continuously through floor penetrations.

3.4 Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

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

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
 - a. Do not weld anchor pins to ASME-labeled pressure vessels.
 - b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
 - c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
 - d. Do not overcompress insulation during installation.

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

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

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

3.5 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 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 on above ambient services, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below ambient services, 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.

3.7 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

- A. Seal longitudinal seams and end joints with manufacturers 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 manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.

2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.8 MINERAL-FIBER INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

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

C. Insulation Installation on Pipe Fittings and Elbows:

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

D. Insulation Installation on Valves and Pipe Specialties:

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

E. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area.
2. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Impale insulation over pins and attach speed washers.
 - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
3. 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. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1-inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

- a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches.
4. 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.
 5. 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.
 6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

F. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area.
2. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

3. 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. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1-inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches.
4. 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.
5. 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.

3.9 POLYOLEFIN INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Seal split-tube longitudinal seams and end joints with manufacturers 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 polyolefin sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturers 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 polyolefin 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 cut sections of polyolefin pipe and sheet 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.
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.

3.10 FIELD-APPLIED JACKET INSTALLATION

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

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturers 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.

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

D. Where PVDC jackets are indicated, install as follows:

1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
2. Wrap factory-presizes jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presized jacket with an

approximate overlap at butt joint of 2 inches over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.

3. Continuous jacket can be spiral wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. The 33-1/2-inch-circumference limit allows for 2-inch- overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect ductwork, randomly selected by ENGINEER, 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.
2. Inspect field-insulated equipment, randomly selected by ENGINEER, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
3. Inspect pipe, fittings, strainers, and valves, randomly selected by ENGINEER, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

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

3.12 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 nonconditioned space.
4. Indoor, exposed return located in nonconditioned space.
5. Outdoor, concealed supply and return.
6. Outdoor, exposed supply and return.
7. Outdoor, Exhaust duct carrying moist or humid air.

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.

3.13 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed or exposed, Supply Air Duct, Return Air Duct and Outside Air Duct:

1. Insulation for concealed and round ducts shall be Type 75 fiberglass duct wrap, 2" thick with foil reinforced Kraft jacket.
2. Insulation for exposed rectangular ducts shall be Type 703 rigid fiberglass board, 1-1/2" thick with ASJ25 white Kraft foil laminate facing. Ductwork shall be considered exposed in all cases where it is not enclosed in shafts or is not located above hard or lay-in ceilings.

3.14 EQUIPMENT INSULATION SCHEDULE

- A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is CONTRACTOR's option.
- B. Insulate indoor and outdoor equipment in paragraphs below that is not factory insulated.
- C. **Heat-Exchanger (Water-to-Water for Heating Service) Insulation:** Mineral-fiber pipe and tank, 2 inches.

- D. **Heating-Hot-Water Expansion/Compression Tank Insulation:** Mineral-Fiber Pipe and Tank: 1 inch thick.
- E. **Heating-Hot-Water Air-Separator Insulation:** Mineral-Fiber Pipe and Tank: 2 inches thick.

3.15 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.

3.16 INDOOR PIPING INSULATION SCHEDULE

- A. **Heating-Hot-Water Supply and Return, 200 Deg F and below:** Insulation shall be Owens-Corning Fiberglass 25 ASJ/SSL or equal:

Pipe Size	Insulation Thickness
1-1/2" & under	1-1/2"
2" – 4"	2"
5" – 6"	2-1/2"

- B. **Chilled Water, above 40 Deg F:** Insulation shall be Owens-Corning Fiberglass 25 ASJ/SSL or equal:

Pipe Size	Insulation Thickness
1-1/2" & under	1-1/2"
2" – 4"	1-1/2"

- C. **Refrigerant Suction and Hot-Gas Piping:** Flexible elastomeric, 1-1/2 inch thick.

3.17 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

- A. **Heating-Hot-Water Supply and Return, 200 Deg F and below:** Insulation shall be Owens-Corning Fiberglass 25 ASJ/SSL or equal:

Pipe Size	Insulation Thickness
-----------	----------------------

1-1/2" & under	1-1/2"
2" – 4"	2"
5" – 6"	2-1/2"

- B. **Chilled Water, above 40 Deg F:** Insulation shall be Owens-Corning Fiberglass 25 ASJ/SSL or equal:

Pipe Size	Insulation Thickness
1-1/2" & under	1-1/2"
2"-4"	1-1/2"

- C. **Refrigerant Suction and Hot-Gas Piping:** Insulation shall be one of the following:

1. Flexible Elastomeric: 2 inches thick.

3.18 OUTDOOR, UNDERGROUND PIPING INSULATION SCHEDULE

- A. Loose-fill insulation, for belowground piping, is specified in Division 33 piping distribution Sections.
- B. Chilled Water, All Sizes: Cellular glass, 2 inches thick.
- C. Heating-Hot-Water Supply and Return, All Sizes, 200 Deg F and below: Cellular glass, 3 inches thick.

3.19 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is CONTRACTOR's option.

C. **Ducts and Plenums, Concealed:**

1. None.

D. **Ducts and Plenums, Exposed:**

1. None.

E. **Equipment, Concealed:**

1. None.

F. **Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:**

1. Hot equipment shall be insulated with Type 700 Series fiberglass board, 2" thick, unfaced with 8-ounce canvas jacket applied with a white adhesive such as Aerbol meeting flame spread and smoke restrictions as listed.

G. Piping, Concealed:

1. None.

H. Piping, Exposed:

1. Any insulated piping which spans mechanical rooms less than 18" above the floor shall be covered with metal jacket. Jacket material shall be one of the following:
 - a. Aluminum, embossed, 0.016" thick with stainless steel tie-bands.
 - b. Stainless steel, smooth surface, 0.010" thick with stainless steel tie bands.

3.20 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is CONTRACTOR's option.

C. Piping, Exposed:

1. Aluminum, embossed, .016" thick with stainless steel tie-bands.
2. Stainless steel, smooth surface, 0.010" thick with stainless steel tie bands.
3. Fittings shall be covered with pre-formed metal jackets.

3.21 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

- A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 23 00 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes refrigerant piping used for air-conditioning applications.

1.2 PERFORMANCE REQUIREMENTS

A. **Line Test Pressure for Refrigerant R-410A:**

1. Suction Lines for Air-Conditioning Applications: 300 psig
2. Suction Lines for Heat-Pump Applications: 535 psig
3. Hot-Gas and Liquid Lines: 535 psig

1.3 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.
- B. **Product Data:** For each type of valve and refrigerant piping specialty indicated. Include pressure drop based on manufacturer's test data.
- C. **Shop Drawings:** Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.
 1. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
- D. Field quality-control test reports.
- E. Operation and maintenance data.

1.4 QUALITY ASSURANCE

- A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
- B. Comply with ASHRAE 34, "Refrigeration Systems and Designation and Safety Classification of Refrigerants."
- C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.5 PRODUCT STORAGE AND HANDLING

- A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

- A. **Copper Tube:** ASTM B88, Type K or L.
- B. **Wrought-Copper Fittings:** ASME B16.22.
- C. **Wrought-Copper Unions:** ASME B16.22.
- D. **Solder Filler Metals:** ASTM B32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.
- E. **Brazing Filler Metals:** AWS A5.8.
- F. **Flexible Connectors:**
 - 1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
 - 2. End Connections: Socket ends.
 - 3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
 - 4. Pressure Rating: Factory test at minimum 500 psig.
 - 5. Maximum Operating Temperature: 250 deg F.

2.2 VALVES AND SPECIALTIES

- A. **Diaphragm Packless Valves:**
 - 1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
 - 2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
 - 3. Operator: Rising stem and hand wheel.
 - 4. Seat: Nylon.
 - 5. End Connections: Socket, union, or flanged.
 - 6. Working Pressure Rating: 500 psig.
 - 7. Maximum Operating Temperature: 275 deg F.

B. Packed-Angle Valves:

1. Body and Bonnet: Forged brass or cast bronze.
2. Packing: Molded stem, back seating, and replaceable under pressure.
3. Operator: Rising stem.
4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 275 deg F.

C. Check Valves:

1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 275 deg F.

D. Service Valves:

1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig.

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.

1. Body and Bonnet: Plated steel.
 2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
 3. Seat: Polytetrafluoroethylene.
 4. End Connections: Threaded.
 5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24-VAC coil.
 6. Working Pressure Rating: 400 psig.
 7. Maximum Operating Temperature: 240 deg F.
 8. Manual operator.
- F. **Safety Relief Valves:** Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
 2. Piston, Closing Spring, and Seat Insert: Stainless steel.
 3. Seat Disc: Polytetrafluoroethylene.
 4. End Connections: Threaded.
 5. Working Pressure Rating: 400 psig.
 6. Maximum Operating Temperature: 240 deg F.
- G. **Thermostatic Expansion Valves:** Comply with ARI 750.
1. Body, Bonnet, and Seal Cap: Forged brass or steel.
 2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
 3. Packing and Gaskets: Non-asbestos.
 4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
 5. Suction Temperature: 40 deg F.
 6. Superheat: Adjustable.
 7. Reverse-flow option (for heat-pump applications).
 8. End Connections: Socket, flare, or threaded union.
 9. Working Pressure Rating: 450 psig.

H. Straight-Type Strainers:

1. Body: Welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig.
5. Maximum Operating Temperature: 275 deg F.

I. Angle-Type Strainers:

1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig.
6. Maximum Operating Temperature: 275 deg F.

J. Moisture/Liquid Indicators:

1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 240 deg F.

K. Replaceable-Core Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated.

4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig.
8. Rated Flow:
9. Working Pressure Rating: 500 psig.
10. Maximum Operating Temperature: 240 deg F.

L. **Permanent Filter Dryers:** Comply with ARI 730.

1. Body and Cover: Painted-steel shell.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig.
8. Rated Flow:
9. Working Pressure Rating: 500 psig.
10. Maximum Operating Temperature: 240 deg F.

M. **Liquid Accumulators:** Comply with ARI 495.

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

2.3 REFRIGERANTS

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

1. **Atofina Chemicals, Inc.**
2. **DuPont Company; Fluorochemicals Div.**
3. **Honeywell, Inc.; Genetron Refrigerants.**
4. **INEOS Fluor Americas LLC.**

B. ASHRAE 34, R-410A.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Suction Lines NPS 4 NPS 2 to NPS 4 for Conventional Air-Conditioning Applications: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
- B. **Hot-Gas and Liquid Lines:** Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

- A. Install service valves for gage taps at strainers if they are not an integral part of strainers.
- B. Install a check valve at the compressor discharge.
- C. Install solenoid valves upstream from each expansion valve. Install solenoid valves in horizontal lines with coil at top.
- D. Install thermostatic expansion valves as close as possible to distributors on evaporators.
 1. Install valve so diaphragm case is warmer than bulb.
 2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
 3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.
- E. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.
- F. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.
- G. **Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:**
 1. Solenoid valves.

- 2. Thermostatic expansion valves.
- 3. Compressor.
- H. Install filter dryers in liquid line between compressor and thermostatic expansion valve.
- I. Install flexible connectors at compressors.

3.3 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.
- B. Install refrigerant piping according to ASHRAE 15.
- C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping adjacent to machines to allow service and maintenance.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Refer to Section 23 09 00 – Instrumentation and Control for HVAC and for solenoid valve controllers, control wiring, and sequence of operation.
- K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 08 31 13 – Access Doors and Frames if valves or equipment requiring maintenance is concealed behind finished surfaces.
- M. Install refrigerant piping in protective conduit where installed belowground.
- N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. **Slope refrigerant piping as follows:**

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
 2. Install horizontal suction lines with a uniform slope downward to compressor.
 3. Install traps and double risers to entrain oil in vertical runs.
 4. Liquid lines may be installed level.
- P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
- Q. Install pipe sleeves at penetrations in exterior walls and floor assemblies.
- R. Seal penetrations through fire and smoke barriers according to Section 07 84 13 – Penetration Firestopping.
- S. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- T. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.
- U. Seal pipe penetrations through exterior walls according to Section 07 92 00 – Sealants and Caulking for materials and methods.

3.4 PIPE JOINT CONSTRUCTION

- A. **Soldered Joints:** Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook."
- B. **Brazed Joints:** Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
 2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

3.5 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor products are specified in Section 22 05 29 – Hangers and Support for Plumbing Piping and Equipment.
- B. **Install the following pipe attachments:**
1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
 2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.

3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4 inch.
2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.
3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.
4. NPS 1-1/4: Maximum span, 96 inches; minimum rod size, 3/8 inch.
5. NPS 1-1/2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
6. NPS 2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
7. NPS 2-1/2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
8. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.
9. NPS 4: Maximum span, 12 feet; minimum rod size, 1/2 inch.

D. Support multifloor vertical runs at least at each floor.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping and specialties. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
 - a. Fill system with nitrogen to the required test pressure.
 - b. System shall maintain test pressure at the manifold gage throughout duration of test.
 - c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.

- d. Remake leaking joints using new materials and retest until satisfactory results are achieved.

3.7 SYSTEM CHARGING

A. **Charge system using the following procedures:**

1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

- A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
- B. Adjust high and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.
- D. **Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:**
 1. Open shutoff valves in condenser water circuit.
 2. Verify that compressor oil level is correct.
 3. Open compressor suction and discharge valves.
 4. Open refrigerant valves except bypass valves that are used for other purposes.
 5. Check open compressor-motor alignment and verify lubrication for motors and bearings.
- E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 31 13 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. **Section Includes:**

1. Rectangular ducts and fittings
2. Round ducts and fittings
3. Sheet metal materials
4. Sealants and gaskets
5. Hangers and supports
6. Seismic-restraint devices

1.2 PERFORMANCE REQUIREMENTS

- A. **Delegated Duct Design:** Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible" and performance requirements and design criteria indicated. All ductwork main runs shall be pressure tested to verify they meet the required static pressure class for the ductwork system. All duct pressure testing will be performed and scheduled with the owner's representative. Once complete the CONTRACTOR will provide signed copies of the pressure test results bearing the CONTRACTOR'S and owners rep's signatures. All reports will be dated showing the date and time the pressure testing was conducted.

1. Static-Pressure Classes:

- a. Supply Ducts (Upstream from Air Terminal Units): 2.5-inch wg.
- b. Supply Ducts (Downstream from Air Terminal Units): 1-inch wg.
- c. Supply Ducts (in Mechanical Equipment Rooms): 2.5-inch wg.
- d. Return Ducts (Negative Pressure): 1-inch wg.
- e. Exhaust Ducts (Negative Pressure): 1-inch wg.

2. Leakage Class:

- a. Round Supply-Air Duct: 3 cfm/100 sq. ft. at 1-inch wg.
- b. Rectangular Supply-Air Duct: 6 cfm/100 sq. ft. at 1-inch wg.
- c. Flexible Supply-Air Duct: 6 cfm/100 sq. ft. at 1-inch wg.

- B. **Structural Performance:** Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards – Metal and Flexible" and SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems." All Seismic calculations to be stamp and sealed by a licensed professional engineer that is licensed in the state the project is located in.

1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
2. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
3. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

1.3 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.

- B. **Product Data:** For each type of product indicated.

- C. **Shop Drawings:**

1. Fittings.
2. Reinforcement and spacing.
3. Seam and joint construction.
4. Penetrations through fire-rated and other partitions.
5. Equipment installation based on equipment being used on Project.
6. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

- D. **Delegated-Design Submittal:**

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations for selecting hangers, supports, and seismic restraints.

- E. Welding certificates.

1.4 QUALITY ASSURANCE

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

1. AWS D1.1/D1.1M, "Structural Welding Code – Steel," for hangers and supports.
2. AWS D1.2/D1.2M, "Structural Welding Code – Aluminum," for aluminum supports.
3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

PART 2 - PRODUCTS

2.1 RECTANGULAR DUCTS AND FITTINGS

- A. **General Fabrication Requirements:** Comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- B. **Transverse Joints:** Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Figure 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."
- C. **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."
- D. **Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction:** Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Chapter 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 ROUND DUCTS AND FITTINGS

- A. **General Fabrication Requirements:** Comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
1. **Manufacturers:** Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. **Lindab Inc.**
 - b. **McGill AirFlow LLC.**
 - c. **SEMCO Incorporated.**

- d. **Sheet Metal Connectors, Inc.**
 - e. **Spiral Manufacturing Co., Inc.**
- B. **Transverse Joints:** Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Figure 3-2, "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 in Diameter: Flanged.
- C. **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 in diameter with butt-welded longitudinal seams.
- D. **Tees and Laterals:** Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Figure 3-4, "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 A653/A653M.
- 1. Galvanized Coating Designation: G90.
 - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. **Carbon-Steel Sheets:** Comply with ASTM A1008/A1008M, with oiled, matte finish for exposed ducts.
- D. **Stainless-Steel Sheets:** Comply with ASTM A480/A480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

- E. **Aluminum Sheets:** Comply with ASTM B209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
- F. **Reinforcement Shapes and Plates:** ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.
 - 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- G. **Tie Rods:** Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.4 SEALANT AND GASKETS

- A. **General Sealant and Gasket Requirements:** Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. **Two-Part Tape Sealing System:**
 - 1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
 - 2. Tape Width: 3 inches.
 - 3. Sealant: Modified styrene acrylic.
 - 4. Water resistant.
 - 5. Mold and mildew resistant.
 - 6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
 - 7. Service: Indoor and outdoor.
 - 8. Service Temperature: Minus 40 to plus 200 deg F.
 - 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
- C. **Water-Based Joint and Seam Sealant:**
 - 1. Application Method: Brush on.
 - 2. Solids Content: Minimum 65 percent.
 - 3. Shore A Hardness: Minimum 20.
 - 4. Water resistant.

5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.5 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments:** Cadmium-plated steel rods and nuts.
- B. Hanger Rods for Corrosive Environments:** Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Strap and Rod Sizes:** Comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables for Galvanized-Steel Ducts:** Galvanized steel complying with ASTM A603.
- E. Steel Cables for Stainless-Steel Ducts:** Stainless steel complying with ASTM A492.

- F. **Steel Cable End Connections:** Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- G. **Duct Attachments:** Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- H. **Trapeze and Riser Supports:**
 - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 - 2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
 - 3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.6 SEISMIC-RESTRAINT DEVICES

- A. **Manufacturers:** Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. **Cooper B-Line, Inc.; a division of Cooper Industries.**
 - 2. **Ductmate Industries, Inc.**
 - 3. **Hilti Corp.**
 - 4. **Kinetics Noise Control.**
 - 5. **Loos & Co.; Cableware Division.**
 - 6. **Mason Industries.**
 - 7. **TOLCO; a brand of NIBCO INC.**
 - 8. **Unistrut Corporation; Tyco International, Ltd.**
- B. **General Requirements for Restraint Components:** Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.
 - 1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
- C. **Channel Support System:** 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.

- D. **Restraint Cables:** ASTM A603, 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.
- E. **Hanger Rod Stiffener:** Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.
- F. **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 E488.
- G. All Seismic calculations to be stamp and sealed by a licensed professional engineer that is licensed in the state the project is located in.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install ducts according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible" unless otherwise indicated.
- C. Install round ducts in maximum practical lengths.
- D. Install ducts with fewest possible joints.
- E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

- K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.
- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."
- M. The use of "Bull Head" style Taps and Tees is not allowed with the ENGINEERS approval.

3.2 SEAM AND JOINT SEALING

- A. Seal duct seams and joints for duct static-pressure and leakage classes specified in "Performance Requirements" Article, according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Table 1-2, "Standard Duct Sealing Requirements," unless otherwise indicated.
- B. **Seal Classes:** Comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Table 1-2, "Standard Duct Sealing Requirements."

3.3 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 thick.
 - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
 - 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. **Hanger Spacing:** Comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Table 4-1, "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 of each elbow and within 48 inches of each branch intersection.
- D. **Hangers Exposed to View:** Threaded rod and angle or channel supports.

- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum interval of 16 feet.
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.4 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 o.c., and longitudinal supports a maximum of 80 feet o.c.
 - 2. Brace a change of direction longer than 12 feet.
- 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 Architect 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.

3.5 CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 DUCT SCHEDULE

A. **Fabricate ducts with galvanized sheet steel except as follows:**

1. Moist Environment Ducts: Aluminum or Stainless Steel at Contractors option

B. **Intermediate Reinforcement:**

1. Galvanized-Steel Ducts: Galvanized steel.
2. Stainless-Steel Ducts: Galvanized steel.
3. Aluminum Ducts: Aluminum or galvanized sheet steel coated with zinc chromate.

C. **Elbow Configuration:**

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Figure 2-2, "Rectangular Elbows."
 - a. Velocity 1,000 fpm or Lower:
 - 1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
 - 2) Mitered Type RE 4 without vanes.
 - b. Velocity 1,000 to 1,500 fpm:
 - 1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
 - c. Velocity 1,500 fpm or Higher:
 - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.

- 2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
2. 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 or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - 2) Velocity 1,000 to 1,500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - 3) Velocity 1,500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
 - b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 Inches and Larger in Diameter: Welded.

D. 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 or high efficiency style taps
 - b. Rectangular Main to Round Branch: Spin in or saddle style taps
2. Round: 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 or Lower: 90-degree tap.
 - b. Velocity 1,000 to 1,500 fpm: Conical tap.
 - c. Velocity 1,500 fpm or Higher: 45-degree lateral.

- END OF SECTION -

SECTION 23 33 00 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers
2. Manual volume dampers
3. Control dampers
4. Fire dampers
5. Smoke dampers
6. Fire / Smoke dampers
7. Flange connectors
8. Turning vanes
9. Duct-mounted access doors
10. Flexible connectors
11. Flexible ducts
12. Duct accessory hardware
13. Louvers and penthouses

1.2 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.
- B. **Product Data:** For each type of product indicated.
- 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 and smoke-damper installations, including sleeves; and duct-mounted access doors.
 - e. Wiring Diagrams: For power, signal, and control wiring.
 - D. Operation and maintenance data.
- 1.3 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.

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 A653/A653M.
 - 1. Galvanized Coating Designation: G90.
 - 2. Exposed-Surface Finish: Mill phosphatized.
- C. **Stainless-Steel Sheets:** Comply with ASTM A480/A480M, Type 304, and having a No. 2 finish for concealed ducts and finish for exposed ducts.
- D. **Aluminum Sheets:** Comply with ASTM B209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- E. **Extruded Aluminum:** Comply with ASTM B221, Alloy 6063, Temper T6.
- F. **Reinforcement Shapes and Plates:** Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- G. **Tie Rods:** Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.2 BACKDRAFT AND PRESSURE RELIEF DAMPERS

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

1. **American Warming and Ventilating**
2. **Greenheck Fan Corporation**
3. **Lloyd Industries, Inc.**
4. **Nailor Industries Inc.**
5. **NCA Manufacturing, Inc.**
6. **Pottorff; a division of PCI Industries, Inc.**
7. **Ruskin Company**
8. **SEMCO Incorporated**
9. **Vent Products Company, Inc.**

B. **Description:** Gravity balanced.

C. **Frame:** galvanized sheet steel, with welded corners and mounting flange.

D. **Blades:** Multiple single-piece blades, maximum 6-inch width, with sealed edges.

E. **Blade Action:** Parallel.

F. **Return Spring:** Adjustable tension.

G. **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. Front of rear screens.
6. 90-degree stops.

H. **Sleeve:** Minimum 20-gage thickness.

2.3 MANUAL VOLUME DAMPERS

A. **Standard, Steel, Manual Volume Dampers:**

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

- a. **American Warming and Ventilating; a division of Mestek, Inc.**
 - b. **Flexmaster U.S.A., Inc.**
 - c. **McGill AirFlow LLC.**
 - d. **METALAIRE, Inc.**
 - e. **Nailor Industries Inc.**
 - f. **Penn**
 - g. **Ruskin Company**
 - h. **Vent Products Company, Inc.**
 - i. **NCA Manufacturing, Inc.**
- 2. Standard leakage rating
 - 3. Suitable for horizontal or vertical applications.
 - 4. Basis of Design:
 - a. Rectangular dampers may be single blade up to 24"x12" size and multiple, opposed blade design for larger sizes. Control shaft shall be solid 3/8" square or hex steel with synthetic or bronze bearings. Provide with 2" stand-off bracket and manual quadrant operator. Provide Ruskin model CD-15 or approved equal, rated for 1,500 FPM velocity and 2-1/2" static pressure differential.
 - b. Round dampers shall have solid 3/8" or 1/2" square or hex steel shaft with synthetic or bronze bearings. Provide with 2" operator stand-off bracket and manual quadrant operator. Provide Ruskin model CDRS25 or approved equal, rated for 1,500 FPM velocity.
 - c. All damper blades shall be secured to damper axles by mechanical (threaded) fasteners or by welding. Shop fabricated dampers are not acceptable.
 - d. Combination spin-ins with dampers are acceptable only if damper requirements listed herein are met. If damper requirements cannot be met by combination units, provide separate spin-in and volume damper.

2.4 CONTROL DAMPERS

- A. **Manufacturers:** Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. **American Warming and Ventilating; a division of Mestek, Inc.**
 - 2. **Duro Dyne Inc.**

3. **Flexmaster U.S.A., Inc.**
4. **Greenheck Fan Corporation**
5. **Lloyd Industries, Inc.**
6. **McGill AirFlow LLC.**
7. **METALAIRE, Inc.**
8. **Metal Form Manufacturing, Inc.**
9. **Nailor Industries Inc.**
10. **Ruskin Company**
11. **Vent Products Company, Inc.**
12. **Young Regulator Company**
13. **NCA Manufacturing, Inc.**

B. Basis of Design:

1. Motorized dampers shall be Ruskin CD-50 or CD-40 low leakage damper with airfoil blades and vinyl double edge seals or Johnson Controls D1300 with edge seals. Dampers shall be opposed blade unless otherwise noted. Substitute units shall be AMCA certified as a low leakage damper and shall be equal to the models specified above in construction, features and quality. Damper actuators shall be provided under temperature control unless otherwise scheduled or noted on plans.

2.5 FIRE DAMPERS

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

1. **Air Balance Inc.; a division of Mestek, Inc.**
2. **Greenheck Fan Corporation.**
3. **McGill AirFlow LLC.**
4. **METALAIRE, Inc.**
5. **Nailor Industries Inc.**
6. **Penn**
7. **Pottorff; a division of PCI Industries, Inc.**

8. **Prefco; Perfect Air Control, Inc.**

9. **Ruskin Company.**

10. **Vent Products Company, Inc.**

11. **Or Equal**

B. **Type:** Dynamic; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 4,000-fpm velocity.

D. **Fire Rating:** 1-1/2 and 3 hours.

E. Basis of Design:

1. Fire dampers shall be Ruskin dynamic curtain type DIBD2 Style B with 1-1/2-hour UL label, or approved equal. Where space does not permit installation of Style B, then Style A shall be used.

2. Fire dampers shall be furnished with factory sleeve; wall angles and 212-degree F fusible links to conform to U.L. tested and approved mounting means. Provide complete mounting details to the Contractor.

3. Fire dampers installed in flanged duct systems (Duct Mate) shall be furnished with Duct Mate break-away connections.

2.6 SMOKE DAMPERS

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

1. **Air Balance Inc.; a division of Mestek, Inc.**

2. **Greenheck Fan Corporation.**

3. **Nailor Industries Inc.**

4. **Penn**

5. **Ruskin Company Manufacturers**

B. **General Requirements:** Label according to UL 555S by an NRTL

C. **Basis of Design:** Ruskin SD50 or SDS25

1. Damper to be power open / fail close with 120 V actuator.

2. Smoke dampers shall be furnished with factory sleeves and wall angles to conform to U.L. tested and approved mounting means. Provide complete mounting details to the Contractor.
 3. Smoke dampers installed in flanged duct systems (Duct Mate systems) shall be furnished with Duct Mate break-away connections.
- D. **Smoke Detector:** Integral, factory wired for single-point connection.
- E. **Frame:** fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.
- F. **Blades:** Roll-formed, horizontal, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.
- G. **Leakage:** Class I.
- H. Rated pressure and velocity to exceed design airflow conditions.
- I. **Mounting Sleeve:** Factory-installed, 0.052-inch- thick, galvanized sheet steel; length to suit wall or floor application.
- J. **Damper Motors:** two-position action.
- K. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors 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 motor to operate in service factor range above 1.0.
 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
 3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
 4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
 5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
 6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
 7. Electrical Connection: 115 V, single phase, 60 Hz.

L. **Accessories:**

1. Auxiliary switches for signaling or position indication.
2. Test and reset switches, damper, or remote mounted as required.

2.7 COMBINATION FIRE AND SMOKE DAMPERS

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

1. **Air Balance Inc.; a division of Mestek, Inc.**
2. **Cesco Products; a division of Mestek, Inc.**
3. **Greenheck Fan Corporation**
4. **Nailor Industries Inc.**
5. **Ruskin Company**

B. **Type:** Static and dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 4,000-fpm velocity.

D. **Fire Rating:** 1-1/2 and 3 hours.

E. **Frame:** Multiple-blade type; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.

F. **Heat-Responsive Device:** Electric resettable link and switch package, factory installed, rated.

G. **Smoke Detector:** Integral, factory wired for single-point connection.

H. **Blades:** Airfoil-shaped, double-skin, single piece construction with 14 gage equivalent thickness, maximum 6" wide.

I. Rated pressure and velocity to exceed design airflow conditions.

J. **Mounting Sleeve:** Factory-installed, 0.052-inch- thick, galvanized sheet steel; length to suit wall or floor application.

K. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors 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 motor to operate in service factor range above 1.0.

2. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
3. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
4. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
5. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
6. Electrical Connection: 115 V, single phase, 60 Hz.

L. Accessories:

1. Auxiliary switches for signaling.
2. Test and reset switches, remote mounted.

2.8 FLANGE CONNECTORS

- A. **Manufacturers:** Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. **Ductmate Industries, Inc.**
 2. **Nexus PDQ; Division of Shilco Holdings Inc.**
 3. **Ward Industries, Inc.; a division of Hart & Cooley, Inc.**
- B. **Description:** roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
- C. **Material:** Galvanized steel.
- D. **Gage and Shape:** Match connecting ductwork.

2.9 TURNING VANES

- A. **Manufacturers:** Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. **Ductmate Industries, Inc.**
 2. **Duro Dyne Inc.**

3. **METALAIRE, Inc.**
 4. **SEMCO Incorporated.**
 5. **Ward Industries, Inc.; a division of Hart & Cooley, Inc.**
- B. **Turning Vanes for Metal Ducts:** Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
1. **Acoustic Turning Vanes:** Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
- C. **Manufactured Turning Vanes for Nonmetal Ducts:** Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- D. **General Requirements:** Comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."
- E. **Vane Construction:** Single wall for ducts up to 36 inches wide and double wall for larger dimensions.

2.10 DUCT-MOUNTED ACCESS DOORS

- A. **Manufacturers:** Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. **American Warming and Ventilating; a division of Mestek, Inc.**
 2. **Cesco Products; a division of Mestek, Inc.**
 3. **Ductmate Industries, Inc.**
 4. **Flexmaster U.S.A., Inc.**
 5. **Greenheck Fan Corporation**
 6. **McGill AirFlow LLC**
 7. **Nailor Industries Inc.**
 8. **Pottorff; a division of PCI Industries, Inc.**
 9. **Ventfabrics, Inc.**
 10. **Ward Industries, Inc.; a division of Hart & Cooley, Inc.**
- B. **Duct-Mounted Access Doors:** Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels – Round Duct."