

SECTION 23 31 13
METAL DUCTS AND ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air Movement and Control Association (AMCA): 500, Test Methods for Louvers, Dampers and Shutters.
2. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Handbook.
3. American Society of Mechanical Engineers (ASME): A13.1, Scheme for the Identification of Piping Systems.
4. Association of the Nonwoven Fabrics Industry (INDA): IST 80.6, Water Resistance (Hydrostatic Pressure).
5. ASTM International (ASTM):
 - a. A36/A36M, Standard Specification for Carbon Structural Steel.
 - b. A90/A90M, Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.
 - c. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 - d. A176, Standard Specification for Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip.
 - e. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
 - f. A480/A480M, Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate Sheet and Strip.
 - g. A568/A568M, Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for.
 - h. A653/A653M, Standard Specifications for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
 - i. A700, Standard Practices for Packaging, Marking, and Loading Methods for Steel Products for Shipment.
 - j. A924/A924M, Specification for General Requirements for Sheet Steel, Metallic-Coated by the Hot-Dip Process.
 - k. A1008/A1008M, Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.

- l. A1011/A1011M, Standard Specification for Steel, Sheet, and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
 - m. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
 - n. C423, Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
 - o. C916, Standard Specification for Adhesives for Duct Thermal Insulation.
 - p. C1071, Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
 - q. C1139, Standard Specification for Fibrous Glass Thermal Insulation for Sound Absorbing Blanket and Board for Military Applications.
 - r. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
 - s. E96/E96M, Standard Test Methods for Water Vapor Transmission of Materials.
6. National Air Duct Cleaners Association (NADCA): General Specifications for the Cleaning of Commercial Heating, Ventilation and Air Conditioning Systems.
7. National Fire Protection Association (NFPA):
 - a. 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
 - b. 90B Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
 - c. 96, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
 - d. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
 - e. 259, Standard Test Method for Potential Heat of Building Materials.
 - f. 701, Standard Methods of Fire Tests for Flame Propagation of Textiles and Films.
8. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
 - a. Duct Construction Standards.
 - b. Fire, Smoke, and Radiation Damper Installation Guide for HVAC Systems.
 - c. HVAC Air Duct Leakage Test Manual.

9. UL:
 - a. 181, Standard for Safety Factory-Made Air Ducts and Connectors.
 - b. 214, Standard for Tests for Flame-Propagation of Fabrics and Films.
 - c. 555, Standard for Safety Fire Dampers.
 - d. 555S, Standard for Safety Smoke Dampers.

1.02 ABBREVIATIONS

A. The following is a list of abbreviations which may be used in this section:

1. CFM: cubic feet per minute.
2. FPM: feet per minute.
3. PCF: pounds per cubic foot.
4. WC: water column.

1.03 DEFINITIONS

A. Sealing Requirements:

1. For the purpose of duct systems sealing requirements specified in this section, the following definitions apply:
 - a. Seams: Joining of two longitudinally (in direction of airflow) oriented edges of duct surface material occurring between two joints. All other duct surface connections made on perimeter are deemed to be joints.
 - b. Joints, duct surface connections including:
 - 1) Girth joints.
 - 2) Branch and subbranch intersections.
 - 3) Duct collar tap-ins.
 - 4) Fitting subsections.
 - 5) Louver and air terminal connections to ducts.
 - 6) Access door, and access panel frames and jambs.
 - 7) Duct, plenum, and casing abutments to building structures.

1.04 SUBMITTALS

A. Action Submittals:

1. Product Data:
 - a. Rectangular and Rigid Round Ductwork:
 - 1) Schedules of duct systems, materials, joints, sealing, gage and reinforcement.
 - 2) SMACNA Figure Numbers for each shop fabricated item.
 - 3) Reinforcing details and spacing.

- 4) Seam and joint construction details.
- 5) Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.
- b. Ductwork Accessories:
 - 1) Manufacturer's product data including catalog sheets, diagrams, standard schematic drawings, installation instructions and details, details of materials, construction, dimensions of individual components, and finishes, including the following items:
 - a) Fittings and volume control damper installation (both manual and automatic) details.
 - b) Duct liner.
 - c) Sealing materials.
 - d) Dampers: include leakage, pressure drop, and maximum back pressure data.
 - e) Duct-mounted access panels and doors.
 - f) Flexible ducts.
 - g) Sheet metal fasteners.

B. Informational Submittals:

1. Record Drawings: Include duct systems routing, fittings details, and installed accessories and devices.

1.05 QUALITY ASSURANCE

A. Industry Standards:

1. Sheet metal ductwork shall be constructed and installed in accordance with SMACNA Duct Construction Standards relevant to ductwork system being provided. These standards are herein referenced as the SMACNA Manual.
2. Comply with ASHRAE Fundamentals Handbook recommendations.
3. NFPA Compliance: NFPA 90A and NFPA 90B.

B. Manufacturers: Firms regularly engaged in manufacture of ductwork products of types, materials, and sizes required, whose products have been satisfactorily used in similar service for not less than 5 years.

C. Suppliers of duct and fitting components shall provide on request the following information:

1. Laboratory performance data for duct, including leakage rate, bursting strength, collapse strength, seam strength, and pressure loss.
2. Laboratory performance data for fittings, including zero-length dynamic losses.

- D. Installer shall be a firm with at least 3 years' experience of successful installation on ductwork systems similar to that required for this Project.
- E. Changes or alterations to layout or configuration of duct system shall be:
 - 1. Specifically approved in writing by Contracting Officer.
 - 2. Proposed layout shall provide original design results, without increasing system total pressure.

1.06 EXTRA MATERIALS

- A. Furnish, tag, and box for shipment and storage the following spare parts, special tools, and materials:

Item	Quantity
Fusible Links	10 percent of amount installed
Special tools required to maintain or dismantle	One complete set for each different size unit

- B. Delivery: In accordance with Section 01 67 00, Product Requirements.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Protect ductwork from dirt, water, and debris. During storage on Job Site, keep ends of ductwork covered to prevent foreign objects and water from entering ductwork.
- B. Deliver sealant materials to Site in original unopened containers labeled with manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.
- C. Store and handle sealant materials in compliance with manufacturers' recommendations to prevent deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.
- D. Deliver and store stainless steel sheets with mill-applied adhesive protective paper, maintained through fabrication and installation.

PART 2 PRODUCTS

2.01 SCHEDULES

- A. Ductwork Schedule: Refer to Article Supplement.

2.02 GENERAL

A. Physical Characteristics:

1. Specified components of this ductwork system, including facings, mastics, and adhesives, shall have fire hazard rating not to exceed 25 for flame spread without evidence of continued progressive combustion, and 50 for smoke developed, as per test conducted in accordance with ASTM E84 and NFPA 255 methods.
2. Internally Lined Ductwork: Duct sizes indicated for internally lined ducts are the clear inside dimensions and shall be increased in both dimensions by twice the thickness of the liner.
3. Ductwork thinner than 26-gauge will not be allowed.
4. Ductwork Interior Surfaces:
 - a. Smooth.
 - b. No sheet metal parts, tabs, angles, or other items may project into air ducts.
 - c. Seams and joints shall be external.

B. Functional Characteristics: None.

C. Performance Characteristics: None.

2.03 SHEET METAL MATERIALS

A. Construct metal duct systems from materials as indicated in Article Supplement: Schedules for HVAC.

B. Where no specific ductwork materials are indicated in Specifications or on the Drawings, galvanized steel sheet metal shall be basis of Contract.

C. Galvanized Steel Ductwork:

1. Physical Characteristics:
 - a. Comply with ASTM A653/A653M and ASTM A924/924M.
 - b. Product Name: Steel Sheet, Zinc Coated (Galvanized Steel).
 - c. Sheet Designation: CS Type B.
 - d. Applicable Specification: ASTM A653/A653M.
 - e. (Zinc) Coating Designation: G90.
 - f. Coating designation in accordance with Test Method A, ASTM A90/A90M. and ASTM A924/A924M.
 - g. Provide mill-phosphatized finish for ducts exposed to view and for ducts scheduled to be painted.
 - h. Provide sheet metal packaged and marked as specified in ASTM A700.
2. Functional Characteristics: None.
3. Performance Characteristics: None.

D. Aluminum Ductwork:

1. Physical Characteristics:
 - a. Comply with ASTM B209.
 - b. Aluminum Sheet: Alloy 3003-H14, unless indicated otherwise.
 - c. Aluminum Connectors and Bar Stock: Alloy 6061-T6 or equivalent.
2. Functional Characteristics: None.
3. Performance Characteristics: None.

E. Stainless Steel Ductwork:

1. Physical Characteristics:
 - a. Comply with ASTM A167, ASTM A176, ASTM A240/A240M, and ASTM A480/A480M.
 - b. Stainless Steel Sheet: Type 316, unless indicated otherwise.
 - c. Gauge shall comply with SMACNA manual.
 - d. Finish: No. 2 B (cold-rolled, bright) finish.
 - e. For Foul Air service provide full welds and smooth interior.
2. Functional Characteristics: None.
3. Performance Characteristics: None.

F. Exposed Ductwork: Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, oil canning, stains, discoloration, and other imperfections, including those which would impair painting.

G. Reinforcement Shapes and Plates: Unless otherwise indicated, provide reinforcements of same material as ductwork.

2.04 DUCT SEALING MATERIALS

A. General: The term sealant used here is not limited to materials of adhesive or mastic nature, but also includes tapes and combinations of open weave fabric strips and mastics.

B. Adhesives, Cements, Sealant, and Installation Accessories: As recommended by duct manufacturer for application.

C. Solvent-Based Sealants:

1. Manufacturers and Products:
 - a. Hardcast, Inc.; Versagrip 102.
 - b. Or equal.
2. Physical Characteristics: None.

3. Functional Characteristics:
 - a. Ultraviolet light resistant.
 - b. Mildew resistant.
 - c. Flashpoint: Greater than 70 degrees F, SETA CC.
4. Performance Characteristics: None.

D. Water-Based Sealants:

1. Manufacturers and Products:
 - a. Foster; Series 32.
 - b. Or equal.
2. Physical Characteristics: None.
3. Functional Characteristics: Listed by manufacturer as nonflammable in wet and dry state.
4. Performance Characteristics: None.

2.05 FIRESTOPPING

- A. Refer to Section 07 84 00, Firestopping.

2.06 DUCTWORK FASTENERS

A. General:

1. Rivets, bolts, or sheet metal screws.
2. Ductwork fasteners shall be same metal as duct being supported, unless otherwise noted.

B. Self-Drilling Screws:

1. Galvanized Steel Ductwork System:
 - a. Manufacturers:
 - 1) DB Building Fasteners Inc., Santa Fe Springs, CA.
 - 2) Or equal.
 - b. Physical Characteristics:
 - 1) Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated carbon steel with zinc electroplated finish.
 - c. Functional Characteristics: None.
 - d. Performance Characteristics: None.
2. Aluminum Ductwork System:
 - a. Physical Characteristics:
 - 1) Sheet metal screws shall be hex washer head (HWH) self-drilling type, formed from heat-treated stainless steel with strength of Type 410 stainless steel and corrosion resistance of Type 304 stainless steel, complete with bonded metal and fiber washer for dielectric separation.

- b. Functional Characteristics: None.
- c. Performance Characteristics: None.
- 3. Stainless Steel Ductwork System:
 - a. Manufacturers:
 - 1) DB Building Fasteners Inc., Santa Fe Springs, CA.
 - 2) Or equal.
 - b. Physical Characteristics:
 - 1) Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated Marutex® stainless steel with strength of Type 410 stainless steel and corrosion resistance of Type 304 stainless steel.
 - c. Self-drilling screws shall not be used for Foul Air ductwork.
 - d. Functional Characteristics: None.
 - e. Performance Characteristics: None.

2.07 DUCTWORK PRESSURE CLASS

- A. Construct duct systems to pressure classifications indicated in Ductwork Schedule.
- B. Where no specific duct pressure designations are indicated in Specifications or on the Drawings, 2-inch WC pressure class shall be basis of Contract.

2.08 RECTANGULAR DUCTWORK

- A. Fabricate rectangular ducts in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible.
- B. Crossbreaking or Cross Beading: Crossbreak or bead duct sides that are 19 inches and larger and are 20-gauge or less, with more than 10 square feet of unbraced panel area, as indicated in SMACNA Manual, unless they are lined or are externally insulated.

2.09 RECTANGULAR DUCTWORK FITTINGS

- A. Fabricate elbows, transitions, offsets, branch connections, and other duct construction in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible.
- B. Elbows:
 - 1. Manufacturers and Products:
 - a. Elgen; All-Tight.
 - b. Or equal.

2. Physical Characteristics:
 - a. Fit square-turn elbows with vane side rails.
 - b. Shop fabricated, double-blade turning vanes of same material as ductwork.
 - c. Fabricate with equal inlet and outlet.
 - d. Rectangular radius elbows with inside radius of 3/4 of duct width in direction of turn.
3. Functional Characteristics: None.
4. Performance Characteristics: None.

2.10 RECTANGULAR DUCTWORK BRANCH CONNECTIONS

- A. Branch duct connections to rectangular duct mains shall be made using factory fabricated fittings with spot welded tap to main duct connections or with factory fabricated, field installed taps, with spin-in or mechanical fastened tap to main duct connections.

2.11 RECTANGULAR DUCTWORK INSULATION LINER

- A. Manufacturers:
 1. Certain Teed, Toughgard.
 2. Or equal.
- B. Physical Characteristics:
 1. Location: Provide ductwork with internal insulation liner where indicated on the Drawings or in Ductwork Schedule.
 2. Material:
 - a. Fiberglass, nominal 1.5 pcf density liner, K factor 0.25 maximum at 75 degrees F mean.
 - b. Black composite coating on surface exposed to airstream to prevent erosion of glass fibers, for temperatures to 250 degrees F.
 - c. Liquid water repellency rating not less than 4.0 when tested in accordance with INDA IST 80.6.
 - d. Potential heat value not exceeding 3,500 Btu per hour per pound when tested in accordance with NFPA 259 and meeting classification of "Limited Combustible" as defined by NFPA 90A.
 - e. Maximum rated velocity not less than 6,000 fpm when tested in accordance with ASTM C1071.
 - f. Resistant to microbial growth using a "no growth criteria" when tested in accordance with ASTM C1139.
 3. Thickness: Minimum 1 inch or greater thickness where indicated on the Drawings or Ductwork Schedule.
 4. Mechanical Fasteners:
 - a. Same material as ductwork, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct.

- b. Provide fasteners that do not damage liner when applied as recommended by manufacturer, that do not cause leakage in duct and will indefinitely sustain 50-pound tensile dead load test perpendicular to duct wall.
 - c. Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into airstream.
 - d. Adhesive for Attachment of Mechanical Fasteners: In accordance with Fire Hazard Classification of duct liner system.
5. Liner Application:
- a. Ductwork liner shall be applied at time of ductwork manufacture in an approved sheet metal workshop.
 - b. Adhere single layer of indicated thickness of duct liner with 90 percent coverage of adhesive at liner contact surface area. Multiple layers of insulation to achieve indicated thickness is prohibited.
 - c. Apply coat of adhesive to liner facing in direction of airflow not receiving metal nosing.
 - d. Butt transverse joints without gaps and coat joint with adhesive.
 - e. Fold and compress liner in corners of rectangular ducts or cut and fit to assure butted edge overlapping.
 - f. Longitudinal Joints:
 - 1) Shall not occur except at corners of ducts unless size of duct and standard liner product dimensions make longitudinal joints necessary.
 - 2) Apply adhesive coating on longitudinal seams in ducts exceeding 2,500 fpm air velocity.
 - g. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely around perimeter, at 3 inches from transverse joints, and at intervals not exceeding 18 inches longitudinally.
 - h. Secure transversely oriented liner edges facing airstream with metal nosing that are either channel or "Z" profile or are integrally formed from duct wall at the following locations:
 - 1) Fan discharge.
 - 2) Intervals of lined duct preceding unlined duct.
 - 3) Upstream edges of transverse joints in ducts.
 - i. Seal insulation edges.
 - j. Repair abrasions or tears with mastic.
6. Liner Adhesive: In accordance with NFPA 90A and ASTM C916.

C. Functional Characteristics: None.

D. Performance Characteristics:

- 1. R-Value: Minimum 6 hours foot squared degrees F per Btu or greater, where indicated on the Drawings or Ductwork Schedule.

2.12 RIGID ROUND DUCTWORK

A. Physical Characteristics:

1. Construct rigid round ducts in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible.
2. Basic Round Diameter: As used in this Article, is inside diameter of size of round duct.
3. Where space limitations prevent use of round duct or where shown on the Drawings, provide ductwork of flat oval construction hydraulically equivalent to round ductwork.
4. Fabricate round ducts with spiral seam construction, except where diameters exceed 72 inches. Fabricate ducts having diameters greater than 72 inches with longitudinal butt-welded seams.

B. Functional Characteristics: None.

C. Performance Characteristics: None.

2.13 RIGID ROUND DUCTWORK FITTINGS

A. Physical Characteristics:

1. Construct rigid round ductwork fittings in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible.
2. 90-Degree Tees, Laterals, and Conical Tees: Fabricate to conform to SMACNA manual with metal thicknesses specified for longitudinal seam straight duct.
3. Diverging Flow Fittings: Fabricate with a reduced entrance to branch taps with no excess material projecting from body onto branch tap entrance.
4. Elbows:
 - a. Fabricate in stamped (die-formed), pleated, or segmented (gored) construction 1.5 times elbow diameter. Two-piece segment elbows are not allowed, except with turning vanes.
 - b. Segmented Elbows: Fabricate with welded construction.
 - c. Round Elbows 8 Inches and Smaller:
 - 1) Stamped elbows for 45-degree and 90-degree elbows and pleated elbows for 30 degrees, 45 degrees, 60 degrees, and 90 degrees configuration.
 - 2) Fabricate nonstandard bend angle configurations or nonstandard sized (for example, 3-1/2 inches and 4-1/2 inches) elbows with segmented construction.
 - d. Round Elbows 9 Inches Through 14 Inches:
 - 1) Segmented or pleated elbows for 30 degrees, 45 degrees, 60 degrees, and 90 degrees.

- 2) Fabricate nonstandard bend angle configurations or nonstandard sized (for example, 9-1/2 inches and 10-1/2 inches) elbows with segmented construction.

B. Functional Characteristics: None.

C. Performance Characteristics: None.

2.14 ROUND DUCTWORK BRANCH CONNECTIONS

- A. Branch duct connections (taps) to round duct mains shall be made using factory fabricated fittings.

2.15 INSULATED FLEXIBLE DUCT

A. Manufacturers and Products:

1. Flex-Master; Type 5M.
2. Or equal.

B. Physical Characteristics:

1. Construction:

- a. Outer Jacket: Fire retardant reinforced metalized vapor barrier jacket with reinforced cross-hatched scrim having a permeance of not greater than 0.1 perm when tested in accordance with ASTM E96/E96M, Procedure A.
- b. Inner Liner: Tri-laminate of aluminum foil, fiberglass, and aluminized polyester.
- c. Reinforcing: Galvanized steel wire helix, mechanically locked to and encapsulated by inner liner fabric.
- d. Insulation:
 - 1) Factory insulated with fiberglass insulation.
 - 2) R-value: 6.0 minimum at a mean temperature of 75 degrees F.

C. Functional Characteristics:

1. Internal Working Pressure: Rating shall be minimum 4-inch WC positive and 5-inch WC negative, with bursting pressure of at least 2-1/2 times working pressure.
2. Air Velocity Rating: 4,000 fpm, minimum.
3. Environment: Suitable for continuous operation at temperature range of minus 20 degrees F to plus 200 degrees F.

- D. Performance Characteristics:
 - 1. Fabricate in accordance with:
 - a. UL 181, Class 1.
 - b. NFPA 90A and NFPA 90B.

2.16 DUCTWORK HANGERS AND SUPPORTS

A. General:

- 1. Attachments, hangers, and supports for ductwork shall be in accordance with SMACNA Manual referenced for type of duct system being installed.
- 2. Duct hanging system shall be composed of three elements: Upper attachment to building, hanger itself, and lower attachment to duct.
- 3. Wire hangers are not acceptable.
- 4. Hanger Spacing:
 - a. Ducts Up to 60 inches in Largest Dimension: 10 feet, maximum.

B. Construction Materials:

- 1. Supporting devices including, but not limited to, angles used for support and bracing, baseplates, rods, hangers, straps, screws, bolts shall be as follows:
 - a. Physical Characteristics:
 - 1) Galvanized Steel Ductwork:
 - a) Indoors: Carbon steel, zinc electroplated.
 - b) Outdoors: Carbon steel, hot-dipped galvanized after fabrication.
 - 2) Aluminum Ductwork Indoors and Outdoors:
 - a) Carbon steel, hot-dipped galvanized after fabrication.
 - b) Non-metallic pad between lower attachment and ductwork, to achieve dielectric separation.
 - 3) Stainless Steel Ductwork Indoors and Outdoors: Stainless steel, same ASTM Grade as ductwork.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics: None.

C. Building Attachments:

- 1. Concrete inserts, powder-actuated fasteners, or structural steel fasteners appropriate for building materials.
- 2. Do not use powder-actuated concrete fasteners for lightweight aggregate concrete or for slabs less than 4 inches thick.
- 3. Upper Attachment (Concrete):
 - a. Drive pin fastener and expansion nail anchor may be used for ducts up to 18-inch maximum dimension.

- b. Threaded stud fastener may be used for ducts up to 36-inch maximum dimension.
 - c. Concrete attachments shall be made of steel.
- D. Duct Fasteners: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials and conforming to requirements of Article Ductwork Fasteners.
- E. Trapeze and Riser Supports: Steel shapes conforming to ASTM A36/A36M, hot-dipped galvanized after fabrication.

2.17 DUCTWORK FLEXIBLE CONNECTIONS

A. Manufacturers:

- 1. Ductmate; PROflex, Commercial.
- 2. Or equal.

B. General:

- 1. Physical Characteristics:
 - a. Factory fabricated metal-edged fabric flexible connectors for commercial or industrial applications.
 - b. Sheet metal permanently secured to fabric with double fabric fold, double metal crimp.
 - c. Comply with NFPA 90A and NFPA 90B requirements.
 - d. Airtight and waterproof.
- 2. Functional Characteristics: None.
- 3. Performance Characteristics: None.

C. Materials:

- 1. Physical Characteristics:
 - a. Flame-retarded or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.
 - b. Metal Edges: Construct from same material as ductwork, unless otherwise noted.
 - c. Fabric:
 - 1) Comply with NFPA 701 or UL 214 (except polytetrafluoroethylene coated).
 - 2) Woven polyester or polyamide for most applications.
 - 3) Woven fiberglass for high temperature applications.
 - 4) Coating: Vinyl for most applications
- 2. Functional Characteristics: None.
- 3. Performance Characteristics: None.

D. Construction:

1. Physical Characteristics:
 - a. Fold and crimp metal edge strips onto fabric as illustrated in SMACNA Manual.
 - b. Standard Metal Edged Connectors: Strip of fabric 3 inches wide attached to two strips of 3-inch-wide sheet metal.
 - c. Wide Metal Edged Connectors: Strip of fabric 4 inches wide attached to two strips of 4-inch-wide sheet metal.
 - d. Extra Wide Metal Edged Connectors: Strip of fabric 6 inches wide attached to two strips of 6-inch-wide sheet metal.
2. Functional Characteristics: None.
3. Performance Characteristics: None.

2.18 CEILING ACCESS DOORS

A. Manufacturers:

1. Inryco Milcor.
2. Or equal.

B. Physical Characteristics:

1. As specified in Section 08 30 00, Specialty Doors.
2. Size: 30 inches by 30 inches.
3. Finish in baked white enamel.

C. Functional Characteristics: None.

D. Performance Characteristics: None.

2.19 DUCT INSPECTION DOORS

A. Manufacturers:

1. Ventlok.
2. Or equal.

B. General:

1. Physical Characteristics:
 - a. Insulated, gasketed, and at least 15 inches by 15 inches when duct dimensions are large enough.
 - b. On ductwork where largest side dimension is less than 16 inches, furnish inspection doors at least 8 inches by 8 inches.

- c. Complete with necessary hardware and either Amerlock 10 or Ventlock No. 100 latches, and Ventlock Series No. 100 hinges.
 - d. Fabricated of same material as ductwork.
- 2. Functional Characteristics: None.
- 3. Performance Characteristics: None.

C. Casing and Plenum Access Doors:

- 1. Physical Characteristics:
 - a. Size: 57 inches high by 24 inches wide minimum where possible.
 - b. Complete with hardware, hinges, seals, and latch handles.
 - c. Doors and frames shall be designed to close with pressure.
 - d. Latch Handles: Ventlock, Series No. 260.
 - e. Hinges: Ventlock, Series No. 200 and No. 300.
- 2. Functional Characteristics: None.
- 3. Performance Characteristics: None.

2.20 MANUAL DAMPERS

A. Butterfly Manual Dampers:

- 1. Damper Manufacturers:
 - a. Ruskin.
 - b. Or equal.
- 2. Operator Manufacturers:
 - a. Accessible Ductwork:
 - 1) Ventlok; Type 620 or Type 635.
 - 2) Or equal.
 - b. Accessible Insulated Ductwork:
 - 1) Ventlok; Type 639.
 - 2) Or equal.
 - c. Concealed Ductwork:
 - 1) Ventlok; Type 677 with extended operating rod and concealed regulator with plain cover.
 - 2) Or equal.
- 3. Physical Characteristics:
 - a. Fabricate from two gauges heavier than duct in which installed, of same material as ductwork.
 - b. Align operating handle with damper blade.
 - c. Provide 2-inch standoff bracket for insulated duct systems.
- 4. Functional Characteristics: None.
- 5. Performance Characteristics: None.

B. Manual Opposed-Blade Balancing Dampers:

1. Manufacturers and Products:
 - a. Ruskin; CD102.
 - b. Or equal.
2. Physical Characteristics:
 - a. Externally operated gang airfoil, damper blades.
 - b. Fabricate from same material as ductwork.
 - c. Stainless steel or polyamide sleeve bearings.
 - d. Construction shall have interlocking edges and maximum 10-inch blade width.
3. Functional Characteristics: None.
4. Performance Characteristics: None.

2.21 BACK DRAFT DAMPERS

A. General: Damper pressure drop ratings shall be based on tests and procedures performed in accordance with AMCA 500.

B. Steel Frame, Nonmetallic Blades:

1. Manufacturers and Products:
 - a. Ruskin; Model NMS2.
 - b. Or equal.
2. Physical Characteristics:
 - a. Fabrication:
 - 1) Frame: 2 inches by minimum 18-gauge (51 mm by minimum 1.6 mm) galvanized steel with windstops to reduce backflow.
 - 2) Blades:
 - a) Style: Single piece, independent.
 - b) Action: Parallel.
 - c) Material: Noncombustible, polychloroprene coated fiberglass.
 - d) Orientation: Horizontal.
 - e) Width: Maximum 6 inches (152 mm).
 - 3) Rear Bird Screen: Galvanized expanded metal.
 - 4) Mounting:
 - a) Suitable for mounting in vertical or horizontal airflow up positions.
 - b) Configured for positions as shown.
 - 5) Finish: Mill galvanized.
 - b. Accessories:
 - 1) Screen:
 - a) Type: Bird.
 - b) Material: Galvanized steel.

3. Functional Characteristics: None.
 4. Performance Characteristics:
 - a. Performance Data:
 - 1) Temperature Rating: Withstand minus 30 degrees to 200 degrees F (minus 34 degrees to 93 degrees C).
 - 2) Maximum Back Pressure: 4-inch WC (1.0 kPa).
 - 3) Maximum System Air Velocity: 1,000 fpm (5.1 m/s).
 - 4) Maximum Spot Air Velocity: 1,200 fpm (6.1 m/s).
- C. Aluminum, Counterbalanced, Standard Duty:
1. Manufacturers and Products:
 - a. Ruskin; Model CBD2.
 - b. Or equal.
 2. Physical Characteristics:
 - a. Fabrication:
 - 1) Frame: 2 inches by minimum 0.06 inch (51 mm by minimum 1.5 mm), 6063-T5 extruded aluminum channel with mitered corners.
 - 2) Blades:
 - a) Style: Single piece, overlap frame.
 - b) Action: Parallel.
 - c) Material: Minimum 0.025-inch (0.6 mm) 6063-T5 formed aluminum.
 - d) Width: Maximum 6 inches (152 mm).
 - 3) Bearings: Corrosion-resistant, long-life, synthetic, formed as single piece with axles.
 - 4) Blade Seals: Extruded vinyl, mechanically attached to blade edge.
 - 5) Linkage: Concealed in frame.
 - 6) Axles: Corrosion-resistant, long-life, synthetic, locked to blade and formed as single piece with bearings.
 - 7) Counterbalances: Adjustable zinc plated steel weights mechanically attached to blade enabling damper to operate over wide range of pressures.
 - a) Mounting: Suitable for mounting in vertical, horizontal airflow up, and horizontal airflow down positions.
 - 8) Finish: Mill aluminum.
 - b. Accessories:
 - 1) Screen:
 - a) Type: Bird.
 - b) Material: Galvanized steel.
 3. Functional Characteristics: None.

4. Performance Data:

- 1) Temperature Rating: Withstand minus 40 degrees to 200 degrees F (minus 40 degrees to 93 degrees C).
- 2) Maximum Back Pressure: 2-inch WC (500 Pa).
- 3) Maximum Spot Air Velocity: 1,000 fpm (5 mps).
- 4) Operation of Blades:
 - a) Start to Open: 0.01-inch WC (0.002 kPa).
 - b) Fully Open: 0.06-inch WC (0.01 kPa).
- 5) Pressure Drop: Maximum 0.04-inch WC (0.01 kPa) at 1,000 fpm (305 mpm) through 24-inch by 24-inch (610 mm by 610 mm) damper.

2.22 CONTROL DAMPERS

- A. Refer Section 23 09 13, HVAC Controls, Field Components, and Instruments, for requirements.

2.23 EXTERNAL DUCT INSULATION

- A. For external duct insulation refer to Section 23 07 00, HVAC Insulation.

2.24 MISCELLANEOUS ACCESSORIES

A. Auxiliary Drain Pans:

1. Physical Characteristics:
 - a. Dimensions: Minimum 6 inches larger in both dimensions than equipment it is serving and 2 inches high, minimum.
 - b. Construction: 16-gauge stainless steel with welded joints. Pans shall be watertight and have hemmed edges.
 - c. Drain Connection:
 - 1) Minimum 1-inch IPS or as shown.
 - 2) Locate at lowest point of drain pan.
 - 3) In lieu of drain connection, float switch may be installed. Float switch shall shut down air handling equipment upon sensing water.
2. Functional Characteristics: None.
3. Performance Characteristics: None.

B. Louver and Grille Blank-Off Sections:

1. Physical Characteristics:
 - a. Fabricate from 20-gauge sheets of same material as louver/grille.
 - b. Line with sound attenuation/insulating material.
 - c. Shop-prime and paint outside face of blank-off section with two coats of flat black exterior paint.

2. Functional Characteristics: None.
 3. Performance Characteristics: None.
- C. Prefabricated Roof Curb: Refer to Section 07 70 01, Roof Specialties and Accessories.
- D. Accessories Hardware:
1. Instrument Test Holes:
 - a. Physical Characteristics:
 - 1) Cast metal, material to suit duct material, including screw cap and gasket and flat mounting gasket.
 - 2) Size to allow insertion of pitot tube and other testing instruments.
 - 3) Provide in length to suit duct insulation thickness.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics: None.
 2. Flexible Duct Clamps:
 - a. Physical Characteristics:
 - 1) Stainless steel band with cadmium-plated hex screw to tighten band with worm-gear action.
 - 2) Provide in sizes from 3 inches to 18 inches to suit duct size.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics: None.
 3. Adhesives:
 - a. Physical Characteristics: High strength, quick setting, polychloroprene based, waterproof and resistant to gasoline, and grease.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics: None.

2.25 DUCTWORK IDENTIFICATION

- A. Manufacturers:
1. W.H. Brady, Co.
 2. Or equal.
- B. Painted Identification Materials:
1. Physical Characteristics:
 - a. Stencils: Standard metal stencils, prepared for required applications with letter sizes generally comply with recommendations of ASME A13.1 for piping and similar applications, but not less than 1-1/4-inch high letters for ductwork and not less than 3/4-inch-high letters for access door signs and similar operational instructions.

- b. Stencil Paint: Standard exterior type stenciling enamel; black; either brushing grade or pressurized spray can form and grade.
 - c. Identification Paint: Standard identification enamel of colors indicated or in accordance with ASME A13.1 for colors for systems not identified herein.
 - 2. Functional Characteristics: None.
 - 3. Performance Characteristics: None.
- C. Plastic Duct Markers:
 - 1. Physical Characteristics:
 - a. Provide manufacturer's standard laminated plastic, color coded duct markers. Conform to the following color code:
 - 1) Black text on yellow background: Odorous Air.
 - 2) White text on blue background.
 - 3) For other hazardous exhausts, use colors and designs recommended by ASME A13.1.
 - 2. Functional Characteristics: None.
 - 3. Performance Characteristics: None.
- D. Nomenclature:
 - 1. Include the following:
 - a. Direction of air flow.
 - b. Duct service (supply, return, exhaust).

PART 3 EXECUTION

3.01 GENERAL INSTALLATION

- A. Miscellaneous:
 - 1. Install sheet metal ductwork and flexible ductwork in accordance with SMACNA Manual, NFPA 90A, and NFPA 90B.
 - 2. Install ductwork using manufacturer's recommended adhesives, cement, sealant, and insulation accessories.
 - 3. Align ductwork accurately at connections, within 1/8-inch misalignment tolerance and with internal surfaces smooth.
 - 4. Interface Between Ductwork and Louvers: At locations where ductwork is connected to louver for either intake or exhaust purposes, ductwork shall be installed, sloped, and connected to louver so water entering ductwork system positively drains back to and out of louver.

B. Ductwork Location:

1. Locate ductwork runs vertically and horizontally, unless otherwise indicated.
2. Avoid diagonal runs wherever possible.
3. As indicated by diagrams, details, and notations or, if not otherwise indicated, run ductwork in shortest route that does not obstruct usable space or block access for servicing building and equipment.
4. In general, install as close to bottom of structure as possible.
5. For ductwork concealed above ceiling, maximize clearance between bottom of ductwork and top of ceiling construction.
6. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
7. Ductwork that must transition and drop below piping or other ductwork shall be transitioned back to bottom of structure immediately adjacent to obstruction.

C. Penetrations:

1. Provide duct sleeves or prepared openings for duct mains, duct branches, and ducts passing through roofs, walls, and ceilings.
2. Clearances:
 - a. For uninsulated ducts, allow 1-inch clearance between duct and sleeve, except at grilles, registers, and diffusers.
 - b. For insulated ducts, allow 1-inch clearance between insulation and sleeve, except at grilles, registers, and diffusers.
3. Closure Collars:
 - a. Minimum 4 inches wide on each side of walls or floors where sleeves or prepared openings are installed.
 - b. Fit collars snugly around ducts and insulation.
 - c. Same gauge and material as duct.
 - d. Grind edges of collar smooth to preclude tearing or puncturing insulation covering or vapor barrier.
 - e. Use fasteners with maximum 6-inch centers on collars.
4. Packing: Mineral fiber in spaces between sleeve or opening and duct or duct insulation.

D. Concealment:

1. Wherever possible in finished and occupied spaces, conceal ductwork from view by locating in mechanical shafts, hollow wall construction, or above suspended ceiling.
2. Do not encase horizontal runs in solid partitions, except as specifically shown.
3. Limit clearance to 1-inch where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any.

E. Coordination with Other Trades:

1. Coordinate duct installation with installation of accessories, dampers, coil frames, equipment, controls, and other associated work of ductwork system.
2. Ductwork shall be configured, positioned, and installed to permit installation of light fixtures as shown.
3. Coordinate ductwork layout with suspended ceiling, lighting and sprinkler head layouts and similar finished work.
4. Electrical Equipment Spaces: Do not run ductwork through transformer vaults and other electrical equipment spaces and enclosures.

F. Shower Room and Toilet Room Exhaust Ductwork:

1. Joints and Seams: Seal watertight.
2. Slope branch ducts downward to grille.

G. Fume Hood, Laboratory, and Chlorine Room Exhaust Ductwork:

1. Seal joints and seams with chemical-resistant mastic.
2. Rivet butt joints with minimum of eight pop rivets.

3.02 RECTANGULAR DUCTWORK

A. General:

1. Where possible, install ductwork so seams and joints will not be cut for installation of grilles, registers, or ceiling outlets.
2. If cutting of seams or joints is unavoidable, reinforce cut portion to original strength.

B. Low Pressure Taps:

1. Use bell mouth or conical fittings with integral locking quadrant damper. Spin-in fitting shall be sealed at duct tap with a gasket or sealed with sealant as specified for medium pressure ductwork.
2. Determine location of spin-in after outlet location is determined.
3. Fitting shall be securely attached to shaft to prevent damper from rotating around shaft.

C. Fittings:

1. Use bell-mouth or conical tee fittings for round duct takeoffs from rectangular mains.
2. Use 45-degree entry fittings conforming to SMACNA requirements for rectangular takeoffs from rectangular or round mains.

3. Make offsets with maximum angle of 45 degrees.
4. Use fabricated fittings for changes in directions, changes in size and shape, and connections.

D. Rectangular Ductwork Transverse Joints:

1. Install each run with a minimum of joints.
2. Install couplings tight to duct wall surface with projections into duct at connections kept to a minimum.
3. Mechanical Joint Option:
 - a. Construct transverse joints with Ductmate 25/35 duct connector systems, Ductmate W.D.C.I. Heavy/Lite duct connector systems, or Ductlok J/E duct connector system. Slip-on duct flange connectors shall have integral sealant pocket with permanently flexible sealant.
 - b. When using Ductmate W.D.C.I. Heavy/Lite system, construct ductwork in accordance to the Ductmate W.D.C.I. Heavy J and Light H Assembly Manual and Duct Construction Standards.
 - c. When using Ductlok J/E duct connector system, construct ductwork in accordance with Ductlok's Rectangular Duct Construction Manual for Low, Medium, and High Pressure.
 - d. For longitudinal seams, use Pittsburgh lock seam sealed internally with permanently elastic sealer such as Ductmate 5511M mastic.
 - e. Conform to SMACNA Class A sealing requirements.

3.03 RIGID ROUND DUCTWORK

- A. General: Except where interrupted by fittings, install round ducts in lengths as long as possible to minimize joints.
- B. Rigid Round Ductwork Joints:
1. Rigid round ductwork joints shall be in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible.
 2. Single and Double Wall Supply and Return System Joints:
 - a. Less Than 36 Inches: Slip coupling.
 - b. 36 Inches and Larger: Flanged connector, Van Stone, or welded companion flange type.
 3. Single and Double Wall Exhaust and Return System Joints:
 - a. Spiral Seam Duct: Welded flanged connector.
 - b. Longitudinal Seam Duct: Van Stone flange connector.

3.04 INSULATED FLEXIBLE DUCT

A. Installation:

1. Where shown, between branch duct and ceiling diffusers and grilles.
2. Without sags, kinks, sharp offsets, or elbows.
3. As straight and taut as possible.

B. Connection: Connect flexible ductwork to round collars, air distribution devices, and terminal units in accordance with flexible duct manufacturer's recommendations.

C. Length: Maximum length of low-pressure flexible duct (construction pressure class up to 2-inch WC) to be 8 feet.

D. Flexible ductwork shall not pass through wall, floor, or fire-resistant rated assembly.

3.05 DUCTWORK HANGERS AND SUPPORTS

A. Install ductwork with support systems in accordance with SMACNA Manual, unless otherwise noted.

B. Support ducts rigidly with suitable ties, braces, hangers, and anchors of type, which will hold ducts true-to-shape and to prevent buckling.

C. Install additional bracing on ductwork as required, to prevent ballooning or breathing.

D. Support horizontal ducts within 2 feet of each elbow and within 4 feet of each branch intersection.

E. Support vertical ducts at maximum interval of 16 feet and at each floor.

F. Upper attachments to structures shall have allowable load not exceeding 1/4 of failure (proof test) load but are not limited to specific methods indicated.

G. In new construction, install concrete insert prior to placing concrete.

3.06 FLEXIBLE CONNECTIONS

A. Flexible Collars and Connections:

1. Use between fans and ducts.
2. For round ducts, securely fasten flexible connections by zinc-coated steel clinch-type draw bands.
3. For rectangular ducts, lock flexible connections to metal collars.

3.07 DAMPERS

A. General:

1. Inspection:
 - a. Inspect areas to receive dampers.
 - b. Notify Contracting Officer of conditions that would adversely affect installation or subsequent utilization of dampers.
 - c. Do not proceed with installation until unacceptable conditions are corrected.
2. Install dampers at locations indicated on the Drawings and in accordance with manufacturer's installation instructions.
3. Install square and level.
4. Handle damper using sleeve or frame. Do not lift damper using blades or jack-shaft.
5. Damper blades and hardware shall operate freely without obstruction.
6. Damper blades and hardware that bind within frame or obstructed by adjacent construction will not be acceptable.
7. When installed, damper frames shall be gasketed or caulked to eliminate leakage between duct and damper frames.
8. Head and sill shall have stops.
9. Suitable for installation in mounting arrangement shown.
10. Do not compress or stretch damper frame into duct or opening.

B. Manual Dampers:

1. Provide balancing dampers for grilles and diffusers in branch duct as near main as possible.
2. Add or remove balancing dampers as requested by air balancing firm for necessary control of air.

C. Back Draft Dampers:

1. Install dampers square and free from racking with blades running horizontally.
2. Install bracing for multiple section assemblies to support assembly weight and to hold against system pressure. Install bracing as needed.

3.08 ACCESS DOORS

- #### A. Ceilings:
- Install in non-accessible ceilings below each electric duct heater, booster coil, motorized damper, terminal unit, and smoke detector.

B. Ductwork:

1. Install access doors in ductwork, in accordance with manufacturer's instructions, at each:
 - a. Duct mounted fire damper.
 - b. Duct mounted smoke or ionization detector.
 - c. Electric duct heater.
 - d. Booster coil.
 - e. Motorized damper.
 - f. Sail switch.
 - g. Turning vane.
 - h. Volume damper.
 - i. Automatic damper.
 - j. Temperature controller.
 - k. Coil, on both upstream and downstream side.

3.09 MISCELLANEOUS ACCESSORIES

A. Auxiliary Drain Pans:

1. Under equipment for which pan is shown and under all horizontal air handling units located above ceilings and piping located in ceiling space directly above computer facility areas; furnish and install auxiliary drain pans.
2. Route drain lines to nearest floor or hub drain independent of any other drain.
3. Slope drain pans toward drain connection to promote drainage.

B. Louver and Grille Blank-Off Sections: Attach airtight to louver or grille and install to allow for easy removal.

C. Prefabricated Roof Curb: Refer to Section 07 70 01, Roof Specialties and Accessories.

D. Inspection Plates and Test Holes:

1. Where required in ductwork for balance measurements.
2. Test holes shall be airtight and noncorrosive with screw cap and gasket.
3. Extend cap through insulation.

3.10 DUCT SEALING

- A. Seal duct seams and joints as follows:
 - 1. As indicated on Ductwork Schedule.
- B. If no specific duct sealing requirements are specified, requirements of SMACNA manual shall govern.
- C. Seal externally insulated ducts prior to insulation installation.
- D. Provide additional duct sealing as required to comply with Article Ductwork Leakage Testing.
- E. Seal all audible leaks.

3.11 DUCTWORK LEAKAGE TESTING

- A. General:
 - 1. Tests shall be conducted on completed ductwork systems.
 - 2. Testing of partial installations or limited sections of ductwork will not be acceptable.
 - 3. All ductwork leakage test procedures and results shall be submitted to the Contracting Officer for review.
 - 4. Contracting Officer will retain the right to witness some or all ductwork leakage testing procedures.
 - 5. Contractor shall notify Contracting Officer in writing at least 5 working days prior to ductwork testing.
- B. Leakage Criteria: Assemble and install ductwork with maximum leakage limited as indicated in Ductwork Schedule.
- C. Leakage Testing Method:
 - 1. Contractor shall be responsible for providing all necessary test fans and calibrated measuring devices to accomplish ductwork leakage test and to demonstrate that ductwork systems leakage rate is less than maximum rate specified.
 - 2. Pressure testing shall be accomplished using a pressure blower with a calibrated orifice and manometer.
 - 3. Blower shall maintain system design static pressure during test.
 - 4. Perform testing in accordance with procedures given in SMACNA HVAC Air Duct Leakage Test Manual.

3.12 BALANCING OF AIR SYSTEMS

- A. Perform air balancing in accordance with requirements of Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

3.13 PROTECTION OF INSTALLED WORK

- A. Open ends of installed ductwork systems shall be covered to prevent dust, foreign objects and water from entering ductwork.
- B. Ductwork systems shall not be used for air conveyance until adequate air filtration devices are installed in air handling equipment, to prevent ingress of construction dust.

3.14 CLEANING

- A. Ductwork shall be cleaned of rust, dust, and debris, both internally and externally, before placing in operation.
- B. Before installing air outlets, use air handler to blow dry air through entire system at maximum attainable velocity. Provide temporary air filters for this operation.
- C. If duct systems are found to contain construction debris at time of construction completion Contractor shall provide complete ductwork system cleaning in accordance with NADCA Standards.

3.15 SUPPLEMENT

- A. The supplement listed below, following “End of Section,” is a part of this specification:
 - 1. Ductwork Schedule.

END OF SECTION