

SECTION 23 31 13

METAL DUCTS AND ACCESSORIES

PART 1 GENERAL

1.1 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. Association of the Nonwoven Fabrics Industry (INDA): IST 80.6, Water Resistance (Hydrostatic Pressure Test).
 4. 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 Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.
 - 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, 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 Domestic Shipment.
 - j. A924/A924M, Specification for General Requirements for Sheet Steel, Metallic-Coated by the Hot-Dip Process.
 - k. A1008/A1008M, Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
 - l. A1011/A1011M, Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
 - 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.
5. National Air Duct Cleaners Association (NADCA): General Specifications for the Cleaning of Commercial Heating, Ventilation and Air Conditioning Systems.
6. 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. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
 - d. 259, Standard Test Method for Potential Heat of Building Materials.
 - e. 701, Standard Method of Fire Test for Flame Propagation of Textiles and Films.
7. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
- a. Duct Construction Standards.
 - b. Guidelines for Seismic Restraints of Mechanical Systems.
 - c. Fibrous Glass Duct Construction Standards.
 - d. Fire, Smoke, and Radiation Damper Installation Guide for HVAC Systems.
 - e. HVAC Air Duct Leakage Test Manual.
8. Underwriters Laboratories Inc. (UL):
- a. 181, Standard for Safety Factory-Made Air Ducts and Connectors.
 - b. 214, Tests for Flame-Propagation of Fabrics and Films.
 - c. 555, Standard for Safety Fire Dampers.
 - d. 555S, Standard for Safety Smoke Dampers.
 - e. Underwriters Laboratories of Canada (ULC).
 - f. National Fire Code of Canada.
 - g. National Building Code of Canada.

1.2 DEFINITIONS

- A. The following is a list of abbreviations which may be used in this section:
- 1. L/s: litre per second.
 - 2. m/s: m per second.
 - 3. kg/m³: kg per cubic metre.

- B. Sealing Requirements: For the purpose of duct systems sealing requirements specified in this Section, the following definitions apply:
1. 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.
 2. Joints, duct surface connections including:
 - a. Girth joints.
 - b. Branch and subbranch intersections.
 - c. Duct collar tap-ins.
 - d. Fitting subsections.
 - e. Louver and air terminal connections to ducts.
 - f. Access door, and access panel frames and jambs.
 - g. Duct, plenum, and casing abutments to building structures.

1.3 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.
 2. Duct Fabrication Drawings:
 - a. Drawn after actual job measurements are obtained.
 - b. Drawn to a scale not smaller than 6 mm equals 300 mm, on drawing sheets same size as Contract Drawings.

- c. Include the following features:
- 1) Fabrication, assembly, and installation details including plans, elevations, sections, details of components, and attachments to other work.
 - 2) Duct layout, indicating pressure classifications, and sizes in plan view.
 - 3) Duct material and thickness.
 - 4) Fittings and volume control damper installation (both manual and automatic) details.
 - 5) Reinforcing details and spacing.
 - 6) Seam and joint construction details.
 - 7) Penetrations through fire-rated and other partitions.
 - 8) Duct accessories and control devices such as automatic dampers, airflow monitors, terminal units, smoke detectors, regulators, air distribution devices, etc.
 - 9) Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.
 - 10) Fire and smoke damper installations, including sleeves and duct-mounted access door and panel installation.
 - 11) Coordination with ceiling suspension members.
 - 12) Spatial coordination with other systems installed in same space with duct systems.
 - 13) Coordination of ceiling- and wall-mounted access doors and panels required for access to dampers and other operating devices.
 - 14) Coordination with ceiling-mounted lighting fixtures, air outlets, and inlets.
 - 15) Coordination of ductwork with sprinkler piping and other mechanical and electrical services, and equipment installed under Division 23, Heating, Ventilating, and Air-Conditioning (HVAC), Division 40, Process Integration, and Division 26, Electrical.

B. Informational Submittals:

1. Sound Attenuators Certified Test Data:
 - a. Dynamic insertion loss.
 - b. Self-noise power levels.
 - c. Static pressure loss.
 - d. Dimensions and weights.
2. Record Drawings: Include duct systems routing, fittings details, and installed accessories and devices.

1.4 QUALITY ASSURANCE

A. Industry Standards:

1. Unless otherwise indicated or specified, sheet metal ductwork shall be constructed and installed in accordance with SMACNA duct construction

standard relevant to ductwork system being provided. These standards are herein referenced as the SMACNA Manual, unless otherwise indicated.

2. Comply with ASHRAE Fundamentals Handbook recommendations, except as otherwise indicated.
 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 Contract Administrator.
 2. Proposed layout shall provide original design results, without increasing system total pressure.

1.5 EXTRA MATERIALS

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

Item	Quantity
Fusible Links	10% of amount installed

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Protect ductwork from dirt, water, and debris. During storage on jobsite, 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

2.1 SCHEDULES

- A. Ductwork Schedule: Refer to Drawings.
- B. Sound Attenuator Schedule: Refer to Article Supplements.

2.2 GENERAL

- A. 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.
- B. 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.
- C. Ductwork thinner than 26 gauge will not be allowed.
- D. Ductwork Interior Surfaces:
 - 1. Smooth.
 - 2. No sheet metal parts, tabs, angles, screws, or other items may project into air ducts, unless otherwise specified.
 - 3. Seams and joints shall be external.
 - 4. For ductwork that is required to be reinforced. Contractor may use either external or internal reinforcing.

2.3 SHEET METAL MATERIALS

- A. Construct metal duct systems from materials as indicated in Article, Ductwork Schedule.
- B. Where no specific ductwork materials are indicated in Specifications or on Drawings, galvanized steel sheet metal shall be basis of Contract.
- C. Galvanized Steel Ductwork (GV 61):
 - 1. Comply with ASTM A653/A653M and ASTM A924/924M.
 - 2. Product Name: Steel Sheet, Zinc Coated (Galvanized Steel).
 - 3. Sheet Designation: CS Type B.
 - 4. Applicable Specification: ASTM A653/A653M.
 - 5. (Zinc) Coating Designation: G90.
 - 6. Coating designation in accordance with Test Method A, ASTM A90/A90M. and ASTM A924/A924M.
 - 7. Provide mill-phosphatized finish for ducts which are scheduled to be painted.
 - 8. Provide sheet metal packaged and marked as specified in ASTM A700.
- D. Aluminum Ductwork (AL 61):

1. Comply with ASTM B209.
 2. Aluminum Sheet: Alloy 3003-H14, unless indicated otherwise.
 3. Aluminum Connectors and Bar Stock: Alloy 6061-T6 or equivalent.
- E. Stainless Steel Ductwork (SS 64):
1. Comply with ASTM A167, A176, A240/A240M, and ASTM A480.
 2. Stainless Steel Sheet: Type 304, unless indicated otherwise.
 3. Gauge shall comply with SMACNA manual, unless specified otherwise.
 4. Finish: No. 2 B (cold-rolled, bright) finish, except as otherwise noted.
 5. With No.4 finish on exposed surface for ducts exposed to view.
- F. Stainless Steel Ductwork (Odorous Air) (SS 66):
1. Comply with ASTM A167, ASTM A176, ASTM A240/A240M, and ASTM A480/A480M.
 2. Stainless Steel Sheet: Type 316/316L, unless indicated otherwise.
 3. Duct construction, including sheet metal gauge and reinforcements, shall comply with SMACNA Round Industrial Duct Construction Standards and SMACNA Rectangular Industrial Duct Construction Standards as applicable, unless specified otherwise.
 4. Finish: No. 2 B (cold-rolled, bright) finish. Welds shall be grinded smooth and passivated.
 5. Longitudinal fusion welded butt seam, flanged fittings, and joints with all seams welded.
 6. Elbows: Provide centerline equal to radius 1.5 times elbow diameter.
 7. Fittings: Continuously welded along seams.
 8. Duct Classification: Class 5 (Corrosive Fumes).
 9. Maintenance load provision: 113 kg.
 10. Duct support spacing shall not exceed a maximum of 4.5 m.
- G. 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.
- H. Reinforcement Shapes and Plates: Unless otherwise indicated, provide reinforcements of same material as ductwork.

2.4 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. Water-Based Sealants:
 - 1. Listed by manufacturer as nonflammable in wet and dry state.
 - 2. Manufacturers and Products:
 - a. Foster; Series 32.
 - b. Childers; CP-145A, 146.
 - c. Rectorseal; Airlok 181.

2.5 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: Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated carbon steel with zinc electroplated finish.
 - 2. Aluminum Ductwork System:
 - a. 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,] [Type 410 stainless steel,] complete with bonded metal and fiber washer for dielectric separation.
 - b. Manufacturers:
 - 1) DB Building Fasteners Inc., Santa Fe Springs, CA.
 - 2) Clark Craft Fasteners, Tonawanda, NY.
 - 3. Stainless Steel Ductwork System:
 - a. 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] [Type 410 stainless steel].
 - b. Manufacturers:
 - 1) DB Building Fasteners Inc., Santa Fe Springs, CA.
 - 2) Clark Craft Fasteners, Tonawanda, NY.
 - 3) UCAN Fastening Products.

2.6 DUCTWORK PRESSURE CLASS

- A. Where no specific duct pressure designations are indicated in Specifications or on Drawings, 500 Pa pressure class shall be basis of Contract.

2.7 RECTANGULAR DUCTWORK

- A. Fabricate rectangular ducts in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible, unless specified otherwise.

- B. Crossbreaking or Cross Beading: Crossbreak or bead duct sides that are 480 mm and larger and are 20-gauge or less, with more than 1.0 square meter of unbraced panel area, as indicated in SMACNA Manual, unless they are lined or are externally insulated.
- C. Air Handling Unit Discharge Ductwork: Ductwork extending from variable air volume air handling units up to and including first elbow or terminal tap outside air handling unit room shall be constructed of 16-gauge, minimum.

2.8 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. Fit square-turn elbows with vane side rails.
 - 2. Shop fabricate double-blade turning vanes of same material as ductwork.
 - 3. Fabricate with equal inlet and outlet.
 - 4. Rectangular radius elbows with inside radius of 3/4 of duct width in direction of turn.
 - 5. Manufacturers and Products:
 - a. Elgen; All-Tight.
 - b. Duro-Dyne; Type TR.

2.9 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. Field installed taps are not acceptable.

2.10 RECTANGULAR DUCTWORK INSULATION LINER

- A. Location: Provide ductwork with internal insulation liner where indicated in Ductwork Schedule.
- B. Material:
 - 1. Fiberglass, nominal 24.0 kg/m³ density liner, K factor 0.035 maximum at 24 degrees C mean.
 - 2. Black composite coating surface exposed to airstream to prevent erosion of glass fibers, for temperatures to 121 degrees C.
 - 3. Liquid water repellency rating not less than four when tested in accordance with INDA IST 80.6.
 - 4. Potential heat value not exceeding 2250 watt hr per kg when tested in accordance with NFPA 259 and meeting classification of "Limited Combustible" as defined by NFPA 90A.
 - 5. Maximum rated velocity not less than 30 m/s when tested in accordance with ASTM C1071.
 - 6. Resistant to microbial growth using a "no growth criteria" when tested in accordance with ASTM C1139.

7. Manufacturers and Products:
 - a. CertainTeed; Toughgard.
 - b. Johns Manville; Linacoustic RC.
 - c. Knauf; Duct Liner M.

- C. Thickness: Minimum 25 mm or greater thickness where indicated on Drawings or Ductwork Schedule.

- D. R-Value: Minimum 0.74 metre squared degrees C per Watt or greater, where indicated on Drawings or Ductwork Schedule.

- E. Liner Adhesive: In accordance with NFPA 90A and ASTM C916.

- F. Mechanical Fasteners:
 1. Same material as ductwork, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct.
 2. Provide fasteners that do not damage liner when applied as recommended by manufacturer, that do not cause leakage in duct, and will indefinitely sustain 223 N tensile dead load test perpendicular to duct wall.
 3. Fastener Pin Length: As required for thickness of insulation and without projecting more than 3 mm into airstream.
 4. Adhesive for Attachment of Mechanical Fasteners: In accordance with Fire Hazard Classification of duct liner system.

- G. Liner Application:
 1. Ductwork liner shall be applied at time of ductwork manufacture in an approved sheet metal workshop.
 2. 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.
 3. Apply coat of adhesive to liner facing in direction of airflow not receiving metal nosing.
 4. Butt transverse joints without gaps and coat joint with adhesive.
 5. Fold and compress liner in corners of rectangular ducts or cut and fit to assure butted edge overlapping.
 6. Longitudinal Joints:
 - a. Shall not occur except at corners of ducts, unless size of duct and standard liner product dimensions make longitudinal joints necessary.
 - b. Apply adhesive coating on longitudinal seams in ducts exceeding 12.5 m/s air velocity.
 7. Secure liner with mechanical fasteners 102 mm from corners and at intervals not exceeding 305 mm transversely around perimeter, at 76 mm from transverse joints, and at intervals not exceeding 457 mm longitudinally.
 8. 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:
 - a. Fan discharge.

- b. Intervals of lined duct preceding unlined duct.
- c. Upstream edges of transverse joints in ducts.
- 9. Seal insulation edges.
- 10. Repair abrasions or tears with mastic.

2.11 RIGID ROUND DUCTWORK

- A. Construct rigid round ducts in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible, unless specified otherwise.
- B. Basic Round Diameter: As used in this Article, is diameter of size of round duct that has circumference equal to perimeter of a given size of flat oval duct.
- C. Where space limitations prevent use of round duct or where shown on Drawings, provide ductwork of flat oval construction.
- D. Fabricate round ducts with spiral seam construction, except where diameters exceed 1800 mm. Fabricate ducts having diameters greater than 1800 mm with longitudinal butt-welded seams.

2.12 RIGID ROUND DUCTWORK FITTINGS

- A. Construct rigid round ductwork fittings in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible, unless otherwise specified.
- B. 90-Degree Tees, Laterals, and Conical Tees: Fabricate to conform to SMACNA manual with metal thicknesses specified for longitudinal seam straight duct.
- C. Diverging Flow Fittings: Fabricate with a reduced entrance to branch taps with no excess material projecting from body onto branch tap entrance.
- D. Elbows:
 - 1. 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.
 - 2. Segmented Elbows: Fabricate with welded construction.
 - 3. Round Elbows 200 mm and Smaller:
 - a. Stamped elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees configuration.
 - b. Fabricate nonstandard bend angle configurations or nonstandard sized (e.g., 90 and 115 mm) elbows with segmented construction.
 - 4. Round Elbows 225 mm Through 350 mm:
 - a. Segmented or pleated elbows for 30, 45, 60, and 90 degrees.
 - b. Fabricate nonstandard bend angle configurations or nonstandard sized (e.g., 240 and 265 mm) elbows with segmented construction.

2.13 ROUND DUCTWORK BRANCH CONNECTIONS

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

2.14 ROUND DUCTWORK INSULATION LINER

- A. Location: Provide round ductwork with internal insulation liner where indicated on Drawings or in Ductwork Schedule.
- B. Material:
1. Fiberglass, nominal 64 kg per cubic metre density, K factor 0.23 maximum at 24 degrees C mean.
 2. Black composite coating on surface exposed to air stream, to prevent erosion of glass fibers.
 3. Suitable for temperatures up to 121 degrees C.
 4. Noise Reduction Coefficient: Minimum 20 for 25 mm thickness, in accordance with ASTM C423.
 5. Liquid water repellency rating not less than 4.0 when tested in accordance with INDA IST 80.6.
 6. Potential heat value not exceeding 2.3 kW per kg when tested in accordance with NFPA 259 and meeting classification of "Limited Combustible" as defined by NFPA 90A.
 7. Maximum rated velocity not less than 30 m/s when tested in accordance with ASTM C1071.
 8. Resistant to microbial growth using a "no growth criteria" when tested in accordance with ASTM C1139.
 9. Manufacturers and Products:
 - a. CertainTeed.
 - b. Johns Manville; Spiracoustic Plus.
 - c. Knauf.
- C. Thickness: Minimum 25 mm or greater thickness where indicated on Drawings or Ductwork Schedule.
- D. R-Value: Minimum 0.74 metre squared degrees C per Watt, or greater, where indicated on Drawings or Ductwork Schedule.
- E. Liner Application:
1. Install liner in accordance with manufacturer's instructions.
 2. In Straight Duct Sections: Apply at time of ductwork manufacture in an approved sheet metal workshop, or field install.
 3. In Duct Fittings: Apply at time of ductwork manufacture in an approved sheet metal workshop only.
 4. Install single layer of indicated thickness of duct liner. Multiple layers of insulation to achieve indicated thickness is prohibited.
 5. Fastening: Interference fit.
 6. Seal insulation edges.

7. Repair abrasions or tears with mastic.

2.15 INSULATED FLEXIBLE DUCT

- A. Fabricate in accordance with:
 1. UL 181, Class 1.
 2. NFPA 90A and NFPA 90B.
- B. Construction:
 1. Outer Jacket: Fire retardant reinforced aluminum 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, Procedure A.
 2. Inner Liner: Tri-laminate of aluminum foil, fiberglass, and aluminized polyester.
 3. Reinforcing: Galvanized steel wire helix, mechanically locked to and encapsulated by inner liner fabric.
 4. Insulation:
 - a. Factory insulated with fiberglass insulation.
 - b. R-value: 1.05 m² k/w minimum at a mean temperature of 24 degrees C.
 5. Internal Working Pressure: Rating shall be minimum 1500 Pa positive and 1000 Pa negative, with bursting pressure of at least 2-1/2 times working pressure.
 6. Air Velocity Rating: 20 m/s, minimum.
- C. Environment: Suitable for continuous operation at temperature range of minus 29 degrees C to plus 121 degrees C.
- D. Manufacturers and Products:
 1. Flexmaster; Type 5M.
 2. Thermaflex Type M-KC.

2.16 HIGH TEMPERATURE FLEXIBLE DUCTWORK

- A. Metal flexible ductwork for high heat applications.
- B. Fully interlocked, stainless steel, 0.305 mm thickness.
- C. Manufacturer and Product:
 1. Flexmaster; RT-6.

2.17 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 1500 mm in Largest Dimension: 3.0 m, maximum.
 - b. Ducts Over 1525 mm in Largest Dimension: 2.4 m, maximum.
- B. Construction Materials: Supporting devices including, but not limited to, angles used for support and bracing, baseplates, rods, hangers, straps, screws, bolts shall be as follows:
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: Carbon steel, hot-dipped galvanized after fabrication.
 3. Stainless Steel Ductwork Indoor and Outdoors: Stainless steel, same ASTM Grade as ductwork.
- 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 100 mm thick.
 3. Upper Attachment (Concrete):
 - a. Drive pin fastener and expansion nail anchor may be used for ducts up to 450 mm maximum dimension.
 - b. Threaded stud fastener may be used for ducts up to 900 mm 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 Fastener.
- E. Trapeze and Riser Supports: Steel shapes conforming to ASTM A36/A36M, hot-dipped galvanized after fabrication.

2.18 DUCTWORK FLEXIBLE CONNECTIONS

- A. General:
1. Factory fabricated metal-edged fabric flexible connectors for commercial or industrial applications.
 2. Sheet metal permanently secured to fabric with double fabric fold, double metal crimp.
 3. Comply with NFPA 90A and 90B requirements.
 4. Airtight and waterproof.
- B. Materials:
1. Flame-retarded or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.
 2. Metal Edges: Construct from same material as ductwork, unless otherwise noted.
 3. Fabric:
 - a. Comply with UL 214 (except teflon coated).

- b. Woven polyester or nylon for most applications.
- c. Woven fiberglass for high temperature applications.
- d. Coating: Vinyl.

C. Construction:

- 1. Fold and crimp metal edge strips onto fabric as illustrated in SMACNA Manual.
- 2. Standard Metal Edged Connectors: Strip of fabric 90 mm wide attached to two strips of 70 mm wide sheet metal.
- 3. Extra Wide Metal Edged Connectors: Strip of fabric 145 mm wide attached to two strips of 70 mm wide sheet metal.
- 4. Transverse Metal Edged Connectors: Strip of fabric 90 mm wide attached to two strips of 110 mm wide sheet metal.

D. Manufacturers:

- 1. Ductmate; PROflex, Commercial.
- 2. Ventfabrics.
- 3. Duro-Dyne.

2.19 CEILING ACCESS DOORS

A. Size: 750 mm by 750 mm.

B. Finish in baked white enamel.

C. Manufacturers:

- 1. Inryco Milcor.
- 2. Krueger.

2.20 DUCT INSPECTION DOORS

A. General:

- 1. Insulated, gasketed, and at least 375 mm by 375 mm when duct dimensions are large enough.
- 2. On ductwork where largest side dimension is less than 400 mm, furnish inspection doors at least 200 mm by 200 mm.
- 3. Complete with necessary hardware.
- 4. Fabricated of same material as ductwork.

B. Round Spin-in Type Access Doors:

- 1. Size: 450 mm and 600 mm diameter will be acceptable in lieu of comparable size square or rectangular access doors specified herein.
- 2. Complete with insulation, spin-in frame, inner door, attachment cable, gaskets, three latches, and pull ring.
- 3. Manufacturers:
 - a. Flexmaster, Inspector Series.

- C. Casing and Plenum Access Doors:
 - 1. Size: 1425 mm high by 600 mm wide minimum where possible.
 - 2. Complete with hardware, hinges, seals, and latch handles.
 - 3. Latch Handles: Ventlock, Series No. 260.
 - 4. Hinges: Venlock, Series No. 200 and No. 300.
- D. Manufacturers:
 - 1. Ventlock.
 - 2. Flexmaster.
 - 3. Duro-Dyne.

2.21 MANUAL DAMPERS

- A. Butterfly Manual Dampers:
 - 1. Fabricate from two gauges heavier than duct in which installed, of same material as ductwork.
 - 2. Align operating handle with damper blade.
 - 3. Provide 50 mm standoff bracket for insulated duct systems.
 - 4. Damper Manufacturers:
 - a. Ruskin.
 - b. American Warming and Ventilating.
 - 5. Operator Manufacturers:
 - a. Accessible Ductwork: Ventlok; Type 620 or 635.
 - b. Accessible Insulated Ductwork: Ventlok; Type 639.
 - c. Concealed Ductwork: Ventlok; Type 677 with extended operating rod and concealed regulator with plain cover.
- B. Manual Opposed-Blade Balancing Dampers:
 - 1. Externally operated gang airfoil, damper blades.
 - 2. Fabricate from same material as ductwork.
 - 3. Stainless steel or nylon sleeve bearings.
 - 4. Construction shall have interlocking edges and maximum 250 mm blade width.
 - 5. Manufacturers and Products:
 - a. Ruskin; CD102.
 - b. American Warming & Ventilating; Model VC-31.

2.22 BACK DRAFT DAMPERS

- A. General:
 - 1. Damper pressure drop ratings shall be based on tests and procedures performed in accordance with AMCA 500.
- B. Steel Frame, Nonmetallic Blades:
 - 1. Fabrication:
 - a. Frame: 2 inches by minimum 51 mm by minimum 1.6 mm galvanized steel with windstops to reduce backflow.
 - b. Blades:
 - 1) Style: Single piece, independent.

- 2) Action: Parallel.
 - 3) Material: Noncombustible, neoprene coated fiberglass.
 - 4) Orientation: Horizontal.
 - 5) Width: Maximum 152 mm.
 - c. Rear Bird Screen: Galvanized expanded metal.
 - d. Mounting:
 - 1) Suitable for mounting in vertical or horizontal airflow up positions.
 - 2) Configured for positions as shown on Drawings.
 - e. Finish: Factory applied air-dried epoxy paint on steel damper parts.
 2. Performance Data:
 - a. Temperature Rating: Withstand minus minus 34 degrees to 93 degrees C.
 - b. Maximum Back Pressure: 1.0 kPa.
 - c. Maximum System Air Velocity: 5.1 m/s.
 - d. Maximum Spot Air Velocity: 6.1 m/s.
 3. Manufacturers and Products:
 - a. Ruskin; Model NMS2.
 - b. Vent Products, Co.
- C. Aluminum, Counterbalanced, Heavy Duty:
1. Fabrication:
 - a. Frame: 57 mm by minimum 3.2 mm 6063-T5 extruded aluminum channel with front flange and rear flange and galvanized steel braces at mitered corners.
 - b. Blades:
 - 1) Style: Single piece, overlap frame.
 - 2) Action: Parallel.
 - 3) Orientation: Horizontal.
 - 4) Material: Minimum 1.8 mm 6063-T5 extruded aluminum.
 - 5) Width: Maximum 152 mm.
 - c. Bearings: Corrosion-resistant, long-life, synthetic, formed as single piece with axles.
 - d. Blade Seals: Extruded vinyl, mechanically attached to blade edge.
 - e. Linkage: Minimum 13 mm aluminum tie bar with stainless steel pivot pins mounted on blades.
 - f. Axles: Corrosion-resistant, long-life, synthetic, locked to blade and formed as single piece with bearings.
 - g. Counterbalances: Adjustable zinc plated steel weights mechanically attached to blade enabling damper to operate over wide range of pressures.
 - h. Mounting:
 - 1) Suitable for mounting in vertical, horizontal airflow up, and horizontal airflow down positions.
 - 2) Configured for positions as shown on Drawings.
 - i. Finish: Factory applied air-dried epoxy paint on all damper parts.

2. Performance Data:
 - a. Temperature Rating: Withstand minus 40 to 93 degrees C.
 - b. Maximum Back Pressure: 4 kPa.
 - c. Maximum Air Velocity: 12.7 m/s.
 - d. Operation of Blades:
 - 1) Start to Open: 2.5 Pa.
 - 2) Fully Open: 12.5 Pa.
 - e. Pressure Drop: Maximum 38 Pa at 7.6 m/s through 600 mm by 600 mm damper.
3. Manufacturer and Product: Ruskin; Model CBD6.

2.23 FIRE DAMPERS

- A. Duct Mounted Fire Dampers in Fire Walls with Rating of 2 Hours or Less:
 1. NFPA 90A rated for 1-1/2-hour service.
 2. Blades, frame, and mounting angles same material as ductwork.
 3. Accordion style folded blades.
 4. 74 degrees C fusible link.
 5. Approved for installation with 2-hour fire rating.
 6. Rated, manufactured, tested, and approved in accordance with UL 555.
 7. Blades out of airstream when open (Type B or CR) except as noted on the drawings.
 8. Furnish with sleeved frame for duct connections.
 9. Labeled for use in static mode.
 10. Furnish dynamic and horizontal mounted dampers with springs for proper closure.
 11. Corrosive Service Dampers: Type 316 stainless steel.
 12. Manufacturers and Products:
 - a. Nailor-Hart; Model 0120, Type B, Model 0130, Type CR.
 - b. Ruskin; IBD20.
 - c. Price; model FD, style B and C, Model FDD; style B and C.
- B. Duct Mounted Fire Dampers in Walls with 3-Hour or Greater Fire Rating:
 1. NFPA 90A rated for 3-hour service.
 2. Blades, frame, and mounting angles.
 3. Accordion style folding blades. Air foil type blades for multiblade dampers.
 4. 74 degrees C fusible link.
 5. Approved for installation in 4-hour wall.
 6. Rated, manufactured, tested, and approved in accordance with UL 555.
 7. Blades out of airstream when open (Type B).
 8. Furnish with sleeved frame for duct connection.
 9. Labeled for use in static mode.
 10. Furnish dynamic and horizontal mounted dampers with springs for proper closure.
 11. Corrosive Service Dampers: Type 316 stainless steel.
 12. Manufacturers and Products:
 - a. Nailor-Hart; Model 0520, Type B, Model 0530, Type CR.

- b. Ruskin; IBD230.
 - c. Price; model FD, style B and C, Model FDD; style B and C.
- C. Ceiling Grille and Diffuser Fire Dampers:
- 1. UL Listed assembly with frame.
 - 2. Butterfly type blades.
 - 3. 74 degrees C fusible link.
 - 4. Radiation type damper.
 - 5. Manufacturers and Products:
 - a. Nailor-Hart; Model 0722 or 0716.
 - b. Ruskin; Type CFD Series.
 - c. Price; model CD.

2.24 CONTROL DAMPERS (INDOOR ONLY)

- A. General:
- 1. Specification applies to control dampers, except those specified to be furnished with equipment.
 - 2. Furnish opposed-blade type for proportional action and parallel-blade type for two-position action, except where indicated otherwise.
- B. Heavy Duty Control Dampers (M):
- 1. Frame:
 - a. 203 mm by 51 mm by minimum 2 mm channel.
 - b. Bolt Holes: Both flanges.
 - c. Material: As scheduled in Control Damper Schedule, Article Supplements.
 - 2. Blades:
 - a. Style: Airfoil-shaped, double-skin.
 - b. Orientation: Horizontal or vertical with thrust washers, as indicated on Drawings.
 - c. Minimum 14 gauge (2 mm) equivalent thickness.
 - d. Material: As scheduled in Control Damper Schedule, Article Supplements.
 - e. Width: 127 mm to 203 mm maximum.
 - 3. Bearings: Stainless steel sleeve pressed into frame.
 - 4. Seals:
 - a. Blade Seals: EPDM blade seals, maximum 121 degrees C. Mechanically attached to blade edge.
 - b. Jamb Seals: Compressible stainless steel located between blade edge and jamb.
 - 5. Linkage:
 - a. Side linkage out of airstream.
 - b. Constructed of minimum 10-gauge (3.5-mm) galvanized steel clevis arms with minimum 4.8 mm by 19 mm plated steel tie bars pivoting on minimum 9.5-mm diameter stainless steel pivot pins with lock-type retainers.

6. Axles:
 - a. Minimum 12 mm diameter, hex-shaped, mechanically attached to blade.
 - b. Material: Type 316 stainless steel.
7. Performance Data: As follows:
 - a. Maximum Operating Temperature: 121 degrees C.
 - b. Maximum System Pressure: 2.5 kPa.
 - c. Maximum System Velocity: 1,219 meter per minute.
 - d. Leakage with Seals: Based on pressure differential of 0.25 kPa.
 - 1) Percent of Maximum Flow: 0.10.
 - 2) Leakage: 1.2 cubic meters per minute per square meters.
8. Accessories: As follows:
 - a. Actuator: Refer to Article Control Damper Operators, for requirements.
 - b. Switch Package: Two-position indicator switches linked directly to damper blade to remotely indicate damper blade position.
9. Manufacturers and Products:
 - a. Ruskin; Model CD-80AF, Model CDR82 (for round damper).
 - b. American Warming and Ventilating.
 - c. TAMCO.

2.25 CONTROL DAMPER OPERATORS (INDOOR ONLY)

- A. General:
 1. Drawings and Control Diagrams indicate only one damper motor for each motorized damper (M).
 2. Select actual quantity of motors required to operate each damper in accordance with size of damper provided.
 3. Coordinate exact quantity of damper motors with electrical work to ensure that necessary wiring and conduit is provided for installation.
 4. Provide operators for motorized dampers and motorized louvers.
- B. Electric Damper Operators:
 1. Performance: As scheduled in Motorized Damper Schedule, Article Supplements.
 2. Mounting: External side plate.
 3. Ample power to overcome friction of damper linkage and air pressure acting on damper blades.
 4. Furnished with external adjustable stops to limit stroke.
 5. Operators on modulating dampers that are to be sequenced with other control devices shall have full relay type pilot positioner and interconnecting linkage to provide mechanical feedback that will accurately position and control damper.
 6. Intake, relief, and exhaust dampers shall close and return dampers shall open on control failure, unless indicated otherwise.
 7. Operating Torque:
 - a. Provide multiple independent damper sections, each with separate actuator, as needed to provide minimum of 120 percent of operating torque required by damper(s).

- b. Required damper operating torque for actuator sizing calculations shall include friction of damper linkage and 200 Pa air pressure on damper blades:
 - 1) Opposed-Blade Dampers: Minimum 6 Nm per square meter of damper area, unless higher values are recommended by damper manufacturer.
 - 2) Parallel-Blade Dampers: Minimum 8.5 Nm per square meter of damper area, unless higher values are recommended by damper manufacturer.
- 8. All modulating damper actuators shall have 4-20 mA control and feedback signal. Refer to P&ID drawings for details.
- 9. Manufacturers:
 - a. Siemens Building Technologies, Open Air GCA Series.
 - b. Belimo.
 - c. Johnson Controls.
 - d. Honeywell.

2.26 CONTROL DAMPER (OUTDOOR AND ODOUR DUCT)

- A. General:
 - 1. Dampers to be AMCA certified low leak per standard 500-D-97.
- B. Construction:
 - 1. Damper frame to be constructed of 200 mm by 50 mm by 14 gauge 316 stainless steel.
 - 2. Blades are to be 16 gauge airfoil profile with a maximum blade width 200 mm. The blade to be injected with a two part polyurethane (CFC) free foam, and debridged for thermal isolation.
 - 3. Blade frame to have a mill finish.
- C. Linkage:
 - 1. Linkage to be concealed in 316 stainless steel 16 gauge cover to be mounted on the exterior of the jamb.
 - 2. The crank arm and linkage bar shall be a flat plate welded 316 stainless steel.
- D. Bearings:
 - 1. Bearings to be Teflon sleeve type rated for minus 40 degrees C to plus 93.3 degrees C.
- E. Shaft:
 - 1. Shaft to be 12 mm diameter 316 stainless steel, full length.
- F. Seals:
 - 1. Blades to have extreme low temperature seal system of extruded silicone rubber edge seal with a 316 stainless steel seal at jambs.
 - 2. The temperature ratings for the seal to be minus 40 degrees C to plus 93.3 degrees C.

- G. Manufacturer:
1. AWV; Model V421.
 2. Arrow.

2.27 DAMPER ACTUATOR (OUTDOOR ONLY)

- A. General:
1. Drawings and Control Diagrams will indicate the required operation of damper actuators and their hazardous area rating (Class 1, Zone 1).
 2. It is the responsibility of the Contractor under this Section to determine and include for the total number and service of damper actuators required.
 3. Coordinate quantity and type of damper motors with electrical work to ensure that necessary wiring and conduit is provided for installation.
 4. Provide actuators for motorized dampers and motorized louvers.
- B. Actuators:
1. Provide actuators with a power supply that is suitable and self-adaptable to 24-240 VAC/VDC power sources, 100 percent overload protected.
 2. The actuator to have aluminum housing NEMA 8 for HRC Facility and NEMA 4X for Chemical Facility with a 985 mm cable. Actuator housing must also allow for direct mounted to dampers via manufacturer approved coupling and be rated for hazardous area installation without the use of a separate, cast metal, bolted enclosure. Damper actuator to include expolar heating system complete with explosion proof heater, control thermostat, terminal box, insulated stainless steel enclosure and stainless steel cable protection.
 3. Damper to include a mechanical, spring-return mechanism for failsafe operation with an option for fast acting spring return speed (3 to 10 seconds). Actuator parameters such as run time, torque and spring return speed shall be fully adjustable and programmable by means of DIP switch programming stick.
 4. Visual position indication must be visible on actuator face at all times.
 5. The actuator is to be rated for minus 40 degrees C, plus 40 degrees C with an integral heater.
 6. Actuator Model: ExMax, CSA, UL certified.
 7. Acceptable Manufacturers: Schischek by Rotork Controls (Canada) Ltd.

2.28 SOUND ATTENUATORS

- A. Packed Type:
1. Fabricate from not less than 22-gauge sheet metal of same material as ductwork.
 2. Furnish perforated interior partitions with moisture-resistant mineral fiber carrying an NFPA 255 Flame Spread Index of no greater than 20.
 3. Pressure rated airtight at 1500 Pa.
 4. Furnish vapor barrier lining on inside face of sound trap.
 5. Size and Performance: As indicated on Sound Attenuator Schedule.
 6. Manufacturers:
 - a. Industrial Acoustics Co.
 - b. Rink.

c. Vibro-Acoustics.

2.29 MISCELLANEOUS ACCESSORIES

- A. Sheet Metal Plenums:
1. Fabricate from minimum 18-gauge metal of same material as ductwork.
 2. Brace with frame of same material for rigidity.
 3. Line with sound attenuation material where indicated.
- B. Louver and Grille Blank-Off Sections:
1. Fabricate from 20-gauge sheets of same material as louver/grille.
 2. Line with sound attenuation/insulating material.
 3. Shop-prime and paint outside face of blank-off section with two coats of flat black exterior paint.
- C. Auxiliary Drain Pans:
1. Dimensions: Minimum 150 mm larger in both dimensions than equipment it is serving and 51 mm high, minimum.
 2. Construction: 16-gauge galvanized steel with brazed joints. Pans shall be watertight and have hemmed edges.
 3. Drain Connection:
 - a. Minimum 25 mm or as shown on Drawings.
 - b. Locate at lowest point of drain pan.
 - c. In lieu of drain connection, float switch may be installed. Float switch shall shut down air handling equipment upon sensing water.
- D. Prefabricated Roof Curb:
1. Lower section of roof curb that will be integrated with roofing system shall be constructed to accommodate roofing system provided.
 2. Top surface of curb shall have rubber weather-seal pad. Provide wooden nailer sections as required for installation.
 3. Sheet metal counterflashing shall be provided to accommodate rectangular or round ductwork.
 4. Sheet metal screws and rivets shall be stainless steel or coated with corrosion-resistant material.
 5. Height of roof curb shall be 305 mm, unless otherwise indicated herein or on Drawings.
 6. Length and width of roof curb shall be sized by Contractor for particular application.
 7. Manufacturer:
 - a. Factory fabricated by equipment manufacturer.
- E. Accessories Hardware:
1. Instrument Test Holes:
 - a. Cast metal, material to suit duct material, including screw cap and gasket and flat mounting gasket.
 - b. Size to allow insertion of pitot tube and other testing instruments.
 - c. Provide in length to suit duct insulation thickness.

2. Flexible Duct Clamps:
 - a. Stainless steel band with cadmium-plated hex screw to tighten band with worm-gear action.
 - b. Provide in sizes from 75 mm to 450 mm to suit duct size.
3. Adhesives: High strength, quick setting, neoprene based, waterproof and resistant to gasoline, and grease.

2.30 REMOVABLE INSECT SCREENS

A. General

Frame	- extruded aluminum channel, 65 mm x 18 mm
	- extruded aluminum angle, 40 x 25 x 3 mm screen frame retainers
Screen Retention Frame	- extruded aluminum with rubber retainer gasket
Insect Screen	- 18 x 14 mesh, .011 gauge, grade 304 stainless steel
Max. Section Size	- 1.5 m x 1.5 m

B. Mounting

Ducting Mounting	- "slide out" screen
	- rubber gasket around screen slot in frame
	- cast aluminum handle rigidly attached to screen retention frame. 2 handles per screen section
Face Mounting	- "lift and remove" screen
	- nylon finger pulls, 25 x 30 x 1.5 mm mounted in screen retention frame

- C. In locations where removable insect screen is associated with air control dampers, supply the two units as an integrated, factory assembled unit.
- D. Manufacturer
 1. T.A. Morrison & Company Inc. Series 6000.

2.31 DUCTWORK IDENTIFICATION

A. Painted Identification Materials:

1. 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 32 mm high letters for ductwork and not less than 20 mm high letters for access door signs and similar operational instructions.
2. Stencil Paint: Standard exterior type stenciling enamel; black, except as otherwise indicated; either brushing grade or pressurized spray can form and grade.

3. Identification Paint: Standard identification enamel of colors indicated or in accordance with ASME A13.1 for colors for systems not identified herein.
- B. Plastic Duct Markers
1. General: Provide manufacturer's standard laminated plastic, color coded duct markers. Conform to the following color code:
 - a. Black text on yellow background: Odorous Air.
 - b. White text on blue background: Services other than hazardous exhaust and odorous air.
 - c. For other hazardous exhausts, use colors and designs recommended by ASME A13.1.
- C. Nomenclature: Include the following:
1. Direction of air flow.
 2. Duct service (supply, return, exhaust).
 3. Duct origin (from).
 4. Duct destination (to).
 5. Design L/s.
- D. Manufacturers:
1. W.H. Brady, Co.
 2. Seton Identification Products.
 3. Craftmark.
 4. Brimar Industries, Inc.

PART 3 EXECUTION

3.1 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 3.2 mm 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 run 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 25 mm clearance between duct and sleeve, except at grilles, registers, and diffusers.
 - b. For insulated ducts, allow 25 mm clearance between insulation and sleeve, except at grilles, registers, and diffusers.
 3. Closure Collars:
 - a. Minimum 102 mm 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 152 mm 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 25 mm 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 indicated on Drawings.
 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.

3.2 RECTANGULAR DUCTWORK

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

3.3 RECTANGULAR DUCTWORK FITTINGS

- A. Use bell-mouth or conical tee fittings for round duct takeoffs from rectangular mains.
- B. Use 45-degree entry fittings conforming to SMACNA requirements for rectangular takeoffs from rectangular or round mains.
- C. Make offsets with maximum angle of 45 degrees.
- D. Use fabricated fittings for changes in directions, changes in size and shape, and connections.

3.4 RECTANGULAR DUCTWORK TRANSVERSE JOINTS

- A. Install each run with a minimum of joints.
- B. Install couplings tight to duct wall surface with projections into duct at connections kept to a minimum.
- C. Mechanical Joint Option:
 1. Construct transverse joints with Ductmate 25/35 duct connector systems, W.D.C.I. Heavy/Lite duct connector systems, or Ductlok J/E duct connector system.
 2. When using W.D.C.I. Heavy/Lite system, construct ductwork in accordance to the W.D.C.I. Heavy J and Light H Assembly Manual and Duct Construction Standards.
 3. 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.
 4. For longitudinal seams, use Pittsburgh lock seam sealed internally with permanently elastic sealer such as Ductmate 5511M mastic.
 5. Conform to SMACNA Class A sealing requirements.

3.5 RIGID ROUND DUCTWORK

- A. Except where interrupted by fittings, install round ducts in lengths not less than 3.6 meters.

3.6 RIGID ROUND DUCTWORK JOINTS

- A. Rigid round ductwork joints shall be in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible, unless otherwise specified.
- B. Single and Double Wall Supply and Return System Joints:
 - 1. Less than 900 mm: Slip coupling.
 - 2. Larger than 900 mm: Flanged connector, Van Stone, or welded companion flange type.
- C. Single and Double Wall Exhaust and Return System Joints:
 - 1. All Sizes, Spiral Seam Duct: Welded flanged connector.
 - 2. All Sizes, Longitudinal Seam Duct: Van Stone flange connector.

3.7 FIBERGLASS DUCTBOARD

- A. Grooves shall be modified ship-lap.
- B. Closure to be Therm-Lok or fiberglass fabric mesh and mastic.

3.8 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:
 - 1. Maximum length of low-pressure flexible duct (construction pressure class up to 500 Pa) to be 2400 mm.
 - 2. Maximum length of medium pressure flexible duct (construction pressure class up to 1000 Pa) to be 2400 mm.
- D. Flexible ductwork shall not pass through wall, floor, or fire resistant rated assembly.

3.9 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 610 mm of each elbow and within 1220 mm of each branch intersection.
- E. Support vertical ducts at maximum interval of 4880 mm 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.

3.10 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.

3.11 DAMPERS

- A. General:
 - 1. Inspection:
 - a. Inspect areas to receive dampers.
 - b. Notify Contract Administrator of conditions that would adversely affect installation or subsequent utilization of dampers.
 - c. Do not proceed with installation until unsatisfactory conditions are corrected.
 - 2. Install dampers at locations indicated on 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.

- D. Fire Dampers:
 - 1. At ceiling grille and diffuser fire dampers, provide thermal blankets where required by local authorities.
 - 2. Install 1-1/2-hour rated, unless otherwise indicated, at locations shown and in accordance with SMACNA Fire, Smoke, and Radiation Damper Installation Guide for HVAC Systems.

- E. Control Dampers:
 - 1. Install at locations indicated on Drawings and in accordance with manufacturer's instructions.
 - 2. Install square and free from racking with blades running horizontally.
 - 3. Operate opposed blade dampers from a power blade or drive axle.
 - 4. Bracing:
 - a. Install for multiple section assemblies to support assembly weight and to hold against system pressure.
 - b. Install at every horizontal and vertical mullion.

3.12 ACCESS DOORS

- A. Ceilings:
 - 1. Install in nonaccessible ceilings below each electric duct heater, booster coil, motorized damper, terminal unit, smoke detector, and fire damper.

- B. Ductwork: Install access doors in ductwork, in accordance with manufacturer's instructions, at each:
 - 1. Duct mounted fire damper.
 - 2. Duct mounted smoke or ionization detector.
 - 3. Electric duct heater.
 - 4. Booster coil.
 - 5. Humidifier.
 - 6. Motorized damper.
 - 7. Sail switch.
 - 8. Turning vane.
 - 9. Volume damper.
 - 10. Automatic damper.
 - 11. Temperature controller.
 - 12. Coil, on both upstream and downstream side.

3.13 SOUND ATTENUATORS

- A. Install where shown and in accordance with applicable SMACNA Manual and manufacturer's recommendations.
- B. Provide dielectric separation where attenuator material differs from connected duct system.

3.14 MISCELLANEOUS ACCESSORIES

- A. Auxiliary Drain Pans:
 - 1. Under equipment for which pan is shown on Drawings 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.
 - 4. Louver and Grille Blank-off Sections: Attach airtight to louver or grille and install to allow for easy removal.
- B. Prefabricated Roof Curb:
 - 1. Provide for ductwork roof penetrations and curb-mounted roof fans.
 - 2. Roof curb installation, including flashing and counterflashing, shall provide watertight weatherproof enclosure.
 - 3. Attach counterflashing to ductwork via rubber gasketed sheet metal screws.
 - 4. Fill space between counterflashing and ductwork with silicon-based sealant. Sealant shall also be applied at all sheet metal screw locations.
- C. 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.

3.15 DUCT SEALING

- A. Seal duct seams and joints as follows:
 - 1. In accordance with SMACNA requirements.
 - 2. In accordance with the following:
 - a. Pressure Classifications Greater than 750 Pa: Transverse joints, longitudinal seams, and duct penetrations.
 - b. Pressure Classification Between 500 Pa and 750 Pa: Transverse joints and longitudinal seams.
 - c. Pressure Classification Less than 500 Pa: Transverse joints only.
- 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 leak.

3.16 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.

3.17 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.

END OF SECTION