SECTION 233113 – HVAC DUCT SYSTEMS AND ACCESSORIES

Latest Update: 09-05-2025 See Underlined Text for Edits

(Engineer shall edit specifications and blue text in header to meet project requirements. This includes but is not limited to updating Equipment and/or Material Model Numbers indicated in the specifications and adding any additional specifications that may be required by the project. Also turn off all "Underlines".)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section and all other sections of Division 23.

1.2 SUMMARY

A. This section includes the requirements for HVAC Duct Systems and related accessories as follows: <Delete items and equipment not included in project>.

1. Sheet metal materials.
2. Sealants and gaskets.
3. Single-wall rectangular ducts and fittings.
4. Single-wall round <and flat-oval> ducts and fittings
5. Double wall rectangular ducts and fittings.
6. Double-wall round <and flat-oval> ducts and fittings.
7. Duct liner.
8. Hangers and supports.
9. Seismic-restraint devices.
10. Backdraft dampers.
11. Manual volume dampers.
12. Remote Manual Volume Damper Operator.
13. Fire dampers.
14. Ceiling radiation dampers.
15. Smoke dampers.
16. Combination fire and smoke dampers.
17. Duct-mounted access doors.
18. Duct silencers.
19. Flexible connectors.
20. Flexible ducts

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems." <Delete seismic if not required>

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

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 ACTION SUBMITTALS

A. Product Data: For each specified product, include manufacturers cut sheets, dimensional data, performance data, installation instructions, wirings diagrams, power requirements, specified options, and warranty information.

B. For each type of the following products:

1. Construction details for ductwork and fittings.
2. Liners and adhesives.
3. Sealants and gaskets.
4. Seismic-restraint devices.

C. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
3. Retain first subparagraph below if leak testing is retained in "Field Quality Control" Article.
4. Leakage Test Report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1, Section 6.4.4.2.2 - "Duct Leakage Tests."
   <Retain paragraph below if retaining "Duct Cleaning" Article.>
5. Duct-Cleaning Test Report for Prerequisite IEQ 1: Documentation of work performed for compliance with ASHRAE 62.1, Section 7.2.4 - "Ventilation System Start-up."

6. "Product Data for Credit IEQ 4.1" Subparagraph below applies to LEED-NC, LEED-CI, and LEED-CS; coordinate with requirements for adhesives and sealants.
7. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
8. "Laboratory Test Reports for Credit IEQ 4" Subparagraph below applies to LEED for Schools.
9. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. Shop Drawings: <Delete if not required for project>.

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment< seismic restraints,> and vibration isolation.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:

a. Lighting fixtures.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.
f. Perimeter moldings.

B. Welding certificates.

C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTAL

A. Operation and Maintenance Data: Include a copy of each approved submittal along with any applicable maintenance data in the project operation and maintenance manual.

1.7 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

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

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

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

1.8 WARRANTY/GUARANTEE

A. See Division 23 Specification Section “Basic Mechanical Requirements – HVAC” for warranty and guarantee requirements.

PART 2 - PRODUCTS

2.1 GENERAL PRODUCT REQUIREMENTS

A. Material Design and Selection: HVAC Duct Systems and Accessories shall be designed and selected, for the intended use, in accordance with the sizes on the drawings and the requirements of this specification. All sizes indicated on construction documents

represent clear inside dimensions for all ductwork and plenums. If ductwork requires duct liner increase the size of the duct on each side by the thickness of the duct liner to retain/provide the indicated clear inside dimensions of the ductwork and plenums.

1. Example Based on One (1) Inch Duct Liner: 12 inch x 12 inch duct with one (1) inch duct liner will require a 14 inch x 14 inch duct to retain the clear inside dimension of 12 inches x 12 inches.

2.2 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. PVC-Coated, Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.
2. Minimum Thickness for Factory-Applied PVC Coating: 4 mils thick on sheet metal surface of ducts and fittings exposed to corrosive conditions, and minimum 2 mil thick on opposite surface.
3. Coating Materials: Acceptable to authorities having jurisdiction for use on ducts listed and labeled by an NRTL for compliance with UL 181, Class 1.

D. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

E. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

F. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

G. Factory- or Shop-Applied Antimicrobial Coating: <Edit for Project>

1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.

2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
4. Surface-Burning Characteristics: Maximum flame-spread index of twenty five (25) and maximum smoke-developed index of fifty (50) when tested according to UL 723; certified by an NRTL.
5. Shop-Applied Coating Color: [Black] [White].
6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.

H. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

I. Tie Rods: Galvanized steel, one quarter (1/4) inch minimum diameter for lengths thirty six (36) inches or less; three eights (3/8) inch minimum diameter for lengths longer than thirty six (36) inches.

2.3 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of twenty five (25) and a maximum smoke-developed index of fifty (50) when tested according to UL 723; certified by an NRTL.

B. Two (2) Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: Three (3) inches.
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: Ten (10) inch wg. positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: - 40°F to +200°F.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

11. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65%.
3. Shore A Hardness: Minimum Twenty (20).
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: Ten (10) inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: Twenty five (25).
5. Use: O.
6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

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

F. Round Duct Joint O-Ring Seals:

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

G. Duct Connection Joint Sealant: For renovation projects where new ductwork connects to existing ductwork provide the following material as a joint sealer between the new and existing duct surfaces:

1. Permatite, Butyl gray non curing tape of sufficient width to seal the duct joints. Material can be purchased from the manufacturer or from Grainger using the either the manufacturers model number DS5285, or the Grainger item number 2EJR3. Seal the external joints as required by these specifications and the ductwork can be placed in service.

2.4 SINGLE WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. Crossbreaking or Cross Beading: Crossbreak or bead duct sides that are nineteen (19) inches and larger and are 20 gauge or less, with more than ten (10) sq. ft. of unbraced panel area, as indicated in SMACNA "HVAC Duct Construction Standard," Figure 1-4, unless they are lined or are externally insulated.

2.5 SINGLE WALL ROUND [AND FLAT-OVAL] DUCTS AND FITTINGS <Delete Flat Oval if not used in project>

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

   a. Lindab Inc.
   b. McGill AirFlow LLC.
   c. SEMCO Incorporated.
   d. Sheet Metal Connectors, Inc.
   e. Spiral Manufacturing Co., Inc.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

   1. Transverse Joints in Ducts Larger Than sixty (60) Inches in Diameter: Flanged.

D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

   1. Snaplock seams are prohibited.

   2. Fabricate round ducts larger than ninety (90) inches in diameter with butt-welded longitudinal seams.
   3. Fabricate flat-oval ducts larger than seventy two (72) inches in width (major dimension) with butt-welded longitudinal seams.

E. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

F. Elbows: Fabricate in die-formed, gored, pleated, or mitered construction. Fabricate the bend radius of die-formed, gored, and pleated elbows one and one half (1.5) times the elbow diameter. Unless elbow construction type is indicated, provide elbows meeting the following requirements:

G. Mitered Elbows: Fabricate mitered elbows with welded construction in gauges specified below:

1. Mitered Elbows Radius and Number of Pieces: Unless otherwise indicated, construct elbow to comply with SMACNA "HVAC Duct Construction Standards," Table 3-1.
2. Round Mitered Elbows: Solid welded and with metal thickness listed below for pressure classes from minus two (2) inches to plus two (2) inches:

    a. Three (3) inches to twenty six (26) inches: 24 gauge.
    b. Twenty seven (27) inches to thirty six (36) inches: 22 gauge.
    c. Thirty seven (37) inches to fifty (50) inches: 20 gauge.
    d. Fifty two (52) inches to sixty (60) inches: 18 gauge.
    e. Sixty two (62) inches to eighty four (84) inches: 16 gauge.

H. Round Mitered Elbows: Solid welded and with metal thickness listed below for pressure classes from two (2) inches to ten (10) inches:

1. Three (3) inches to fourteen (14) inches: 24 gauge.
2. Fifteen (15) inches to twenty six (26) inches: 22 gauge.
3. Twenty seven (27) inches to fifty (50) inches: 20 gauge.
4. Fifty two (52) inches to sixty (60) inches: 18 gauge.
5. Sixty two (62) inches to eighty four (84) inches: 16 gauge.

I. Flat Oval Mitered Elbows: Solid welded and with the same metal thickness as longitudinal seam flat oval duct.

J. 90-Degree, Two (2) Piece, Mitered Elbows: Use only for supply systems, or exhaust systems for material handling classes A and B, and only where space restrictions do not permit the use of one and one half (1.5) bend radius elbows. Fabricate with a single-thickness turning vanes.

K. Round Elbows – Eight (8) Inches and Smaller: Die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate nonstandard bend angle configurations or one half (1/2) inch-diameter (e.g. 3-1/2- and 4-1/2-inch) elbows with gored construction.

L. Round Elbows – Nine (9) Inches Through Fourteen (14) Inches: Gored or pleated elbows for 30, 45, 60, and 90 degrees, except where space restrictions require a mitered elbow. Fabricate nonstandard bend angle configurations or 1/2-inch-diameter (e.g. 9-1/2- and 10-1/2-inch) elbows with gored construction.

M. Round Elbows - Larger Than Fourteen (14) Inches and All Flat Oval Elbows: Gored elbows, except where space restrictions require a mitered elbow.

N. Die-Formed Elbows for Sizes through Eight (8) Inches and All Pressures: 20 gauge with two (2) piece welded construction.

O. Round Gored Elbows Gages: Same as for nonelbow fittings specified above.

P. Flat Oval Elbows Gages: Same as longitudinal seam flat oval duct.

Q. Pleated Elbows Sizes through Fourteen (14) Inches and Pressures through Ten (10) Inches: 26 gauge.

2.6 DOUBLE WALL RECTANGULAR DUCTS AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Lindab Inc.
2. McGill AirFlow LLC.
3. SEMCO Incorporated.
4. Sheet Metal Connectors, Inc.

B. Rectangular Ducts: Fabricate ducts with indicated dimensions for clear internal dimensions of the inner duct.

C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

1. Construct ducts of galvanized sheet steel unless otherwise indicated.
2. For ducts exposed to weather, construct outer duct of [Type 304] [Type 316] stainless steel indicated by manufacturer to be suitable for outdoor installation.

D. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. For ducts with longest side less than 36 inches (914 mm), select joint types in accordance with Figure 2-1.
2. For ducts with longest side 36 inches (914 mm) or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.
3. [Where specified for specific applications, all joints shall be welded.]

E. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." All longitudinal seams shall be Pittsburgh lock seams unless otherwise specified for specific application.

1. [Where specified for specific applications, all joints shall be welded.]

<Retain one of two "Interstitial Insulation" paragraphs below. If the objective of interstitial insulation includes achievement of both thermal performance and sound absorption, then ducts may need additional external insulation to achieve the thermal portion of the objective. See Section 230700 "Insulation for HVAC Systems and Equipment" for applicable duct insulation and installation requirements for external duct application.>

F. Interstitial Insulation: Fibrous-glass liner complying with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

<Retain "Maximum Thermal Conductivity" Subparagraph below to require thermal conductivity exceeding requirements in ASTM C1071. Retaining subparagraph may create a restrictive proprietary specification. Verify availability of performance with manufacturers.>

1. Maximum Thermal Conductivity: [0.27 Btu x in./h x sq. ft. x °F (0.039 W/m x K)] <Insert conductivity> at 75 °F (24 °C) mean temperature.
2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
3. Coat insulation with antimicrobial coating.
4. Retain subparagraph below for additional protection of airstream.
5. Cover insulation with polyester film complying with UL 181, Class 1.

G. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C534/C534M, Type II for sheet materials, and with NFPA 90A or NFPA 90B.

1. Retain "Maximum Thermal Conductivity" Subparagraph below to require thermal conductivity exceeding requirements in ASTM C1071. Retaining subparagraph may create a restrictive proprietary specification. Verify availability of performance with manufacturers.
2. Maximum Thermal Conductivity: [0.25 Btu x in./h x sq. ft. x °F (0.034 W/m x K)] <Insert conductivity> at 75 °F (24 °C) mean temperature.

H. Inner Duct: Minimum 24-gauge (0.7-mm) [perforated galvanized sheet steel having 3/32-inch- (2.4-mm-) diameter perforations, with overall open area of 23%] [solid galvanized sheet steel].

2.7 DOUBLE-WALL ROUND [AND FLAT-OVAL] DUCTS AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Lindab Inc.
2. McGill AirFlow LLC.

3. SEMCO Incorporated.
4. Sheet Metal Connectors, Inc.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.

C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.

1. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

   a. Transverse Joints in Ducts Larger Than sixty (60) Inches in Diameter: Flanged.

2. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

   a. Fabricate round ducts larger than ninety (90) inches in diameter with butt-welded longitudinal seams.
   b. Fabricate flat-oval ducts larger than seventy two (72) inches in width (major dimension) with butt-welded longitudinal seams.

3. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Inner Duct: Minimum 0.028-inch [perforated galvanized sheet steel having 3/32-inch-diameter perforations, with overall open area of 23%] [solid sheet steel].

E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x °F at 75°F mean temperature.

2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
3. Coat insulation with antimicrobial coating.
4. Cover insulation with polyester film complying with UL 181, Class 1.

2.8 DUCT LINER

A. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. CertainTeed Corporation; Insulation Group.
b. Johns Manville.
c. Knauf Insulation.
d. Owens Corning.
e. Maximum Thermal Conductivity:

1) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x °F at 75°F mean temperature.

2. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. [Solvent] [Water]-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.

a. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
b. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Aeroflex USA Inc.
b. Armacell LLC.
c. Rubatex International, LLC

2. Surface-Burning Characteristics: Maximum flame-spread index of twenty five (25) and maximum smoke-developed index of fifty (50) when tested according to UL 723; certified by an NRTL.
3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

    a. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
    b. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-diameter shank, length to suit depth of insulation indicated with integral one and one half (1-1/2) inch galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-(0.41-mm-) thick galvanized steel with beveled edge sized as required to hold insulation securely in place but not less than one and one half (1-1/2) inches in diameter.

D. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2,500 fpm.
7. Secure liner with mechanical fasteners four (4) inches from corners and at intervals not exceeding twelve (12) inches transversely; at three (3) inches from transverse joints and at intervals not exceeding eighteen (18) inches longitudinally.

8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

   a. Fan discharges.
   b. Intervals of lined duct preceding unlined duct.
   c. Upstream edges of transverse joints in ducts where air velocities are higher than 2,500 fpm or where indicated.

9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.

   a. Sheet Metal Inner Duct Perforations: 3/32-inch diameter, with an overall open area of 23%.

10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.9 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

   1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
   2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.

3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.10 SEISMIC-RESTRAINT DEVICES <Delete if not a project requirement>

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Cooper B-Line, Inc.; a division of Cooper Industries.
2. Ductmate Industries, Inc.
3. Hilti Corp.
4. Kinetics Noise Control.
5. Mason Industries.
6. Unistrut Corporation; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

D. Restraint Cables: ASTM A 603, galvanized-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

F. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.11 BACKDRAFT DAMPERS <Edit damper selections based on system velocity, temperature rating, and intake or exhaust duty.>

A. Light to Medium Duty (1,000 to 1,500 FPM maximum velocity)

1. Basis-of-Design Product: Subject to compliance with requirements, Ruskin BD2/A1 and Ruskin BD2/A2 or comparable product by one (1) of the following:

a. American Warming and Ventilating; a division of Mestek, Inc.

b. Greenheck Fan Corporation.
c. Ruskin Company.

2. Description: Gravity balanced.
3. Operation Pressure: BD2A1 blades open at 0.03 in. wg. and are fully open at 0.10 inch wg. BD2A2 blades open at 0.10 inch wg. and are fully open at 0.15 inch w.g.
4. Frame: Hat-shaped, 0.090-inch-thick extruded aluminum, with mitered corners.
5. Blades: (1000 FPM maximum velocity) -. Ruskin BD2/A1, 0.025 inch formed aluminum, extruded vinyl edge seals. (1,500 FPM maximum velocity) - Ruskin BD2/A2, 6063T5 extruded aluminum, 0.050 inch wall thickness, extruded vinyl edge seals.
6. Blade Action: Parallel.
7. Blade Seals: Extruded vinyl, mechanically locked.
8. Blade Axles:

   a. Material: Nonferrous metal.
   b. Diameter: 0.20 inch.

9. Return Spring: Adjustable tension.
10. Bearings: synthetic pivot bushings.
11. Accessories:

    a. Electric actuators. <Where indicated.>
    b. Screen Mounting: Rear mounted.
    c. Screen Material: Galvanized steel.
    d. Screen Type: Bird.

B. Heavy Duty Backdraft Dampers (1,500 to 2,500 FPM maximum velocity)

1. Basis-of-Design Product: Subject to compliance with requirements, Ruskin BDG or comparable product by one (1) of the following:

   a. American Warming and Ventilating; a division of Mestek, Inc.
   b. Greenheck Fan Corporation.
   c. Ruskin Company.

2. Description: Gravity balanced.
3. Operation Pressure: Blades open at 0.12 inch wg. And are fully open at .20 inch wg.
4. Frame: Hat-shaped, 0.0125-inch-thick extruded aluminum, with galvanized steel braced corners.
5. Blades: Extruded aluminum 0.070 inch wall thickness.
6. Blade Action: Parallel.
7. Blade Seals: Extruded vinyl mechanically locked.
8. Blade Axles:

a. Material: Nonferrous metal.
b. Diameter: 0.20 inch.

9. Tie Bars and Brackets: Aluminum.
10. Return Spring: Adjustable tension.
11. Bearings: synthetic pivot bushings.
12. Accessories:

a. Electric actuators. <Where indicated.>
b. Adjustable static pressure control.
c. Screen Mounting: Rear mounted.
d. Screen Material: Galvanized steel.
e. Screen Type: Bird.

C. Counterbalanced Backdraft Dampers

1. Basis-of-Design Product: Subject to compliance with requirements, provide Ruskin CBD2 or comparable product by one (1) of the following:

a. American Warming and Ventilating; a division of Mestek, Inc.
b. Greenheck Fan Corporation.
c. Ruskin Company.

D. Description: Gravity balanced.

E. Maximum System Pressure: Max0.04 inch wg. at 1,000 feet per minute

F. Frame: Hat-shaped, 0.090-inch- thick, extruded aluminum, with welded corners or mechanically attached and mounting flange.

G. Blades: Multiple single-piece blades, maximum 6-inch width, 0.025-inch-thick, roll-formed aluminum with sealed edges.

H. Blade Action: Parallel.

I. Blade Seals: Extruded vinyl, mechanically locked.

J. Blade Axles:

1. Material: Synthetic
2. Diameter: 0.20 inch.

K. Tie Bars and Brackets: Aluminum.

L. Return Spring: Adjustable tension.

M. Bearings: synthetic pivot bushings.

N. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.

2.12 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Ruskin Model No. CD36 or comparable product by one (1) of the following:

   a. American Warming and Ventilating; a division of Mestek, Inc.
   b. Greenheck Corporation.
   c. Ruskin Company.

2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames:

   a. Frame: Hat-shaped, 0.094-inch- thick, galvanized sheet steel.
   b. Mitered and welded corners.
   c. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

   a. Multiple blade with three longitudinal grooves for reinforcement.
   b. Parallel or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Galvanized-steel, 0.064 inch thick.

6. Blade Axles: Galvanized steel.
7. Bearings:

   a. Molded synthetic.
   b. Dampers in ducts with pressure classes of three (3) inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Galvanized steel.

B. Low-Leakage, Steel, Manual Volume Dampers:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Ruskin Model No. CD60 or comparable product by one (1) of the following:

   a. American Warming and Ventilating; a division of Mestek, Inc.
   b. Greenheck Corporation.
   c. Ruskin Company.

2. Comply with AMCA 500-D testing for damper rating.
3. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
4. Suitable for horizontal or vertical applications.
5. Frames:

    a. Hat shaped.
    b. 0.094-inch-thick, galvanized sheet steel.
    c. Mitered and welded corners.
    d. Flanges for attaching to walls and flangeless frames for installing in ducts.

6. Blades:

    a. Multiple blade six (6) inch wide.
    b. Parallel or opposed-blade design.
    c. Stiffen damper blades for stability.
    d. Galvanized, roll-formed steel, 0.064 inch thick.

7. Blade Axles: Galvanized steel.
8. Bearings:

    a. Molded synthetic.
    b. Dampers in ducts with pressure classes of three (3) inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

9. Blade Seals: Neoprene.
10. Jamb Seals: Cambered stainless steel.
11. Tie Bars and Brackets: Galvanized steel.
12. Accessories:

    a. Include locking device to hold single-blade dampers in a fixed position without vibration.

C. Low-Leakage, Aluminum, Manual Volume Dampers:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Ruskin Model CD50 or comparable product by one (1) of the following:

    a. American Warming and Ventilating; a division of Mestek, Inc.
    b. Greenheck Corporation.
    c. Ruskin Company.

2. Comply with AMCA 500-D testing for damper rating.
3. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
4. Suitable for horizontal or vertical applications.

5. Frames: Hat-shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
6. Blades:

    a. Multiple 6 inch wide.
    b. Parallel- or opposed-blade design.
    c. Roll-Formed Aluminum Blades: 0.10-inch-thick aluminum sheet.
    d. Extruded-Aluminum Blades: 0.050-inch-thick extruded aluminum.

7. Blade Axles: Galvanized steel.
8. Bearings:

    a. Molded synthetic.
    b. Dampers in ducts with pressure classes of three (3) inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

9. Blade Seals: Neoprene, replaceable.
10. Jamb Seals: Cambered stainless steel.
11. Tie Bars and Brackets: Galvanized steel.
12. Accessories:

    a. Include locking device to hold single-blade dampers in a fixed position without vibration.

D. Jackshaft:

1. Size: 0.5-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

E. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of three thirty second (3/32) inch- thick zinc-plated steel, and a three quarter (3/4) inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.13 REMOTE MANUAL VOLUME DAMPER OPERATOR <Delete if not required>

A. Remote Manual Volume Damper Operator: Provide remote volume dampers where required and/or where indicated on the drawings and details. Remote volume damper operators shall be Model 1200 Worm Gear Operator with Flex Shaft and Termination Mounting Bracket as manufactured by young regulator company or approved equal complying with the following:

1. Operator: Self-locking regulator designed for one half (1/2) inch round or three eights (3/8) inch damper shafts. Optional Model 1200- 1/4 is available for five sixteenths (5/16) inch round and one quarter (1/4) inch square damper shafts. Contractor to coordinate with manual damper types provided.

2. Flex Shaft: Flex steel shaft shall be a single wire wrapped with multi stranded layers of wire. Assembly shall be 0.250 inches in diameter with a brass finish and capable of delivering more than 50 lbs. of torque without damage. Shafts are available in one (1) foot, three (3) foot, six (6) foot and eight (8) foot lengths. Contractor shall include required lengths on the product submittal.

3. Termination PLBR: The flexible steel shaft shall be coupled to the worm gear operating shaft and terminated to the PLBR mounting bracket. Damper operation shall be by turning a Phillips head screw on the bracket.

2.14 FIRE DAMPERS

A. Static Type Fire Damper: <Edit for Project>

1. Basis-of-Design Product: Subject to compliance with requirements, provide Ruskin <IBDD2, IBD23 for three (3) hour rating> or comparable product by one (1) of the following:

   a. Air Balance Inc.; a division of Mestek, Inc.
   b. Ruskin Company.
   c. United Sheet Metal.

2. Type: <Static>; rated and labeled according to UL 555 by an NRTL.<Coordinate fire damper type with UMB>
3. Closing rating in ducts up to four (4) inch wg static pressure class and minimum 2000-fpm velocity.
4. Fire Rating: [One and one half (1-1/2)] [and] [Three (3)] hours.
5. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, four and seven eighth (4-7/8) inches wide, 20 gauge galvanized steel channel complete with integral 20 gauge galvanized steel sleeve with twelve (12) inch, fourteen (14) inch, or sixteen (16) inch length as required to suit wall construction. Sleeve may be omitted if wall thickness matches damper construction per UL 555.
6. Mounting Orientation: Vertical or horizontal as indicated.
7. Blades: Roll-formed, interlocking, 0.024-inch-thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.
8. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
9. Heat-Responsive Device: Replaceable, [165°F] [212°F] [285°F] rated, fusible links.

B. Dynamic Type Fire Damper: <Edit for Project>

1. Basis-of-Design Product: Subject to compliance with requirements, provide Ruskin <DIBD2, DIBD23 for three (3) hour rating> or comparable product by one (1) of the following:

   a. Air Balance Inc.; a division of Mestek, Inc.
   b. Ruskin Company.
   c. United Sheet Metal.

2. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.<Coordinate fire damper type with UMB>
3. Closing rating in ducts up to four (4) inch wg static pressure class and minimum 2,000-fpm velocity.
4. Fire Rating: [One and one half (1-1/2)] hours.
5. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, four and seven eight (4-7/8) inches wide, 20 gauge galvanized steel channel complete with integral 20 gauge galvanized steel sleeve with twelve (12) inch, fourteen (14) inch, or sixteen (16) inch length as required to suit wall construction. Sleeve may be omitted if wall thickness matches damper construction per UL 555.
6. Mounting Orientation: Vertical or horizontal as indicated.
7. Blades: Roll-formed, interlocking, 0.024-inch-thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.
8. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
9. Heat-Responsive Device: Replaceable, [165°F] [212°F] [285°F] rated, fusible links.

2.15 CEILING RADIATION DAMPERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide <Ruskin CFD2, CFD,3 CFDR3, CFDR3 OR CFD4> with 22 gauge construction or comparable product by one (1) of the following:

   a. Air Balance Inc.; a division of Mestek, Inc.
   b. Ruskin Company.
   c. United Sheet Metal.

B. General Requirements: <Edit for Project>

1. Labeled according to UL 555C by an NRTL.
2. Comply with construction details for tested floor- and roof-ceiling assemblies as indicated in UL's "Fire Resistance Directory."

C. Frame: 20 gauge galvanized sheet steel, round or rectangular, style to suit ceiling construction.

D. Blades: 20 gauge galvanized sheet steel with refractory insulation.

E. Heat-Responsive Device: Replaceable, [165°F] [212°F] rated, fusible links.

F. Fire Rating: [One (1)] [Two (2)] [Three (3)] hours.

G. Maximum Size: Twenty four (24) inches

H. Minimum Size: Four (4) inch x four (4) inch.

2.16 SMOKE DAMPERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Ruskin SDRS25 and SDS60 for round and square multiple blade models or comparable product by one (1) of the following:

1. Air Balance Inc.; a division of Mestek, Inc.
2. Ruskin Company.
3. United Sheet Metal.

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

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

D. Frame: Hat-shaped, 16 gauge, galvanized sheet steel, with welded or mechanically attached corners and mounting flange.

E. Blades: two (2) piece 14 gauge (round), one piece airfoil (square), thick, galvanized sheet steel.

F. Leakage: Class I.

G. Rated pressure and velocity: Four (4) inch wg. in the closed position and 3,500 FPM in the open position.

H. Blade Seals: Silicone edge type, mechanical fastened to the blade edge, for smoke seal to 450°F.

I. Bearings: Stainless steel, sleeve type.

J. Mounting Sleeve: Factory-installed, 0.05-inch- thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.

<Retain "Damper Motors" Paragraph below if damper actuators are part of smoke-damper assembly and are not specified in Section 230900 "Instrumentation and Control for HVAC.">

K. Actuator: Electric or pneumatic - actuator shall be specified and provided under Section "Building Automation System" for factory mounting during smoke damper fabrication. Each damper shall be provided with a blade position indicator linked directly to the damper blade to remotely indicate damper position to the ATC/Fire alarm system as required under system operating sequences in Section or as indicated. Damper and actuator shall be successfully factory cycled ten (10) times.

L. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Specification Section "Motor Requirements for HVAC Equipment."

M. Accessories: <Edit for Project>

1. Auxiliary switches for [signaling] [fan control] [or] [position indication].
2. Test and reset switches, damper mounted.

2.17 COMBINATION FIRE AND SMOKE DAMPERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Ruskin FSD60, FSD60-2, FSD60-3 or comparable product by one (1) of the following:

1. Air Balance Inc.; a division of Mestek, Inc.
2. Ruskin Company.
3. United Sheet Metal.

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

C. Closing rating in ducts up to four (4) inch wg static pressure class and minimum 2,000-fpm velocity.

D. Fire Rating: [One and one half (1-1/2)], [Three (3)] hours. <Edit for Project>

E. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel.

F. Heat-Responsive Device: Resettable, [165°F] [212°F] rated. <Edit for Project>

G. Actuator: Electric or pneumatic - actuator shall be specified and provided under Division 23 Specification Sections for the "Building Automation Systems" for factory mounting during smoke damper fabrication. Each damper shall be provided with a blade position indicator linked directly to the damper blade to remotely indicate damper position to the ATC/Fire alarm system as required under system operating sequences or as indicated Damper and actuator shall be successfully factory cycled ten (10) times. Each assembly shall be equipped with a controlled seven (7) to fifteen (15) second heat actuated release device allowing the damper to close and lock during test, smoke detection, power failure or fire conditions. Dampers shall be capable of automatic remote reset.

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

I. Vertical blades are available for special applications.

J. Blades: One piece air foil, 16 gauge, galvanized sheet steel.

K. Leakage: [Class I] [Class II]. <Edit for Project>

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

M. Mounting Sleeve: Factory-installed, 0.039-inch thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.

N. Master control panel for use in dynamic smoke-management systems.

O. Damper Motors: Two (2) position action.

P. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section "Common Motor Requirements for HVAC Equipment."

Q. Accessories: <Edit for Project>

1. Auxiliary switches for [signaling] [fan control] [or] [position indication].
2. Test and reset switches, damper mounted.

2.18 DUCT-MOUNTED ACCESS DOORS

A. Manufacturers: Subject to compliance with requirements provide products by one (1) of the following:

1. Air Balance, Inc.
2. Ruskin.
3. United Sheet Metal

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:

a. 22 gauge, double wall, rectangular.
b. Galvanized sheet metal with 1 inch thick fiberglass insulation.
c. Hinges and Latches: Continuous piano hinge and cam latches.
d. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

2.19 DUCT SILENCERS<Silencers for fume hood exhaust are specialized products. Do not use this spec. for fume hood systems>:

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Air Balance, Inc.
2. Ruskin Company.
3. United Sheet Metal.

B. General Requirements:

1. Factory fabricated.
2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding twenty five (25) and smoke-developed index not exceeding fifty (50) when tested according to ASTM E 84.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Shape:

1. Rectangular straight with splitters or baffles.
2. Round straight with center bodies or pods.
3. Rectangular elbow with splitters or baffles.
4. Round elbow with center bodies or pods.
5. Rectangular transitional with splitters or baffles.

D. Rectangular Silencer Outer Casing: ASTM A 653/A 653M, G90, galvanized sheet steel, 22 gauge.

E. Round Silencer Outer Casing: ASTM A 653/A 653M, G90, galvanized sheet steel.

1. Sheet Metal Thickness for Units up to twenty four (24) Inches in Diameter: 22 gauge.
2. Sheet Metal Thickness for Units twenty six (26) through forty (40) Inches in Diameter: 20 gauge.
3. Sheet Metal Thickness for Units forty two (42) through fifty two (52) Inches in Diameter: 18 gauge.
4. Sheet Metal Thickness for Units fifty four (54) through sixty (60) Inches in Diameter: 16 gauge.

F. Inner Casing and Baffles: ASTM A 653/A 653M, G90 galvanized sheet metal 22 gauge.

G. Connection Sizes: Match connecting ductwork unless otherwise indicated.

H. Principal Sound-Absorbing Mechanism:

1. Controlled impedance membranes and broadly tuned resonators without absorptive media.
2. Dissipative type with fill material.

    a. Fill Material: Moisture-proof nonfibrous material.
    b. Erosion Barrier: Polymer bag enclosing fill, and heat sealed before assembly.

I. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.

1. Joints: Lock formed and sealed or continuously welded.
2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
3. Reinforcement: Cross or trapeze angles for rigid suspension.

J. Accessories:

1. Factory-installed end caps to prevent contamination during shipping.
2. Removable splitters.

K. Source Quality Control: Test according to ASTM E 477.

1. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2,000 fpm face velocity.
2. Leak Test: Test units for airtightness at 200% of associated fan static pressure or six (6) inch wg. static pressure, whichever is greater
.

2.20 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements products by one (1) of the following:

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip three and one half (3-1/2) inches wide attached to two (2) strips of two and three quarter (2-3/4) inch wide, 0.028-inch thick, galvanized sheet steel or 0.032-inch thick aluminum sheets. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd.
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: - 40°F to + 200°F.

F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd.
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: - 50°F to + 250°F.

2.21 FLEXIBLE DUCTS <Select product for specific project>

A. Manufacturers: Subject to compliance with requirements provide products by one (1) of the following:

1. Flexmaster U.S.A., Inc.
2. McGill AirFlow LLC.
3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Insulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.

1. Pressure Rating: four (4) inch wg. positive and 0.5-inch wg. negative.
2. Maximum Air Velocity: 4,000 fpm.
3. Temperature Range: - 20°F to + 175°F.
4. Insulation R-Value: Comply with ASHRAE/IESNA 90.1.

C. Insulated, Flexible Duct: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.

1. Pressure Rating: Ten (10) inch wg. positive and one (1) inch wg. negative.
2. Maximum Air Velocity: 4,000 fpm.
3. Temperature Range: -20°F to + 210°F.
4. Insulation R-value: Comply with ASHRAE/IESNA 90.1.

D. Insulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.

1. Pressure Rating: Ten (10) inch wg. positive and one (1) inch wg. negative.
2. Maximum Air Velocity: 4,000 fpm.
3. Temperature Range: -20°F to + 210°F.
4. Insulation R-value: Comply with ASHRAE/IESNA 90.1.

E. Flexible Duct Connectors:

1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes three (3) inches through eighteen (18) inches, to suit duct size.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round [and flat-oval] ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of one (1) inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least one and one half (1-1/2) inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or No. 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 ADDITIONAL INSTALLATION REQUIREMENTS FOR COMMERCIAL HOOD EXHAUST DUCT

A. Install commercial hood exhaust ducts without dips and traps that may hold grease, and sloped at a minimum of 2% to drain condensation back to the hood.

B. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of twenty (20) feet in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings. Locate access panel on top or sides of duct a minimum of one and one half (1-1/2) inches from bottom of duct.

C. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

3.4 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.

2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than four (4) inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than four (4) inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within twenty four (24) inches of each elbow and within forty eight (48) inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of sixteen (16) feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.6 SEISMIC-RESTRAINT-DEVICE INSTALLATION <Delete if not applicable to project.>

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with [SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."] [ASCE/SEI 7.]

1. Space lateral supports a maximum of forty (40) feet o.c., and longitudinal supports a maximum of eighty (80) feet o.c.
2. Brace a change of direction longer than twelve (12) feet.

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.7 CONNECTIONS

A. Make connections to equipment with flexible connectors.

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.8 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Architectural Specification Sections "Exterior Painting" and/or "Interior Painting."

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:
    a. Supply Ducts with a Pressure Class of Two (2) Inch wg. or Higher: Test representative duct sections totaling no less than percent of total installed duct area for each designated pressure class.

b. Return Ducts with a Pressure Class of Two (2) Inch wg. or Higher: Test representative duct sections totaling no less than 50% of total installed duct area for each designated pressure class.
c. Exhaust Ducts with a Pressure Class of Two (2) Inch wg. or Higher: Test representative duct sections totaling no less than 50% of total installed duct area for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
6. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.10 DUCT CLEANING - EXISTING SYSTEMS

A. Clean existing duct system(s) before testing, adjusting, and balancing. See Division 23 Specification Section “HVAC Air Distribution System Cleaning” for requirements.

3.11 START UP

A. Air Balance: Comply with requirements in Division 23 Specification Section "Testing, Adjusting, and Balancing HVAC Systems."

3.12 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

1. Underground Ducts: Concrete-encased, [galvanized sheet steel] [PVC-coated, galvanized sheet steel with thicker coating on duct exterior] [stainless steel].

B. Supply Ducts:

1. Pressure Class: Positive three (3) inch wg.
2. Minimum SMACNA Seal Class: A.
3. SMACNA Leakage Class for Rectangular: 6.
4. SMACNA Leakage Class for Round and Flat Oval: 3.

C. Return Ducts:

1. Pressure Class: Positive or negative two (2) inch wg.
2. Minimum SMACNA Seal Class: B.
3. SMACNA Leakage Class for Rectangular: 12.
4. SMACNA Leakage Class for Round and Flat Oval: 6.

D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

    a. Pressure Class: Negative two (2) wg.
    b. Minimum SMACNA Seal Class: B if negative pressure, and A if positive pressure.
    c. SMACNA Leakage Class for Rectangular: 12.
    d. SMACNA Leakage Class for Round and Flat Oval: 6.

2. Ducts Connected to Commercial Kitchen Hoods: Comply with NFPA 96.

    a. Exposed to View: Type 304, stainless-steel sheet finish.
    b. Concealed: Type 304, stainless-steel sheet, No. 2D finish.
    c. Welded seams and joints.
    d. Pressure Class: Positive or negative two (2) wg.
    e. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
    f. SMACNA Leakage Class: 3.

3. Ducts Connected to Dishwasher Hoods:

    a. Type 304, stainless-steel sheet.
    b. Exposed to View: No. 4 finish.
    c. Concealed: No. 2D finish.
    d. Welded seams and flanged joints with watertight EPDM gaskets.
    e. Pressure Class: Positive or negative two (2) wg.
    f. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
    g. SMACNA Leakage Class: 3.

4. Ducts Connected to Fans Exhausting Laboratory and Process (ASHRAE 62.1, Class 3 and 4) Air:

    a. [Type 316] [Type 304], stainless-steel sheet.

1) Exposed to View: No. 4 finish.
2) Concealed: No. 2B finish.

b. PVC-coated, galvanized sheet steel with thicker coating on duct interior.
c. Pressure Class: Positive or negative three (3) inch wg.
d. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
e. SMACNA Leakage Class: 3.

E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Pressure Class: Positive or negative two (2) wg.
2. Minimum SMACNA Seal Class: B.
3. SMACNA Leakage Class for Rectangular: 12.
4. SMACNA Leakage Class for Round and Flat Oval: 6.

F. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.
2. PVC-Coated Ducts:

a. Exposed to Airstream: Match duct material.
b. Not Exposed to Airstream: Match duct material.

3. Stainless-Steel Ducts:

a. Exposed to Airstream: Match duct material.
b. Not Exposed to Airstream: Match duct material.

4. Aluminum Ducts: Aluminum.

G. Liner:<Designer to indicate on drawings where liner is used> <Edit for Project>

1. [Fibrous glass, Type I] [Flexible elastomeric], [1/2 inch] [1 inch] [1-1/2 inches] thick.

H. Double-Wall Duct Interstitial Insulation:

1. Air Ducts: One (1) inch thick.

I. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Velocity 1,000 fpm or Lower:

1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.

2) Mitered Type RE 4 without vanes.

b. Velocity 1,000 to 1,500 fpm:

1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

c. Velocity 1,500 fpm or Higher:

1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

1) Velocity 1,000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
2) Velocity 1,000 to 1,500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
3) Velocity 1,500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.

4) Radius-to Diameter Ratio: 1.5.

b. Round Elbows, twelve (12) Inches and Smaller in Diameter: Stamped or pleated.
c. Round Elbows, fourteen (14) Inches and Larger in Diameter: Standing seam.

J. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

a. Rectangular Main to Rectangular Branch: 45-degree entry.
b. Rectangular Main to Round Branch: Spin in.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

a. Velocity 1,000 fpm or Lower: 90-degree tap.
b. Velocity 1,000 to 1500 fpm: Conical tap.
c. Velocity 1,500 fpm or Higher: 45-degree lateral.

3.13 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire and smoke dampers according to UL listing.

H. Connect ducts to duct silencers with flexible duct connectors.

I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. Upstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
7. At each change in direction and at maximum fifty (50) foot spacing.
8. Upstream from turning vanes.
9. Upstream or downstream from duct silencers.
10. Control devices requiring inspection.
11. Elsewhere as indicated.

J. Install access doors with swing against duct static pressure.

K. Access Door Sizes:

1. One-Hand or Inspection Access: Eight (8) inches by five (5) inches.
2. Two-Hand Access: Twelve (12) inches by six (6) inches.
3. Head and Hand Access: Eighteen (18) inches by ten (10) inches.
4. Head and Shoulders Access: twenty one (21) inches by fourteen (14) inches.
5. Body Access: Twenty five (25) inches by fourteen (14) inches.
6. Body plus Ladder Access: Twenty five (25) inches by seventeen (17) inches.

L. Label access doors according to Division 23 Specification Section "Identification for HVAC Systems and Equipment" to indicate the purpose of access door.

M. Install flexible connectors to connect ducts to equipment.

N. Connect terminal units to supply ducts with maximum six (6) inch lengths of flexible duct. Do not use flexible ducts to change directions.

O. Connect flexible ducts to metal ducts with adhesive plus sheet metal screws.

P. Install duct test holes where required for testing and balancing purposes.

Q. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of one quarter (1/4) inch movement during start and stop of fans.

3.14 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233113