

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and Divisions 00 and 01, apply to this Section.
- B. Related Sections include the following:
- C. Related Sections:
 - 1. Division 07.
 - 2. Division 08.
 - 3. Division 23.

1.2 SUMMARY

- A. This Section includes fabrication and installation of rectangular, round, and flat-oval metal ducts and plenums for heating, ventilating, and air-conditioning systems in pressure classes from minus 2- to plus 10-inch wg.

1.3 SYSTEM DESCRIPTION

- A. Duct system design, as indicated, has been used to select and size air-moving and -distribution equipment and other components of air system. Changes to layout or configuration of duct system must be specifically approved in writing by Architect. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

1.4 SUBMITTALS

- A. General: See Section 23 05 00 for general requirements of Product Data, Shop Drawings, Reports and Certificates, and Operation and Maintenance data submittals.
- B. Product Data: Provide submittals of the following:
 - 1. Duct Liner and adhesives.
 - 2. Joint Sealants.
 - 3. Gaskets joint systems.
- C. Shop Drawings: In addition to requirements set forth in Section 23 05 00, shop drawings for the listed systems shall also include duct sizes, top and/or bottom elevations, pressure classifications, combination fire/smoke dampers, fire dampers and smoke dampers, building structural components, connections to equipment, seam and joint construction, location of duct accessories, including dampers, turning vanes and access doors, and required service clearances. Provide submittals of the following metal duct systems:
 - 1. Supply Air
 - 2. Return Air
 - 3. Exhaust Air
 - 4. Outside Air
 - 5. Duct Fittings

D. Coordination Drawings:

1. Comply with requirements in Section 01 33 00 and Section 23 05 00 for providing coordination drawings for areas as indicated on the drawings. Approved ductwork shop drawings shall be used to generate coordination drawings.

E. Reports and Certificates: Provide submittals of the following:

1. Duct Leakage Test Report.
2. Duct Cleanliness Tests.
3. Welding certificates.

F. Welding and finish sample for exposed stainless steel and aluminum ducts.

1.5 CODES AND STANDARDS

- A. Codes and Standards shall be the current version adopted by the Authority Having Jurisdiction.

1.6 QUALITY ASSURANCE

- A. Fabricate ducts and fittings according to SMACNA "HVAC Duct Construction Standards--Metal and Flexible" unless otherwise indicated.
- B. Welding Standards: Qualify welding procedures and welding personnel to perform welding processes for this Project according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports; AWS D1.2, "Structural Welding Code--Aluminum," for aluminum supporting members, AWS D9.1; and "Sheet Metal Welding Code," for duct joint and seam welding.
- C. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems" unless otherwise indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Keep metal ducts and duct liner dry and dust free during fabrication and storage at factory.
- B. Before shipment shrink-wrap all openings of ducts fabricated with duct liner. During shipment, protect all metal ducts from weather.
- C. Store all metal ducts in dry location on-site on elevated dunnage. Protect metal ducts from moisture, dirt, and dust.
- D. Retain shrink-wrap protection of openings (where required to be protected) until immediately prior to connection of that opening to erected duct system.
- E. On the event that any duct liner does get wet, dry duct liner within 48-hours using forced air heater. Ducts detected with moist fiberglass liner will be required to be replaced at no additional cost to the Owner.

- F. Remove dust from the inside of metal duct sections as they are erected. Cover all openings with 6-mil poly and duct tape, shrink wrap, or high-tack adhesive film at the end of each workday to prevent dust migration into ducts.
- G. Deliver and store stainless-steel sheets with mill-applied adhesive protective paper maintained through fabrication and installation.

PART 2 – PRODUCTS

2.1 SHEET METAL MATERIALS

- A. Galvanized, Sheet Steel: Lock-forming quality; ASTM A 653/A 653M, G90 coating designation; mill-phosphatized finish for surfaces of ducts exposed to view.
- B. Carbon-Steel Sheets: ASTM A 1008/A 1008M, cold-rolled sheets; commercial quality; with oiled, exposed matte finish.
- C. Stainless Steel: ASTM A 480/A 480M, Type 304 or 316L, sheet form with [No. 4] polished finish for surfaces of ducts exposed to view; Type 304, sheet form with No. 2D [No. 1] finish for concealed ducts.
- D. Aluminum Sheets: ASTM B 209, Alloy 3003, Temper H14, sheet form with standard, one-side bright finish for ducts exposed to view and with mill finish for concealed ducts.
- E. Reinforcement Shapes and Plates: Galvanized steel reinforcement where installed on galvanized, sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for 36-inch length or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.2 PERFORMANCE REQUIREMENTS

- A. Duct Pressure Classifications:
 - 1. Rectangular Duct Static-Pressure Classifications: Construct ducts to the following:
 - a. Supply Ducts, unless indicated otherwise: [2-inch wg][3-inch wg][4-inch wg][6-inch wg][10-inch wg].
 - b. Supply Ducts: [3-inch wg][4-inch wg][6-inch wg][10-inch wg] for ducts between the supply fan and first combination fire/smoke damper in each branch downstream of the supply fan.
 - c. Supply Ducts: [2-inch wg][3-inch wg][4-inch wg][6-inch wg][10-inch wg] for ducts between [the supply fan or air handling unit][the first combination fire/smoke damper in each branch downstream of the supply fan] and air terminals.
 - d. Return Ducts: 2-inch wg, negative pressure.
 - e. Exhaust Ducts: 2-inch wg, negative pressure.
 - f. Outside Air Intake Ducts: 2-inch wg, negative pressure.
 - 2. Round Duct Static Pressure Classifications: Construct ducts to the following:
 - a. Supply Ducts, unless indicated otherwise: [2-inch wg][4-inch wg][10-inch wg].

- b. Supply Ducts: [4-inch wg][10-inch wg] for ducts between the supply fan or air handling unit and the first combination fire/smoke damper in each branch downstream of the supply fan.
 - c. Supply Ducts: [2-inch wg][4-inch wg][10-inch wg] for ducts between the [supply fan or air handling unit][the first combination fire/smoke damper in each branch downstream of the supply fan] and air terminals.
 - d. Return Ducts: 2-inch wg, negative pressure.
 - e. Exhaust Ducts: 2-inch wg, negative pressure.
 - f. Outside Air Intake Ducts: 2-inch wg, negative pressure.
3. Flat Oval Static Pressure Classifications: Construct ducts to the following:
- a. Supply Ducts, unless indicated otherwise: [2-inch wg][3-inch wg][4-inch wg][6-inch wg][10-inch wg].
 - b. Supply Ducts: [4-inch wg][6-inch wg][10-inch wg] for ducts between the supply fan or air handling unit and the first combination fire/smoke damper in each branch downstream of the supply fan.
 - c. Supply Ducts: [2-inch wg][3-inch wg][4-inch wg][6-inch wg][10-inch wg] for ducts between [the supply fan or air handling unit][the first combination fire/smoke damper in each branch downstream of the supply fan] and air terminals.
 - d. Return Ducts: 2-inch wg, negative pressure.
 - e. Exhaust Ducts: 2-inch wg, negative pressure.
 - f. Outside Air Intake Ducts: 2-inch wg, negative pressure.
- B. Pressure Classification:
- 1. 3-inch wg and Greater: Seal Class A; all transverse joints, longitudinal seams and duct wall penetrations.
 - 2. Below 3-inch wg: Seal Class B; all transverse joints and longitudinal seams.

2.3 DUCT LINER

- A. Fibrous Glass Duct Liner: Comply with NFPA 90A and NAIMA AH124 "Fibrous Glass Duct Liner Standard." Can operate in temperatures up to 250 deg F and air velocities up to 5,000 fpm. ASTM C 1071 with coated surface exposed to airstream to prevent erosion of glass fibers. Coating contains EPA registered anti-microbial agent so it will not support the growth of fungus or bacteria, and is water repellent. Antimicrobial compound shall be tested for efficacy by the EPA for use in HVAC systems.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CertainTeed Corporation; Insulation Group.
 - b. Johns Manville.
 - c. Knauf Insulation.
 - d. Owens Corning.
 - e. Or Approved Equal
 - 2. Density: Minimum 2 lb per cubic foot.
 - 3. Maximum Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.
 - 4. Fire-Hazard Classification: Maximum flame-spread rating of 25 and smoke-developed rating of 50, when tested according to ASTM E 84 and UL 723.

5. Minimum Noise Reduction Criteria (NRC): 0.55 for 1/2-inch, 0.70 for 1-inch, 0.90 for 1-1/2-inch and 1.0 for 2-inch tested per ASTM C 423 using Type A mounting.
 6. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in duct.
 - a. Tensile Strength: Indefinitely sustain a 50-lb-tensile, dead-load test perpendicular to duct wall.
 - b. Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into airstream.
 - c. Adhesive for Attaching Mechanical Fasteners: Comply with fire-hazard classification of duct liner system.
 7. Johns Manville Spiracoustic Plus Round Duct Lining System. Preformed liner for ducts 8-inch through 18-inch diameter, round duct liner board for ducts greater than 18-inch diameter.
- B. Natural-Fiber Duct Liner: 85 percent cotton, 10 percent borate, and 5 percent polybinding fibers, treated with a microbial growth inhibitor and complying with NFPA 90A or NFPA 90B.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Bonded Logic, Inc.
 - b. Reflectix Inc.
 - c. Or Approved Equal
 2. Maximum Thermal Conductivity: 0.24 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature when tested according to ASTM C 518.
 3. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to ASTM E 84; certified by an NRTL.
 4. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
- C. Duct Liner Applications:
1. Supply-Air Ducts: Fibrous glass, 1 inch thick. Use perforated metal liner for all supply ducts above 2500 fpm.
 2. Return-Air Ducts: Fibrous glass, 1 inch thick, unless noted otherwise.
 3. Exhaust Air: Fibrous glass, 1 inch thick, unless noted otherwise.
 4. Outdoor Return-Air and Fan Plenum: Fibrous glass, 2 inches thick, unless noted otherwise.
 5. Transfer Ducts: Fibrous glass, 1 inch thick, unless noted otherwise.

2.4 SEALANT AND ADHESIVE MATERIALS

A. Joint and Seam Sealants:

1. Joint and Seam Sealant: One-part, nonsag, water-based, synthetic polymer sealant, formulated with a minimum of 69 percent solids by weight.

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

- 1) Foster.
- 2) Childers.
- 3) Or Approved Equal.

2. Flanged Joint Gasket Material: Elastomer butyl.

- B. Duct Liner Adhesive: Water-based vinyl copolymer adhesive formulated to withstand temperatures from minus 20 to plus 160 Degrees F. Comply with NFPA 90A and ASTM C 916

2.5 HANGERS, SUPPORTS AND RESTRAINTS

- A. Comply with Division 23, Section "Vibration and Seismic Controls for Mechanical Piping and Equipment."

- B. Building Attachments: Concrete inserts, stud-wedge or female wedge, mechanical-anchor bolts, or structural-steel fasteners appropriate for building materials. Powder actuated concrete fasteners are not allowed.

1. If concrete inserts cannot be used, install mechanical-anchor (stud-wedge or female wedge type) bolts in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions. Concrete inserts and mechanical-anchor fasteners shall be made of steel. Stainless steel for outdoor applications.

- C. Hanger Materials: Galvanized, sheet steel or round, threaded steel rod.

1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rod or galvanized rods with threads painted after installation.
2. Straps and Rod Sizes: Comply with SMACNA "HVAC Duct Construction Standards--Metal and Flexible" for sheet steel width and thickness and for steel rod diameters.

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

- E. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.

1. Supports for Galvanized-Steel Ducts: Galvanized steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel support materials.
3. Supports for Aluminum Ducts: Aluminum support materials, unless materials are electrolytically separated from ductwork.

2.6 RECTANGULAR DUCT AND FITTING FABRICATION

- A. Alternate Manufactured Rectangular Duct and Fittings:

1. The contractor has the option to use Accuduct Mfg. SPIRAQUAD. SPIRAQUAD is considered equal to standard rectangular ducts of the same SMACNA static pressure class.

- B. General: Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction with galvanized, sheet steel, according to SMACNA "HVAC Duct Construction Standards--Metal and Flexible," based on indicated static pressure class, unless indicated otherwise. Comply with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.
1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure classification.
 2. Materials: Free from visual imperfections such as pitting, seam marks, roller marks, stains, and discolorations.
 3. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - a. Prefabricated transverse joints shall comply SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," for static-pressure class, leakage rating.
 - 1) Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a) Duct Mate Industries, Inc.
 - b) Ward Flange.
 - c) Or Approved Equal.
 4. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 5. Material Thickness: For SMACNA "HVAC Duct Construction Standard – Metal and Flexible," but not less than 26 gauge.
- C. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359-inch-thick or less, with more than 10 sq. ft. of unbraced panel area, unless ducts are lined.
- D. Elbow Configuration:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
 - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
- E. Branch Configuration:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."

- a. Rectangular Main to Rectangular Branch: 45-degree entry.
- b. Rectangular Main to Round Branch: Conical or Bellmouth.

2.7 SHOP APPLICATION OF LINER IN RECTANGULAR DUCTS

- A. Adhere a single layer of [fibrous glass] [natural fiber] duct liner with 90 percent coverage of adhesive at liner contact surface area. Thickness shall be 1-inch unless indicated otherwise. Multiple layers of insulation to achieve indicated thickness is not allowed.
- B. Apply adhesive to liner facing in direction of airflow not receiving metal nosing.
- C. Butt transverse joints without gaps and coat joint with adhesive.
- D. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
- E. Do not apply liners in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary.
- F. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12-inches transversely around perimeter; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
- G. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profile or are integrally formed from duct wall. Fabricate edge facings at the following locations:
 - 1. Fan discharge.
 - 2. Intervals of lined duct preceding unlined duct.
- H. Additional liner requirements for duct velocities over 2500 fpm
 - 1. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.
 - 2. Upstream edges of transverse joints in ducts with metal nosings that have either channel or "Z" profile or are integrally formed from duct wall.
 - 3. Secure insulation liner with perforated sheet metal liner of same metal thickness as specified for duct, secured to ducts with mechanical fasteners that maintain metal liner distance from duct without compressing insulation.
 - 4. Sheet Metal Liner Perforations: 3/32-inch diameter, with an overall open area of 23 percent.
- I. Terminate liner with duct buildouts installed in ducts to attach dampers, turning vane assemblies, and other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct wall with bolts, screws, rivets, or welds. Terminate liner at fire dampers at connection to fire-damper sleeve.

2.8 ROUND AND FLAT-OVAL DUCT FABRICATION

- A. General: Diameter as applied to flat-oval ducts in this Article is the diameter of the size of round duct that has a circumference equal to perimeter of a given size of flat-oval duct. Minimum 26-gauge duct wall thickness.

- B. Round Ducts: Fabricate supply ducts of galvanized steel according to SMACNA "HVAC Duct Construction Standards--Metal and Flexible," unless indicated otherwise.
- C. Flat-Oval Ducts: Fabricate supply ducts with standard spiral lock seams or with butt-welded longitudinal seams according to SMACNA "HVAC Duct Construction Standards--Metal and Flexible," unless indicated otherwise.
- D. Double-Wall (Insulated) Ducts: Fabricate double-wall (insulated) ducts with an outer shell and an inner liner. Dimensions indicated on internally insulated ducts are inside dimensions.
 - 1. Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.
 - 2. Outer Shell: Base outer-shell metal thickness on actual outer-shell dimensions. Fabricate outer-shell lengths 2 inches longer than inner shell and insulation, and in metal thickness specified for single-wall duct.
 - 3. Insulation: [1-inch][2-inch][3-inch]-thick fibrous-glass insulation, unless otherwise indicated. Terminate insulation where internally insulated duct connects to single-wall duct or uninsulated components. Terminate insulation and reduce outer duct diameter to inner liner diameter.
 - 4. Solid Inner Liner: Fabricate round and flat-oval inner liners with solid sheet metal of thickness listed below:
 - 5. Perforated Inner Liner: Fabricate round and flat-oval inner liners with sheet metal having 3/32-inch-diameter perforations, with an overall open area of 23 percent. Use the following sheet metal thicknesses and seam construction:
 - a. Ducts 3 to 8 Inches in Diameter: 28-gauge with standard spiral seam construction.
 - b. Ducts 9 to 42 Inches in Diameter: 26-gauge with single-rib spiral seam construction.
 - c. Ducts 44 to 60 Inches in Diameter: 24 gauge with single-rib spiral seam construction.
 - d. Ducts 62 to 88 Inches in Diameter: 22-gauge with standard spiral seam construction.
 - 6. Maintain concentricity of liner to outer shell by mechanical means. Retain insulation from dislocation by mechanical means.
- E. Elbow Configuration:
 - 1. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "Round Duct Elbows."
 - a. Round Elbows, 8 Inches and Smaller: Fabricate stamped elbows for 45- and 90-degree elbows and pleated elbows for 30-, and 60-degree elbows. Stamped elbows shall be 20-gauge thick minimum with two-piece welded construction. Fabricate nonstandard bend-angle configuration or nonstandard diameter elbows with mitered construction.
 - b. Round Elbows, 9 through 12 Inches: Fabricate segmented (mitered) or pleated elbows for 30, 45, 60, and 90 degrees. Fabricate nonstandard bend-angle configuration or nonstandard diameter elbows with mitered construction.
 - c. Round Elbows, Larger than 12-Inches: Segmented (mitered) elbows for all bend angle configurations.
 - d. Round Elbows, Segmented (mitered) Two-Piece 90-Degree: Use only where specifically indicated. Fabricate with single turning vane.

- e. Flat Oval Elbows: Segmented (mitered) type.

F. Branch Configuration:

- 1. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees." Saddle taps are not permitted.
 - a. 90-degree Tee Fittings:
 - 1) Main to Branch (branch greater than $\frac{2}{3}$ the diameter of main or 12-inch diameter branch): Use 90-degree conical tee fitting. 90-degree conical taps or 90-degree lateral fittings can be used for all others.
 - 2) 45-degree lateral tee and 45-degree elbow in lieu of 90-degree tee fitting or tap on supply ductwork where space allows.
 - b. 45-degree Tee Fittings:
 - 1) Main to Branch (branch greater than $\frac{2}{3}$ the diameter of main or 12-inch diameter branch): Use 45-degree lateral fitting. 45-degree lateral taps or 45-degree lateral can be used for all others.

2.9 ROUND AND FLAT-OVAL SUPPLY AND EXHAUST FITTING FABRICATION

- A. 90-Degree Tee Fittings and Taps: Fabricate to comply with SMACNA "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal seam straight duct.
- B. Diverging-Flow Fittings: Fabricate with a reduced entrance to branch taps with no excess material projecting from body onto branch tap entrance.
- C. Round Elbow Construction: Fabricate in die-stamped, pleated, or mitered construction as indicated above. Fabricate bend radius of elbows to one and one-half times elbow diameter. Unless elbow construction type is indicated otherwise, fabricate elbows as follows:
 - 1. Mitered Elbow Pieces: Welded construction with 5-pieces for 90-degree elbow, 4-pieces for 60-degree elbow and 3-pieces for 45-degree elbow.
 - 2. Metal Thickness, Pressure Classes from Minus 2- to Plus 2-inch wg:
 - a. Ducts 3 to 26 Inches in Diameter: 24-gauge.
 - b. Ducts 27 to 36 Inches in Diameter: 22-gauge.
 - c. Ducts 37 to 50 Inches in Diameter: 20-gauge.
 - d. Ducts 52 to 60 Inches in Diameter: 18-gauge.
 - e. Ducts 62 to 84 Inches in Diameter: 16-gauge.
 - 3. Metal Thickness, Pressure Classes from Minus 2- to 10-inch wg:
 - a. Ducts 3 to 14 Inches in Diameter: 24-gauge.
 - b. Ducts 15 to 26 Inches in Diameter: 22-gauge.
 - c. Ducts 27 to 50 Inches in Diameter: 20-gauge.
 - d. Ducts 52 to 60 Inches in Diameter: 18-gauge.
 - e. Ducts 62 to 84 Inches in Diameter: 16-gauge.

- D. Flat-Oval Elbow Construction: Welded construction with same metal thickness as longitudinal seam flat-oval duct. Use 5-piece construction for hard bend 90-degree elbows, 4-piece construction for hard bend 45-degree elbow and 3-piece construction for easy bend 90-degree elbow.
- E. Double-Wall (Insulated) Fittings: Fabricate double-wall (insulated) fittings with an outer shell and an inner liner. Dimensions indicated on internally insulated ducts are inside dimensions.
1. Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.
 2. Outer Shell: Base outer-shell metal thickness on actual outer-shell dimensions. Fabricate outer-shell lengths 2 inches longer than inner shell and insulation. Use the same metal thicknesses for outer duct as for uninsulated fittings.
 3. Insulation: Same insulation thickness as adjoining double-wall ducts. Terminate insulation where internally insulated duct connects to single-wall duct or uninsulated components. Terminate insulation and reduce outer duct diameter to nominal single-wall size.
 4. Solid Inner Liner: Fabricate round and flat-oval inner liners with solid sheet metal of thickness listed below:
 5. Perforated Inner Liner: Fabricate round and flat-oval inner liners with sheet metal having 3/32-inch-diameter perforations, with an overall open area of 23 percent. Use the following sheet metal thicknesses:
 - a. Ducts 3 to 34 Inches in Diameter: 24-gauge.
 - b. Ducts 35 to 58 Inches in Diameter: 22-gauge.
 - c. Ducts 60 to 88 Inches in Diameter: 20-gauge.
 6. Maintain concentricity of liner to outer shell by mechanical means. Retain insulation from dislocation by mechanical means.
- F. Elbow Configuration:
1. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "Round Duct Elbows."
 - a. Round Elbows, 8 Inches and Smaller: Fabricate stamped die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30-, and 60-degree elbows. Stamped Die formed elbows shall be 20-gauge thick minimum with two-piece welded construction. Fabricate nonstandard bend-angle configuration or nonstandard diameter elbows with mitered construction.
 - b. Round Elbows, 9 through 12 Inches: Fabricate segmented (mitered) or pleated elbows for 30, 45, 60, and 90 degrees. Fabricate nonstandard bend-angle configuration or nonstandard diameter elbows with mitered construction.
 - c. Round Elbows, Larger than 12-Inches: Segmented (mitered) elbows for all bend angle configurations.
 - d. Round Elbows, Segmented (mitered) Two-Piece 90-Degree: Use only where specifically indicated. Fabricate with single turning vane.
 - e. Flat Oval Elbows: Segmented (mitered) type.
- G. Branch Configuration:
1. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees." Saddle taps are not permitted.

- a. 90-degree Tee Fittings:
 - 1) Main to Branch (branch greater than 2/3 the diameter of main or 12-inch diameter branch): Use 90-degree conical tee fitting. 90-degree conical taps or 90-degree lateral fittings can be used for all others.
 - 2) 45-degree lateral tee and 45-degree elbow in lieu of 90-degree tee fitting or tap on supply ductwork where space allows.
- b. 45-degree Tee Fittings:
 - 1) Main to Branch (branch greater than 2/3 the diameter of main or 12-inch diameter branch): Use 45-degree lateral fitting. 45-degree lateral taps or 45-degree lateral can be used for all others.

2.10 UNDERGROUND DUCT FABRICATION

- A. Reference Division 23 Section "Nonmetal Ducts" for underground duct fabrication.

2.11 SPECIAL EXHAUST DUCT AND FITTING FABRICATION

- A. Fabricate ducts with galvanized sheet steel except as follows:
- B. Grease Ducts (Type 1):
 - 1. Field Fabricated Exhaust Ducts:
 - a. Comply with NFPA 96.
 - b. Minimum 18-gauge Type 304 stainless steel sheet.
 - c. Exposed to view: [No. 4][No. 3] finish.
 - d. Concealed: [Type 304, stainless-steel sheet, No. 2D finish] [Carbon-steel sheet].
 - e. Welded seams and joints.
 - 2. Manufactured Grease Duct Systems:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Metal-Fab, Inc.
 - 2) Selkirk.
 - 3) Schebler.
 - 4) Or Approved Equal.
 - b. Description: Double-wall grease duct system, 2-hour rated, zero clearance to combustibles, tested according to UL 2221 and UL 1978.
 - c. Construction: Inner shell and outer jacket separated by 4-inch annular space filled with high-temperature, ceramic-fiber insulation.
 - d. Inner Shell: ASTM A 666, [Type 304][Type 316] stainless steel, minimum 20-gauge.
 - e. Outer Jacket: Aluminized steel minimum 22-gauge where concealed. Type 304 stainless steel, minimum 20-gauge where exposed.
 - f. Accessories: Tees, elbows, increasers, hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight

sections; all listed for same assembly. Include unique components required to comply with NFPA 96 including cleanouts, transitions, adapters and drain fittings.

C. Dishwasher (Type 2) Hood Exhaust Duct:

1. Fabricate per SMACNA "HVAC Duct Construction Standards - Metal and Flexible, and the following:
 - a. Minimum 18-gauge Type 304 stainless steel sheet.
 - b. Exposed to view: [No. 4] [No. 3] finish.
 - c. Concealed: No. 2D finish.
 - d. Welded seams and welded or flanged joints with watertight EPDM gaskets.

D. Cart Washer Exhaust Duct Systems:

1. Fabricate per SMACNA "HVAC Duct Construction Standards - Metal and Flexible, and the following:
2. Minimum 18-gauge Type 304 stainless steel sheet.
3. Exposed to view: [No. 4] [No. 3] finish.
4. Concealed: No. 2D finish.
5. Welded seams and welded or flanged joints with watertight EPDM gaskets.

E. Dryer Exhaust Duct:

1. Fabricate dryer exhaust ducts of aluminum sheet according to SMACNA "HVAC Duct Construction Standards – Metal and Flexible," unless otherwise indicated.

F. Fume Hood Exhaust Duct:

1. Fabricate per SMACNA "HVAC Duct Construction Standards - Metal and Flexible, and the following:
 - a. Minimum 18-gauge Type 316L stainless steel sheet.
 - b. Exposed to view: [No. 4] [No. 3] finish.
 - c. Concealed: No. 2D finish.
 - d. Welded seams and joints.

G. Autoclave Hood Exhaust Duct:

1. Fabricate per SMACNA "HVAC Duct Construction Standards - Metal and Flexible, and the following:
 - a. Minimum 18-gauge Type 316 stainless steel sheet.
 - b. Exposed to view: [No. 4] [No. 3] finish.
 - c. Concealed: No. 2D finish.
 - d. Welded seams and joints.

2.12 INTERMEDIATE REINFORCEMENT

- A. Galvanized-Steel Ducts: Galvanized steel.
- B. Stainless-Steel Ducts: Galvanized steel.

- C. Aluminum Ducts: Aluminum or galvanized sheet steel coated with zinc chromate.

PART 3 – EXECUTION

3.1 DUCT INSTALLATION, GENERAL

- A. Duct installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts, fittings, and accessories.
- B. Provide access panels every 50 feet on all medium pressure ductwork for inspection and duct clearing.
- C. Construct and install each duct system for the specific duct pressure classification indicated.
- D. Install round and flat-oval ducts in lengths not less than 12 feet, unless interrupted by fittings.
- E. Install ducts with fewest possible joints.
- F. Install fabricated fittings for changes in directions, changes in size and shape, and connections.
- G. Install couplings tight to duct wall surface with a minimum of projections into duct.
- H. Install ducts, unless otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs.
- I. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- J. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- K. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions, unless specifically indicated.
- L. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work. Allow for post-construction access to air terminals, volume dampers, and other components requiring maintenance and/or readjustment.
- M. Electrical Equipment Spaces: Route ductwork to avoid passing through transformer vaults and electrical equipment spaces and enclosures, unless ductwork is intended to serve these spaces.
- N. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same metal thickness as duct. Overlap opening on four sides by at least 1-1/2 inches.
- O. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated combination fire/smoke damper or fire damper sleeve, and firestopping sealant. Fire, smoke and combination fire/smoke dampers are specified in Division 23 Section "Duct Accessories." Firestopping materials and installation methods are specified in Division 07 Section "Firestopping."

3.2 GREASE HOOD (TYPE 1) EXHAUST DUCT INSTALLATIONS

- A. Install Type 1 exhaust ducts according to NFPA 96 "Ventilation Control and Fire Protection of Commercial Cooking Operations."
- B. Install ducts to allow for thermal expansion of ductwork through 2000 deg F temperature range.
- C. Install ducts without dips or traps that may collect residues, unless traps have continuous or automatic residue removal. Slope ducts a minimum of 2% to drain grease back to hood.
- D. Install access openings at each change in direction and at 25-foot intervals in horizontal ducts and at every floor for vertical ducts; locate on sides of duct a minimum of 1-1/2 inches from bottom; and fit with grease tight covers of same material as duct.
- E. Do not penetrate fire-rated assemblies.

3.3 DISHWASHER (TYPE 2) EXHAUST DUCT INSTALLATIONS

- A. Install dishwasher exhaust ducts according to SMACNA "HVAC Duct Construction Standards--Metal and Flexible, Figure 10-2.". Use non-ferrous fasteners; no fasteners or rough surface allowed on inside surface. Slope duct a minimum of 1% to low point drain(s).
- B. Install drains at the base of vertical risers and low points. Route drains to nearby floor drains or floor sinks.

3.4 CART WASHER EXHAUST DUCT INSTALLATIONS

- A. Install cart washer exhaust ducts according to SMACNA "HVAC Duct Construction Standards--Metal and Flexible". Use non-ferrous fasteners; no fasteners or rough surface allowed on inside surface. Slope duct a minimum of 1% to low point drain(s) or back to cart washer.
- B. Install drains at the base of vertical risers and low points. Route drains to nearby floor drains or floor sinks.

3.5 DRYER EXHAUST DUCT INSTALLATIONS

- A. Install dryer exhaust ducts according to SMACNA "HVAC Duct Construction Standards--Metal and Flexible." Use aluminum fasteners; no fasteners or other lint collecting rough surfaces allowed on inside surface of dryer ducts.

3.6 Fume Hood Exhaust Duct INSTALLATIONS

- A. Install fume hood exhaust ducts according to SMACNA "HVAC Duct Construction Standards--Metal and Flexible."

3.7 AUTOCLAVE Exhaust Duct INSTALLATIONS

- A. Install autoclave exhaust ducts according to SMACNA "HVAC Duct Construction Standards--Metal and Flexible."

3.8 SEAM AND JOINT SEALING

- A. General: Seal duct seams and joints according to the duct seal class described in SMACNA "HVAC Duct Construction Standards--Metal and Flexible" corresponding to the pressure class given below.
- B. Pressure Classification:
 - 1. 3-inch wg and Greater: Seal Class A; all transverse joints, longitudinal seams and duct wall penetrations.
 - 2. Below 3-inch wg: Seal Class B; all transverse joints and longitudinal seams.
- C. Seal externally insulated ducts before insulation installation.

3.9 HANGING, RESTRAINING, AND SUPPORTING

- A. Install rigid round, rectangular, and flat-oval metal duct with support systems indicated in SMACNA "HVAC Duct Construction Standards--Metal and Flexible."
- B. Install duct seismic restraints as indicated in Division 23, Section "Vibration and Seismic Controls for Mechanical Piping and Equipment."
- C. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.
- D. Support vertical ducts at a maximum interval of 16 feet and at each floor.
- E. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.
- F. Install concrete inserts before placing concrete.
- G. Install mechanical-anchor fasteners after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

3.10 CONNECTIONS

- A. Unless indicated otherwise, connect metal ducts to rotating equipment with flexible connectors according to Division 23 Section "Air Duct Accessories."
- B. For branch, outlet and inlet, and terminal unit connections, comply with SMACNA "HVAC Duct Construction Standards--Metal and Flexible," unless indicated otherwise.

3.11 FIELD QUALITY CONTROL

- A. Leakage Test:
 - 1. Disassemble, reassemble, and seal segments of systems as required to accommodate leakage testing and as required for compliance with test requirements.
 - 2. Conduct tests, in presence of Owner's Representative, at static pressures equal to maximum design pressure of system or section being tested. If pressure classifications are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing. Test ducts in shafts prior to shaft enclosure.

3. Determine leakage from entire system or section of system by relating leakage to surface area of test section.
 4. Maximum Allowable Leakage: Comply with requirements for Leakage Classification 3 for round and flat-oval ducts, Leakage Classification 12 for rectangular ducts in pressure classifications less than and equal to 2-inch wg (both positive and negative pressures), and Leakage Classification 6 for pressure classifications from 2- to 10-inch wg.
 5. Remake leaking joints and retest until leakage is less than maximum allowable.
 6. Leakage Test: Perform tests according to SMACNA "HVAC Air Duct Leakage Test Manual." Submit test report.
- B. 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.
- C. Duct system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. Leakage Test: Perform tests according to SMACNA "HVAC Air Duct Leakage Test Manual." Submit test report for the following:
1. Ductwork constructed with a duct static pressure classification greater than 3-inch w.g.

3.12 ADJUSTING

- A. Refer to Division 23 Section "Testing, Adjusting, and Balancing for Mechanical" for detailed procedures.

3.13 DUCT CLEANING

- A. Clean [new] [existing] [new and existing] duct system(s) before testing, adjusting, and balancing.
- B. Use service openings for entry and inspection.
1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Division 23 Section "Air Duct Accessories" for access panels and doors.
 2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
 3. Remove and reinstall ceiling to gain access during the cleaning process.
- C. Particulate Collection and Odor Control:
1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.

2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.
- D. Clean the following components by removing surface contaminants and deposits:
1. Air outlets and inlets (registers, grilles, and diffusers).
 2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
 4. Coils and related components.
 5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
 6. Supply-air ducts, dampers, actuators, and turning vanes.
 7. Dedicated exhaust and ventilation components and makeup air systems.
- E. Mechanical Cleaning Methodology:
1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
 2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
 3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
 4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
 5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
 6. Provide drainage and cleanup for wash-down procedures.
 7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

END OF SECTION