

SECTION 233113 METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

- 1. Single-wall rectangular ducts and fittings.
 - 2. Single-wall round and flat-oval ducts and fittings.
 - 3. Prefabricated, double-wall, insulated exterior duct systems.
 - 4. Sheet metal materials.
 - 5. Duct Liner.
 - 6. Sealants and gaskets.
 - 7. Hangers and supports.

- B. Related Sections:

- 1. Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
 - 2. Division 23 Section "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, duct sealing, 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 shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"
- C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 SUBMITTALS

- A. Product Data: For each type of the following products:
 - 1. Liners and adhesives.
 - 2. Sealants and gaskets.

B. Shop Drawings:

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 for all systems indicated on drawings.
4. Elevation of bottom of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Seam, joint and wall penetration sealing class and product data.
10. Penetrations through fire-rated and other partitions.
11. Equipment installation based on equipment being used on Project.
12. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
13. Hangers and supports, including methods for duct and building attachment and vibration isolation.
14. Chiller and Boiler Plant Ventilation System
15. Chiller Plant Refrigerant Relief Ventilation System

C. 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. Penetrations of smoke barriers and fire-rated construction.

D. Welding certificates.

E. Field quality-control reports.

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

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."
- E. NFPA Compliance:
 - 1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
 - 2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- F. Comply with NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operations," Ch. 3, "Duct System," for range hood ducts, unless otherwise indicated.

PART 2 - PRODUCTS

2.1 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. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.
- C. Carbon-Steel Sheets: ASTM A 366/A 366M, cold-rolled sheets; commercial quality; with oiled, matte finish for exposed ducts.
- D. Aluminum Sheets: ASTM B 209 (ASTM B 209M), alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- E. Stainless Steel Sheets: Type 304, 2B Finish.
- F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.
- G. 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."
- H. 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."
- I. 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."

2.2 SINGLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Lindab Inc.
 - b. McGill AirFlow LLC.
 - c. SEMCO Incorporated.
 - d. Airside Sheet Metal, Inc.
 - e. Or approved equivalent.
 - 2. Shop fabricated single wall spiral round duct will be accepted as fabricated by the project Sheet Metal Contractor in accordance with SMACNA Standards.
- 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 in accordance with 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 60 Inches in Diameter: Flanged.
- D. Longitudinal Seams: Select seam types and fabricate in accordance with 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. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
 - 2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.
- E. Tees and Laterals: Select types and fabricate in accordance with 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."

2.3 PREFABRICATED, DOUBLE-WALL, INSULATED EXTERIOR DUCT SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
1. Dual-Tech System, by PTM Manufacturing, LLC
 2. Or approved equivalent.
- B. General: Exterior duct system shall be double wall Kingspan KoolDuct encased with PTM beaded and silicone sealed .032Aluminum.
- C. Fire and Smoke Performance: The rigid phenolic insulation panels used in the fabrication of Dual-Tech ductwork and / or ductwork sections fabricated from the Kingspan KoolDuct System shall achieve the following fire and smoke performance requirements:
1. ASTM E 84-08a – unfaced or composite (insulation, facing and adhesive) of low contribution to fire growth not exceeding 25 Flame Spread and 50 Smoke Developed indices.
 2. UL 723 – unfaced or composite (insulation, facing and adhesive) of low contribution to fire growth not exceeding 25 Flame Spread and 50 Smoke Developed indices; and
 3. UL 181 – UL/ULC classification as a Class 1 Air Duct to NFPA Standards 90A/90B.
- D. Outdoor Ductwork Material Requirements:
1. Ductwork shall be double wall R8 Kingspan KoolDuct. The panels used in the fabrication of Dual-Tech ductwork from the Kingspan KoolDuct System shall be Kingspan KoolDuct rigid phenolic insulation panels of nominal dimensions 12.89 ft x 3.94 ft and minimum compressive strength 29 psi, as manufactured by Kingspan Insulation Ltd.
 2. Kingspan KoolDuct rigid phenolic insulation panels shall comprise a 3.4–3.75 pcf nominal density CFC/HCFC-free rigid phenolic insulation core with zero Ozone Depletion Potential (ODP), autohesively bonded on both sides to a 1 mil low vapor permeability aluminum foil facing reinforced with a 0.2” glass scrim.
 3. Kingspan KoolDuct rigid phenolic insulation panels are available in thicknesses of 1 3/16” (R-8.1 ft².hr.[°]F/Btu), as per design Thermal Requirements for double wall and a combined R16 thermal value.
 4. All other components required for the fabrication of ductwork from the Kingspan KoolDuct System including the silicone sealant, contact adhesive, aluminum tape, self-adhesive gasket, ductwork reinforcements, closures, connectors, and flanges shall be as approved / supplied by Kingspan Insulation Ltd.
 5. Weather barrier shall be fabricated of mill finished aluminum sheeting (CoolR Aluminum Regal White) .032”in thickness. Exposed seams to be covered with 1” butyl and a 6”wide matching aluminum beaded bands, secured with #10 self tapping, stainless screws with weather seal washers.
 6. At weather barrier abutment locations, an industrial grade RTV silicone caulk shall be utilized, where applicable.
 7. Seams exposed to the weather shall be covered and sealed with a 1” wide by 1/8” thick butyl compound.
 8. All screws utilized to fasten panel system together shall be #10 x 1/2” self-tapping, stainless steel, weather seal washer screws.
 9. Contact cement or 2-sided adhesive tape shall be utilized for laminating insulation material to the weather barrier sheeting.

10. Foil tape used for sealing the insulation edges shall be a minimum thickness of 1.25 mil.
11. Ductwork insulation R-values shall meet or exceed ASHRAE-90.1-2019 requirements.

E. Outdoor Ductwork Insulation Fabrication Requirements:

1. Sizing: Panel system shall be sized in four overlapping sections to provide a complete seal surrounding KoolDuct ducting.
2. Shall be laminated to the weather barrier and sized to allow for sufficient overlap as indicated in section 3.0 above. Second wall ducting shall be adhered utilizing appropriate contact method.
3. Where feasible all general fabrication shall be performed in the shop and be based off of approved project drawing or direct field measurements.
4. Field fabrication should be limited to routing and sealing of the ducting sections to allow for duct angle, supports, gauges or other duct related necessities. All routed areas shall be resealed with appropriate foil faced cast tape. No insulation/phenolic material shall be exposed to the environment.

2.4 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. Tie Rods:** Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.5 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. Basis-of-Design Product: Subject to compliance with requirements, provide Johns-Manville; Linacoustic RC for rectangular ductwork and Spiracoustic Plus for round spiral ductwork or comparable product by one of the following:
 - a. CertainTeed Corporation; Insulation Group.
 - b. Knauf Insulation.
 - c. Or approved equivalent.
 - d. Maximum Thermal Conductivity:
 - 1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

- 2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg 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-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
 - a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. 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, and length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
 2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick galvanized steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
- C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-19, "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. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
 7. 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 2500 fpm or where indicated.
- D. 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.

2.6 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. Water-Based Joint and Seam Sealant:
 - 1. Application Method: Brush on.
 - 2. Solids Content: Minimum 65 percent.
 - 3. Shore A Hardness: Minimum 20.
 - 4. Water resistant.
 - 5. Mold and mildew resistant.
 - 6. VOC: Maximum 75 g/L (less water).
 - 7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
 - 8. Service: Indoor or outdoor.
 - 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- C. Solvent-Based Joint and Seam Sealant:
 - 1. Application Method: Brush on.
 - 2. Base: Synthetic rubber resin.
 - 3. Solvent: Toluene and heptane.
 - 4. Solids Content: Minimum 60 percent.
 - 5. Shore A Hardness: Minimum 60.
 - 6. Water resistant.
 - 7. Mold and mildew resistant.
 - 8. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
 - 9. Service: Indoor or outdoor.
 - 10. 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: 25.
 - 5. Use: O.
- E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

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

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 ducts in maximum practical lengths.
- D. Install ducts with fewest possible joints.
- E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a clearance of 1 inch.
- I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal

flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

- K. Comply with requirements in Division 23 Section "Air Duct Accessories" for installation of fire and smoke dampers.
- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Sheet Metal Contractor shall submit their "Cleaning Procedures Standards" to the Design Build Contractor for review.

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.
- 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 INSTALLATION OF PREFABRICATED, DOUBLE-WALL, INSULATED EXTERIOR DUCT SYSTEMS

- A. Basic Installation Requirements:
 - 1. Ducting system sections shall be fitted into place and connected using aluminium flange and KoolDuct gasket as designed by Kingspan.
 - 2. Once fitted, joints will be filled with 7/8" R6 KoolDuct insulation filler then covered with the 1" butyl gasket on both edges of the metal then the 6" beaded banding fabricated to match the mill finished aluminum sheeting, secured with #10 self-tapping, stainless screws with weather seal washers.
 - 3. At weather barrier abutment locations, an industrial grade RTV silicone caulk shall be utilized around the full duct circumference where applicable.
- B. Sealing Requirements:
 - 1. All internal seams must be fully sealed with an unbroken layer of silicone sealant.
 - 2. Each ductwork section must be duly connected with a jointing system approved Kingspan Insulation Ltd., and sufficient silicone sealant should be applied in order to seal the rigid phenolic insulation panel and ensure minimum air leakage.
 - 3. Ductwork reinforcement, if necessary, shall be applied to protect against side deformation from both positive and negative pressure.
 - 4. All external seams where two separate panels join must be taped to achieve a permanent bond and a smooth wrinkle free appearance.

C. Hanger and Support Requirements:

1. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - a. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
 - b. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
2. Hanger Materials: Galvanized sheet steel or threaded steel rod.
 - a. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
 - b. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards— Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.
 - c. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.
3. Penetration into duct is not permitted.
4. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.
 - a. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 - b. Supports for Stainless-Steel Ducts: Stainless-steel support materials.
 - c. Supports for Aluminum Ducts: Aluminum support materials unless materials are electrolytically separated from ducts.

3.4 ADDITIONAL INSTALLATION REQUIREMENTS FOR COMMERCIAL KITCHEN HOOD EXHAUST DUCT

- A. Kitchen Grease Duct Systems shall be installed in accordance with NFPA 96 and IMC, Section 506.
- B. Joints, Seams, and Penetrations of Grease Ducts: Joints, seams and penetrations of grease ducts shall be made with a continuous liquid-tight weld or braze made on the external surface of the duct system.
- C. Duct Joint Types: Duct joints shall be butt joints or overlapping duct joints of either the telescoping or bell type. Overlapping joints shall be installed to prevent ledges and obstructions from collecting grease or interfering with gravity drainage to the intended collection point. The difference between the inside cross-sectional dimensions of overlapping sections of duct shall not exceed 0.25-inch. The length of overlap for overlapping duct joints shall not exceed 2-inches.
- D. Duct-to-Hood Joints: Duct-to-hood joints shall be made with continuous internal or external liquid-tight welded or brazed joints. Such joints shall be smooth, accessible for inspection, and without grease traps.
 1. Contractor shall provide exception to above by utilizing means and methods outlined in the Exceptions noted in IMC, Section 506.3.2.2.

- E. Duct-to-Exhaust Fan Connections: Duct-to-exhaust fan connections shall be flanged and gasketed at the base of the fan for vertical discharge fans; shall be flanged, gasketed and bolted to the inlet of the fan for side-inlet utility fans; and shall be flanged, gasketed and bolted to the inlet and outlet of the fan for in-line fans.
- F. Grease Duct Supports: Grease duct bracing and supports shall be of non-combustible material securely attached to the structure and designed to carry gravity and seismic loads within the stress limitations of the International Building Code (IBC). Bolts, screws, rivets, and other mechanical fasteners shall not penetrate duct walls.
- G. Grease Duct Clearances: Grease duct systems and exhaust equipment serving a Type I hood shall have a clearance to combustible construction of not less than 18-inches and shall have a clearance to non-combustible construction and gypsum wall board attached to non-combustible structures of not less than 3-inches; unless conforming with exceptions of IMC, Section 506.
- H. Grease Accumulation: Duct systems serving a Type I hood shall be constructed and installed so that grease cannot collect in any portion thereof, and the system shall slope not less than one-fourth unit vertical in 12 units horizontal (2-percent slope) toward the hood or toward an approved grease reservoir. Where horizontal ducts exceed 75-feet in length, the slope shall be not less than one unit vertical in 12 units horizontal (8.3-percent slope).
- I. Grease Duct Cleanouts and Other Openings: Grease duct systems shall not have openings therein other than those required for proper operation and maintenance of the system. All grease duct cleanouts and other openings shall comply with IMC, Section 506.3.8 and 506.3.9.
 - 1. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 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 1-1/2 inches from bottom of duct.
- J. Make-up Air Ducts for Type I Hoods: Make-up air ducts connection to or within 18-inches of a Type I hood shall be constructed and installed in accordance with IMC, Section 603. Duct insulation installed within 18-inches of a Type I hood shall be non-combustible or shall be listed for the application.
- K. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

3.5 ADDITIONAL INSTALLATION REQUIREMENTS FOR EXHAUST DUCTS SERVING COMMERCIAL DISHWASHERS AND OTHER HIGH-HUMIDITY LOCATIONS

- A. Install dishwasher exhaust ducts and other exhaust ducts from wet, high-humidity locations without dips and traps that may hold water. Slope ducts a minimum of 2 percent back to dishwasher or toward drain.
- B. Provide a drain pocket at each low point and at the base of each riser with a 1-inch trapped copper drain from each drain pocket to open site floor drain.
- C. Minimize number of transverse seams.

- D. Do not locate longitudinal seams on bottom of duct.

3.6 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."
- B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
 - 1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 2. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
 - 3. Unconditioned Space, Exhaust Ducts: Seal Class C.

3.7 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 4 inches thick.
 - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
 - 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and angle, channel supports, hanger straps or Gripple cables.
- 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 maximum intervals of 16 feet.
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.8 CONNECTIONS

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

3.9 PAINTING

- A. Coordinate any ductwork that is required to be painted with architectural drawings and specifications. Sheet Metal Contractor shall fabricate exposed duct that needs to be painted with galvaneal steel.

3.10 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 3-Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.
 - b. Exhaust Ducts with a Pressure Class of 3-Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.
 - c. Outdoor Air Ducts with a Pressure Class of 3-Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 percent 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. 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.
 - 5. Give seven days' advance notice for testing.
- C. Duct system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. All open end ducts shall be sealed prior to installation. All ductwork should be stored off the floor and avoid any contact with water.

3.11 START UP

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

3.12 DUCT SCHEDULE

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

HVAC System:	Duct Type:	Static Pressure Construction Class	Seal Class	Sealing Applicable	Leakage Class	
					Rectangular Metal	Round Metal
RTU / DOAS	SA, RA	4"	A	Note 4	6	3
MUA	OA	2"	A	Note 4	6	3
AHU / BCU / FCU / IDU	SA, RA	2"	A	Note 4	6	3
VAV / FPB	SA	2"	A	Note 4	6	3
EF	EA (Grease)	2"	A	Note 4	6	3
EF	EA	2"	A	Note 4	6	3
Ventilation Louver	OA at MER's	2"	C	Note 3	24	12
Fume Hood Duct	EA	2"	A	Note 4	6	3
Dishwasher Duct	EA	2"	A	Note 4	6	3
Boiler Intake	OA	2"	C	Note 3	24	12
Kiln	EA	2"	A	Note 4	6	3

Notes:

1. Refer to SMACNA Tables for additional information.
2. Ventilation (Outside) Air shall be considered/constructed same as Supply Air.
3. Transverse Joints Only.
4. Joints, Seams, and All Wall Penetrations.

- B. For exhaust ducts connected to Commercial Kitchen Hoods: Comply with NFPA 96.

- a. Exposed to View: Type 304, stainless-steel sheet, No. 2B finish.
 - b. Concealed: Carbon-steel sheet.
 - c. Welded seams and joints.
- C. For exhaust ducts connected to dishwashers, showers, moist areas, and science lab fume hoods utilize materials in compliance with ASTM A480/A480M: Type 304 and Type 316 stainless steel.
- D. Intermediate Reinforcement:
 - 1. Galvanized-Steel Ducts: Galvanized steel.
 - 2. Stainless-Steel Ducts:
 - a. Exposed to Airstream: Match duct material.
 - b. Not Exposed to Airstream: Match duct material.
- E. Liner: Provide only in areas noted on the drawings.
 - 1. Supply and Outside Air Ducts: Fibrous glass, Type I, 1 inch thick.
 - 2. Return Air Ducts: Fibrous glass, Type I, 1 inch thick.
 - 3. Transfer Ducts: Fibrous glass, Type I, 1 inch thick.
 - 4. For exterior lined ductwork, provide internal lining plus external lining and jacketing to meet overall outdoor insulation R-value required to meet ASHRAE 90.1-2019.
- F. Roof-mounted, Exterior Ductwork for RTU's: Prefabricated, double-wall, insulated exterior duct systems or combination of internal liner, exterior insulation, and PVC jacketing in accordance with "Mechanical Insulation" section. Contractor to price line item as part of bid for installation of either system.
- G. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Velocity 1000 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 1000 to 1500 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 1500 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 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - 2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - 3) Velocity 1500 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, 12 Inches and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam or Welded.

H. 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 1000 fpm or Lower: 90-degree tap.
 - b. Velocity 1000 to 1500 fpm: Conical tap.
 - c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 233113