SECTION 233116 - NONMETAL DUCTS

Revise this Section by deleting and inserting text to meet Project-specific requirements.

This Section uses the term "Architect." Change this term to match that used to identify the design professional as defined in the General and Supplementary Conditions.

Verify that Section titles referenced in this Section are correct for this Project's Specifications; Section titles may have changed.

1. GENERAL
	* + 1. RELATED DOCUMENTS

Retain or delete this article in all Sections of Project Manual.

* + - * 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
			1. SUMMARY
				1. Section Includes:

Fibrous-glass ducts and fittings.

Phenolic-foam ducts and fittings.

Thermoset FRP ducts and fittings.

PVC ducts and fittings.

CPVC ducts and fittings.

HDPE duct and fittings.

* + - * 1. Related Requirements:

Retain subparagraphs below to cross-reference requirements Contractor might expect to find in this Section but are specified in other Sections.

Section 230130.52 "Existing HVAC Air-Distribution System Cleaning" for cleaning of existing HVAC air-distribution equipment, ducts, plenums, and system components.

Section 230548 "Vibration and Seismic Controls for HVAC" for vibration-isolated and restrained ductwork hangers and supports.

Section 230548.13 "Vibration Controls for HVAC" for vibration-isolated ductwork and hangers.

Section 233113 "Metal Ducts" for single- and double-wall, rectangular and round ducts.

Section 233119.16 "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.

* + - 1. SUBMITTALS
				1. Submittals for this section are subject to the re-evaluation fee identified in Article 4 of the General Conditions.
				2. Manufacturer’s installation instructions shall be provided along with product data.
				3. Submittals shall be provided in the order in which they are specified and tabbed (for combined submittals).
				4. Product Data: For each type of the following products:

Fibrous-glass duct materials.

Phenolic-foam duct materials.

Thermoset FRP duct materials.

PVC duct materials.

CPVC duct materials.

HDPE duct materials.

* + - * 1. Sustainable Design Submittals:
				2. Shop Drawings:

Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.

Duct layout indicating sizes and pressure classes.

Elevation of top of ducts.

Dimensions of main duct runs from building grid lines.

Fittings.

Reinforcement and spacing.

Seam and joint construction.

Penetrations through fire-rated, smoke-rated, and other partitions.

Fire and smoke damper locations.

Equipment installation based on equipment being used on Project.

Hangers and supports, including methods for duct and building attachment[**, seismic restraints,**] and vibration isolation.

Retain "Delegated-Design Submittal" paragraph below if design services have been delegated to Contractor.

Retain "Coordination Drawings" paragraph below for situations where limited space necessitates maximum utilization for efficient installation of different components or if coordination is required for installation of products and materials by separate installers. Coordinate paragraph with other Sections specifying products listed below. Preparation of coordination drawings requires the participation of each trade involved in installations within the limited space.

* + - * 1. Coordination Drawings: Plans, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.

Retain "Seismic Qualification Data" paragraph below if required by seismic criteria applicable to Project. Coordinate with Section 230548 "Vibration and Seismic Controls for HVAC." See ASCE/SEI 7 for certification requirements for equipment and components.

* + - * 1. Seismic Qualification Data: Certificates, for nonmetal ducts, accessories, and components, from manufacturer.

Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

Retain "Welding certificates" paragraph below if retaining "Hanger and Support Welding Qualifications" paragraph in "Quality Assurance" Article.

* + - * 1. Welding certificates.

Retain "Field quality-control reports" paragraph below if Contractor is responsible for field quality- control testing and inspecting.

* + - * 1. Field quality-control reports.
			1. QUALITY ASSURANCE
				1. Hanger and Support Welding Qualifications: Qualify procedures and personnel according to the following:

AWS D1.1, "Structural Welding Code - Steel," for steel hangers and supports.

AWS D1.2, "Structural Welding Code - Aluminum," for aluminum hangers and supports.

Retain "Mockups" paragraph below only where required for special construction. Mockups are normally required only for static-pressure classes in excess of 3-inch wg (750 Pa) when verification of maximum allowable leakage is important. If retaining, indicate location, size, and other details of mockups on Drawings and retain "Leakage Tests" paragraph in "Field Quality Control" Article.

ASHRAE/IES 90.1 requires leakage testing for representative sections totaling no less than 25 percent of installed duct area for ducts designated to operate at a static-pressure class in excess of 3-inch wg (750 Pa) and for all ductwork located outdoors. Consider building a mockup of typical portions of the system that can be tested early in the construction process. This standard, as enforced by some authorities having jurisdiction, requires duct systems with static-pressure classes in excess of 3-inch wg (750 Pa) to be indicated on Drawings.

* + - * 1. Mockups:

Before installing duct systems, build mockups representing static-pressure classes [**3-inch wg**] <**Insert value**> and higher. Build mockups to comply with the following requirements, using materials indicated for the completed Work:

[**Five**] <**Insert number**> transverse joints.

[**One**] <**Insert number**> access door(s).

[**Two**] <**Insert number**> typical branch connections, each with at least one elbow.

[**Two**] <**Insert number**> typical flexible duct or flexible-connector connections for each duct and apparatus.

[**One**] <**Insert number**> 90-degree turn(s) with turning vanes.

[**One**] <**Insert number**> fire damper(s).

[**One**] <**Insert number**> smoke damper(s).

Perform leakage tests specified in "Field Quality Control" Article. Revise mockup construction and perform additional tests as required to achieve specified minimum acceptable results.

Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

* + - 1. WARRANTY

When warranties are required, verify with Director’s Representativ counsel that warranties stated in this article are not less than remedies available to Owner under prevailing local laws.

* + - * 1. Warranty: Manufacturer agrees to repair or replace components of ductwork system that fail in material or workmanship within specified warranty period.

Warranty Period, HDPE Duct System: [**10**] <**Insert number**> year(s) from date of Substantial Completion.

1. PRODUCTS

Manufacturers and products listed in SpecAgent and MasterWorks Paragraph Builder are neither recommended nor endorsed by the AIA or Deltek. Before inserting names, verify that manufacturers and products listed there comply with requirements retained or revised in descriptions and are both available and suitable for the intended applications.

* + - 1. PERFORMANCE REQUIREMENTS

Retain "Delegated Duct Design" paragraph below if Contractor is required to assume responsibility for duct construction design.

* + - * 1. Delegated Duct Design: Duct construction, including duct closure, reinforcements, and hangers and supports, shall comply with the following and with the Works' performance requirements and design criteria:

SMACNA's "Fibrous Glass Duct Construction Standards."

SMACNA's "Phenolic Duct Construction Standards."

SMACNA's "Thermoplastic Duct (PVC) Construction Manual."

SMACNA's "Thermoset FRP Duct Construction Manual."

Retain "Static-Pressure Classes" subparagraph below if static-pressure classes are not indicated on Drawings. See "Static-Pressure Classes" Article in the Evaluations for information about static-pressure limitations for fibrous-glass ducts.

Static-Pressure Classes:

Supply Ducts (except in Mechanical Rooms): [**2-inch wg**] <**Insert value**>.

Supply Ducts (Upstream from Air Terminal Units): [**2-inch wg**] <**Insert value**>.

Supply Ducts (Downstream from Air Terminal Units): [**1-inch wg**] <**Insert value**>.

Supply Ducts (in Mechanical Equipment Rooms): [**2-inch wg**] <**Insert value**>.

Return Ducts (Negative Pressure): [**1-inch wg**] <**Insert value**>.

Exhaust Ducts (Negative Pressure): [**1-inch wg**] <**Insert value**>.

<**Insert duct systems and static-pressure class**>.

Retain "Seismic Performance" paragraph below with "Seismic Qualification Data" paragraph in "Informational Submittals" Article for projects requiring seismic design. Model building codes and ASCE/SEI 7 establish criteria for buildings subject to earthquake motions. Verify requirements of authorities having jurisdiction. Coordinate with Section 230548 "Vibration and Seismic Controls for HVAC."

* + - * 1. Seismic Performance: Ducts to withstand the effects of earthquake motions determined in accordance with [**ASCE/SEI 7**] <**Insert requirement**>. See Section 230548 "Vibration and Seismic Controls for HVAC."

Retain first subparagraph below to define the term "withstand" as it applies to this Project. Definition varies with type of building and occupancy and is critical to valid certification. Option is used for essential facilities where equipment must operate immediately after an earthquake.

The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."

Coordinate "Component Importance Factor" subparagraph below with Section 230548 "Vibration and Seismic Controls for HVAC" and ASCE/SEI 7.

Component Importance Factor: [**1.5**] [**1.0**].

See ASCE/SEI 7, Coefficients for Architectural Component Table and Seismic Coefficients for Mechanical and Electrical Components Table, for requirements to be inserted in subparagraph below. Coordinate with Section 230548 "Vibration and Seismic Controls for HVAC."

<**Insert requirements for Component Amplification Factor and Component Response Modification Factor**>.

Retain "Wind-Restraint Performance" paragraph below with "Delegated-Design Submittal" paragraph in "Action Submittals" Article for projects requiring wind-restraint design. Model building codes and ASCE/SEI 7 establish criteria for wind loads. Verify requirements of authorities having jurisdiction.

* + - * 1. Wind-Restraint Performance:

See [**Section 230548 "Vibration and Seismic Controls for HVAC"**] [**Section 230548.13 "Vibration Controls for HVAC"**] for requirements.

* + - * 1. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1, Section 5.4 - "Airstream Surfaces."
				2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."
				3. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
				4. NFPA Compliance:

NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."

NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

* + - 1. FIBROUS-GLASS DUCTS AND FITTINGS

Maximum performance parameters are static-pressure classes from minus 2- to plus 2-inch wg (minus 500 to plus 500 Pa), velocity up to 2400 fpm (12.2 m/s), and leakage class 6 cfm/100 sq. ft. at 1-inch wg (0.3 L/s per sq. m at 250 Pa) with all joints sealed. Confirm acceptable applications with authorities having jurisdiction. In general, fibrous-glass ducts should not be used for the following:

Kitchen hood or fume exhaust.

Installation in contact with concrete or buried below grade.

Outdoor installation.

As casings for built-up equipment.

Immediately adjacent to electric heating coils.

For vertical risers in air duct systems serving more than two stories.

For air ducts connected to coal- or wood-fueled equipment.

In variable-air-volume systems on the high pressure side unless reinforced to withstand full fan pressure.

With fire damper unless installed according to SMACNA or NAIMA and fire-damper manufacturer details.

* + - * 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Certainteed; SAINT-GOBAIN.

Johns Manville; a Berkshire Hathaway company.

Knauf Insulation.

Owens Corning.

Approved equivalent.

* + - * 1. Fibrous-Glass Duct Materials: Resin-bonded fiberglass, faced on the outside surface with fire-resistive FSK vapor retarder and with a smooth fiberglass mat finish on the air-side surface.

Duct Board: Factory molded into rectangular boards.

Temperature Limits: 40 to 250 deg F inside ducts; 150 deg F ambient temperature surrounding ducts.

Maximum Thermal Conductivity: [**0.24 Btu x in./h x sq. ft. x deg F**] <**Insert conductivity**> at 75 deg F mean temperature.

Moisture Absorption: Not exceeding 5 percent by weight at 120 deg F and 95 percent relative humidity for 96 hours when tested according to ASTM C1104.

Acoustical Performance: Conform to sound absorption coefficients listed in NAIMA AH116.

Permeability: 0.02 perm maximum when tested according to ASTM E96, Procedure A.

Antimicrobial Agent: Compound shall be tested for efficacy by an NRTL, and registered by the EPA for use in HVAC systems.

Noise-Reduction Coefficient: 0.65 minimum when tested according to ASTM C423, Mounting A.

Fire/Smoke Resistance: Duct material shall comply with UL 181, Class 1, maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL according to ASTM E84.

Required Markings: EI stiffness rating, UL label, and other markings required by UL 181 on each full sheet of duct board.

* + - * 1. Closure Materials:

Retain "Pressure-Sensitive Tape," "Heat-Activated Tape," or "Two-Part Tape Sealing System" subparagraph below, or retain all to permit Contractor's choice.

Pressure-Sensitive Tape: Comply with UL 181A; imprinted by manufacturer with coding "181A-P," manufacturer's name, and a date code.

Tape: Aluminum foil-scrim tape imprinted with listing information.

Minimum Tape Width: 2-1/2 inches; 3 inches for duct board thicker than 1 inch.

Staples: 1/2-inch outward clinching, 2 inches o.c. in tabs, one tab per joint.

Water resistant.

Mold and mildew resistant.

Heat-Activated Tape: Comply with UL 181A; imprinted by manufacturer with coding "181A-H," manufacturer's name, and a date code.

Tape: Aluminum foil-scrim tape imprinted with listing information.

Minimum Tape Width: 3 inches.

Heat-Sensitive Imprint: Printed indicator on tape to show proper heating during application has been achieved.

Water resistant.

Mold and mildew resistant.

Two-Part Tape Sealing System: Comply with UL 181A; imprinted by manufacturer with coding "181A-M," manufacturer's name, and a date code.

Tape: Woven glass fiber impregnated with mineral gypsum.

Minimum Tape Width: 3 inches.

Sealant: Modified styrene acrylic.

Water resistant.

Mold and mildew resistant.

* + - * 1. Fabrication:

Comply with: [**SMACNA's "Fibrous Glass Duct Construction Standards," Ch. 3, "Specifications and Closure," and Ch. 4, "Fittings and Connections"**] [**NAIMA AH116, "Fibrous Glass Duct Construction Standards," Section II, "Fabrication of Straight Duct Modules," Section III, "Fabrication of Fittings from Modules or Flat Board," and Section IV, "Closure"**] for the following:

Joints, seams, transitions, elbows, and branch connections.

Reinforcements, including channel and tie rod reinforcement materials, spacing, and fabrications.

Fabricate 90-degree mitered elbows to include turning vanes.

* + - * 1. Reinforcements: Comply with requirements in [**SMACNA's "Fibrous Glass Duct Construction Standards," Ch. 5, "Reinforcement"**] [**NAIMA AH116, "Fibrous Glass Duct Construction Standards," Section V, "Reinforcement"**] for channel- and tie-rod reinforcement materials, spacing, and fabrication.
			1. PHENOLIC-FOAM DUCTS AND FITTINGS

Maximum performance parameters are static-pressure classes from minus 4- to plus 4-inch wg (minus 1000 to plus 1000 Pa), velocity up to 5000 fpm (25 m/s), and leakage class 6 cfm/100 sq. ft. at 1-inch wg (0.3 L/s per sq. m at 250 Pa) with all joints sealed.

* + - * 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

AQC Industries, LLC.

Kingspan Insulation Limited.

PTM Manufacturing, LLC.

Approved equivalent.

* + - * 1. Duct Panel: CFC-free phenolic-foam bonded on both sides with factory-applied, 0.001-inch- thick, aluminum foil reinforced with fiberglass scrim.

Temperature Limits:

Maximum 176 deg F.

Minimum: Minus 4 deg F.

Maximum Thermal Conductivity: [**0.15 Btu x in./h x sq. ft. x deg F**] <**Insert conductivity**> at 75 deg F mean temperature.

Permeability: 0.0002 perm maximum when tested according to ASTM E96, Procedure A.

Antimicrobial Agent: Compound shall be tested for efficacy by an NRTL, and registered by the EPA for use in HVAC systems.

Noise-Reduction Coefficient: 0.65 minimum when tested according to ASTM C423, Mounting A.

Fire/Smoke Resistance: Duct material shall comply with UL 181, Class 1, maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL according to ASTM E84.

Required Markings: UL label and other markings required by UL 181 on each full sheet of duct panel; UL ratings for closure materials.

* + - * 1. Closure Materials:

V-Groove Adhesive: Silicone.

Retain "Pressure-Sensitive Tape" or "Polymeric Sealing System" subparagraph below, or both, to permit Contractor's choice.

Pressure-Sensitive Tape: Comply with UL 181A; imprinted by manufacturer with coding "181A-P," manufacturer's name, and a date code.

Tape: Aluminum foil tape imprinted with listing information.

Minimum Tape Width: 3 inches.

Water resistant.

Mold and mildew resistant.

Polymeric Sealing System:

Structural Membrane: Woven glass fiber.

Minimum Tape Width: 3 inches.

Sealant: Water based.

Color: White.

Water resistant.

Mold and mildew resistant.

* + - * 1. Fabrication:

Fabricate joints, seams, transitions, reinforcement, elbows, branch connections, access doors and panels, and damage repairs according to manufacturer's written instructions.

Fabricate 90-degree mitered elbows to include turning vanes.

* + - 1. THERMOSET FRP DUCTS AND FITTINGS

Maximum performance parameters vary among manufacturers but are typically static-pressure classes from minus 4- to plus 10-inch wg (minus 1000 to plus 2500 Pa), velocity up to 2500 fpm (12.7 m/s), and leakage class 6 cfm/100 sq. ft. at 1-inch wg (0.29 L/s per sq. m at 250 Pa) with all joints sealed. Thermoset FRP ducts are available to comply with NFPA 90A and NFPA 90B requirements to comply with UL 181, Class 1. If these ducts are specified, they may generally be used inside and outside of buildings and may also be direct buried with proper protection. Verify duct material selection with authorities having jurisdiction.

* + - * 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Monoxivent Co.

Perry Fiberglass Products, Inc.

Approved equivalent.

* + - * 1. Duct and Fittings:

Retain "Thermoset FRP Resin" or "Inner Liner" subparagraph below, or both. Retain first subparagraph if duct is to be installed indoors aboveground and is approved for installation in the building by authorities having jurisdiction. Retain second if duct is to be installed underground; this is least costly duct.

Thermoset FRP Resin: Comply with UL 181, Class 1, maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL according to ASTM E84.

Inner Liner: FSK liner rated by an NRTL to comply with UL 181, Class 1.

Verify minimum thickness in subparagraphs below with manufacturer. Thickness varies with manufacturer and duct size.

Round Duct: ASTM D2996, Type I, Grade 2, Class E, filament-wound duct, minimum [**0.125-inch**] <**Insert dimension**> wall thickness, with tapered bell-and-spigot ends for adhesive joints or with plain ends with couplings.

Round Fittings: Compression or spray-up/contact, molded of same material, pressure class, and joining method as duct.

Rectangular Fittings: Minimum [**0.125-inch-**] <**Insert dimension**> thick, flat sheet with fiberglass roving and resin-reinforced joints and seams.

Double-Wall Insulated Duct: Inner and outer duct complying with requirements in "Round Duct" Subparagraph. Polyurethane foam or isocyanurate insulation with maximum thermal conductivity of [**0.14 Btu x in./h x sq. ft. x deg F**] <**Insert conductivity**> at 75 deg F mean temperature.

* + - * 1. Joining Materials: Roving and polyester resin.
				2. Fabrication:

Fabricate joints, seams, transitions, reinforcement, elbows, branch connections, and access doors and panels according to SMACNA's "Thermoset FRP Duct Construction Manual," Ch. 7, "Requirements."

Fabricate 90-degree rectangular mitered elbows to include turning vanes, and 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.

Retain "Drains" paragraph below if duct is installed underground and drain piping can be run to air-gap drain.

* + - * 1. Drains: Formed drain pockets with a minimum of NPS 1 threaded pipe connections.
			1. PVC DUCTS AND FITTINGS

Maximum performance parameters vary among manufacturers but are typically static-pressure classes from minus 4- to plus 10-inch wg (minus 1000 to plus 2500 Pa), velocity up to 2500 fpm (12.7 m/s), and leakage class 6 cfm/100 sq. ft. at 1-inch wg (0.29 L/s per sq. m at 250 Pa) with all joints sealed. These ducts may be installed underground or outside the building; however, because the material does not comply with NFPA 90A and NFPA 90B requirements to comply with UL 181, Class 1, they generally are unsuitable for indoor use. Verify duct material selection with authorities having jurisdiction. Maximum temperature rating of PVC ducts is generally about 140 deg F (60 deg C). PVC ducts are resistant to most, but not all, acids, bases, salts, aliphatic solutions, oxidants, and halogens. Before retaining product type, verify that this material is resistant to specific fumes to be conveyed.

* + - * 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

General Plastics, Inc.

GPK Products, Inc.

Kroy Industries, Inc.

Spears Manufacturing Company.

Approved equivalent.

* + - * 1. Duct and Fittings:

Material: Rigid, virgin PVC compound complying with ASTM D1784 Cell Classification 12454-B.

Flammability: Maximum flame-spread index of not more than 25 without evidence of continued progressive combustion.

External Loading Properties: ASTM D2412.

Minimum Round Duct Wall Thickness: [**0.187 inch for up to 18-inch**] [**0.219 inch for up to 20-inch**] [**0.25 inch for up to 24-inch**] <**Insert dimensions**> duct.

Round Fittings: Socket end molded of same material, pressure class, and joining method as duct.

Verify minimum thickness in "Rectangular Fittings" subparagraph below with manufacturers. Thickness varies with manufacturer and duct size.

Rectangular Fittings: Minimum [**0.125-inch-**] <**Insert dimension**> thick, flat sheet with heat-formed corners and continuous welded butt joints.

* + - * 1. Joining Materials: PVC solvent cement complying with ASTM D2564.
				2. Fabrication:

Fabricate joints, seams, transitions, reinforcement, elbows, branch connections, and access doors and panels according to SMACNA's "Thermoplastic Duct (PVC) Construction Manual," Ch. 3, "Standards of Construction for PVC Duct Systems."

Fabricate 90-degree rectangular mitered elbows to include turning vanes, and 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.

Retain "Drains" paragraph below if duct is installed underground and drain piping can be run to air-gap drain.

* + - * 1. Drains: PVC drain pockets with a minimum of NPS 1 threaded PVC pipe connections.
			1. CPVC DUCTS AND FITTINGS

Maximum performance parameters vary among manufacturers but are typically static-pressure classes from minus 4- to plus 10-inch wg (minus 1000 to plus 2500 Pa), velocity up to 2500 fpm (12.7 m/s), and leakage class 6 cfm/100 sq. ft. at 1-inch wg (0.29 L/s per sq. m at 250 Pa) with all joints sealed. These ducts are generally installed underground or outside the building because of NFPA 90A and NFPA 90B requirements to comply with UL 181, Class 1. Some, but not all products comply with UL 181, Class 1. Verify duct material selection with authorities having jurisdiction prior to design. Maximum temperature rating of CPVC ducts is generally about 200 deg F (93 deg C). CPVC ducts are generally resistant to most, but not all acids, bases, salts, aliphatic solutions, oxidants, and halogens. Before retaining product type, verify that this material is resistant to specific fumes to be conveyed.

* + - * 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Harrison Machine & Plastic Corporation.

Harvel Plastics, Inc.

Spears Manufacturing Company.

Approved equivalent.

* + - * 1. Duct and Fittings:

Material: Rigid, virgin CPVC compound complying with ASTM D1784 Cell Classification 23447.

Flammability: Maximum flame-spread index of not more than 25 without evidence of continued progressive combustion and a smoke-developed index of not more than 50.

Maximum Service Temperature: 200 deg F.

External Loading Properties: ASTM D2412.

Round Fittings: Socket end molded of same material, pressure class, and joining method as duct.

Verify minimum thickness in "Rectangular Fittings" subparagraph below with manufacturer. Thickness varies with manufacturer and duct size.

Rectangular Fittings: Minimum [**0.125-inch-**] <**Insert dimension**> thick, flat sheet with heat-formed corners and continuous welded butt joints.

* + - * 1. Joining Materials: CPVC solvent cement complying with ASTM D2564.
				2. Fabrication:

Fabricate joints, seams, transitions, reinforcement, elbows, branch connections, and access doors and panels according to SMACNA's "Thermoplastic Duct (PVC) Construction Manual," Ch. 3, "Standards of Construction for PVC Duct Systems."

Fabricate 90-degree rectangular mitered elbows to include turning vanes, and 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.

Retain "Drains" paragraph below if duct is installed underground and drain piping can be run to air-gap drain.

* + - * 1. Drains: CPVC drain pockets with a minimum of NPS 1 threaded CPVC pipe connections.
			1. HDPE DUCT AND FITTINGS
				1. Manufacturers: Subject to compliance with requirements, provide products by the following:

AQC Industries, LLC.

Approved equivalent.

* + - * 1. Source Limitations: Obtain HDPE duct system components from single manufacturer.
				2. Description: Complete HDPE underground duct system consisting of factory-manufactured components to suit duct layout configuration including straight round duct, elbows, [**plenums,**] [**run-outs,**] [**diffuser boots,**] fitting clamps, gaskets, bolts, sealant, and other components required for a complete underground ductwork system.
				3. Duct and Fittings:

Material:

Closed-cell recyclable HDPE plastic.

Does not emit VOCs.

Leakage: Air leakage testable, exceeding SMACNA Leakage Class 3 requirements at system design static pressure.

Thermal Distribution Efficiency: Inherent R-10 equivalent thermal insulation efficiency without using a separate insulation layer, tested in accordance with NSF P374 protocol and verified by an NSF thermal testing report.

Resistant to mildew, mold, and rust.

Remains stable, without cracking, when subjected to underground stresses and strains.

Rated for maximum 10-inch wg positive pressure and maximum rated 2-inch wg negative pressure.

Surface-Burning Characteristics: Flame-spread index of 200 or less when tested in accordance with ASTM E84.

Flood Plain Elevation: Tested to withstand 8-foot water column pressure for seven days with no leakage.

* + - * 1. Joining Materials:

Flanged Ductwork: Join with stainless steel bolts and water- and UV-resistant copolymer adhesive caulking sealant.

Unflanged Ductwork:

Clamps: Polyethylene clamps with stainless steel plates and stainless steel screws.

Gaskets: Butyl rubber gaskets, minimum 0.25 inch thick.

* + - 1. HANGERS AND SUPPORTS

Indicate extent of corrosive environment on Drawings.

* + - * 1. Hanger Rods for Noncorrosive Environments: Zinc-plated steel rods and nuts.
				2. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
				3. 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."
				4. Steel Cables: [**ASTM A603, galvanized**] [**ASTM A492, stainless**]-steel cables with end connections made of [**zinc-plated**] [**stainless-**]steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
				5. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
				6. Trapeze and Riser Supports: Steel shapes complying with ASTM A36.
			1. SEISMIC-RESTRAINT DEVICES

Coordinate specifications for seismic-restraint components in this article with structural engineer and with Drawings. See "Seismic Considerations" Article in the Evaluations for discussion on seismic restraints.

* + - * 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Hilti, Inc.

Kinetics Noise Control, Inc.

Mason Industries, Inc.

Approved equivalent.

See the Evaluations in Section 230548 "Vibration and Seismic Controls for HVAC" for discussion on seismic-restraint capacities and rating services.

* + - * 1. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by [**an evaluation service member of ICC-ES**] [**an agency acceptable to authorities having jurisdiction**].

Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least [**four**] <**Insert number**> times the maximum seismic forces to which they will be subjected.

* + - * 1. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels 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.
				2. Restraint Cables: [**ASTM A603, galvanized**] [**ASTM A492, stainless**]-steel cables with end connections made of [**zinc plated**] [**stainless-**]steel assemblies with brackets, swivel, and bolts designed for restraining cable service; with an automatic-locking and clamping device or double-cable clips.

Retain "Hanger Rod Stiffener" paragraph below for strengthening resistance of hanger rods against seismic forces that may cause rods to buckle. Use with either channel- or cable-type bracing assemblies when required to counter seismic forces. Detail fabrication and indicate locations on Drawings.

* + - * 1. Hanger Rod Stiffener: [**Steel tube or steel slotted-support-system sleeve with internally bolted connections**] [**Reinforcing steel angle clamped**] to hanger rod.
				2. 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 E488.
1. EXECUTION
	* + 1. DUCT INSTALLATION

Coordinate duct layout and duct accessory arrangement with Drawings.

* + - * 1. 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.
				2. Install duct sections in maximum practical lengths with fewest possible joints.
				3. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
				4. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
				5. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
				6. Install ducts with a minimum clearance of 1 inch, plus allowance for insulation thickness.
				7. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
				8. 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. Overlap openings on four sides by at least 1-1/2 inches.
				9. Install fire[**, combination fire/smoke,**] and smoke dampers where indicated on Drawings and as required by code and by authorities having jurisdiction. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the fire damper UL listing.
				10. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.
				11. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation.[**Comply with SMACNA's "IAQ Guidelines for Occupied Buildings under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."**]
				12. Elbows: Use long-radius elbows wherever they fit.

Fabricate 90-degree rectangular mitered elbows to include turning vanes, and 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.

* + - * 1. Branch Connections: Use lateral or conical branch connections.
				2. Install fibrous-glass ducts and fittings to comply with [**NAIMA AH116, "Fibrous Glass Duct Construction Standards."**] [**SMACNA's "Fibrous Glass Duct Construction Standards."**]
				3. Install phenolic-foam ducts and fittings to comply with SMACNA's "Phenolic Duct Construction Standards."
				4. Install thermoset FRP ducts and fittings to comply with SMACNA's "Thermoset FRP Duct Construction Manual."
				5. Install PVC ducts and fittings to comply with SMACNA's "Thermoplastic Duct (PVC) Construction Manual."
				6. Install CPVC ducts and fittings to comply with SMACNA's "Thermoplastic Duct (PVC) Construction Manual."
				7. Install HDPE ducts, fittings, and components to comply with manufacturer's written installation instructions. Installer to complete manufacturer's installation training prior to installation.
			1. HANGER AND SUPPORT INSTALLATION
				1. Install hangers and supports for fibrous-glass ducts and fittings to comply with [**SMACNA's "Fibrous Glass Duct Construction Standards," Ch. 6, "Hangers and Supports."**] [**NAIMA AH116, "Fibrous Glass Duct Construction Standards," Section VI, "Hangers and Supports."**]
				2. Install hangers and supports for phenolic-foam ducts and fittings to comply with SMACNA's "Phenolic Duct Construction Standards" Ch. 6, "Hangers and Supports" and with manufacturer's written instructions.
				3. Install hangers and supports for thermoset FRP ducts and fittings to comply with SMACNA's "Thermoset FRP Duct Construction Manual," Ch. 7, "Requirements."
				4. Install hangers and supports for PVC ducts and fittings to comply with SMACNA's "Thermoplastic Duct (PVC) Construction Manual," Ch. 3, "Standards of Construction for PVC Duct Systems."
				5. Install hangers and supports for CPVC ducts and fittings to comply with SMACNA's "Thermoplastic Duct (PVC) Construction Manual," Ch. 3, "Standards of Construction for PVC Duct Systems."

Verify attachment selection and spacing in two paragraphs below with Structural Engineer.

* + - * 1. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

Install concrete inserts before placing concrete.

Powder-actuated fasteners may be banned for use in certain occupancies. Consult authorities having jurisdiction and Owner's Project requirements.

Install powder-actuated concrete fasteners after concrete is placed and completely cured.

Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.

Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

Retain subparagraph below for projects that require seismic restraints.

Do not use powder-actuated concrete fasteners for seismic restraints.

* + - * 1. 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.
			1. SEISMIC-RESTRAINT-DEVICE INSTALLATION
				1. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. See Section 230548 "Vibration and Seismic Controls for HVAC." Comply with [**SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."**] [**ASCE/SEI 7.**]

Options for 40 and 80 feet in first subparagraph below are per SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems." Revise these dimensions based on duct configuration and seismic hazard.

Space lateral supports a maximum of [**40 feet**] <**Insert dimension**> o.c., and longitudinal supports a maximum of [**80 feet**] <**Insert dimension**> o.c.

Brace a change of direction longer than 12 feet.

* + - * 1. Select sizes of components so strength will be adequate to carry calculated static and seismic loads within restraint device capacity.
				2. Install restraint cables so they do not bend across edges of adjacent equipment or building structure.
				3. Install restraint cables where ducts are suspended with vibration isolators.
				4. Install seismic-restraint devices using methods approved by [**an agency acceptable to authorities having jurisdiction**].
				5. 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.
				6. Drilling for Post-Installed Concrete Anchors:

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 Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and water and gas lines.

Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.

Mechanical-Type Anchor Bolts: 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.

Adhesive-Type Anchor Bolts: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.

Set anchors to manufacturer's recommended torque, using a torque wrench.

Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

* + - 1. PAINTING

Retain this article if thermoset FRP, PVC, or CPVC ducts are specified.

* + - * 1. Paint interior of [**thermoset FRP**] [**PVC**] [**and**] [**CPVC**] ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, acrylic or latex paint that is chemically compatible with duct material. Confirm compatibility information with paint manufacturer. Oil-based paint is not recommended. Paint materials and application requirements are specified in Section 099123 "Interior Painting."
			1. STARTUP SERVICE

Sustainable design systems require compliance with ASHRAE 62.1; see Section 7 - "Construction and System Start-up."

* + - * 1. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
			1. FIELD QUALITY CONTROL

Retain first option in "Testing Agency" paragraph below if Owner will hire an independent testing agency.

Retain "Manufacturer's Field Service" paragraph below to require a Company Service Advisor to perform tests and inspections.

* + - * 1. Manufacturer's Field Service: Engage a company field advisor to test and inspect components, assemblies, and equipment installations, including connections.

Retain "Perform tests and inspections" paragraph below to require Contractor to perform tests and inspections and retain option to require Contractor to arrange for the assistance of a Company Service Advisor.

* + - * 1. Perform tests and inspections[**with the assistance of a company field advisor**].

Retain test requirements below with any combination of paragraphs above.

Retain "Leakage Tests" paragraph below for ducts in pressure classes higher than 3-inch wg (750 Pa) or if required for sustainable design systems. It may not be economically practical to test ducts in pressure classes less than 3-inch wg (750 Pa).

Leakage Tests:

Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.

Where static pressure and leakage values shown below differ from those in the SMACNA manual, the more stringent values shall apply.

Test the following systems:

Sustainable design systems require compliance with ASHRAE/IES 90.1, in which Section 6.4.4.2.2 - "Duct Leakage Tests" requires leak testing of at least 25 percent of total installed duct area with a pressure class in excess of 3-inch wg (750 Pa). Retain first subparagraph below to comply with ASHRAE/IES 90.1. To define more stringent requirements, retain subsequent subparagraphs as applicable and delete first subparagraph. Consider cost impact when specifying extent of duct area to be tested. It is not common to leak test all ducts or ducts with a pressure class less than 3-inch wg (750 Pa).

Ducts with a Pressure Class Higher Than 3-Inch wg: Test representative duct sections[**, selected by Architect from sections installed,**] totaling no less than 25 percent of total installed duct area for each designated pressure class.

Supply Ducts with a Pressure Class of [**2-Inch wg**] [**3-Inch wg**] [**4-Inch wg**] <**Insert value**> or Higher: Test representative duct sections[**, selected by Architect from sections installed,**] totaling no less than [**50**] [**100**] <**Insert number**> percent of total installed duct area for each designated pressure class.

Return Ducts with a Pressure Class of [**2-Inch wg**] [**3-Inch wg**] [**4-Inch wg**] <**Insert value**> or Higher: Test representative duct sections[**, selected by Architect from sections installed,**] totaling no less than [**50**] [**100**] <**Insert number**> percent of total installed duct area for each designated pressure class.

Exhaust Ducts with a Pressure Class of [**2-Inch wg**] [**3-Inch wg**] [**4-Inch wg**] <**Insert value**> or Higher: Test representative duct sections[**, selected by Architect from sections installed,**] totaling no less than [**50**] [**100**] <**Insert number**> percent of total installed duct area for each designated pressure class.

Outdoor Air Ducts with a Pressure Class of [**2-Inch wg**] [**3-Inch wg**] [**4-Inch wg**] <**Insert value**> or Higher: Test representative duct sections[**, selected by Architect from sections installed,**] totaling no less than [**50**] [**100**] <**Insert number**> percent of total installed duct area for each designated pressure class.

Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

Retain first subparagraph below for field-insulated thermoset FRP, PVC, or CPVC ducts.

Test for leaks before applying external insulation.

Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.

Give [**seven**] <**Insert number**> days' advance notice for testing.

Retain "Duct System Cleanliness Tests" paragraph below if duct cleaning is required. Text was taken from NADCA ACR. "Method 2 Protocol," which omits the NADCA Vacuum Test, is used on fibrous-glass duct systems because the vacuum sampling would risk damage to the duct surface.

Sustainable design systems require compliance with ASHRAE 62.1, in which Section 7.2.4 - "Ventilation System Start-up" requires that distribution systems be clean of dirt and debris.

Duct System Cleanliness Tests:

Test protocols shall be performed according to NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems," "Section 5 - Cleanliness Verification and Documentation."

Visually inspect duct system to ensure that no visible contaminants are present.

Test sections of fibrous-glass duct system chosen randomly by Director’s Representative for cleanliness according to "Method 2 Protocol."

Test sections of Phenolic-foam, Thermoset FRP, PVC, and CPVC duct systems chosen randomly by Director’s Representative, for cleanliness according to "Method 3 - NADCA Vacuum Test."

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

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

Prepare test and inspection reports.

* + - 1. DUCT CLEANING

Retain this article for applications where construction dust and debris in duct system must be removed before air-system operation. Where applicable, indicate on Drawings extent of ductwork to be cleaned. Cleaning methods specified in this article and in NADCA ACR apply to fibrous-glass, phenolic-foam, thermoset FRP, PVC, and CPVC ductwork. Sustainable design systems require compliance with ASHRAE 62.1, in which Section 7.2.4 - "Ventilation System Start-up" requires that distribution systems be clean of dirt and debris.

* + - * 1. Clean duct system(s) before testing, adjusting, and balancing.
				2. Use service openings for entry and inspection.

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 duct as recommended by duct manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.

Disconnect and reconnect flexible ducts as needed for cleaning and inspection.

Remove and reinstall ceiling to gain access during the cleaning process.

* + - * 1. Particulate Collection and Odor Control:

When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron (or larger) particles.

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.

* + - * 1. Clean the following components by removing surface contaminants and deposits:

Air outlets and inlets (registers, grilles, and diffusers).

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.

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.

Coils and related components.

Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.

Supply-air ducts, dampers, actuators, and turning vanes.

Dedicated exhaust and ventilation components and makeup air systems.

* + - * 1. Mechanical Cleaning Methodology:

All duct cleaning shall be performed according to NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

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.

Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of ducts or duct accessories.

Clean fibrous-glass duct with HEPA vacuuming equipment; do not permit duct to get wet. Replace fibrous-glass duct that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.

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.

Provide drainage and cleanup for washdown procedures.

Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removing surface deposits and debris.

* + - 1. DUCT SCHEDULE

Retain and revise required duct applications in this article. Coordinate with materials specified in Part 2.

Sustainable design systems require that duct insulation R-values comply with ASHRAE/IES 90.1 tables titled "Minimum Duct Insulation R-Value, Cooling and Heating Only Supply Ducts and Return Ducts" and "Minimum Duct Insulation R-Value, Combined Heating and Cooling Supply Ducts and Return Ducts." If using duct material alone to satisfy thermal requirements, verify that material is available in thickness needed to provide thermal performance without jeopardizing other requirements.

* + - * 1. Indoor Ducts and Fittings:

Retain one of or both subparagraphs below for materials of ducts to be installed indoors. Indicate materials on Drawings if more than one is required. Only rectangular ducts are noted because no manufacturers were found that offer round fibrous-glass ducts.

Fibrous-Glass Rectangular Ducts and Fittings:

Retain first subparagraph below to require minimum flexural rigidity of fibrous-glass ducts. Otherwise, Contractor will select EI rating as part of duct design based on size of ducts and static-pressure class. SMACNA's "Fibrous Glass Duct Construction Standards" does not recognize EI-1400 but NAIMA AH116 does.

Minimum Flexural Rigidity: EI-[**475**] [**800**] [**1400**].

Retain board thickness below to achieve required thermal and acoustical performance. Flexural rigidity and acoustic performance are a function of board thickness.

Minimum Board Thickness: [**1 inch**] [**1-1/2 inches**] [**2 inches**].

Phenolic-Foam Rectangular Ducts and Fittings:

Retain first subparagraph below for minimum thermal performance of phenolic-foam ducts. Retain board thickness below to achieve required thermal performance.

Minimum Panel Thickness: [**7/8 inch**] [**1-3/32 inches**].

Retain first subparagraph below for factory-applied aluminum cladding for indoor installation of ducts exposed to view.

Aluminum Cladding: Minimum 0.025 inch thick.

Joints: Secure joints with adhesive or clips according to duct manufacturer's written instructions, then tape joints with aluminum vapor tape.

Sealing: All joints shall be sealed with a generous and continuous bead of silicone sealant and pressed into corners using a smooth radius tool.

* + - * 1. Outdoor Ducts and Fittings:

Provide suitable external surface protection as recommended by manufacturer.

Retain one of or both subparagraphs below for materials of ducts to be installed outdoors. Indicate materials on Drawings if more than one is required.

Phenolic-Foam Rectangular Ducts and Fittings:

Retain first subparagraph below for minimum thermal performance of phenolic-foam ducts. Otherwise, Contractor will select thickness based on structural requirements of ducts.

Minimum Panel Thickness: [**7/8 inch**] [**1-3/32 inches**].

Aluminum Cladding: Minimum 0.032 inch thick.

Joints: Secure joints with adhesive or clips according to duct manufacturer's written instructions, then tape joints with aluminum vapor tape.

Sealing: All joints shall be sealed with a generous and continuous bead of silicone sealant and pressed into corners using a smooth radius tool.

Thermoset FRP Round Ducts and Fittings:

Insulation thickness in first subparagraph below varies with manufacturer.

Double-Wall Insulated Ducts: Minimum [**5/8-inch**] [**7/8-inch**] [**1-inch**] insulation thickness with [**k-factor of 14**] <**Insert value**> insulation thickness.

* + - * 1. Underground Ducts:

Underground ducts must be drained efficiently. Water can infiltrate or condense in underground ducts. Mold growth in damp underground ducts will cause significant indoor-air-quality issues. Drawings must include a suitable drain design.

Provide suitable external surface protection as recommended by manufacturer.

Retain one or more of three subparagraphs below for materials of ducts to be installed underground. Indicate materials on Drawings if more than one is required.

Thermoset FRP Round Ducts and Fittings:

Double wall.

Insulation Thickness: [**1 inch**] <**Insert dimension**>.

Drain: Minimum NPS 1 PVC pipe with P-trap to air-gap drain.

PVC Round Ducts and Fittings:

Drain: Minimum NPS 1 PVC pipe with P-trap to air-gap drain.

CPVC Round Ducts and Fittings:

Drain: Minimum NPS 1 CPVC pipe with P-trap to air-gap drain.

HDPE Round Ducts and Fittings: Drain as recommended by manufacturer.

* + - * 1. Fume Exhaust:

Thermoset FRP ducts and fittings.

Install exhaust ducts without dips and traps that may hold condensate or other liquid, and sloped a minimum of 2 percent to drain. Where indicated on Drawings, install trapped drain piping.

Connect duct to fume hood or other equipment where indicated on Drawings.

END OF SECTION 233116