SECTION 230713 - DUCT INSULATION

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 insulating the following duct services:

The list below matches the various systems in the schedule articles. Coordinate the revision of list with "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles.

Indoor, concealed supply and outdoor air.

Indoor, exposed supply and outdoor air.

Indoor, concealed return located in unconditioned space.

Indoor, exposed return located in unconditioned space.

Indoor, concealed, Type I, commercial, kitchen hood exhaust.

Indoor, exposed, Type I, commercial, kitchen hood exhaust.

Indoor, concealed oven and warewash exhaust.

Indoor, exposed oven and warewash exhaust.

Indoor, concealed exhaust between isolation damper and penetration of building exterior.

Indoor, exposed exhaust between isolation damper and penetration of building exterior.

Outdoor, concealed supply and return.

Outdoor, exposed supply and return.

* + - 1. QUALITY ASSURANCE

Retain first paragraph below if available at Project location. Apprenticeship programs are usually associated with union shops. Other craft training programs are available.

* + - * 1. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

When fire-performance characteristics are important requirements, verify surface-burning characteristics of insulation materials by an independent testing agency and require test report submittals.

* + - * 1. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

If retaining "Mockups" Paragraph below, indicate location, size, and other details of mockups on Drawings or by inserts. Revise if only one mockup is required.

* + - 1. DELIVERY, STORAGE, AND HANDLING

Retain this article to require shipping container markings. Container marking is an option in ASTM standards; default condition does not include the marking in this article unless specified in the Contract.

* + - * 1. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.
			1. COORDINATION
				1. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
				2. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
				3. Coordinate installation and testing of heat tracing.
			2. SCHEDULING
				1. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
				2. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.
1. PRODUCTS
	* + 1. INSULATION MATERIALS

If retaining more than one type of insulation in this article, indicate where each type applies in insulation system schedules.

* + - * 1. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.

See "Product Characteristics" Article in the Evaluations for comparisons and temperature ranges for insulation material properties.

* + - * 1. Products shall not contain asbestos, lead, mercury, or mercury compounds.
				2. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.
				3. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.
				4. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

"Flexible Elastomeric Insulation" Paragraphparagraph below is unsuitable for temperatures lower than minus 70 deg F (minus 57 deg C) and higher than 220 deg F (104 deg C).

* + - * 1. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, Type II for sheet materials.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3062) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Aeroflex USA](http://www.specagent.com/Lookup?uid=123457117444).

[Armacell LLC](http://www.specagent.com/Lookup?uid=123457117445).

[K-Flex USA](http://www.specagent.com/Lookup?uid=123457117446).

Approved equivalent.

For operating temperatures higher than 250 deg F (121 deg C), use blanket insulation in first paragraph below. Retain ASTM C1290 types as follows: Type I for insulation without jackets, Type II for insulation with vinyl jackets, and Type III for insulation with FSK or FSP jackets.

* + - * 1. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type II and ASTM C1290, [**Type I**] [**Type II with factory-applied vinyl jacket**] [**Type III with factory-applied FSK jacket**] [**Type III with factory-applied FSP jacket**]. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3063) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[CertainTeed Corporation](http://www.specagent.com/Lookup?uid=123457117294).

[Johns Manville; a Berkshire Hathaway company](http://www.specagent.com/Lookup?uid=123457117296).

[Knauf Insulation](http://www.specagent.com/Lookup?uid=123457117297).

Approved equivalent.

For operating temperatures higher than 250 deg F (121 deg C), use board insulation in first paragraph below. The most common jacket for ductwork and plenum applications is FSK.

* + - * 1. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type IA or Type IB. For duct and plenum applications, provide insulation [**without factory-applied jacket**] [**with factory-applied ASJ**] [**with factory-applied FSK jacket**]. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3064) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[CertainTeed Corporation](http://www.specagent.com/Lookup?uid=123457117303).

[Johns Manville; a Berkshire Hathaway company](http://www.specagent.com/Lookup?uid=123457117305).

[Knauf Insulation](http://www.specagent.com/Lookup?uid=123457117306).

Approved equivalent.

Pipe and tank insulation is used for large-diameter piping and vessels. ASJ is commonly used.

* + - * 1. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied [**ASJ**] [**FSK jacket**] complying with ASTM C1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C612, Type IB. Nominal density is 2.5 lb/cu. ft.2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3065) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[CertainTeed Corporation](http://www.specagent.com/Lookup?uid=123457117449).

[Johns Manville; a Berkshire Hathaway company](http://www.specagent.com/Lookup?uid=123457117447).

[Knauf Insulation](http://www.specagent.com/Lookup?uid=123457117450).

Approved equivalent.

* + - 1. FIRE-RATED INSULATION SYSTEMS

Retain this article for fire-rated insulation, which is sometimes used in lieu of fire-rated assemblies. A common application is for Type I, commercial, kitchen hood exhaust ductwork. See Evaluations.

* + - * 1. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700 deg F1700 deg F (927 deg C). Comply with ASTM C656, Type II, Grade 6. Tested and certified to provide a [**1**] [**2**]-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3067) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Johns Manville; a Berkshire Hathaway company](http://www.specagent.com/Lookup?uid=123457117452).

Approved equivalent.

* + - * 1. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a [**1**] [**2**]-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3068) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[CertainTeed Corporation](http://www.specagent.com/Lookup?uid=123457117313).

[Johns Manville; a Berkshire Hathaway company](http://www.specagent.com/Lookup?uid=123457117314).

[Nelson Firestop; a brand of Emerson Industrial Automation](http://www.specagent.com/Lookup?uid=123457117315).

Approved equivalent.

* + - 1. ADHESIVES

Military Specification in this article was the only standard available when this Section was written. MIL-A-3316C was last updated in October 1987.

* + - * 1. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

Product attributes in first paragraph below are based on Foster Brand products; there are variations among manufacturers.

* + - * 1. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3069) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Armacell LLC](http://www.specagent.com/Lookup?uid=123457117454).

[Foster Brand; H. B. Fuller Construction Products](http://www.specagent.com/Lookup?uid=123457117455).

[K-Flex USA](http://www.specagent.com/Lookup?uid=123457117456).

Approved equivalent.

* + - * 1. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3070) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Childers Brand; H. B. Fuller Construction Products](http://www.specagent.com/Lookup?uid=123457117321).

[Foster Brand; H. B. Fuller Construction Products](http://www.specagent.com/Lookup?uid=123457117322).

[Mon-Eco Industries, Inc](http://www.specagent.com/Lookup?uid=123457117323).

Approved equivalent.

* + - * 1. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3071) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Childers Brand; H. B. Fuller Construction Products](http://www.specagent.com/Lookup?uid=123457117327).

[Foster Brand; H. B. Fuller Construction Products](http://www.specagent.com/Lookup?uid=123457117329).

[Mon-Eco Industries, Inc](http://www.specagent.com/Lookup?uid=123457117330).

Approved equivalent.

* + - * 1. PVC Jacket Adhesive: Compatible with PVC jacket.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3072) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Johns Manville; a Berkshire Hathaway company](http://www.specagent.com/Lookup?uid=123457117333).

[P.I.C. Plastics, Inc](http://www.specagent.com/Lookup?uid=123457117334).

[The Dow Chemical Company](http://www.specagent.com/Lookup?uid=123457117336).

Approved equivalent.

* + - 1. MASTICS AND COATINGS

Mastic and coating terminology is used interchangeably in this article. Manufacturers refer to vapor barrier formulations and vapor-retarder formulations as "mastics" or "coatings." Low-permeance mastics and coatings are termed "vapor retarders." Products with a perm rating of greater than 1.0 are called "breathable." Consider ambient conditions and operating temperatures when selecting mastics and coatings. Consider using water-based mastics and coatings for environmental reasons.

LEED 2009 IEQ Credit 4.1 does not address requirements for mastics and coatings. LEED 2009 IEQ Credit 4.2 does address requirements for mastics and coatings. LEED v4 EQ Credit "Low-Emitting Materials" does address requirements for mastics and coatings.

* + - * 1. Materials shall be compatible with insulation materials, jackets, and substrates.

Verify that products listed comply with water-vapor permeance. Require proof of performance and certified test reports from vapor-barrier mastic manufacturer to support product literature claims.

Retain one of four paragraphs below. Consider insulation type and operating conditions when selecting mastics and coatings.

* + - * 1. Vapor-Retarder Mastic: Water based; suitable for indoor use on below ambient services.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3073) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Childers Brand; H. B. Fuller Construction Products](http://www.specagent.com/Lookup?uid=123457117343).

[Foster Brand; H. B. Fuller Construction Products](http://www.specagent.com/Lookup?uid=123457117339).

[Knauf Insulation](http://www.specagent.com/Lookup?uid=123457117342).

Approved equivalent.

Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.

Service Temperature Range: Minus 20 to plus 180 deg FMinus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).

Retain MIL-PRF-19565C in first subparagraph below for vapor-retarder mastics and coatings if applicable to project.

Comply with MIL-PRF-19565C, Type II, for permeance requirements[**, with supplier listing on DOD QPD - Qualified Products Database**].

Color: [**White**] <**Insert color**>.

Retain solvent-based "Vapor-Retarder Mastic" Paragraphparagraph below if low-VOC mastics and coatings are not required, or if a lower permeance is required.

* + - * 1. Vapor-Retarder Mastic: Solvent based; suitable for indoor use on below ambient services.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3074) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Childers Brand; H. B. Fuller Construction Products](http://www.specagent.com/Lookup?uid=123457117457).

[Foster Brand; H. B. Fuller Construction Products](http://www.specagent.com/Lookup?uid=123457117459).

[Mon-Eco Industries, Inc](http://www.specagent.com/Lookup?uid=123457117460).

Approved equivalent.

Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.

Service Temperature Range: 0 to 180 deg F0 to 180 deg F (Minus 18 to plus 82 deg C).

Color: [**White**] <**Insert color**>.

* + - * 1. Vapor-Retarder Mastic: Solvent based; suitable for outdoor use on below ambient services.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3075) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Childers Brand; H. B. Fuller Construction Products](http://www.specagent.com/Lookup?uid=123457117462).

[Eagle Bridges - Marathon Industries](http://www.specagent.com/Lookup?uid=123457117463).

[Foster Brand; H. B. Fuller Construction Products](http://www.specagent.com/Lookup?uid=123457117461).

Approved equivalent.

Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.

Service Temperature Range: Minus 50 to plus 220 deg FMinus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).

Color: [**White**] <**Insert color**>.

* + - * 1. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3076) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Childers Brand; H. B. Fuller Construction Products](http://www.specagent.com/Lookup?uid=123457117345).

[Foster Brand; H. B. Fuller Construction Products](http://www.specagent.com/Lookup?uid=123457117347).

[Knauf Insulation](http://www.specagent.com/Lookup?uid=123457117350).

Approved equivalent.

Water-Vapor Permeance: ASTM E96, greater than 1.0 perm1.0 perm (0.66 metric perms) at manufacturer's recommended dry film thickness.

Service Temperature Range: Minus 20 to plus 180 deg FMinus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).

Color: [**White**] <**Insert color**>.

* + - 1. LAGGING ADHESIVES
				1. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3077) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Childers Brand; H. B. Fuller Construction Products](http://www.specagent.com/Lookup?uid=123457117465).

[Foster Brand; H. B. Fuller Construction Products](http://www.specagent.com/Lookup?uid=123457117466).

[Vimasco Corporation](http://www.specagent.com/Lookup?uid=123457117464).

Approved equivalent.

Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.

Service Temperature Range: 0 to plus 180 deg F0 to plus 180 deg F (Minus 18 to plus 82 deg C).

Color: White.

* + - 1. SEALANTS

Materials in first paragraph below are for sealing metal jacket seams and joints.

* + - * 1. FSK and Metal Jacket Flashing Sealants:

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3078) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Childers Brand; H. B. Fuller Construction Products](http://www.specagent.com/Lookup?uid=123457117352).

[Foster Brand; H. B. Fuller Construction Products](http://www.specagent.com/Lookup?uid=123457117354).

[Mon-Eco Industries, Inc](http://www.specagent.com/Lookup?uid=123457117355).

Approved equivalent.

Materials shall be compatible with insulation materials, jackets, and substrates.

Fire- and water-resistant, flexible, elastomeric sealant.

Service Temperature Range: Minus 40 to plus 250 deg FMinus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).

Color: Aluminum.

* + - * 1. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3079) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Childers Brand; H. B. Fuller Construction Products](http://www.specagent.com/Lookup?uid=123457117358).

Approved equivalent.

Materials shall be compatible with insulation materials, jackets, and substrates.

Fire- and water-resistant, flexible, elastomeric sealant.

Service Temperature Range: Minus 40 to plus 250 deg FMinus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).

Color: White.

* + - 1. FACTORY-APPLIED JACKETS

Coordinate types of factory-applied jacket insulation materials selected and types of factory-applied jackets indicated in insulation system schedules.

For insulation materials with factory-applied jackets for use on applications above 140 deg F (60 deg C), specify sufficient insulation thickness to maintain outer surface temperature of insulation below 140 deg F (60 deg C). 140 deg F (60 deg C) surface temperature is set by OSHA for personnel protection.

Knauf is the only mineral-fiber insulation manufacturer that offers factory-applied FSP jacket for blanket insulation. CertainTeed and Johns Manville offer a vinyl jacket, but it does not comply with ASTM C1136. Owens Corning does not offer an FSP or a vinyl product.

* + - * 1. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.

ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.

FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.

Vinyl Jacket: White vinyl with a permeance of 1.3 perms1.3 perms (0.86 metric perm) when tested according to ASTM E96/E96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

* + - 1. FIELD-APPLIED FABRIC-REINFORCING MESH

Both glass-fiber- and polyester-fabric-reinforcing meshes are acceptable.

Retain both paragraphs below to give Contractor option to use either glass-fiber or polyester fabric.

* + - * 1. Woven Glass-Fiber Fabric: Approximately 6 oz./sq. yd.6 oz./sq. yd. (203 g/sq. m) with a thread count of 5 strands by 5 strands/sq. in.5 strands by 5 strands/sq. in. (2 strands by 2 strands/sq. mm) for covering ducts.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3080) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Childers Brand; H. B. Fuller Construction Products](http://www.specagent.com/Lookup?uid=123457117467).

Approved equivalent.

* + - * 1. Woven Polyester Fabric: Approximately 1 oz./sq. yd.1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in.10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for ducts.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3081) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Foster Brand; H. B. Fuller Construction Products](http://www.specagent.com/Lookup?uid=123457117361).

[Vimasco Corporation](http://www.specagent.com/Lookup?uid=123457117362).

Approved equivalent.

* + - 1. FIELD-APPLIED CLOTHS
				1. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd.8 oz./sq. yd. (271 g/sq. m).

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3082) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Alpha Associates, Inc](http://www.specagent.com/Lookup?uid=123457117468).

Approved equivalent.

* + - 1. FIELD-APPLIED JACKETS

Insulation jackets in this article are for field application. ASTM C921, Type I, is for use over insulation on ducts operating at below ambient temperatures at least part of the time or where a vapor barrier is required. ASTM C921, Type II, is for use over insulation on ducts operating above ambient temperatures or where a vapor retarder is not required.

* + - * 1. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.

A properly sealed FSK jacket, common with most forms of factory-applied jackets for mineral-fiber insulation, complies with vapor-retarder requirements in ASTM C921, Type I.

* + - * 1. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

Although other thicknesses for PVC jackets are available, a flame-spread index of 25 and a smoke-developed index of 50 apply only to thicknesses of 30 mils (0.8 mm) and less.

* + - * 1. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3083) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Johns Manville; a Berkshire Hathaway company](http://www.specagent.com/Lookup?uid=123457117365).

[P.I.C. Plastics, Inc](http://www.specagent.com/Lookup?uid=123457117367).

[Proto Corporation](http://www.specagent.com/Lookup?uid=123457117368).

Approved equivalent.

Adhesive: As recommended by jacket material manufacturer.

PVC jackets are available in several colors. Colored jackets may be used to replace field painting. UV rays fade colors in exterior applications. Some colors (black, gray, and white) do not fade as quickly as other colors (red, orange, and green). Colored jackets have different emissivity and are not recommended for outdoor use.

Color: [**White**] [**Color-code jackets based on system. Color as selected by Director’s Representative**].

* + - * 1. Metal Jacket:

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3085) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[ITW Insulation Systems; Illinois Tool Works, Inc](http://www.specagent.com/Lookup?uid=123457117471).

[RPR Products, Inc](http://www.specagent.com/Lookup?uid=123457117470).

Approved equivalent.

Aluminum Jacket: Comply with ASTM B209ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.

[**Sheet and roll stock ready for shop or field sizing**] [**Factory cut and rolled to size**].

Finish and thickness are indicated in field-applied jacket schedules.

Among the three moisture barriers in first subparagraph below, 1-mil (0.025-mm) barrier provides the least protection against galvanic corrosion, 3-mil (0.075-mm) barrier offers better protection, and polysurlyn barrier offers the best protection. For most indoor applications, 1-mil (0.025-mm) barrier is adequate. For outdoor applications, select either 3-mil (0.075-mm) or polysurlyn barrier.

Moisture Barrier for Indoor Applications: [**1-mil-1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper**] [**3-mil-3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper**] [**2.5-mil-2.5-mil- (0.063-mm-) thick polysurlyn**].

Moisture Barrier for Outdoor Applications: [**3-mil-3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper**] [**2.5-mil-2.5-mil- (0.063-mm-) thick polysurlyn**].

Stainless-Steel Jacket: ASTM A167 or ASTM A240/A240M.

[**Sheet and roll stock ready for shop or field sizing**] [**Factory cut and rolled to size**].

Material, finish, and thickness are indicated in field-applied jacket schedules.

Among the three moisture barriers in first subparagraph below, 1-mil (0.025-mm) barrier provides the least protection against galvanic corrosion, 3-mil (0.075-mm) barrier offers better protection, and polysurlyn barrier offers the best protection. For most indoor applications, 1-mil (0.025-mm) barrier is adequate.

Moisture Barrier for Indoor Applications: [**1-mil-1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper**] [**3-mil-3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper**] [**2.5-mil-2.5-mil- (0.063-mm-) thick polysurlyn**].

Moisture Barrier for Outdoor Applications: [**3-mil-3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper**] [**2.5-mil-2.5-mil- (0.063-mm-) thick polysurlyn**].

* + - * 1. Self-Adhesive Outdoor Jacket: 60-mil-60-mil- (1.5-mm-) thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross laminated polyethylene film covered with [**white**] [**stucco-embossed**] aluminum-foil facing.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3087) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Polyguard Products, Inc](http://www.specagent.com/Lookup?uid=123457117371).

Approved equivalent.

* + - 1. TAPES

Product performance is based on products manufactured by Venture Tape; there are slight variations among manufacturers.

* + - * 1. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3089) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Compac Corporation](http://www.specagent.com/Lookup?uid=123457117376).

[Ideal Tape Co., Inc., an American Biltrite Company](http://www.specagent.com/Lookup?uid=123457117374).

[Knauf Insulation](http://www.specagent.com/Lookup?uid=123457117379).

Approved equivalent.

Width: 3 inches3 inches (75 mm).

Thickness: 11.5 mils11.5 mils (0.29 mm).

Adhesion: 90 ounces force/inch90 ounces force/inch (1.0 N/mm) in width.

Elongation: 2 percent.

Tensile Strength: 40 lbf/inch40 lbf/inch (7.2 N/mm) in width.

ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

* + - * 1. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3091) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Compac Corporation](http://www.specagent.com/Lookup?uid=123457117383).

[Ideal Tape Co., Inc., an American Biltrite Company](http://www.specagent.com/Lookup?uid=123457117381).

[Knauf Insulation](http://www.specagent.com/Lookup?uid=123457117386).

Approved equivalent.

Width: 3 inches3 inches (75 mm).

Thickness: 6.5 mils6.5 mils (0.16 mm).

Adhesion: 90 ounces force/inch90 ounces force/inch (1.0 N/mm) in width.

Elongation: 2 percent.

Tensile Strength: 40 lbf/inch40 lbf/inch (7.2 N/mm) in width.

FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

* + - * 1. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3093) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Compac Corporation](http://www.specagent.com/Lookup?uid=123457117389).

[Ideal Tape Co., Inc., an American Biltrite Company](http://www.specagent.com/Lookup?uid=123457117388).

[Venture Tape](http://www.specagent.com/Lookup?uid=123457117390).

Approved equivalent.

Width: 2 inches2 inches (50 mm).

Thickness: 6 mils6 mils (0.15 mm).

Adhesion: 64 ounces force/inch64 ounces force/inch (0.7 N/mm) in width.

Elongation: 500 percent.

Tensile Strength: 18 lbf/inch18 lbf/inch (3.3 N/mm) in width.

* + - * 1. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3099) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Compac Corporation](http://www.specagent.com/Lookup?uid=123457117395).

[Ideal Tape Co., Inc., an American Biltrite Company](http://www.specagent.com/Lookup?uid=123457117393).

[Knauf Insulation](http://www.specagent.com/Lookup?uid=123457117398).

Approved equivalent.

Width: 2 inches2 inches (50 mm).

Thickness: 3.7 mils3.7 mils (0.093 mm).

Adhesion: 100 ounces force/inch100 ounces force/inch (1.1 N/mm) in width.

Elongation: 5 percent.

Tensile Strength: 34 lbf/inch34 lbf/inch (6.2 N/mm) in width.

* + - 1. SECUREMENTS
				1. Bands:

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3101) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[ITW Insulation Systems; Illinois Tool Works, Inc](http://www.specagent.com/Lookup?uid=123457117400).

[RPR Products, Inc](http://www.specagent.com/Lookup?uid=123457117401).

Approved equivalent.

Wing seals are primarily used for fastening bands together. Closed seals are occasionally used for large, 84-inch- (2130-mm-) diameter applications and where fastening bands are used with springs. Wing seals are reusable; closed seals are not.

Stainless Steel: ASTM A167 or ASTM A240/A240M, [**Type 304**] [**or**] [**Type 316**]; 0.015 inch0.015 inch (0.38 mm) thick, [**1/2 inch1/2 inch (13 mm)**] [**3/4 inch3/4 inch (19 mm)**] wide with [**wing seal**] [**or**] [**closed seal**].

Aluminum: ASTM B209ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch0.020 inch (0.51 mm) thick, [**1/2 inch1/2 inch (13 mm)**] [**3/4 inch3/4 inch (19 mm)**] wide with [**wing seal**] [**or**] [**closed seal**].

Springs are used for large, 84-inch- (2130-mm-) diameter applications and on applications with rapid changes in expansion and contraction.

Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

* + - * 1. Insulation Pins and Hangers:

Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, [**0.106-inch-0.106-inch- (2.6-mm-)**] [**0.135-inch-0.135-inch- (3.5-mm-)**] diameter shank, length to suit depth of insulation indicated.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3102) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[AGM Industries, Inc](http://www.specagent.com/Lookup?uid=123457117404).

[Gemco](http://www.specagent.com/Lookup?uid=123457117405).

[Midwest Fasteners, Inc](http://www.specagent.com/Lookup?uid=123457117406).

Approved equivalent.

Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, [**0.106-inch-0.106-inch- (2.6-mm-)**] [**0.135-inch-0.135-inch- (3.5-mm-)**] diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch1-1/2-inch (38-mm) galvanized carbon-steel washer.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3103) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[AGM Industries, Inc](http://www.specagent.com/Lookup?uid=123457117409).

[Gemco](http://www.specagent.com/Lookup?uid=123457117411).

[Midwest Fasteners, Inc](http://www.specagent.com/Lookup?uid=123457117410).

Approved equivalent.

Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3104) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[AGM Industries, Inc](http://www.specagent.com/Lookup?uid=123457117417).

[Gemco](http://www.specagent.com/Lookup?uid=123457117416).

[Midwest Fasteners, Inc](http://www.specagent.com/Lookup?uid=123457117415).

Approved equivalent.

Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch0.030 inch (0.76 mm) thick by 2 inches2 inches (50 mm) square.

Spindle: [**Copper- or zinc-coated, low-carbon steel**] [**Aluminum**] [**Stainless steel**], fully annealed, 0.106-inch-0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.

Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3105) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Gemco](http://www.specagent.com/Lookup?uid=123457117420).

[Midwest Fasteners, Inc](http://www.specagent.com/Lookup?uid=123457117421).

Approved equivalent.

Baseplate: Perforated, nylon sheet, 0.030 inch0.030 inch (0.76 mm) thick by 1-1/2 inches1-1/2 inches (38 mm) in diameter.

Spindle: Nylon, 0.106-inch-0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches2-1/2 inches (63 mm).

Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3106) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[AGM Industries, Inc](http://www.specagent.com/Lookup?uid=123457117425).

[Gemco](http://www.specagent.com/Lookup?uid=123457117424).

[Midwest Fasteners, Inc](http://www.specagent.com/Lookup?uid=123457117426).

Approved equivalent.

Baseplate: Galvanized carbon-steel sheet, 0.030 inch0.030 inch (0.76 mm) thick by 2 inches2 inches (50 mm) square.

Spindle: [**Copper- or zinc-coated, low-carbon steel**] [**Aluminum**] [**Stainless steel**], fully annealed, 0.106-inch-0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.

Adhesive-backed base with a peel-off protective cover.

Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-0.016-inch- (0.41-mm-) thick, [**galvanized-steel**] [**aluminum**] [**stainless-steel**] sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches1-1/2 inches (38 mm) in diameter.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3107) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[AGM Industries, Inc](http://www.specagent.com/Lookup?uid=123457117431).

[Gemco](http://www.specagent.com/Lookup?uid=123457117432).

[Midwest Fasteners, Inc](http://www.specagent.com/Lookup?uid=123457117433).

Approved equivalent.

Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches1-1/2 inches (38 mm) in diameter.

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3108) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Gemco](http://www.specagent.com/Lookup?uid=123457117437).

[Midwest Fasteners, Inc](http://www.specagent.com/Lookup?uid=123457117438).

Approved equivalent.

* + - * 1. Staples: Outward-clinching insulation staples, nominal 3/4-inch-3/4-inch- (19-mm-) wide, stainless steel or Monel.

In paragraph below, stainless steel is the most common wire used and is best suited for all applications.

* + - * 1. Wire: [**0.080-inch0.080-inch (2.0-mm) nickel-copper alloy**] [**0.062-inch0.062-inch (1.6-mm) soft-annealed, stainless steel**] [**0.062-inch0.062-inch (1.6-mm) soft-annealed, galvanized steel**].

[Manufacturers:](http://www.specagent.com/Lookup?ulid=3109) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[C & F Wire](http://www.specagent.com/Lookup?uid=123457117441).

Approved equivalent.

* + - 1. CORNER ANGLES
				1. PVC Corner Angles: [**30 mils30 mils (0.8 mm)**] <**Insert dimension**> thick, minimum 1 by 1 inch1 by 1 inch (25 by 25 mm), PVC according to ASTM D1784, Class 16354-C. White or color-coded to match adjacent surface.
				2. Aluminum Corner Angles: [**0.040 inch0.040 inch (1.0 mm)**] <**Insert dimension**> thick, minimum 1 by 1 inch1 by 1 inch (25 by 25 mm), aluminum according to ASTM B209ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14.
				3. Stainless-Steel Corner Angles: [**0.024 inch0.024 inch (0.61 mm)**] <**Insert dimension**> thick, minimum 1 by 1 inch1 by 1 inch (25 by 25 mm), stainless steel according to ASTM A167 or ASTM A240/A240M, [**Type 304**] [**or**] [**Type 316**].
1. EXECUTION
	* + 1. EXAMINATION
				1. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

Verify that systems to be insulated have been tested and are free of defects.

Verify that surfaces to be insulated are clean and dry.

* + - * 1. Proceed with installation only after unsatisfactory conditions have been corrected.
			1. PREPARATION
				1. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
			2. GENERAL INSTALLATION REQUIREMENTS
				1. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.
				2. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.
				3. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
				4. Install insulation with longitudinal seams at top and bottom of horizontal runs.
				5. Install multiple layers of insulation with longitudinal and end seams staggered.
				6. Keep insulation materials dry during application and finishing.
				7. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
				8. Install insulation with least number of joints practical.
				9. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

Install insulation continuously through hangers and around anchor attachments.

For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

* + - * 1. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
				2. Install insulation with factory-applied jackets as follows:

Draw jacket tight and smooth.

Cover circumferential joints with 3-inch-3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches4 inches (100 mm) o.c.

Overlap jacket longitudinal seams at least 1-1/2 inches1-1/2 inches (38 mm). Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at [**2 inches2 inches (50 mm)**] [**4 inches4 inches (100 mm)**] o.c.

For below ambient services, apply vapor-barrier mastic over staples.

Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.

Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

* + - * 1. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
				2. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
				3. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
			1. PENETRATIONS
				1. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

Seal penetrations with flashing sealant.

For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

Extend jacket of outdoor insulation outside roof flashing at least 2 inches2 inches (50 mm) below top of roof flashing.

Seal jacket to roof flashing with flashing sealant.

* + - * 1. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

Seal penetrations with flashing sealant.

For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches2 inches (50 mm).

Seal jacket to wall flashing with flashing sealant.

* + - * 1. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
				2. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches2 inches (50 mm).

Comply with requirements in Section 078413 "Penetration Firestopping."

* + - * 1. Insulation Installation at Floor Penetrations:

Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches2 inches (50 mm).

Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

* + - 1. INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION
				1. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
			2. INSTALLATION OF MINERAL-FIBER INSULATION
				1. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

In first subparagraph below, many manufacturers do not recommend 100 percent coverage of adhesive because of the effect on the overall insulation system's fire-performance characteristics. Verify application coverage recommendations with insulation manufacturer.

Apply adhesives according to manufacturer's recommended coverage rates per unit area, for [**100**] [**50**] <**Insert number**> percent coverage of duct and plenum surfaces.

Revise first subparagraph below to allow adhesive to be omitted from top surface of horizontal rectangular ducts.

Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

On duct sides with dimensions 18 inches18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches3 inches (75 mm) maximum from insulation end joints, and 16 inches16 inches (400 mm) o.c.

On duct sides with dimensions larger than 18 inches18 inches (450 mm), place pins 16 inches16 inches (400 mm) o.c. each way, and 3 inches3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.

Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

Do not over compress insulation during installation.

Impale insulation over pins and attach speed washers.

Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches2 inches (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch1/2-inch (13-mm) outward-clinching staples, 1 inch1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

Install vapor stops for ductwork and plenums operating below 50 deg F50 deg F (10 deg C) at 18-foot18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches3 inches (75 mm).

Overlap unfaced blankets a minimum of 2 inches2 inches (50 mm) on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches18 inches (450 mm) o.c.

Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches6 inches (150 mm) o.c.

* + - * 1. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

In first subparagraph below, many manufacturers do not recommend 100 percent coverage of adhesive because of the effect on the overall insulation system's fire-performance characteristics. Verify application coverage recommendations with insulation manufacturer.

Apply adhesives according to manufacturer's recommended coverage rates per unit area, for [**100**] [**50**] <**Insert number**> percent coverage of duct and plenum surfaces.

Revise first subparagraph below to allow adhesive to be omitted from top surface of horizontal rectangular ducts.

Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

On duct sides with dimensions 18 inches18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches3 inches (75 mm) maximum from insulation end joints, and 16 inches16 inches (400 mm) o.c.

On duct sides with dimensions larger than 18 inches18 inches (450 mm), space pins 16 inches16 inches (400 mm) o.c. each way, and 3 inches3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.

Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

Do not over compress insulation during installation.

Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches2 inches (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch1/2-inch (13-mm) outward-clinching staples, 1 inch1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

Install vapor stops for ductwork and plenums operating below 50 deg F50 deg F (10 deg C) at 18-foot18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches3 inches (75 mm).

Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches6 inches (150 mm) o.c.

* + - 1. FIELD-APPLIED JACKET INSTALLATION
				1. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

Draw jacket smooth and tight to surface with 2-inch2-inch (50-mm) overlap at seams and joints.

Embed glass cloth between two 0.062-inch-0.062-inch- (1.6-mm-) thick coats of lagging adhesive.

Completely encapsulate insulation with coating, leaving no exposed insulation.

* + - * 1. Where FSK jackets are indicated, install as follows:

Draw jacket material smooth and tight.

Install lap or joint strips with same material as jacket.

Secure jacket to insulation with manufacturer's recommended adhesive.

Install jacket with 1-1/2-inch1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch-3-inch- (75-mm-) wide joint strips at end joints.

Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

* + - * 1. Where PVC jackets are indicated, install with 1-inch1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

* + - * 1. Where metal jackets are indicated, install with 2-inch2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches12 inches (300 mm) o.c. and at end joints.
			1. FIRE-RATED INSULATION SYSTEM INSTALLATION
				1. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.
				2. Insulate duct access panels and doors to achieve same fire rating as duct.
				3. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 078413 "Penetration Firestopping."
			2. FINISHES

Coordinate first paragraph below with Section 0991143 "Exterior Painting" and Section 099123 "Interior Painting." If PVC jackets are specified, consult jacket manufacturers to determine suitable paint products and revise painting Sections to suit Project.

* + - * 1. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 0991143 "Exterior Painting" and Section 099123 "Interior Painting."

Retain paint system in subparagraphs below for a flat, latex-emulsion size over insulation covering an exterior that is subject to normal use and moderate environments.

Flat Acrylic Finish: [**Two**] <**Insert number**> finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

Finish Coat Material: Interior, flat, latex-emulsion size.

* + - * 1. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
				2. Color: Final color as selected by Director’s Representative. Vary first and second coats to allow visual inspection of the completed Work.
				3. Do not field paint aluminum or stainless-steel jackets.
			1. FIELD QUALITY CONTROL

Inspections in this article are destructive. Retain if workmanship quality is an important requirement. ArchitectDirector’s Representative should be prepared to reject all work if defective work is discovered in sample inspection.

Retain one of first two paragraphs below to identify who shall perform tests and inspections. If retaining second option in first paragraph, or if retaining second paragraph, retain "Field quality-control reports" Paragraphparagraph in "Informational Submittals" Article.

* + - * 1. Testing Agency: [**Director’s Representative will engage**] [**Engage**] a qualified testing agency to perform tests and inspections.

Retain first paragraph below to require Contractor to perform tests and inspections.

* + - * 1. Perform tests and inspections.

Retain first paragraph below to describe tests and inspections to be performed.

* + - * 1. Tests and Inspections:

Inspect ductwork, randomly selected by Director’s Representative, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to [**one**] <**Insert number**> location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

See Section 014000 "Quality Requirements" for retesting and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.

* + - * 1. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

Materials and thicknesses in schedules below are for single-layer applications. If multilayer applications are needed, insert additional requirements.

* + - 1. DUCT INSULATION SCHEDULE, GENERAL
				1. Plenums and Ducts Requiring Insulation:

Indoor, concealed supply and outdoor air.

Indoor, exposed supply and outdoor air.

Indoor, concealed return located in unconditioned space.

Indoor, exposed return located in unconditioned space.

Indoor, concealed, Type I, commercial, kitchen hood exhaust.

Indoor, exposed, Type I, commercial, kitchen hood exhaust.

Indoor, concealed oven and warewash exhaust.

Indoor, exposed oven and warewash exhaust.

Indoor, concealed exhaust between isolation damper and penetration of building exterior.

Indoor, exposed exhaust between isolation damper and penetration of building exterior.

Outdoor, concealed supply and return.

Outdoor, exposed supply and return.

* + - * 1. Items Not Insulated:

Fibrous-glass ducts.

Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.

Factory-insulated flexible ducts.

Factory-insulated plenums and casings.

Flexible connectors.

Vibration-control devices.

Factory-insulated access panels and doors.

Duct and plenum insulation schedules in first two articles below specify commonly used insulation materials and thicknesses for each service type. LEED Prerequisite EA 2 requires that duct insulation R-value comply with ASHRAE/IESNA 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." Not all materials and thicknesses may be suitable for a specific project. Revise to suit Project after considering all parameters that impact selection. Do not duplicate requirements inserted in "Insulation Materials" Article. See Evaluations for more information and guidance.

Flexible elastomeric and polyolefin thicknesses are limited to 1 inch (25 mm) to meet a flame-spread index of 25 and a smoke-developed index of 50. Condensation control and energy efficiency are limited by thickness.

Consider the exposure of installed insulation to damage. Concealed applications have less risk than exposed.

* + - 1. INDOOR DUCT AND PLENUM INSULATION SCHEDULE

See the Insulation Evaluation tables in the Evaluations for rankings of different insulation types for different service ranges.

Retain "one of" option in paragraphs below to allow Contractor to select piping materials from those retained.

* + - * 1. Supply and return air ducts and plenums shall be insulated with not less than R-6 insulation where located in unconditioned spaces. Where located within a building envelope assembly, the duct or plenum shall be separated from the building exterior or unconditioned or exempt spaces by not less than R-8 insulation in climate zones 1 through 4 and not less than R-12 insulation in climate zones 5 through 8.
				2. Concealed, round and flat-oval, supply-air duct insulation shall be[**one of**] the following:

Retain one or more of four subparagraphs below.

Flexible Elastomeric: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

Mineral-Fiber Blanket: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

Polyolefin: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

* + - * 1. Concealed, round and flat-oval, return-air duct insulation shall be[**one of**] the following:

Retain one or more of four subparagraphs below.

Flexible Elastomeric: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

Mineral-Fiber Blanket: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

Polyolefin: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

* + - * 1. Concealed, round and flat-oval, outdoor-air duct insulation shall be[**one of**] the following:

Retain one or more of four subparagraphs below.

Flexible Elastomeric: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

Mineral-Fiber Blanket: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

Polyolefin: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

* + - * 1. Concealed, round and flat-oval, exhaust-air duct insulation shall be[**one of**] the following:

Retain one or more of four subparagraphs below.

Flexible Elastomeric: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

Mineral-Fiber Blanket: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

Polyolefin: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

* + - * 1. Concealed, rectangular, supply-air duct insulation shall be[**one of**] the following:

Retain one or more of four subparagraphs below.

Flexible Elastomeric: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

Mineral-Fiber Blanket: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

Polyolefin: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

* + - * 1. Concealed, rectangular, return-air duct insulation shall be[**one of**] the following:

Retain one or more of four subparagraphs below.

Flexible Elastomeric: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

Mineral-Fiber Blanket: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

Polyolefin: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

* + - * 1. Concealed, rectangular, outdoor-air duct insulation shall be[**one of**] the following:

Retain one or more of four subparagraphs below.

Flexible Elastomeric: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

Mineral-Fiber Blanket: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

Polyolefin: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

* + - * 1. Concealed, rectangular, exhaust-air duct insulation between isolation damper and penetration of building exterior shall be[**one of**] the following:

Retain one or more of four subparagraphs below.

Flexible Elastomeric: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

Mineral-Fiber Blanket: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

Polyolefin: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

* + - * 1. Concealed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated [**blanket**] [**or**] [**board**]; thickness as required to achieve 2-hour fire rating.
				2. Concealed, supply-air plenum insulation shall be[**one of**] the following:

Retain one or more of four subparagraphs below.

Flexible Elastomeric: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

Mineral-Fiber Blanket: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

Polyolefin: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

* + - * 1. Concealed, return-air plenum insulation shall be[**one of**] the following:

Retain one or more of four subparagraphs below.

Flexible Elastomeric: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

Mineral-Fiber Blanket: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

Polyolefin: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

* + - * 1. Concealed, outdoor-air plenum insulation shall be[**one of**] the following:

Retain one or both subparagraphs below.

Mineral-Fiber Blanket: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

* + - * 1. Concealed, exhaust-air plenum insulation shall be[**one of**] the following:

Retain one or both subparagraphs below.

Mineral-Fiber Blanket: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

* + - * 1. Exposed, round and flat-oval, supply-air duct insulation shall be[**one of**] the following:

Retain one or more of five four subparagraphs below.

Flexible Elastomeric: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

Mineral-Fiber Blanket: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

Mineral-Fiber Pipe and Tank: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick.

Polyolefin: [**1 inch1 inch (25 mm)**] <Insert dimension> thick.

* + - * 1. Exposed, round and flat-oval, return-air duct insulation shall be[**one of**] the following:

Retain one or more of fourive subparagraphs below.

Flexible Elastomeric: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

Mineral-Fiber Blanket: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

Mineral-Fiber Pipe and Tank: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick.

Polyolefin: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

* + - * 1. Exposed, round and flat-oval, outdoor-air duct insulation shall be[**one of**] the following:

Retain one or more of fourive subparagraphs below.

Flexible Elastomeric: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

Mineral-Fiber Blanket: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

Mineral-Fiber Pipe and Tank: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick.

Polyolefin: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

* + - * 1. Exposed, round and flat-oval, exhaust-air duct insulation shall be[**one of**] the following:

Retain one or more of fourive subparagraphs below.

Flexible Elastomeric: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

Mineral-Fiber Blanket: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

Mineral-Fiber Pipe and Tank: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick.

Polyolefin: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

* + - * 1. Exposed, rectangular, supply-air duct insulation shall be[**one of**] the following:

Retain one or more of four three subparagraphs below.

Flexible Elastomeric: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

Mineral-Fiber Blanket: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96 kg/cu. m)**] nominal density.

Polyolefin: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

* + - * 1. Exposed, rectangular, return-air duct insulation shall be[**one of**] the following:

Retain one or more of four three subparagraphs below.

Flexible Elastomeric: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

Mineral-Fiber Blanket: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

Polyolefin: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

* + - * 1. Exposed, rectangular, outdoor-air duct insulation shall be[**one of**] the following:

Retain one or more of threefour subparagraphs below.

Flexible Elastomeric: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

Mineral-Fiber Blanket: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

Polyolefin: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

* + - * 1. Exposed, rectangular, exhaust-air duct insulation shall be[**one of**] the following:

Retain one or more of four three subparagraphs below.

Flexible Elastomeric: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

Mineral-Fiber Blanket: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

Polyolefin: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

* + - * 1. Exposed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated [**blanket**] [**or**] [**board**]; thickness as required to achieve 2-hour fire rating.
				2. Exposed, supply-air plenum insulation shall be[**one of**] the following:

Retain one or more of four three subparagraphs below.

Flexible Elastomeric: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

Mineral-Fiber Blanket: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

Polyolefin: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

* + - * 1. Exposed, return-air plenum insulation shall be[**one of**] the following:

Retain one or more of threefour subparagraphs below.

Flexible Elastomeric: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

Mineral-Fiber Blanket: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

Polyolefin: [**1 inch1 inch (25 mm)**] <**Insert dimension**> thick.

* + - * 1. Exposed, outdoor-air plenum insulation shall be[**one of**] the following:

Retain one or both subparagraphs below.

Mineral-Fiber Blanket: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

* + - * 1. Exposed, exhaust-air plenum insulation shall be[**one of**] the following:

Retain one or both subparagraphs below.

Mineral-Fiber Blanket: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

* + - 1. ABOVEGROUND, OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE

See the Insulation Evaluation tables in the Evaluations for rankings of different insulation types for different service ranges.

Retain "one of" option in paragraphs below to allow Contractor to select piping materials from those retained.

To comply with ASHRAE/IESNA 90.1, insulation should have an R-value of 8 or higher.

* + - * 1. Supply and return air ducts and plenums where located outside the building shall be insulated with not less than R-8 insulation in climate zones 1 through 4 and not less than R-12 insulation in climate zones 5 through 8.
				2. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.
				3. Concealed, round and flat-oval, supply-air duct insulation shall be[**one of**] the following:

Retain one or both subparagraphs below.

Mineral-Fiber Blanket: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

* + - * 1. Concealed, round and flat-oval, return-air duct insulation shall be[**one of**] the following:

Retain one or both subparagraphs below.

Mineral-Fiber Blanket: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

* + - * 1. Concealed, round and flat-oval, outdoor-air duct insulation shall be[**one of**] the following:

Retain one or both subparagraphs below.

Mineral-Fiber Blanket: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

* + - * 1. Concealed, rectangular, supply-air duct insulation shall be[**one of**] the following:

Retain one or both subparagraphs below.

Mineral-Fiber Blanket: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

* + - * 1. Concealed, rectangular, return-air duct insulation shall be[**one of**] the following:

Retain one or both subparagraphs below.

Mineral-Fiber Blanket: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

* + - * 1. Concealed, supply-air plenum insulation shall be[**one of**] the following:

Retain one or both subparagraphs below.

Mineral-Fiber Blanket: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

* + - * 1. Concealed, return-air plenum insulation shall be[**one of**] the following:

Retain one or both subparagraphs below.

Mineral-Fiber Blanket: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

* + - * 1. Exposed, round and flat-oval, supply-air duct insulation shall be[**one of**] the following:

Retain one or more of three subparagraphs below.

Mineral-Fiber Blanket: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

Mineral-Fiber Pipe and Tank: [**1-1/2 inches1-1/2 inches (38 mm)**] [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick.

* + - * 1. Exposed, round and flat-oval, return-air duct insulation shall be[**one of**] the following:

Retain one or both subparagraphs below.

Mineral-Fiber Blanket: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

* + - * 1. Exposed, rectangular, supply-air duct insulation shall be[**one of**] the following:

Retain one or both subparagraphs below.

Mineral-Fiber Blanket: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

* + - * 1. Exposed, rectangular, return-air duct insulation shall be[**one of**] the following:

Retain one or both subparagraphs below.

Mineral-Fiber Blanket: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

* + - * 1. Exposed, supply-air plenum insulation shall be[**one of**] the following:

Retain one or both subparagraphs below.

Mineral-Fiber Blanket: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

* + - * 1. Exposed, return-air plenum insulation shall be[**one of**] the following:

Retain one or both subparagraphs below.

Mineral-Fiber Blanket: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> and [**0.75-lb/cu. ft.0.75-lb/cu. ft. (12-kg/cu. m)**] [**1.5-lb/cu. ft.1.5-lb/cu. ft. (24-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] nominal density.

Mineral-Fiber Board: [**2 inches2 inches (50 mm)**] [**3 inches3 inches (75 mm)**] <**Insert dimension**> thick and [**2-lb/cu. ft.2-lb/cu. ft. (32-kg/cu. m)**] [**3-lb/cu. ft.3-lb/cu. ft. (48-kg/cu. m)**] [**6-lb/cu. ft.6-lb/cu. ft. (96-kg/cu. m)**] nominal density.

* + - 1. INDOOR, FIELD-APPLIED JACKET SCHEDULE

Possible variations of jackets by location are endless. This article specifies locations in two broad categories: concealed and exposed. Revise if additional delineation is necessary.

* + - * 1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
				2. If more than one material is listed, selection from materials listed is Contractor's option.
				3. Ducts and Plenums, Concealed:

Retain one of six subparagraphs below.

None.

[**PVC**] [**PVC, Color-Coded by System**]: [**20 mils20 mils (0.5 mm)**] [**30 mils30 mils (0.8 mm)**] thick.

Use paragraph below for projects other than office of mental health where insulated piping is required to be sheet metal jacketed. This includes power houses and heating plants.

Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch0.016 inch (0.41 mm)**] [**0.020 inch0.020 inch (0.51 mm)**] [**0.024 inch0.024 inch (0.61 mm)**] [**0.032 inch0.032 inch (0.81 mm)**] [**0.040 inch0.040 inch (1.0 mm)**] thick.

Painted Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch0.016 inch (0.41 mm)**] [**0.020 inch0.020 inch (0.51 mm)**] [**0.024 inch0.024 inch (0.61 mm)**] [**0.032 inch0.032 inch (0.81 mm)**] thick.

Stainless Steel, [**Type 304**] [**or**] [**Type 316**], [**Smooth 2B Finish**] [**Corrugated**] [**Stucco Embossed**]: [**0.010 inch0.010 inch (0.25 mm)**] [**0.016 inch0.016 inch (0.41 mm)**] [**0.020 inch0.020 inch (0.51 mm)**] [**0.024 inch0.024 inch (0.61 mm)**] thick.

<**Insert jacket type**>.

* + - * 1. Ducts and Plenums, Exposed:

Retain one of six subparagraphs below.

None.

[**PVC**] [**PVC, Color-Coded by System**]: [**20 mils20 mils (0.5 mm)**] [**30 mils30 mils (0.8 mm)**] thick.

Use paragraph below for projects other than office of mental health where insulated piping is required to be sheet metal jacketed. This includes power houses and heating plants.

Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch0.016 inch (0.41 mm)**] [**0.020 inch0.020 inch (0.51 mm)**] [**0.024 inch0.024 inch (0.61 mm)**] [**0.032 inch0.032 inch (0.81 mm)**] [**0.040 inch0.040 inch (1.0 mm)**] thick.

Painted Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch0.016 inch (0.41 mm)**] [**0.020 inch0.020 inch (0.51 mm)**] [**0.024 inch0.024 inch (0.61 mm)**] [**0.032 inch0.032 inch (0.81 mm)**] thick.

Stainless Steel, [**Type 304**] [**or**] [**Type 316**], [**Smooth 2B Finish**] [**Corrugated**] [**Stucco Embossed**]: [**0.010 inch0.010 inch (0.25 mm)**] [**0.016 inch0.016 inch (0.41 mm)**] [**0.020 inch0.020 inch (0.51 mm)**] [**0.024 inch0.024 inch (0.61 mm)**] thick.

<**Insert jacket type**>.

* + - 1. OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

Possible variations of jackets by location are endless. This article specifies locations in two broad categories: concealed and exposed. Revise if additional delineation is necessary.

30-mil (0.8-mm) or heavier PVC is recommended for outdoor applications. 40-mil (1.0-mm) PVC does not meet a flame-spread index of 25 and a smoke-developed index of 50; however, a flame-spread or smoke-developed index is not a requirement for outdoor applications.

0.024-inch (0.61-mm) or heavier aluminum is recommended for outdoor applications.

Painted aluminum increases surface emissivity and provides added chemical resistance. See Evaluations for discussion of emissivity.

0.016-inch (0.41-mm) or heavier stainless steel is recommended for outdoor applications.

Z-shaped locking seam is recommended for metal jackets located in unprotected applications that are exposed to severe weather.

* + - * 1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
				2. If more than one material is listed, selection from materials listed is Contractor's option.
				3. Ducts and Plenums, Concealed:

Retain one of six subparagraphs below.

None.

[**PVC**] [**PVC, Color-Coded by System**]: [**20 mils20 mils (0.5 mm)**] [**30 mils30 mils (0.8 mm)**] thick.

Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch0.016 inch (0.41 mm)**] [**0.020 inch0.020 inch (0.51 mm)**] [**0.024 inch0.024 inch (0.61 mm)**] [**0.032 inch0.032 inch (0.81 mm)**] [**0.040 inch0.040 inch (1.0 mm)**] thick.

Painted Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch0.016 inch (0.41 mm)**] [**0.020 inch0.020 inch (0.51 mm)**] [**0.024 inch0.024 inch (0.61 mm)**] [**0.032 inch0.032 inch (0.81 mm)**] thick.

Stainless Steel, [**Type 304**] [**or**] [**Type 316**], [**Smooth 2B Finish**] [**Corrugated**] [**Stucco Embossed**]: [**0.010 inch0.010 inch (0.25 mm)**] [**0.016 inch0.016 inch (0.41 mm)**] [**0.020 inch0.020 inch (0.51 mm)**] [**0.024 inch0.024 inch (0.61 mm)**] thick.

<**Insert jacket type**>.

* + - * 1. Ducts and Plenums, Exposed, up to 48 Inches48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches72 Inches (1800 mm):

Retain one of four subparagraphs below.

Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch0.016 inch (0.41 mm)**] [**0.020 inch0.020 inch (0.51 mm)**] [**0.024 inch0.024 inch (0.61 mm)**] [**0.032 inch0.032 inch (0.81 mm)**] [**0.040 inch0.040 inch (1.0 mm)**] thick.

Painted Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch0.016 inch (0.41 mm)**] [**0.020 inch0.020 inch (0.51 mm)**] [**0.024 inch0.024 inch (0.61 mm)**] [**0.032 inch0.032 inch (0.81 mm)**] thick.

Stainless Steel, [**Type 304**] [**or**] [**Type 316**], [**Smooth 2B Finish**] [**Corrugated**] [**Stucco Embossed**]: [**0.010 inch0.010 inch (0.25 mm)**] [**0.016 inch0.016 inch (0.41 mm)**] [**0.020 inch0.020 inch (0.51 mm)**] [**0.024 inch0.024 inch (0.61 mm)**] thick.

<**Insert jacket type**>.

* + - * 1. Ducts and Plenums, Exposed, Larger Than 48 Inches48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches72 Inches (1800 mm):

Retain one of three subparagraphs below.

[**Painted**]Aluminum, [**Smooth**] [**Stucco Embossed**] with [**1-1/4-Inch-1-1/4-Inch- (32-mm-) Deep Corrugations**] [**2-1/2-Inch-2-1/2-Inch- (65-mm-) Deep Corrugations**] [**4-by-1-Inch4-by-1-Inch (100-by-25-mm) Box Ribs**]: [**0.032 inch0.032 inch (0.81 mm)**] [**0.040 inch0.040 inch (1.0 mm)**] thick.

Stainless Steel, [**Type 304**] [**or**] [**Type 316**], [**Smooth**] [**Stucco Embossed**], with [**1-1/4-Inch-1-1/4-Inch- (32-mm-) Deep Corrugations**] [**2-1/2-Inch-2-1/2-Inch- (65-mm-) Deep Corrugations**] [**4-by-1-Inch4-by-1-Inch (100-by-25-mm) Box Ribs**]: [**0.020 inch0.020 inch (0.51 mm)**] [**0.024 inch0.024 inch (0.61 mm)**] thick.

<**Insert jacket type**>.

END OF SECTION 230713