SECTION 230713 – DUCT INSULATION

PART 1 - GENERAL

1.1 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, and Section 230500 - Basic Materials and Methods, and other Sections in Division 23 specified herein.

1.2 SCOPE

A. All work to be furnished and installed under this Section shall include, but not necessarily be limited to, providing insulation for the following:

1. Ductwork Insulation:

    a. Duct wrap insulation.
    b. Acoustic duct lining.
    c. Rigid board ductwork and plenum insulation.
    d. Field applied jackets, indoor and outdoor.

2. Section Includes insulating the following duct services:

    a. All supply air ductwork, unless otherwise shown on drawings.
    b. Acoustical duct lining, in vertical/horizontal supply and return ducts within twenty feet (20’) of air handling equipment and where otherwise shown on drawings.

3. Plenums and equipment rooms, as noted.

B. Types of mechanical insulation specified in this Section include the following:

1. Duct wrap insulation: Glass mineral wool also known as fiberglass.
2. Duct wrap insulation: Flexible elastomeric foam.
3. Acoustic duct liner: Glass mineral wool also known as fiberglass.
4. Acoustic duct liner: Flexible elastomeric foam.
5. Acoustic duct liner: Polyimide foam.
6. Rigid board duct and plenum insulation: Calcium silicate.
7. Rigid board duct and plenum insulation: Glass mineral wool.
8. Insulation jackets.
9. Removable covers
10. Insulation accessories.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic HVAC Materials and Methods.

B. Section 233113: Air Distribution.

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1.4 DEFINITIONS

A. Ambient: The air temperature to be maintained in a conditioned room. Typically, between 68°F and 76°F.

B. Insulation Group (IG): Definition of Insulation Materials and Operating Temperatures.

C. Vapor Barrier Jacket: Insulation jacket material that impedes the transmission of water vapor.

D. Unconditioned Space: any space not directly conditioned by mechanical equipment or maintained to temperature by mechanical equipment.

1.5 INSULATION INDUSTRY DEFINITIONS

A. ASJ+: All Service Jacket composed of aluminum foil reinforced with glass scrim bonded to a Kraft paper interleaving with an outer film layer leaving no paper exposed.

B. ASJ: All Service Jacket (no outer film).

C. EPA: Environmental Protection Agency.

D. FHC: Fire Hazard Classification

E. FSK: Foil-Scrim-Kraft facing or vapor barrier.

F. FSP: Foil-Scrim-Polyethylene facing or vapor barrier.

G. ECOSE Technology: a proprietary binder system based on rapidly renewable bio-based materials; rather than petroleum-based chemicals commonly used in other glass mineral wool insulation materials. ECOSE Technology reduces the binder embodied energy by up to 70 percent and does not contain phenol, formaldehyde, acrylics or artificial colors.

H. Imperative 11, Red List – requires that manufacturers disclose the ingredients in their products to document they are free of Red List chemicals and materials. The Red List represents the “worst in class” materials, chemicals and elements known to pose serious risks to human health and the greater ecosystem.

I. PSK: Polypropylene-Scrim-Kraft facing or vapor barrier.

J. PVC: Polyvinyl Chloride.

K. Polybrominated diphenyl ethers (PBDE) such as Penta-BDE, Octa-BDE and Deca-BDE fire retardants: have been linked to adverse health effects after exposure in low concentrations.

L. Recycled Content – Post-Consumer: materials such as bottled glass collected at curbside or other collection sites after consumer use and used in the manufacturing process to create a new product rather than being placed in a landfill or incinerated.

M. Recycled Content – Pre-Consumer (aka Post-Industrial): materials used or created from one manufacturing process which are collected as scrap and placed back into another manufacturing process rather than being placed in a landfill or incinerated.

N. SVF: Synthetic Vitreous Fiber including all forms of manufactured inorganic fibrous insulations such as glass wool (fiberglass) and mineral wool (rock wool and slag wool).

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O. SSL+: Self-Sealing Lap with Advanced Closure System.

P. SSL: Self-Sealing Lap.

Q. Underwriter’s Laboratories Environment (UL Environment): offers independent green claims validation, product assessment and certification.

R. UL Classified: UL has tested and evaluated samples of the product with respect to certain properties of the product. UL classifies products to applicable UL requirements standards for safety and standards of other National and International organizations

S. UL Environment Claims Validation (ECV): service and label tests a manufacturer’s product and validates that the environmental claims they make in their marketing and packaging materials are factual. This ECV service enables products to qualify for LEED® MR Credit 4 Recycled Content LEED-NC 2009 or New LEED V-4 Building product disclosure and optimization – sourcing of raw materials.

T. UL GREENGUARD: Provides independent third-party, Indoor Air Quality (IAQ) certification of products for emissions of respirable particles and Volatile Organic Compounds (VOC's), including formaldehyde and other specific product-related pollutants. Certification is based upon criteria used by EPA, OSHA, and WHO.

U. UL GREENGUARD Gold Certification: (formerly known as GREENGUARD Children & Schools Certification) offers stricter certification criteria, considers safety factors to account for sensitive individuals (such as children and the elderly), and ensures that a product is acceptable for use in environments such as schools and healthcare facilities. It is referenced by both The Collaborative for High Performance Schools (CHPS) and the Leadership in Energy Environmental Design (LEED) Building Rating Systems.

1.6 QUALITY ASSURANCE

A. Codes and Standards: Provide products conforming to the requirements of the following:

1. American Society for Testing and Materials (ASTM): Manufacture and test insulation in accordance with the ASTM Standards, including:

a. B209: Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
b. C165: Recommended Practice for Measuring Compressive Properties of Thermal Insulation.
c. C167: Test Methods for Thickness and Density of Blanket or Batt Thermal Insulations.
d. C168: Terminology for Thermal Insulation.
e. C177: Test Method for Steady-State Heat Flux Measurements and Thermal Transmission by Properties by Means of the Guarded Hot Plate Apparatus.
f. C195: Specification for Mineral Fiber Thermal Insulating Cement.
g. C196: Specification for Expanded or Exfoliated Vermiculite Thermal Insulating Cement.
h. C302: Test Method for Density of Preformed Pipe-Covering-Type Thermal Insulation.
i. C303: Test Method for Density of Preformed Block-Type Thermal Insulation.

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j. C305: Test for Thermal Conductivity of Pipe Insulation.
k. C356: Test for Linear Shrinkage of Preformed High-Temperature Thermal Insulation.
l. C411: Test for Hot-Surface Performance of High Temperature Thermal Insulation.
m. C423: Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
n. C449: Specification of Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
o. C518: Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
p.
q. C612: Specification for Mineral Fiber Block and Board Thermal Insulation.
r. C755: Standard Practice for Selection of Water Vapor Retarders for Thermal Insulation.
s. C795: Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
t. C916: Standard Specification for Adhesives for Duct Thermal Insulation.
u. C921: Practice for Determining Properties of Jacketing Materials for Thermal Insulation.
v. C1104: Standard Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation.
w. C1071: Standard Specification for Thermal and Acoustical Insulation.
x. C1136: Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
y. C1290: Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts.
z. C1338: Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings.
aa. D1667: Standard Specification for Flexible Cellular Material-Vinyl Chloride Polymers and Copolymers (Closed-Cell Foam).
bb. E84: Test Method for Surface Burning Characteristics of Building Materials.
cc. E119: Test for Fire Resistance.
dd. G21: Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
ee. G22: Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Bacteria.
ff. EE2336: Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems.

2. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): Provide and install pipe and duct insulation in accordance with the following ASHRAE Standard:

   a. 90: Energy Conservation in New Building Design.

3. National Fire Protection Association (NFPA): Manufacture insulation in accordance with the following NFPA standards:

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a. 255: Test Methods, Surface Burning Characteristics of Building Materials.

4. Underwriters Laboratory (UL): Manufacture and test insulation in accordance with the UL Standards, including:

a. 181: Standard for Factory-Made Air Ducts and Air Connectors.
b. 723: Standard for Test for Surface Burning Characteristics of Building Materials.
c. 2043: Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces.

B. 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.

C. Do not provide materials with flame proofing treatments subject to deterioration due to the effects of moisture or high humidity.

D. Flame/Smoke Rating: Materials exposed within ducts or plenums shall be noncombustible. Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method or UL 723. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing; or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those specified. Discrete plumbing, mechanical, and electrical products that are located in a plenum and have exposed combustible material shall be in accordance with UL 2043.

E. Corrosiveness: Passes ASTM C1617-05, Standard Practice for Quantitative Accelerated Laboratory Evaluation of Extraction Solutions Containing Ions Leached from Thermal Insulation on Aqueous Corrosion of Metals.

F. Insulation thickness shall be the greater standard of that specified here or the State energy conservation requirements.

G. Sustainable Project Requirements:

1. Formaldehyde Free: Third party certified with UL Environment Validation or Scientific Certification Systems (SCS).
2. Biosoluble: As determined by research conducted by the International Agency for Research on Cancer (IARC) and supported by revised reports from the National Toxicology Program (NTP) and the California Office of Environmental Health Hazard Assessment. Certified by European Certification Board for Mineral Wool Products (EUCEB).
3. Low Emitting Materials: For all thermal and acoustical applications of Glass Mineral Wool Insulation Products, provide materials complying with the testing and products requirements of GREENGUARD CertificationSUBMITTALS

A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, K-value, thickness, and furnished accessories for each

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mechanical system requiring insulation. Also, furnish necessary test data certified by an independent testing laboratory. Submit samples.

1. Products containing the following prohibited chemicals for use as flame retardants or for other purposes will not be acceptable when present in quantities greater than 0.1% by mass. Provide a statement with the submittal indicating that no product submitted contains an amount equal to or greater than 0.10% by mass of the following chemicals:

   a. Pentabrominated diphenyl ether (CAS#32534-81-9).
   b. Octabrominated diphenyl ether (CAS#32536-52-0).
   c. Decabrominated diphenyl ether (CAS#1163-19-5).

B. Maintenance Data: Submit maintenance data and replacement material lists for each type of mechanical insulation. Include this data and product in maintenance manual.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver insulation, coverings, cements, adhesives, and coating to the site in containers with manufacturer's stamp or label affixed showing fire hazard indexes of products.

B. Store and protect insulation against dirt, water, chemical, and mechanical damage. Do not install damaged or wet insulation; remove from project site.

C. Contractor shall make shop available for owner review of cut fabrication and duct liner installation.

1.9 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Comply with requirements in “PART 3 – EXECUTION” for Table 1, Table 2 and Table 3 for application of insulation materials.

B. Products shall not contain asbestos, lead, mercury or mercury compounds if possible. Products shall be certified UL GREENGUARD Gold or Indoor Advantage Gold if possible.

C. Insulation materials for use on austenitic stainless steel shall be qualified per ASTM C795.

D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

E. Each insulation material has been provided a descriptive key code, such as **DW-A**, to simplify the organization and application of materials in following sub-sections.

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F. Acceptable manufacturers include Knauf, Johns Manville, Owens-Corning, Armstrong, Pittsburgh-Corning, Trymer, IIG, Certainteed, Halstead, Rubatex, 3M FireMaster, Pabco, Reflectix. Manufacturer and insulation types listed below indicate a minimum acceptable level of quality required for each classification.

2.2 DUCT WRAP INSULATION (IDENTIFIED BY KEY CODE **DW** AND IN TABLE 1)

A. **DW-A,** Flexible Glass Mineral Wool Blanket:

1. Application: Exterior insulation wrap for ductwork or other HVAC systems.
2. Flexible Glass Mineral Wool Blanket bonded with a bio-based thermosetting resin:
3. Comply with ASTM C553, ASTM C1290, UL 723, and UL Greenguard certified.
4. K-value: 0.29 Btu•in./(hr.•ft²•°F) at 75°F installed full thickness (maximum). Equivalent to “R-Value” per inch of 3.4 (hr.•ft²•°F)/Btu•in. (minimum).
5. Density: 0.75 lb./cu.ft. (minimum).
6. Vapor Barrier Jacket: FSK (Foil-Scrim-Kraft) aluminum foil faced reinforced with glass mineral wool yarn and laminated to fire-resistant Kraft. Or, PSK (Polypropylene-Scrim-Kraft) plastic vapor barrier.
7. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" section.
8. Maximum operating temperature: 250°F.
9. Flame spread index: ASTM E84, less than 25.
10. Smoke developed index: ASTM E84, less than 50.
11. Manufacturers: Knauf Insulation #Atmosphere Duct Wrap, Owens Corning #SOFTR Duct Wrap, Johns Manville #Microlite FSK or PSK.

B. **DW-C,** Black PSK-Faced Flexible Glass Mineral Wool Blanket for Visible Exposed Ducts:

1. Application: Exterior insulation wrap for exposed ductwork or other HVAC systems.
2. Flexible Glass Mineral Wool Blanket bonded with a bio-based thermosetting resin:
3. Comply with ASTM C553, ASTM C1290, UL 723, and UL Greenguard certified.
4. K-value: 0.29 Btu•in./(hr.•ft²•°F) at 75°F installed full thickness (maximum). Equivalent to “R-Value” per inch of 3.4 (hr.•ft²•°F)/Btu•in. (minimum).
5. Density: 0.75 lb./cu.ft. (minimum).
6. Vapor Barrier Jacket: Black PSK (Polypropylene-Scrim-Kraft) faced reinforced with glass mineral wool yarn and laminated to fire-resistant Kraft.
7. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" section.
8. Maximum operating temperature: 250°F.
9. Flame spread index: ASTM E84, less than 25.
10. Smoke developed index: ASTM E84, less than 50.
11. Manufacturers: Johns Manville #Microlite Black PSK.

2.3 ACOUSTIC DUCT LINER (IDENTIFIED BY KEY CODE **ADL** AND IN TABLE 3).

A. **ADL-A,** Glass Mineral Wool Acoustic Duct Liner:

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1. Application: Internal insulated duct lining for acoustic or thermal purposes.
2. Fiberglass acoustical duct liner bonded with a bio based thermosetting resin mat fiber-free facing.
3. Comply with ASTM C411, ASTM C1071, ASTM E84, UL723, and UL Greenguard Low VOC certified.
4. Comply with ASTM G21 and ASTM G22 and ASTM C1338 for microbial resistance.
5. K-value: 0.24 Btu•in./(hr•ft²•°F) at 75°F (maximum). Equivalent to “R-Value” per inch of 4.2 (hr.•ft²•°F)/Btu•in. (minimum).
6. Water vapor absorption: ASTM C1104, less than 3% by weight.
7. Noise Reduction Coefficient (NRC) equal to, or greater than, 0.70 based on ASTM C423 Type “A” mounting.
8. Maximum velocity on mat or coated air side: 6,000 ft./min.
9. Surface burning: NFPA 90 A and 90B.
10. Maximum operating temperature: 250°F.
11. Flame spread index: ASTM E84, less than 25.
12. Smoke developed index: ASTM E84, less than 50.
13. Fasteners: Duct liner galvanized steel pins, welded or mechanically fastened.
14. Manufacturers: Johns Manville #Linacoustic RC, Knauf Insulation #Atmosphere with ECOSE, Owens Corning #QuietR Duct Liner HD or Duct Liner Board.

B. **ADL-B,** Flexible Elastomeric Foam Duct Liner:

1. Application: Internal insulated duct lining for acoustic or thermal purposes.
2. Elastomeric foam insulation with acrylic polymer airstream coating.
3. K-value: ASTM C518, 0.27 Btu•in./(hr•ft²•ºF) at 75°F per ASTM C518. Equivalent to “R-Value” per inch of 3.7 (hr.•ft²•°F)/Btu•in. (minimum).
4. Density: ASTM D 1622, 3.0-6.0 lbs./ft^3.
5. Water vapor absorption: ASTM C209, less than 0.2% by weight.
6. Fungal and bacteria resistance: ASTM G21/22, no growth.
7. Noise Reduction Coefficient: ASTM C 423, 0.49 or higher based on "Type A mounting”.
8. Maximum Velocity on Mat or Coated Air Side: 5,000 ft/min.
9. Maximum operating temperature: 220°F.
10. Flame spread index: ASTM E84, less than 25.
11. Smoke developed index: ASTM E84, less than 50.
12. Adhesive: UL listed waterproof type compliant with ASTM C916.
13. Greenguard certified, low VOC.
14. Fasteners: Duct liner galvanized steel pins, welded or mechanically fastened.
15. Manufacturers: Armacell #Armaflex Ultra.

C. **ADL-C,** Polyimide Foam Acoustic Duct Liner:

1. Application: Internal insulated duct lining for acoustic or thermal purposes.
2. Greenguard certified, low VOC.
3. Polyimide foam insulation with acrylic polymer airstream coating.
4. K-value: ASTM C518, 0.30 Btu•in./(hr•ft²•°F) at 75°F per ASTM C518. Equivalent to “R-Value” per inch of 3.3 (hr.•ft²•°F)/Btu•in. (minimum).
5. Density: ASTM D 3574, 0.80 lbs./ft^3.

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6. Water vapor absorption: ASTM C1104, less than 2% by weight.
7. Fungal and bacteria resistance: ASTM G21/22, no growth.
8. Noise Reduction Coefficient: ASTM C423, 0.70 or higher based on "Type A mounting".
9. Maximum Velocity on Mat or Coated Air Side: 5,000 ft/min.
10. Maximum operating temperature: 250°F.
11. Flame spread index: ASTM E84, less than 25.
12. Smoke developed index: ASTM E84, less than 50.
13. Adhesive: UL listed waterproof type compliant with ASTM C916.
14. Fasteners: Duct liner galvanized steel pins, welded or mechanically fastened.
15. Manufacturers: Boyd Corporation #SOLCOUSTIC.

D. **ADL-D,** Round Duct Liner:

1. Application: Internal insulated round duct lining for acoustic or thermal purposes.
2. Fiberglass acoustical duct liner bonded with a bio based thermosetting resin.
3. Comply with ASTM C411, ASTM C1071, ASTM E84, UL723, and UL Greenguard Low VOC certified.
4. Comply with ASTM G21 and ASTM G22 and ASTM C1338 for microbial resistance.
5. K-value: 0.23 Btu•in./(hr•ft²•°F) at 75°F (maximum). Equivalent to “R-Value” per inch of 4.3 (hr.•ft²•°F)/Btu•in. (minimum).
6. Water vapor absorption: ASTM C1104, less than 3% by weight.
7. Noise Reduction Coefficient (NRC) equal to, or greater than, 0.75 based on ASTM C423 Type “A” mounting.
8. Maximum velocity on mat or coated air side: 6,000 ft./min.
9. Surface burning: NFPA 90 A and 90B.
10. Maximum operating temperature: 250°F.
11. Flame spread index: ASTM E84, less than 25.
12. Smoke developed index: ASTM E84, less than 50.
13. Factory-formed grooves at sufficient intervals to prevent air gaps between back of insulation and spiral duct surface.
14. Manufacturers: Owens Corning #QuietZone Spiral Duct Liner, Johns Manville #Spiracoustic Plus.

2.4 RIGID FIBERGLASS BOARD DUCTWORK AND PLENUM INSULATION (IDENTIFIED BY KEY CODE **RB** BELOW AND IN TABLE 2)

A. **RB–A,** Rigid fiberglass duct board:

1. Application: Rigid duct boards for insulating metal plenums and metal ductwork where rigidity is required.
2. Fiberglass duct board with a bio based thermosetting resin.
3. Comply with ASTM C411, ASTM C1071, ASTM E84, UL723, and UL Greenguard Low VOC certified.
4. Comply with ASTM G21 and ASTM G22 and ASTM C1338 for microbial resistance.
5. K-value: 0.23 Btu•in./(hr•ft²•°F) at 75°F (maximum). Equivalent to “R-Value” per inch of 4.3 (hr.•ft²•°F)/Btu•in. (minimum).

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6. Water vapor absorption: ASTM C1104, less than 3% by weight.
7. Noise Reduction Coefficient (NRC) equal to, or greater than, 0.75 based on ASTM C423 Type “A” mounting.
8. Maximum velocity on mat or coated air side: 6,000 ft./min.
9. Surface burning: NFPA 90 A and 90B.
10. Maximum operating temperature: 250°F.
11. Flame spread index: ASTM E84, less than 25.
12. Smoke developed index: ASTM E84, less than 50.
13. Density: 3.0 lbs./cu ft. (minimum).
14. Vapor Barrier Jacket: ASJ+ (All Service Jacket) or FSK (Foil-Scrim-Kraft) aluminum foil faced reinforced with glass mineral wool yarn and laminated to fire-resistant Kraft paper.
15. Manufacturers: Knauf #Atmosphere Air Duct Board, Johns Manville #SuperDuct RC, Owens Corning #QuietR Duct Board, Certainteed #Ultra*Duct.

2.5 ADHESIVES

A. 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.

B. Flexible Elastomeric and Polyolefin Adhesive:

1. Comply with MIL-A-24179A, Type II, Class I.
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated per 40 CFR 59, Subpart D (EPA Method 24).
3. Manufacturer: Aeroflex #Aeroseal, Armacell #Armaflex 520, H.B.Fuller #Foster 85-75, K-Flex #720-LVOC.

C. Mineral-Fiber Adhesive:

1. Comply with MIL-A-3316C, Class 2, Grade A.
2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated per 40 CFR 59, Subpart D (EPA Method 24).
3. Manufacturer: H.B.Fuller #Childers Chil-Quik CP-127, H.B.Fuller #Foster 85-60 or 85-75, Mon-Eco Industries # 22 Series.

D. ASJ+ Adhesive, and FSK Jacket Adhesive:

1. Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Manufacturer: H.B.Fuller #Childers Chil-Quik CP-127, H.B.Fuller #Foster 85-60 or 85-75, Mon-Eco Industries #22 Series.

E. PVC Jacket Adhesive:

1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Manufacturer: Dow Corning #739 Plastic Adhesive, Johns Manville #Zeston Perma-Weld, Speedline #Polyco Adhesive Low VOC.

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2.6 MASTICS

A. Materials shall be compatible with ductwork material, insulation materials, jackets, and substrates and for sealing joints and seams.

B. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.

1. Water-Vapor Permeance: ASTM E96/E96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
2. Service Temperature Range: -20°F to +180°F (-29°C to +82°C).
3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
4. Color: White.
5. Manufacturer: H.B.Fuller #Foster 30-90, Vimasco #749 Vapor-Blok.

D. Vapor-Barrier Mastic: Solvent based; suitable for indoor use.

1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.03 metric perm) at 35-mil (0.9-mm) dry film thickness.
2. Service Temperature Range: 0 to 180°F (Minus 18 to plus 82°C).
3. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
4. Color: White.
5. Manufacturer: H.B.Fuller #Childers CP-30, H.B.Fuller #Foster 30-35, Mon-Eco Industries #55-10.

E. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use for below ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.
2. Service Temperature Range: Minus 50 to plus 220°F (Minus 46 to plus 104°C).
3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
4. Color: White.
5. Manufacturer: H.B.Fuller #Foster 60-95/60-96.

F. Breather Mastic: Water based; suitable for indoor and outdoor use for above ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180°F (Minus 29 to plus 82°C).
3. Solids Content: 60 percent by volume and 66 percent by weight.
4. Color: White.
5. Manufacturer: H.B.Fuller #Childers CP-10, H.B.Fuller #Foster 46-50, Mon-Eco Industries #55-50, Vimasco #WC-1 or WC-5.

2.7 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

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1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250°F (Minus 40 to plus 1241°C).
4. Color: Aluminum.
5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Manufacturer: H. B. Fuller Company #Childers CP-76, Eagle Bridges - Marathon Industries #405, H. B. Fuller Company #Foster 95-44, Mon-Eco Industries, Inc.#44-05.

B. ASJ+ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250°F (Minus 40 to plus 121°C).
4. Color: White.
5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Manufacturer: H. B. Fuller Company #Childers CP-76.

2.8 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304, 0.020 inch (0.50 mm) thick, 1/2 inch (13 mm) or 3/4 inch (19 mm) wide with wing seal.
2. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) or 3/4 inch (19 mm) wide with wing seal.
3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.
4. Manufacturer: ITW Insulation Systems, Gerrard Strapping and Seals, RPR Products #Insul-Mate Strapping.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated. Manufacturer: AGM Industries, Inc. #CWP-1, GEMCO #CD, Midwest Fasteners #CD, Nelson Stud Welding #TPA/TPC/TPS.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer. Manufacturer: AGM Industries #CHP-1, GEMCO #Cupped Head Weld Pin, Midwest Fasteners #Cupped Head, Nelson Stud Welding #CHP.
3. 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:

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a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
b. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum or Stainless steel coordinated with application, fully annealed, 12 gauge, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
d. Manufacturer: AGM Industries #Tactoo Perforated Base Insul-Hangers, GEMCO #Perforated Base, Midwest Fasteners #Spindle.

4. 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:

a. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
b. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
d. Manufacturer: GEMCO #Nylon Hangers, Midwest Fasteners #Nylon Insulation Hangers.

5. 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:

a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
b. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum, Stainless steel, fully annealed, as coordinated with application. 12-gauge, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
c. Adhesive-backed base with a peel-off protective cover.
d. Manufacturer: AGM Industries #Tactoo Self-Adhering Insul-Hangers, GEMCO; #Peel & Press, Midwest Fasteners #Self Stick.

6. Insulation-Retaining Washers: Self-locking washers formed from 0.015-inch- (0.41-mm-) thick, galvanized-steel, aluminum or stainless steel sheet, as coordinated with application with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
b. Manufacturer: AGM Industries #RC-150, GEMCO #R-150, Midwest Fasteners #WA-150, Nelson Stud Welding #Speed Clips.

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7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 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 inches (38 mm) in diameter.
    a. Manufacturer: GEMCO, Midwest Fasteners.

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

D. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel

2.9 LAGGING ADHESIVES

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

B. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated per 40 CFR 59, Subpart D (EPA Method 24).
2. Service Temperature Range: 0 to +180°F (-18°C to +82°C).
3. Color: White.
4. Manufacturer: H.B.Fuller #Childers CP-50, H.B.Fuller #Foster 30-36, Vimasco #713 or 714.

2.10 TAPES

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

1. Width: 3 inches (75 mm).
2. Thickness: 11.5 mils (0.29 mm).
3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf./inch (7.2 N/mm) in width.
6. ASJ+ Tape Disks and Squares: Precut disks or squares of ASJ+ tape.
7. Manufacturer: ABI Ideal Tape #428 AWF ASJ+, Avery Dennison Corporation Specialty Tapes Division #Fasson 0836, Compac Corporation #104 and 105, Venture Tape #1540 CW Plus, #1542 CW Plus, and #1542 CW Plus/SQ.

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

1. Width: 3 inches (75 mm).
2. Thickness: 6.5 mils (0.16 mm).
3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

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7. Manufacturer: ABI Ideal Tape #491 AWF FSK, Avery Dennison Corporation Specialty Tapes Division #Fasson 0827, Compac Corporation #110 and 111, Venture Tape #1525 CW NT, #1528 CW, and #1528 CW/SQ.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications and UL 723 compliant.

1. Width: 2 inches (50 mm).
2. Thickness: 6 mils (0.15 mm).
3. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.
6. Manufacturer: ABI Ideal Tape #370 White PVC tape, Compac Corporation #130, Venture Tape #1506 CW NS.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive and UL181 compliant.

1. Width: 2 inches (50 mm).
2. Thickness: 3.7 mils (0.093 mm).
3. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.
6. Manufacturer: ABI Ideal Tape Division #488 AWF, Avery Dennison Corporation #Specialty Tapes Division Fasson 0800, Compac Corporation #120, Venture Tape #3520 CW.

2.11 FACTORY-APPLIED JACKETS

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

1. ASJ+: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
3. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.

PART 3 - EXECUTION

3.1 EXAMINATION AND PREPARATION

A. Verify that ductwork has been tested for leakage in accordance with specifications before applying insulation materials. All ductwork shall be inspected by Owner's Representative prior to installation of insulation. Any insulation applied prior to inspection shall be removed and new insulation applied at no additional cost to Owner. Notify Owner's Representative five (5) working days prior to insulation installation.

B. Verify that all surfaces are clean, dry and free of foreign material.

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3.2 INSTALLATION

A. General:

1. Install materials in accordance with manufacturer's recommendations, building codes and industry standards.
2. Remove and replace any insulation that has become wet or damaged during the construction process.
3. Continue insulation and vapor barrier at penetrations and duct supports, except where prohibited by code. Instances where this is required include:

    a. Ductwork support angle or struts.

        1) To prevent crushing of low density insulation, provide separator or high density insulation at point of support. A 12 inch wide strip of 6 pcf density, glass mineral wool board or similar manufactured product, across the bottom side of the duct. Vapor barrier to continue unbroken at point of support.
        2) As an alternative method, where the duct sits directly on the Unistrut or similar support, install board material on either side of the support to allow duct wrap to be tented over the support, providing a smooth transition over the support and maintaining thickness. Rigid 3 pcf board may be used in this method.

B. Insulation Applied on the Outside/Exterior of the Duct:

1. Provide insulated ductwork conveying air below ambient temperature (below room temperature) with vapor retardant jacket.
2. Seal all vapor retardant jacket seams and penetrations with 3” wide pressure-sensitive vapor barrier tape matching the insulation facing.
3. Where insulation is required, all ductwork, fittings, dampers, elbows, flexible ducts, rigid and flexible connectors, runouts, and devices shall be continuously insulated from fan systems to inlets/outlets to minimize heat transfer into ductwork and prevent condensation on exposed surfaces and as required to comply with applicable mechanical code and energy code.
4. Provide insulated ductwork conveying air above ambient temperature (above room temperature) with or without vapor retardant jacket. Where service access is required, bevel and seal ends of insulation.
5. Continue insulation through walls, sleeves, hangers, and other duct penetrations except where prohibited by code.
6. For ductwork exposed in mechanical equipment rooms below 7’ or in finished spaces, finish with jacket material.
7. For interior vapor/moisture conveying duct applications, install glass mineral wool insulation unless specifically indicated otherwise on drawings. Install to meet manufacturer’s requirements and as required by local code authorities.

C. Installation of Mineral-Fiber Insulation (Blanket or Rigid Type):

1. Secure weld pins to duct using adhesive recommended for ductwork material. Pins shall be installed on a minimum of three sides of each duct to assure proper support. For overhead ductwork - pins are not required on the top of the ducts.

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For underfloor ducts - pins are not required on bottom side of ducts. For vertical ducts - pins are not required on surface facing wall. Install pins as follows:

a. On duct sides with dimensions 18 inches (450 mm) and smaller: Place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) on center.
b. On duct sides with dimensions larger than 18 inches (450 mm): Place pins 16 inches (400 mm) on center each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing and reinforcement points.
c. Pins may be omitted from top surface of plenums.
d. Do not over compress insulation during installation.
e. Impale insulation over pins and attach speed washers.
f. 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.

2. Install insulation with a continuous unbroken vapor barrier and insulation butted tight at each joint. Create a facing lap for longitudinal seams and end joints with insulation by removing up to 2 inches (50 mm) from one edge as required to allow stapling. Secure laps to adjacent insulation section with 1/2-inch (13 mm) outward-clinching staples, 6 inch (150 mm) on center, maximum. Staples may be omitted when closures are made by machine using heat-sensitive tape. 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.
3. 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.
4. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 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 inches (150 mm) (maximum) on center.

D. Duct Liner-Insulation Applied on the Interior of the Duct:

1. Adhere insulation to sheet metal with a UL listed adhesive. Adhesive shall be applied to the sheet metal with a minimum coverage of 90%.
2. Secure insulation with mechanical liner fasteners as indicated by SMACNA or manufacturer. Pin length should be as recommended by the liner manufacturer.
3. All exposed edges of the liner must be factory or field coated. Unless factory coated, all transverse edges and longitudinal joints of the duct liner shall be coated. For systems operating at 2,000 fpm or higher, a metal nosing must be installed in all liner facing fan discharge or upstream of the airflow.
4. Repair liner surface penetrations with UL listed adhesive.
5. Duct dimensions indicated on plans are net inside dimensions required for airflow. Increase duct size to allow for insulation thickness.

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6. Liner shall be folded and compressed into corners of rectangular duct or cut and fitted to assure a lapped compressed joint. Longitudinal joints should not occur in rectangular duct except at corners.
7. Longitudinal joints shall be coated with adhesive.

3.3 ENCAPSULATING NON-RATED PIPES AND CABLES

A. Where combustible non-fire rated pipes (plastic) and cables are installed in an air plenum space provide one layer of **FRI-E** fire barrier plenum wrap to fully encapsulate the item to comply with ASTM E84 or UL-723.

3.4 DUCTWORK INSULATION SCHEDULES

A. All insulation thicknesses shall meet or exceed latest edition of applicable ASHRAE 90.1, IECC, State Energy Code, Local Energy Code, and State Mechanical Code requirements as noted below. Minimum thermal resistance in range of 4.0 to 4.2 per inch of thickness. Insulation thicknesses are based on glass mineral wool insulation and may be adjusted for equivalent insulation values for materials with superior “K” factors.

B. The installed thickness of duct insulation used to determine its R-value shall be determined as follows:

1. For duct board, duct liner, and factory-made rigid ducts not normally subjected to compression, the nominal insulation thickness shall be used.
2. For duct wrap, installed thickness shall be assumed to be 75 percent (25 percent compression) of nominal thickness.
3. For factory-made flexible air ducts, the installed thickness shall be determined by dividing the difference between the actual outside diameter and nominal inside diameter by two.

C. All air distribution system ducts and plenums, but not limited to, building cavities, mechanical closets, air handler boxes, and support platforms used as ducts or plenums, shall be installed, sealed, and insulated to meet the requirements of the code. Portions of supply-air and return-air ducts conveying heated or cooled air located in one or more of the following spaces shall be insulated to a minimum level of R-8.

1. Outdoors; or,
2. In a space between the roof and an insulated ceiling; or,
3. In a space directly under a roof with fixed vents or openings to the outside or unconditioned spaces; or,
4. In an unconditioned crawlspace; or,
5. In other unconditioned spaces; or,
6. For buildings subject to compliance with the IECC in any location in Climate Zones 5 through 8 the insulation shall be 3” (R-12) minimum thickness for ductwork exterior to the building envelope.

D. TABLE 1: DUCT WRAP INSULATION SERVICE, THICKNESS, AND MATERIAL TYPE REQUIRED.

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TABLE 1: EXTERNAL DUCT WRAP INSULATION			
SYSTEM	R-Value (Minimum)	FINISH/JACKET	INSULATION KEY CODE AND REMARKS
Supply and/or return ducts within building envelope in unconditioned areas, inside shafts and above ceilings.	R-8	FSK or PSK	**DW-A, B, C**
Supply and/or return duct exposed in the mechanically conditioned space.	R-4.2	Black PSK	**DW-C**
Supply or return duct serving the remote 50 ft. (15 m) of exposed ductwork in the mechanically conditioned space.	NA	NA	Except where noted on drawings for acoustical reasons.
Adjust insulation thicknesses as required to meet minimum R-Values.			

E. TABLE 2: DUCTWORK RIGID INSULATION AND PLENUM INSULATION SERVICE, THICKNESS, AND INSULATION TYPE REQUIRED.

TABLE 2: RIGID INSULATION AND PLENUM INSULATION			
SYSTEM	THICKNESS (Minimum)	FINISH/JACKET	INSULATION KEY CODE AND REMARKS
Interior Plenums	R-8	FSK	**RB-A**
Adjust insulation thicknesses as required to meet minimum R-Values.			

F. TABLE 3: ACOUSTIC DUCT LINER SERVICE, THICKNESS, AND INSULATION TYPE REQUIRED.

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TABLE 3: ACOUSTICAL DUCT LINER			
SYSTEM	THICKNESS (Minimum)	FINISH	INSULATION KEY CODE
Where indicated for rectangular supply or return ductwork installed in conditioned areas.	R-4.2 unless otherwise noted on drawings	Air stream side mat or other fiber-free facing	**ADL-A, B, C**
Where indicated for rectangular supply or return ductwork installed in unconditioned areas without exterior duct insulation.	R-8 unless otherwise noted on drawings	Air stream side mat or other fiber-free facing	**ADL-A, B, C**
Inside supply and return ducts within 20’ of Air Handling Unit connections.	R-8	Air stream side mat or other fiber-free facing	**ADL-A, B, C**
VAV terminal unit outlet plenum	R-4.2 unless otherwise noted on drawings	Air stream side shall be fiber-free with resin mat facing, aluminum or mylar liner, or acrylic polymer facing	**ADL-A, B, C**
Where indicated for round ductwork installed in conditioned areas.	R-4.2	Air stream side mat or other fiber-free facing	**ADL-D**
Where indicated for round ductwork installed in unconditioned areas without exterior insulation.	R-8	Air stream side mat or other fiber-free facing	**ADL-D**
Adjust insulation thicknesses as required to meet minimum R-Values.			

END OF SECTION 230713

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