SECTION 230719 - HVAC PIPING 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. Piping Insulation:

    a. Piping Insulation.
    b. Insulation Jackets.
    c. Removable Covers.

2. Section includes the following HVAC piping systems:

    a. Cooling coil condensate drain piping.

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

1. Glass fiber.
2. Flexible elastomeric closed cell foam.
3. Insulation jackets.
4. Removable covers.
5. Insulation accessories.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Division 22: Plumbing.

B. Section 230500: Basic HVAC Materials and Methods.

C. Section 232113: Hydronic Piping, Valves and Specialties.

1.4 DEFINITIONS

A. Ambient: The air temperature to be maintained in a conditioned room. Typically, between 70°F and 78°F.

B. Insert: Spacer placed between the pipe support system and the piping to allow for the space required for insulation.

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

D. Insulation Shield: Buffer material placed between the pipe support system and the insulation to prevent the insulation material from crushing.

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E. Jacket: Protective covering over the pipe insulation; may be factory applied such as “all service jacket” or field applied to provide additional protection; of such materials as canvas, PVC, aluminum or stainless steel.

F. Piping Insulation: Thermal insulation applied to prevent heat transmission to or from a piping system.

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

H. Freezing Climate: Where outdoor design temperature is less than 34°F (1°C), as stated in ASHRAE Fundamentals under 99% column for winter design conditions.

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

1.5 INSULATION INDUSTRY DEFINITIONS

A. Third Party Independent Product sustainable certification: 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.

1. UL GREENGUARD
2. Scientific Certification Systems (SCS)

B. EPA: Environmental Protection Agency.

C. WHO: World Health Organization.

D. 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.

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

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

G. SSL: Self-Sealing Lap.

H. FSK: Foil Scrim Kraft; jacketing.

I. FSP: Foil Scrim Polyethylene jacketing

J. PSK: Poly Scrim Kraft; jacketing.

K. FHC: Fire Hazard Classification

L. PVC: Polyvinyl Chloride.

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

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N. UL GREENGUARD Gold Certification: 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 the Leadership in Energy Environmental Design (LEED) Building Rating Systems.

O. 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.

P. 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.

Q. 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.

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. 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.

T. Underwriter’s Laboratories Environment (UL Environment): offers independent green claims validation, product assessment and certification.

U. 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 V-4 Building product disclosure and optimization – sourcing of raw materials.

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 Plat.
b. C165: Recommended Practice for Measuring Compressive Properties of Thermal Insulation.
c. C168: Provides standard terminology for thermal insulation.
d. C177: Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
e. C195: Specification for Mineral Fiber Thermal Insulating Cement.
f. C196: Specification for Expanded or Exfoliated Vermiculite Thermal Insulating Cement.

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g. C302: Test Method for Density of Preformed Pipe-Covering-Type Thermal Insulation.
h. C303: Test Method for Density of Preformed Block-Type Thermal Insulation.
i. C305: Test for Thermal Conductivity of Pipe Insulation.
j. C335: Standard Test Method for Steady-State Heat Transfer Properties 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. C533:Specification for Calcium Silicate Block and Pipe Thermal Insulation.
q. C534: Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
r. C547: Specification for Mineral Fiber Pipe Insulation.
s. C552: Specification for Cellular Glass Block and Pipe Thermal Insulation.
t. C553: Specification for Mineral Fiber Blanket-Type Pipe Insulation (Industrial Type).
u. C592: Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered).
v. C612: Specification for Mineral Fiber Block and Board Thermal Insulation.
w. C755: Standard Practice for Selection of Water Vapor Retarders for Thermal Insulation.
x. C795: Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
y. C916: Standard Specification for Adhesives for Duct Thermal Insulation.
z. C921: Practice for Determining Properties of Jacketing Materials for Thermal Insulation.
aa. C1071: Standard Specification for Thermal and Acoustical Insulation.
bb. C1104: Standard Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation.
cc. C1136: Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
dd. C1338: Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings.
ee. C1393: Standard Specification for Perpendicularly Oriented Mineral Fiber Roll and Sheet Thermal Insulation for Pipes and Tanks.
ff. C1617-05: Standard Practice for Quantitative Accelerated Laboratory Evaluation of Extraction Solutions Containing Ions Leached from Thermal Insulation on Aqueous Corrosion of Metals
gg. E84: Test Method for Surface Burning Characteristics of Building Materials.

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hh. E119: Test for Fire Resistance.
ii. G21: Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
jj. G22: Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Bacteria.

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

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. Installers shall also have completed the manufacturer's training program for the type of installation being used such as the Armacell Qualified Installer Program for the installation of flexible elastomeric insulation or similar program for each type of insulation used on the project, where offered. Submit installer resumes per article "1.7

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: 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 where installed in a return air plenum or in a ventilation intake or mechanical room. 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.

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 or Scientific Certification Systems (SCS) Validation.
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).

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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 Certification.

1.7 SUBMITTALS

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 mechanical system requiring insulation.

B. 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:

1. Pentabrominated diphenyl ether (CAS#32534-81-9).
2. Octabrominated diphenyl ether (CAS#32536-52-0).
3. Decabrominated diphenyl ether (CAS#1163-19-50).

C. Installer Resumes: Provide resumes for each installer; each installer shall have a manufacturer’s training certificate for each type of insulation that will be installed, where available. Installer shall have at least 5 years of documented experience installing pipe insulation of the type the installer will be responsible for on the project.

D. 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.

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, Table 1: Piping Services, Fluid Temperature, and Insulation Type Required” for application of insulating materials.

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B. Products shall not contain asbestos, lead, mercury or mercury compounds if possible. Products shall meet UL GREENGUARD certification standards for low-emitting products.

C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to 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 **PI-A**, to simplify the organization and application of materials in following sub-sections.

F. Thickness of insulation is based on meeting or exceeding the minimum requirement of applicable energy code and/or maximum allowable external temperature in relation to adjacent combustible material or other equipment. Exterior surface temperature shall not exceed 140°F at maximum operating capacity except as noted below for generator applications.

G. Acceptable manufacturers include Knauf Insulation, Johns Manville, Owens-Corning, Armstrong, Pittsburgh-Corning, Trymer, IIG, Certainteed, 3M FireMaster, Pabco, Aeroflex, Armacell, Pacor. Manufacturer and insulation types listed below indicate a minimum acceptable level of quality required for each product classification.

2.2 PIPE INSULATIONS (IDENTIFIED BY KEY CODE **PI** BELOW AND IN TABLE 1)

A. **PI-A,** Preformed Mineral Wool or Fiberglass:

1. Materials: Mineral wool or fiberglass bonded with a thermosetting resin. Product to be validated GREENGUARD Gold for low VOC's. In addition, pipe insulation to have a validated EPD from UL Environment or Scientific Certification Systems.Declare Red List Free for Redi-Klad Pipe or unjacketed Earthwool Pipe only. Note that of the fiberglass products only Knauf products are completely free of formaldehyde as of 2017.
2. Applications: Insulation of piping and fittings with thickness as required by local energy code.
3. Compliant with ASTM C335, C356, C411, C447, C547, C585, C795, C1045, C1104 E96, and E84.
4. Compliant with ASTM C547 Type I, 850°F (454°C) or Type IV, 1000°F (538°C).
5. Thermal conductivity (K-value): 0.24 Btu•in./(hr•ft²•ºF) or less, at 100°F (38°C).
6. Service Temperature Range: 0°F to 850°F (-18°C to 454°C).
7. Water Vapor Absorption, % of volume: <5% (maximum) as tested per ASTM C1104.
8. Vapor Retarder Jacket: Factory applied ASJ or ASJ+ with SSL, white kraft paper interleaving reinforced with glass fiber scrim yarn and bonded to aluminum foil, secure with self-sealing longitudinal laps and butt strips.
9. Water Vapor Permeance: 0.02 perms maximum.
10. Nominal density is 2.5 lbs./cu. ft., greater.
11. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
12. Manufacturers: Knauf

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B. **PI-B,** Flexible Closed-Cell Elastomeric, Neoprene or Polyethylene:

1. Applications: Insulation of piping and fittings with thickness as required by local energy code.
2. Compliant with UL 181, ASTM C411, C518, C534, G21/C1338, G22, D1056 and E84.
3. Service Temperature Range: -297°F to 220°F (-183°C to 105°C).
4. Thermal Conductivity (K-value): 0.28 Btu•in./(hr•ft²•ºF) or less, at 75°F (24°C).
5. Water Vapor Absorption, % of volume: <0.2% (maximum) compliant with ASTM C209.
6. Nominal density is 2.5 lbs./cu. ft. or greater.
7. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
8. Seal all seams and joints with contact adhesive or factory self-seal system with lap seal tape.
9. Manufacturers: Armacell #AP, #Lapseal, Armaflex, Aeroflex #Aerocel.

2.3 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. ASJ+: White, polypropylene-coated, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
3. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
4. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
5. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
6. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perm) when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.4 JACKETING MATERIALS

A. Field Applied Jackets (For Indoor Applications):

1. All longitudinal seams shall be located on bottom of pipes.
2. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
3. PVC Plastic:
    a. High-impact-resistant, UV-resistant PVC as tested per ASTM C553, C547, C665, C795, C1338, D1784, E96, C1136 and D3679.
    b. One piece molded type fitting covers and jacketing material.
    c. Adhesive: As recommended by jacket material manufacturer.
    d. Color: White.

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e. Thickness: 20 mil (0.5 mm), minimum.
f. Service Temperature Range: 0°F to 150°F (-18°C to 66°C).
g. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
h. Manufacturers: Johns Manville #Zeston 2000, Proto #LoSmoke, Speedline Corporation.

4. Aluminum Jacket:

a. Comply with ASTM B209/B209M.
b. Aluminum alloy 3003, 3005, 3105 or 5005 with an H-14 temper.
c. Thickness: 0.016” thick sheet (minimum).
d. Finish: Smooth or stucco embossed
e. Moisture Barrier: 3 mil thick polysurlyn or 3 mil thick polyethylene.
f. Longitudinal slip joints and 2” laps, die shaped fitting covers with factory attached protective liner. Secure with 3/8” or 1/2” stainless steel bands on 12” centers.
g. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
h. Manufacturers: Pabco, Childers, RPR, ITW.

5. Canvas Jacket:

a. Cotton or fiberglass cloth.
b. UL listed fabric treated with dilute fire retardant.
c. Lagging adhesive per manufacturer.
d. Manufacturers: GJC General, GLT Products, Foster #Mast-A-Fab, Childers #Chil-Glas No. 5.

B. Removable Covers:

1. Provide removable covers on indoor pumps, valves, air separators, air vent fittings, flanges, strainers, traps, etc., where periodic maintenance or removal of insulation is required.

a. Pre-molded insulation covers:

1) Cold Systems: Provide PVC covers over insulated elbows, fittings and flanges.
2) Cold Systems: Provide flexible closed cell foam or removable cloth insulating blankets for valves, pumps and strainers.
3) Hot Systems: Provide PVC covers over insulated elbows, fittings and flanges.
4) Hot Systems: Provide removable cloth insulating blankets on valves, pumps, and strainers.

b. Removable cloth insulating blankets:

1) Service Operating Temperature: 0-350°F.
2) Jacket and Liner: silicon or teflon impregnated mineral wool cloth.
3) Liner Reinforcement: stainless steel mesh cloth.

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4) Insulation: Fiberglass matt or Pacor #Aerogel, 2” thick (minimum) or R-8 equivalent (minimum), and thicker as required by local energy code.
5) Fastening: 2” Nomex Velcro or 1” straps and stainless steel D-rings or 12-gage stainless steel hooks and stainless steel wire.
6) Thread: Kevlar/stainless steel thread.
7) Outdoor Applications: Jacket shall be UV and ozone resistant with Velcro attachment.
8) Manufacturers: Thermal Energy Products, Coverflex, Thermaxx, Pacor, Unitherm, Advance Thermal, Fit Tight Covers, Alpha.

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. Calcium Silicate Adhesive:

1. Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 1200°F (10 to 649°C).
2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Manufacturers: Childers Brand #CP-97, Johns Manville #CalBond Gold, Marathon Industries #290, Foster Brand #81-27, Mon-Eco Industries #22-30, Vimasco Corporation #760.

C. Cellular-Glass Adhesive:

1. Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200°F (minus 73 to plus 93°C).
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. Manufacturers: Foster Brand #81-84.

D. Phenolic and Polyisocyanurate Adhesive:

1. Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300°F (minus 59 to plus 149°C).
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. Manufacturers: Childers Brand #CP-96, Foster Brand #81-33.

E. 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 according to 40 CFR 59, Subpart D (EPA Method 24).
3. Manufacturers: Armaflex #520 BLVAdhesive, Foster Brand #85-75, K-Flex USA #1120, Aeroflex USA, Aeroseal, Armacell.

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

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1. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Manufacturers: Childers Brand #CP-127, Eagle Bridges - Marathon Industries #225, Foster Brand #85-60/85-70, Mon-Eco Industries, Inc.#22-25.

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

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. Manufacturers: Childers Brand #CP-82, Eagle Bridges - Marathon Industries #225, Foster Brand #85-50, Mon-Eco Industries, Inc.#22-25.

H. PVC Jacket Adhesive: Compatible with PVC jacket.

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. Manufacturers: Dow Corning Corporation #739, Dow Silicone, Johns Manville #Zeston Perma-Weld, CEEL-TITE #Solvent Welding Adhesive, P.I.C. Plastics, Inc. #Welding Adhesive, Speedline Corporation #Polyco VP Adhesive.

I. MASTICS

A. 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).

B. Vapor-Barrier Mastic: Water based for indoor use.

1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180°F (Minus 29 to plus 82°C).
3. Vapor Safe Coating: Shall meet requirements of LEED IEQ Low-Emitting Materials. VOC 33 g/l, less water and exempt solvents.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.
6. Manufacturers: Foster Brand #30-80/30-90, Vimasco Corporation #749.

C. Vapor-Barrier Mastic: Solvent based for outdoor use.

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. Manufacturers: Childers Brand #Encacel X CP-40, Eagle Bridges - Marathon Industries #570, Foster Brand #60-95/60-96.

D. Breather Mastic: Water based for indoor and outdoor use.

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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. Manufacturers: Childers Brand #CP-10/CP-11, Eagle Bridges - Marathon Industries #550, Foster Brand #46-50, Mon-Eco Industries, Inc. #55-50, Vimasco Corporation #WC-1/WC-5.

2.7 LAGGING ADHESIVES

A. Adhesives shall be compatible with insulation materials, jackets, and substrates.

1. Comply with MIL-A-3316C, Class I, Grade.
2. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
4. Service Temperature Range: 0 to 180°F (-18 to 82°C).
5. Color: White.
6. Manufacturers: Childers Brand #CP-50 AHV2, Foster Brand #30-36, Vimasco Corporation #713/714.

2.8 SEALANTS

A. Joint Sealants:

1. Joint Sealants for Cellular-Glass, Phenolic, and Polyisocyanurate.
    a. Manufacturers: Childers Brand #CP-76, Marathon Industries#405, Foster Brand #30-45, Mon-Eco Industries, Inc.#44-05, Pittsburgh Corning Corporation #Pittseal 444.
2. Joint Sealants for Polystyrene.
    a. Manufacturers: Childers Brand #CP-70, Marathon Industries #405, Foster Brand #30-45, Mon-Eco Industries, Inc.#44-05.
3. Materials shall be compatible with insulation materials, jackets, and substrates.
4. Permanently flexible, elastomeric sealant.
5. Service Temperature Range: -100 to 300°F (-73 to 149°C).
6. Color: White or gray.
7. 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). Shall be compliant with requirements of LEED IEQ Low-Emitting Materials.

B. FSK and Metal 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: Aluminum.

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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. Manufacturers: Childers Brand #CP-76, Eagle Bridges - Marathon Industries #405, Foster Brand #95-44, Mon-Eco Industries, Inc. #44-05.

C. 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. Manufacturers: Childers Brand #CP-76.

2.9 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

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. Manufacturers: ABI, Ideal Tape Division #428 AWF ASJ, Avery Dennison Corporation #Fasson 0836, Compac Corporation #105, 3M Venture Tape #1540 CW Plus/1542 CW Plus/1542 CW Plus/SQ.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

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.
7. Manufacturers: ABI Tape #491 AWF FSK, Avery Dennison Corporation #Fasson 0827, Compac Corporation #110 and 111, 3M Venture Tape #1525 CW NT/1528 CW/1528 CW/SQ.

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

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.

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6. Manufacturers: ABI Tape #370 White PVC tape, Compac Corporation #130, Venture Tape #1506 CW NS.

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

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. Manufacturers: ABI Tape #488 AWF, Avery Dennison Corporation #Fasson 0800, Compac Corporation #120, 3M Venture Tape #3520 CW.

2.10 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.Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.
3. Manufacturers: ITW Insulation Systems, Gerrard Strapping and Seals, RPR Products, Inc., Insul-Mate Strapping, Seals, and Springs.

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.

    a. Manufacturers: AGM Industries #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.

    a. Manufacturers: 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 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, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.

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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. Manufacturers: AGM Industries, Inc. #Tactoo Perforated Base Insul-Hangers, GEMCO #Perforated Base, Midwest Fasteners, Inc.#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. Manufacturers: GEMCO #Nylon Hangers, Midwest Fasteners, Inc.#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. Manufacturers: AGM Industries, Inc. #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. Manufacturers: AGM Industries #RC-150, GEMCO #R-150, Midwest Fasteners #WA-150, Nelson Stud Welding #Speed Clips.

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

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hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

a. Manufacturers: GEMCO, Midwest Fasteners, Inc.

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.

1. Manufacturers: C & F Wire.

PART 3 - EXECUTION

3.1 EXAMINATION AND PREPARATION

A. Verify that piping has been tested for leakage in accordance with specifications before applying insulation materials. All piping and 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.

3.2 INSTALLATION

A. General:

1. Install materials in accordance with manufacturer's recommendations, building codes and industry standards.
2. Cold or chilled water systems shall not be operated in normal mode until all piping has been fully insulated with continuous vapor barrier, vapor dams, vapor seals, fitting covers, valves covers, and no exposed joints or seams.

a. Install **PI-A** only if listed in TABLE 1 per NAIMA (North American Insulation Manufacturers Association) - *Guide to Insulating Chilled Water Systems with Mineral Fiber Pipe Insulation* to assure continuous insulation coverage to minimize condensation potential.

3. Remove and replace any insulation that has become wet or damaged during the construction process.
4. Pipe fittings, valves, pipe flanges, pumps, strainers, gauge fittings, etc., shall be insulated to the same insulation thickness as adjoining piping and as required by local energy code.
5. All support points, joints and fittings shall be insulated for continuous insulation coverage with no gaps or voids or exposed cold surfaces are allowed in the system. Continuous insulation implies that insulation shall meet or exceed the minimum thickness throughout the insulated system with no reduction in thickness at any location.
6. Pipes that are to be insulated, including chilled and heating water, shall not be in direct contact with support elements such as clevis or trapeze or saddle or shield devices. This may not apply at seismic restraint locations depending on type of restraint system used. Pipes must use appropriate insulating options at support

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locations to allow the insulation and vapor barrier to be sealed continuously through each support with insulation joints located a minimum of 6” from each support location to allow for commissioning confirmation.

7. At each seismic restraint locations and riser clamps, the support system shall be fully encapsulated with insulation and vapor barrier, and all gaps/joints sealed airtight. Insulation on support elements, including threaded rods, cables and metal bracing, shall extend a minimum of 6” beyond the insulation jacket, or additional as required, to prevent condensation and uncontrolled heat transfer.

B. Piping Insulation:

1. Locate insulation and cover seams in least visible locations unless otherwise specified.
2. Neatly finish insulation at supports, protrusions, and interruptions.
3. Provide vapor retardant jackets with self-sealing laps on insulated cold pipes conveying fluids below ambient temperature. Insulate complete system. Staples used on pipes conveying fluids below ambient temperatures (cold systems) must be covered with approved mastic.
4. For insulated pipes conveying fluids above ambient temperature, secure jackets with self-sealing lap or outward clinched, expanded staples. Seal ends of insulation at equipment, flanges, and unions.
5. For smaller pipe sizes, less than 1-1/2” diameter, provide metal or pre-manufactured plastic insulation shield to support the insulated pipe through the support point at the hanger or saddle. Pipe shield shall be a minimum of 6” long to distribute the weight of the insulated pipe without crushing or damaging the insulation. Pipe shield shall be located outside of the metal insulation jacket where applicable.
6. Use of metal saddles is acceptable as specified in Section 230500. Fill interior voids with segments of insulation matching adjoining pipe insulation.
7. Use of pipe hangers designed with an insulation coupling may be acceptable in lieu of saddles and other devices.
8. For insulated pipe exposed in mechanical equipment rooms or in finished spaces below seven (7) feet above finished floor, cover insulation with PVC or metal jacketing.
9. Pre-manufactured installation elbows shall be used for piping insulation. Foal fill of elbow is unacceptable.
10. Provide reusable insulation blanket shall be provided around piping specialties.
11. Jacket Locations for Pipe, Valve and Fittings. Provide protective insulation jackets for the following locations where not defined elsewhere in the specifications for piping systems:

Insulation Jacket Location	Jacket Material
Indoors: Concealed in Accessible Ceiling Voids.	None.
Indoors: Concealed in Inaccessible Ceiling Voids.	None.

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Indoors: Concealed in Accessible Portions of Shafts or Chaseways.	None.
Indoors: Concealed in Inaccessible Portions of Shafts or Chaseways.	None.
Indoors: Mechanical Rooms.	PVC or Aluminum or Stainless Steel to seven (7) feet AFF.
Indoors: Exposed to view in normally occupied spaces such offices, conference rooms, restaurants and retail spaces.	PVC.
Indoors: Exposed to view in warehouse, storage and manufacturing spaces.	None.
Outdoors: Exposed to weather.	Aluminum or stainless steel with white coating for low emissivity.
Outdoors: Exposed in covered outdoor areas such as garages or under canopies.	Aluminum or stainless steel.
Outdoors: Located in vaults or accessible concrete trenches.	Aluminum or stainless steel.

3.3 PIPING INSULATION SCHEDULE

A. TABLE 1: PIPING SERVICES, FLUID TEMPERATURE, AND INSULATION TYPE REQUIRED.

1. All insulation thicknesses shall meet or exceed state energy code requirements as noted below. Increase thickness by 1/2” (minimum) where insulated pipe is exposed to exterior ambient air. Minimum thermal resistance shall comply with building code minimum ranges and may exceed those minimum levels. Insulation thicknesses may be adjusted for equivalent insulation values for materials with superior “K” factors. Refer to “PART 2-PRODUCTS” for characteristics of each insulation material listed below.

PIPE INSULATION INDEX	
INSULATION KEY CODE	INSULATION TYPE
PI-A	Preformed Flexible Mineral Wool or Fiberglass.
PI-B	Preformed Flexible Closed-Cell Elastomeric, Neoprene or Polyethylene.

2.

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TABLE 1: PIPING SERVICES, FLUID TEMPERATURE, AND INSULATION TYPE REQUIRED		
SERVICE	INSULATION KEY CODE	THICKNESS/REMARKS (Minimum)
Cooling coil condensate drain piping and traps located inside spaces within the building, and above ceilings and in attics.	**PI-A or B**	Provide 1/2” (minimum) thickness insulation, all pipe sizes. Refer to Division 22.
Cooling coil condensate drain piping and traps located inside the building, in mechanical rooms located in buildings located in humid climates defined as “A-Moist” or “C-Marine” in the IECC.	**PI-A or B**	Provide 1/2” (minimum) thickness insulation, all pipe sizes. Refer to Division 22.
Cooling coil condensate drain piping and traps located outdoors.	**N/A**	Not required.
Refrigerant suction piping.	**PI-B**	Provide 1/2” (minimum) thickness insulation or increased thickness as required by State Energy Code. See Table 2 below.
Refrigerant liquid and hot-gas piping.	**PI-B**	Provide 1/2” (minimum) insulation for all warm/hot piping in close proximity to human contact and where located in enclosed ceiling, shaft or chase spaces.

B. TABLE 2: MINIMUM PIPING INSULATION THICKNESS BASED ON FLUID TEMPERATURE AND PIPING SIZE.
   1. Oregon

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Table 2 Insulation Based on Oregon OEESC Energy Code Table 503.2.8 Minimum Pipe Insulation Thicknesses or Greater							
FLUID TEMPERATURE RANGE (°F)	CONDUCTIVITY RANGE (in Btu-inch per hour per square foot °F)	INSULATION MEAN RATING TEMPERATURE (°F)	NOMINAL PIPE DIAMETER (in inches)				
			Less than 1	1 and 1-1/4	1-1/2 to 3	4 to 6	8 and larger
			INSULATION THICKNESS REQUIRED (in inches)				
Space heating systems (steam, steam condensate and hot water)							
Above 350	0.32-0.34	250	4.5	5.0	5.0	5.0	5.0
251-350	0.29-0.32	200	3.0	4.0	4.5	4.5	4.5
201-250	0.27-0.30	150	2.5	2.5	2.5	3.0	3.0
141-200	0.25-0.29	125	1.5	1.5	2.0	2.0	2.0
105-140	0.21-0.28	100	1.0	1.0	1.5	1.5	1.5
Space cooling systems (chilled water, refrigerant and brine)							
40-60	0.21-0.27	75	0.5	0.5	1.0	1.0	1.0
Below 40	0.20-0.26	50	0.5	1.0	1.0	1.0	1.5

END OF SECTION 230719

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