



This Section may be edited and revised by inserting or deleting text to meet requirements specific to your project. The Document is provided in a modified format.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes insulating the following HVAC piping systems:
 - 1. Condensate drain piping, **[indoors] [and] [outdoors]**.
 - 2. Chilled water and brine piping, **[indoors] [and] [outdoors]**.
 - 3. Condenser water piping, **[indoors when used for water side economizer or for condensate control] [and] [outdoors]**.
 - 4. Heating hot water piping, **[indoors] [and] [outdoors]**.
 - 5. Steam and steam condensate piping, **[indoors] [and] [outdoors]**.
 - 6. Refrigerant suction and hot gas piping, **[indoors] [and] [outdoors]**.
 - 7. Dual service heating and cooling piping, **[indoors] [and] [outdoors]**.
 - 8. Heat recovery piping, **[indoors] [and] [outdoors]**.
 - 9. Heated fuel oil piping, **[indoors] [and] [outdoors]**.
- B. Related Sections:
 - 1. Section 230713 "Duct Insulation".
 - 2. Section 230716 "HVAC Equipment Insulation".

1.3 REFERENCE STANDARDS

- A. ASTM International (ASTM).
- B. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. (ASHRAE).
- C. North American Insulation Manufacturers Association (NAIMA).
- D. NAIMA – "Guide to Insulating Chilled Water Piping Systems with Mineral Fiber Pipe Insulation".
- E. "National Commercial & Industrial Insulation Standards" – MICA Manual.
- F. Thermal Insulation Association of Canada (TIAC).

- G. National Fire Protection Association (NFPA).
- H. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA).
- I. Underwriter's Laboratories (UL).
- J. Underwriter's Laboratories Environment (UL Environment).
- K. ASHRAE 189.1 – “Standard for the Design of High-Performance Green Buildings; Except Low-Rise Residential Buildings”.
- L. California Department of Public Health - "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers". Formaldehyde emissions shall not exceed 16.5 mcg/cu. m or 13.5 ppb, whichever is less, except for insulation manufactured without formaldehyde.

1.4 DEFINITIONS

- A. Thermal Conductivity (K value): Heat flow property of a homogeneous material; the lower the “k” the better the insulating value. Expressed in units of Btu-inch/hour per square foot per degree F.
- B. Underwriters Laboratories Environment (UL Environment): independent, third-party green claims validation, product assessment and certification.
 - 1. Environmental Claim Validation (ECV): Independent third-party review to single attribute environmental claims.
 - a. Formaldehyde Free: Independent third-party validation of claim that a product does not contain formaldehyde (or formaldehyde precursors) using a combination of auditing raw material input and testing of chemical emission from the product.
 - b. Recycled Content:
 - 1. Pre-Consumer - 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.
 - 2. Post-Consumer - materials such as bottled glass collected at curbside or other collection sites after consumer use.
 - 2. GREENGUARD Certification: Health based emission testing criteria for chemicals; requiring total VOC emission levels for products.
 - 3. GREENGUARD Gold: Emission testing criteria for chemicals requiring lower total VOC emission limit levels for products acceptable for use in environments such as schools and healthcare facilities. Complies with California’s Department of Public Health (CDPH) “Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers”; Version 1.1 (2010), also known as California Section 01350 .
 - 4. Environmental Product Declaration (EPD): Independently verified and registered document providing information about the life-cycle impact of products.

- C. Health Product Declaration (HPD): Product disclosure document containing an inventory of the contents of a product for its end use and the associated health hazards.
- D. EPA: Environmental Protection Agency.
- E. WHO: World Health Organization.
- F. NIA – National Insulation Association - Thermal Insulation Certified Inspector Program: a recommended certified mechanical insulation inspector program that utilizes inspectors who maintain current certification by NIA to inspect and verify the materials used are, and the total insulation system has been, installed correctly in accordance with the Specifications; throughout the project.
- G. ILFI: International Living Institute; an international sustainable building certification program.
 - 1. DECLARE: Ingredients label for Building Products
 - a. Red List Free: 100% ingredients disclosure to 100 ppm to not contain any Red List chemicals of concern.
 - b. LBC Red List Compliant: Ingredients disclosure to meet 99% of Red List chemicals at 100 ppm and may contain one or more exceptions for meeting Living Building Challenge (LBC) criteria.
 - c. Declared: 100% ingredients disclosure to 100 ppm, but contains one or more Red List chemicals that are covered by an existing exception.
- H. LEED: Leadership in Energy and Environmental Design, a voluntary rating system for high performance green buildings developed by the US Green Building Council (USGBC).
- I. Sustainable Minds (SM) Transparency Catalog: Designed as an educational marketing platform to provide access to products with environmental and material disclosures that qualify for Collaborative for High Performance Schools, LEED v4, Green Globes, the Well Building Standard and the Living Building Challenge — from all manufacturers, all program operators and all material disclosure rating systems. Available at: www.transparencycatalog.com/showroom/knauf-insulation.
- J. EUCEB: The European Certification Board for Mineral Wool Products, a voluntary certification of the conformity to meet the bio-solubility criteria of mineral wool fibers.
- K. Polybrominated diphenyl ethers (PBDE) such as Penta-BDE, Octa-BDE or Deca-BDE fire retardants: used in the manufacture of some insulation facings.
- L. UL Classified: Underwriters Laboratory product label of fire resistance testing that includes on-going evaluation of the product to assure it continues to meet the Fire Hazard Classification (FHC) 25 Flame Spread; 50 Smoke Developed rating; unlike other FHC testing which is a one-time only test.
- M. 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.
- N. ASJ: All Service Jacket (no outer film).

- O. SSL+: Self-Sealing Lap with Advanced Closure System.
- P. SSL: Self-Sealing Lap.
- Q. FSK: Foil Scrim Kraft; jacketing.
- R. PSK: Poly Scrim Kraft; jacketing.
- S. PVC: Poly Vinyl Chloride.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water vapor permeance, thickness, and jackets (both factory and field-applied if any).
- B. EPD or HPD Submittals: Third Party Validated.
- C. Sustainable Design Submittals:
 - 1. Product Data: For recycled content, indicating postconsumer and pre-consumer recycled content and cost.
 - 2. Product Data: For adhesives, indicating VOC content.
 - 3. Laboratory Certificates or Validations: For adhesives, indicating compliance with requirements for low-emitting materials.
 - 4. Laboratory Certificates or Validations: For insulation, indicating compliance with requirements for low-emitting materials.
- D. LEED v 4 Submittals:
 - 1. Product Data for Credit Energy and Atmosphere (EA) – Minimum Energy Performance, Optimize Energy Performance.
 - 2. Product Data for Credit Materials and Resources (MR) – Building Product Disclosure & Optimization – EPD, Building Product Disclosure & Optimization – Source of Raw Materials, Building Product Disclosure & Optimization – Material Ingredients.
 - 3. Product Data for Credit Indoor Environmental Quality (EQ) – Minimum Indoor Quality Performance, Minimum Acoustic Performance, Low Emitting Materials.
- E. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail attachment and covering of heat tracing inside insulation.
 - 3. Detail insulation application at pipe expansion joints for each type of insulation.
 - 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 5. Detail removable insulation at piping specialties.
 - 6. Detail application of field-applied jackets.
 - 7. Detail application at linkages of control devices.

- F. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.
1. Preformed Pipe Insulation Materials: 12 inches (300 mm) long by NPS 2 (DN 50).
 2. Sheet Form Insulation Materials: 12 inches (300 mm) square.
 3. Jacket Materials for Pipe: 12 inches (300 mm) long by NPS 2 (DN 50).
 4. Sheet Jacket Materials: 12 inches (300 mm) square.
 5. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- C. Field quality control reports.

1.7 QUALITY ASSURANCE

- A. 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.
- B. Knauf Insulation recommends the use of the NIA – National Insulation Association, Thermal Insulation Certified Inspector Program (as defined in 1.4 F – above).
- C. Bio-Based Binder: a plant based sustainable chemistry bond that holds the fiberglass product together; replacing the phenol/formaldehyde (PF) binder traditionally used in fiberglass products.
- D. Surface Burning Characteristics: For insulation and related materials, UL/ULC Classified per UL 723 or meeting ASTM E 84, by a testing and inspecting agency acceptable to authorities; having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
1. Insulation Installed Indoors: Flame spread index of 25 or less, and smoke developed index of 50 or less.
 2. Insulation Installed Outdoors: Flame spread index of 75 or less, and smoke developed index of 150 or less.
- E. Products shall not contain formaldehyde, asbestos, lead, mercury, or mercury compounds **[if available]**. Products shall be Certified UL GREENGUARD Gold or Indoor Advantage Gold **[if available]**.
- F. Biosoluble Fiber: Certified by European Certification Board for Mineral Wool Products (EUCEB).

- G. Recycled Content: A minimum of 50 percent recycled glass content certified and UL Validated.
- H. Declare LBC Red List Compliant; minimum.
- I. Products shall contain no polybrominated diphenyl ethers (PBDE) such as Penta-BDE, Octa-BDE or Deca-BDE fire retardants; whenever available.
- J. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.
 - 1. Piping Mockups:
 - a. One 10 foot (3 m) section of NPS 2 (DN 50) straight pipe.
 - b. One each of a 90 degree threaded, welded, and flanged elbow.
 - c. One each of a threaded, welded, and flanged tee fitting.
 - d. One NPS 2 (DN 50) or smaller valve, and one NPS 2-1/2 (DN 65) or larger valve.
 - e. Four support hangers including hanger shield and insert.
 - f. One threaded strainer and one flanged strainer with removable portion of insulation.
 - g. One threaded reducer and one welded reducer.
 - h. One pressure temperature tap.
 - i. One mechanical coupling.
 - 2. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
 - 3. Notify Architect seven days in advance of dates and times when mockups will be constructed.
 - 4. Obtain Architect's approval of mockups before starting insulation application.
 - 5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 - 6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
 - 7. Demolish and remove mockups when directed.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.9 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment".

- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.10 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Piping Insulation Schedule, General", "Indoor Piping Insulation Schedule", "Outdoor, Aboveground Piping Insulation Schedule", and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.
- B. Insulation materials applied to carbon steel shall be Mass Loss Corrosion Rate (MLCR) tested per ASTM 1617.
- C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- E. Products shall comply with the standards in Section 1.7 – Quality Assurance.
- F. Fiberglass, Preformed Pipe Insulation: Fiberglass bonded with a bio-based thermosetting resin. Type I, 850 deg. F (454 deg. C) or Type IV 1000 deg. F (538 deg. C). UL/ULC Classified. Comply with ASTM C 585, ASTM C 411, ASTM C 795, and ASTM C 547, Type I, and Type IV, **[without factory-applied jacket] [with factory-applied ASJ+ or ASJ] [with factory-applied ASJ+-SSL+ or ASJ-SSL]**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Knauf Insulation; Earthwool 1000 Degree Pipe Insulation.

G. Fiberglass Pipe and Tank Insulation: fiberglass bonded with a bio-based thermosetting resin. Semi-rigid board material with factory-applied [ASJ] [ASJ+] [FSK jacket] complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Compressive Strength per ASTM C 165, not less than 102 PSF (5.75 kPa) at 10% deformation. Thermal conductivity (k-value) at 100 deg. F (38 deg. C) is 0.26 Btu x in. /h x sq. ft. x deg. F (0.037 W/m x C) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Knauf Insulation; Earthwool Pipe and Tank Insulation.

H. Fiberglass Pipe and Tank Insulation: Fiberglass bonded with a thermosetting resin. Semi-rigid blanket material with factory-applied [ASJ] [FSK] [PSK] jacket, complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Compressive Strength; per ASTM C 165, not less than 25 PSF (1.2 kPa) at 10% deformation. Thermal conductivity (k value) at 100 deg. F (38 deg. C) is 0.25 Btu x in./h x sq. ft. x deg. F (0.036 W/m x C). Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Knauf Insulation; Kwik-Flex Pipe and Tank Insulation.

2.2 INSULATING CEMENTS

- A. Mineral Fiber Insulating Cement: Comply with ASTM C 195.
- B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.
- C. Mineral Fiber, Hydraulic Setting Insulating and Finishing Cement: Comply with ASTM C 449.

2.3 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. Mineral Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
- C. 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. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers".
- D. 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. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers".

2.4 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates.
 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; suitable for indoor use on below ambient services.
 1. Water Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.04 perm (0.026 metric perm) at 40 mil (1.016 mm) dry film thickness.
 2. Service Temperature Range: Minus 20 to plus 180 deg. F (Minus 29 to plus 82 deg. C).
 3. Solids Content: ASTM D 1644, 52 percent by volume and 62 percent by weight.
 4. Color: White.
- C. Vapor Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.
 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 deg. F (Minus 18 to plus 82 deg. C).
 3. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
 4. Color: White.
- D. Vapor Barrier Mastic: Solvent based; suitable for outdoor use on 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 deg. F (Minus 46 to plus 104 deg. C).
 3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
 4. Color: White.
- E. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
 1. Water Vapor Permeance: ASTM F 1249, 1.8 perm (1.2 metric perm) at 0.0625 inch (1.6 mm) dry film thickness.
 2. Service Temperature Range: Minus 20 to plus 180 deg. F (Minus 29 to plus 82 deg. C).
 3. Solids Content: 50 percent by volume and 58 percent by weight.
 4. Color: White.

2.5 LAGGING ADHESIVES

- A. 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 according to 40 CFR 59, Subpart D (EPA Method 24).

2. Fire resistant, water based lagging adhesive and coating for use indoors to adhere fire resistant lagging cloths over pipe insulation.
3. Service Temperature Range: 0 to plus 180 deg. F (Minus 18 to plus 82 deg. C).
4. Color: White.

2.6 SEALANTS

A. Joint Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Permanently flexible, elastomeric sealant.
3. Service Temperature Range: Minus 100 to plus 300 deg. F (Minus 73 to plus 149 deg. C).
4. Color: White or gray.
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. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers".

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 deg. F (Minus 40 to plus 121 deg. 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. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers".

C. ASJ Flashing Sealants, and Vinyl, PVDC, 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 deg. F (Minus 40 to plus 121 deg. 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. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers".

2.7 FACTORY-APPLIED JACKETS

1. ASJ+ - SSL+; ASJ+ jacket with Self-Sealing Advanced Closure System; complying with ASTM C 1136 Type I, II, III, IV and VII secured with self-sealing longitudinal laps and matching ASJ+ butt strips.

2. ASJ+: All Service Jacket composed of aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C 1136 Type I, II, III, IV and VII.
3. ASJ: White, kraft paper, fiberglass reinforced scrim with aluminum foil backing; complying with ASTM C 1136, Type I.
4. ASJ-SSL: ASJ with self-sealing, pressure sensitive, acrylic based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
5. FSK Jacket: Aluminum foil, fiberglass reinforced scrim with kraft paper backing; complying with ASTM C 1136, Type II.
6. PSK Jacket: Aluminum foil, fiberglass reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Glass Fiber Fabric: Approximately 2 oz. /sq. yd. (68 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm) for covering pipe and pipe fittings.
- B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for pipe.

2.9 FIELD-APPLIED CLOTHS

- A. Woven Glass Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and pre-sized a minimum of 8 oz. /sq. yd. (271 g/sq. m).

2.10 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum foil face, fiberglass reinforced scrim with kraft paper backing.
- C. PVC Jacket: High impact resistant, UV resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 1. Adhesive: As recommended by jacket material manufacturer.
 2. Color: **[White] [Color code jackets based on system. Color as selected by Architect].**
 3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45 and 90 degree, short and long radius elbows, tees, valves, flanges, unions, reducers, end caps, soil pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

D. Metal Jacket:

1. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. **[Sheet and roll stock ready for shop or field sizing] [Factory cut and rolled to size].**
 - b. Finish and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: **[1mil (0.025 mm) thick, heat bonded polyethylene and kraft paper] [3 mil (0.075 mm) thick, heat bonded polyethylene and kraft paper] [2.5 mil (0.063 mm) thick polysurlyn].**
 - d. Moisture Barrier for Outdoor Applications: **[3 mil (0.075 mm) thick, heat bonded polyethylene and kraft paper] [2.5 mil (0.063 mm) thick polysurlyn].**
 - e. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed 2 piece or gore, 45 and 90 degree, short and long radius elbows.
 - 3) Tee covers.
 - 4) Flange and union covers.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field-fabricate fitting covers only if factory-fabricated fitting covers are not available.

2. Stainless Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.
 - a. **[Sheet and roll stock ready for shop or field sizing] [Factory cut and rolled to size].**
 - b. Material, finish, and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: **[1mil (0.025 mm) thick, heat bonded polyethylene and kraft paper] [3 mil (0.075 mm) thick, heat bonded polyethylene and kraft paper] [2.5 mil (0.063 mm) thick polysurlyn].**
 - d. Moisture Barrier for Outdoor Applications: **[3 mil (0.075 mm) thick, heat bonded polyethylene and kraft paper] [2.5 mil (0.063 mm) thick polysurlyn].**
 - e. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed 2 piece or gore, 45 and 90 degree, short and long radius elbows.
 - 3) Tee covers.
 - 4) Flange and union covers.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field-fabricate fitting covers only if factory-fabricated fitting covers are not available.

- E. Self-Adhesive Outdoor Jacket: 60 mil (1.5 mm) thick, laminated vapor barrier and waterproofing membrane; for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross laminated polyethylene film covered with **[white] [stucco embossed]** aluminum foil facing.
1. Products: Subject to compliance with requirements.
 2. Laminated self-adhesive seal: Meeting or exceeding the requirements of UL 723.
 - a. Permanent acrylic self-adhesive system.
 - b. Weather resistant.
 - c. High puncture and tear resistant.
 - d. Applied in strict accordance with manufacturer's recommendations.

2.11 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) or 4 inches (102 mm).
 2. Thickness Total: **[14.3 mil (0.36 mm) for ASJ] [13.3 mil (0.34 mm) for ASJ+]**.
 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.
- 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) or 4 inches (102 mm).
 2. Thickness Total: 13.3 mil (0.34 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.
- 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 mil (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.
- D. Aluminum Foil Tape: Vapor retarder tape with acrylic adhesive.
1. Width: 2 inches (50 mm), 3 inches (75 mm), or 4 inches (102 mm).
 2. Thickness Total: 7.3 mil (0.19 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.

2.12 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, [**Type 304**] [**or**] [**Type 316**]; 0.015 inch (0.38 mm) thick, [**1/2 inch (13 mm)**] [**3/4 inch (19 mm)**] wide with [**wing seal**] [**or**] [**closed 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)**] [**3/4 inch (19 mm)**] wide with [**wing seal**] [**or**] [**closed 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.

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

C. Wire: [**0.080 inch (2.0 mm) nickel copper alloy**] [**0.062 inch (1.6 mm) soft annealed, stainless steel**] [**0.062 inch (1.6 mm) soft annealed, galvanized steel**].

PART 3 - EXECUTION

3.1 EXAMINATION

- #### A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
1. Verify that systems to be insulated have been tested and are free of defects.
 2. Verify that surfaces to be insulated are clean and dry.
 3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mil (0.127 mm) thick and an epoxy finish 5 mil (0.127 mm) thick if operating in a temperature range between 140 and 300 deg. F (60 and 149 deg. C). Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg. F (0 and 149 deg. C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing; that apply to insulation.
 - D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during application and finishing.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor barrier mastic.
 1. Install insulation continuously through hangers and around anchor attachments.
 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor barrier mastic.
 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

- L. Install insulation with non-self-sealing factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3 inch (75 mm) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) oc.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive longitudinal lap. Staple laps with outward clinching staples along edge at [**2 inches (50 mm)**] [**4 inches (100 mm)**] oc.
 - a. For below ambient services, apply vapor barrier mastic over staples.
 - 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

- M. Install insulation with self-sealing factory-applied jackets as follows:
 - 1. Locate all longitudinal pipe insulation jacketing laps in least visible location.
 - 2. Draw jacket tight and smooth.
 - 3. For proper sealing, seal lap joints with reasonable pressure being applied with a plastic squeegee or sealing tool.
 - 4. Vapor seal all circumferential joints with factory furnished matching pressure sensitive butt strips installed with reasonable pressure being applied with a plastic squeegee or sealing tool.

- N. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

- O. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

- P. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

- Q. For above ambient services, do not install insulation to the following:
 - 1. Vibration control devices.
 - 2. Testing agency labels and stamps.
 - 3. Nameplates and data plates.
 - 4. Manholes.
 - 5. Handholes.
 - 6. Cleanouts.

3.4 FIBERGLASS INSULATION INSTALLATION

- A. Insulation Installation on Straight Pipes and Tubes.

1. Secure pipe insulation to pipe using self-sealing lap system.
2. On high temperature piping, above 500 deg. F (260 deg. C), apply insulation using double layer and staggered joints. For double layer installation, secure the unjacketed inner layer using filament tape; without deforming insulation material. All joints and ends must be firmly butted and secured with appropriate securing material.
3. Firmly rub all longitudinal and circumferential joints using a squeegee or sealing tool.
4. Longitudinal jacket laps for pipe insulation installed on piping systems with operating temperatures below ambient shall be vapor sealed with factory-applied pressure-sensitive adhesive vapor retarder, self-sealing lap. For proper sealing, firmly rub lap joints with reasonable pressure being applied with a plastic squeegee or sealing tool. Vapor seal all circumferential joints with factory-furnished, matching pressure-sensitive butt strips installed with reasonable pressure being applied with a plastic squeegee or sealing tool. Additionally, coat raw edges of pipe insulation sections with vapor retarder mastic at 12 foot (3.6 m) to 21 foot (6.4 m) intervals; at Engineer's discretion on straight piping, and on either side of all fittings, flanges, or valves. Vapor retarder mastic shall completely coat the ends of the pipe and extend onto the bore of the pipe insulation and onto the jacketing a minimum of 2 inches (51 mm). Follow NAIMA's "Guide to Insulating Chilled Water Piping Systems with Mineral Fiber Pipe Insulation" for additional details.
5. Install metal shields between hangers or supports and the pipe insulation. Install rigid insulation inserts as required between the pipe and the insulation shields. Inserts shall be of equal thickness to the adjacent insulation, and shall be vapor sealed as required. Insulation shields shall be no less than the following lengths:
 - a. 1-1/2 inch (38 mm) to 2-1/2 inch (64 mm) IPS: 10 inch (254 mm) long.
 - b. 3 inch (76 mm) to 6 inch (152 mm) IPS: 12 inch (305 mm) long.
 - c. 8 inch (203 mm) to 10 inch (254 mm) IPS: 16 inch (406 mm) long.
 - d. 12 inch (305 mm) and over IPS: 22 inch (559 mm).
6. For piping subject to abuse in mechanical rooms or high traffic areas, protect insulation from mechanical abuse by the use of appropriate thickness of PVC jacketing, metal jacketing, or laminated self-adhesive water and weather seal.
7. For piping exposed to the elements, install a jacket that shall be UV resistant PVC with a minimum thickness of 0.030 inch (0.7 mm), a minimum 0.016 inch (0.406 mm) thick aluminum jacket with factory-applied moisture barrier, or a minimum 0.010 inch (0.254 mm) thick stainless steel jacket with factory-applied moisture barrier. Fittings shall be of similar materials or outdoor weatherable PVC. Apply all jacketing per manufacturer's recommendations for the conditions.

B. Insulation Installation for Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with fiberglass blanket insulation.
4. Install jacket material using manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed formaldehyde free fiberglass fittings; minimum 50 percent recycled glass content, of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed formaldehyde free fittings; minimum 50 percent recycled glass content, of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

E. Pipe and Tank Insulation

1. Apply on clean, dry surfaces.
2. Cut to appropriate length using manufacturers' stretch out guide for the specific pipe size. Add an additional 2 inches (51 mm) to 4 inches (102 mm) for a staple flap.
3. Install insulation around the duct circumference in a manner that ensures a firm fiber mesh at all joints. Fasten the longitudinal with outward clinching staples placed 3 inches on center (76 mm). As an alternative, individual sections may be fastened in place using continuous and overlapping strands of 3/4" wide glass fiber filament tape around the insulation jacketing O.D. Longitudinal and circumferential joints shall be sealed with 4" wide matching pressure sensitive tape squeegeed along the entire length.
4. For duct exposed to the elements, jacketing shall be UV resistant PVC with a minimum thickness of 0.030 inches, or 0.016 inches (0.406) thick aluminum with factory applied moisture barrier or 0.010 inches (0.254mm) thick stainless steel with a factory applied moisture barrier or laminated self-adhesive water and weather seals. Fitting covers shall be of similar materials. The insulation and jacketing shall be held firmly in place with a friction type Z lock or a minimum 2" overlap joint. For systems operating below ambient, all PVC joints shall be sealed completely along the longitudinal and circumferential seams and installed so as to shed water. When required, all PVC circumferential joints shall be sealed by use of preformed butt strips; minimum 2" wide or a minimum 2" overlap. Butt strips shall overlap the adjacent jacketing a minimum 1/2 inch and be completely weather sealed. PVC Jacketing shall be limited to a maximum 20 inch OD of the insulation when exposed to direct sunlight. For systems operating above ambient, circumferential joints should overlap a minimum of 2" and not be sealed. Insulation thickness for duct covered by PVC Jacketing shall be such that the surface temperature of the PVC does not exceed 125°F (52°C).
5. On below ambient straight duct, vapor retarder mastic shall be applied to raw glass fiber ends at 12 foot to 21 foot intervals; at the Engineer's discretion, and on either side of fittings, flanges or valves before taping. Mastic shall extend a minimum of 2 inches onto the bore of the pipe and 2 inches onto the jacketing.

3.5 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
 - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
 - 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire rated walls and partitions.
 - 1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire resistive joint sealers.
- F. Insulation Installation at Floor Penetrations:
 - 1. Pipe: Install insulation continuously through floor penetrations.
 - 2. Seal penetrations through fire rated assemblies. Comply with requirements in Section 078413 "Penetration Fire-stopping".

3.6 FIELD-APPLIED JACKET INSTALLATION

- A. Where glass cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
 - 1. Draw jacket smooth and tight to surface with 2 inch (50 mm) overlap at seams and joints.
 - 2. Embed glass cloth between two 0.062 inch (1.6 mm) thick coats of lagging adhesive.
 - 3. Completely encapsulate insulation with coating, leaving no exposed insulation.
- B. Where FSK jackets are indicated, install as follows:
 - 1. Draw jacket material smooth and tight.
 - 2. Install lap or joint strips with same material as jacket.
 - 3. Secure jacket to insulation using manufacturer's recommended adhesive.
 - 4. Install jacket with 1-1/2 inch (38 mm) laps at longitudinal seams and 3 inch (75 mm) wide joint strips at end joints.
 - 5. Seal openings, punctures, and breaks in vapor retarder jackets and exposed insulation with vapor barrier mastic.
- C. Where PVC jackets are indicated, install with minimum 1 inch (25 mm) overlap at longitudinal seams and end joints; for horizontal applications. Seal using manufacturer's recommended adhesive.
 - 1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- D. Where metal jackets are indicated, install with minimum 2 inch (50 mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless steel bands 12 inches (300 mm) oc. and at end joints.
- E. Where Laminated Self-Adhesive Water and Weather Seals are indicated, install in strict compliance with manufacturer's recommended installation procedures.

3.7 FINISHES

- A. Pipe Insulation with ASJ+, ASJ, Glass Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting". **NOTE: Painting MAY affect the FHC Classification of the Jacketing material.**

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

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

B. Color: Final color as selected by Architect / Engineer. Vary first and second coats to allow visual inspection of the completed Work.

C. Do not field paint aluminum or stainless steel jackets.

3.8 FIELD QUALITY CONTROL

A. Testing Agency: **[Owner will engage] [Engage]** a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to **[three] <Insert number>** locations of straight pipe, **[three] <Insert number>** locations of threaded fittings, **[three] <Insert number>** locations of welded fittings, **[two] <Insert number>** locations of threaded strainers, **[two] <Insert number>** locations of welded strainers, **[three] <Insert number>** locations of threaded valves, and **[three] <Insert number>** locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.9 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome plated pipes and fittings unless there is a potential for personnel injury.

3.10 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 deg. F (16 deg. C):

1. All Pipe Sizes: Insulation shall be:
 - a. Fiberglass, Preformed Pipe, Type I and Type IV: 1 inch (25 mm) <Insert dimension> thick.
- B. Chilled Water and Brine, 40 deg. F (5 deg. C) and below:
 1. NPS 3 (DN 80) and Smaller: Insulation shall be:
 - a. Fiberglass, Preformed Pipe, Type I or Type IV: 1 inch (25 mm) <Insert dimension> thick.
 2. NPS 4 (DN 100) to NPS 12 (DN 300): Insulation shall be:
 - a. Fiberglass, Preformed Pipe, Type I or Type IV: 1-1/2 inches (38 mm) <Insert dimension> thick.
 3. NPS 14 (DN 350) and Larger: Insulation shall be:
 - a. Fiberglass, [Preformed Pipe, Type I or Type IV] or [Pipe and Tank Insulation]: [2 inches (50 mm)] [3 inches (75 mm)] <Insert dimension> thick.
- C. Chilled Water and Brine, above 40 deg. F (5 deg. C):
 1. NPS 12 (DN 300) and Smaller: Insulation shall be:
 - a. Fiberglass, Preformed Pipe, Type I or Type IV: 1 inch (25 mm) <Insert dimension> thick.
 2. NPS 14 (DN 350) and Larger: Insulation shall be:
 - a. Fiberglass [Preformed Pipe, Type I or Type IV] or [Pipe and Tank Insulation]: 1-1/2 inches (38 mm) <Insert dimension> thick.
- D. Condenser Water Supply and Return:
 1. NPS 12 (DN 300) and Smaller: Insulation shall be:
 - a. Fiberglass, Preformed Pipe, Type I or Type IV: 1-1/2 inches (38 mm) <Insert dimension> thick.
 2. NPS 14 (DN 350) and Larger: Insulation shall be:
 - a. Fiberglass, Preformed Pipe, Type I or Type IV or Pipe and Tank Insulation: 2 inches (50 mm) <Insert dimension> thick.
- E. Heating Hot Water Supply and Return, 200 deg. F (93 deg. C) and Below:
 1. NPS 12 (DN 300) and Smaller: Insulation shall be:

- a. Fiberglass, Preformed Pipe, Type I or Type IV: 2 inches (50 mm) <Insert dimension> thick.
 - 2. NPS 14 (DN 350) and Larger: Insulation shall be:
 - a. Fiberglass, [Preformed Pipe, Type I or Type IV] [or] [Pipe and Tank Insulation]: 3 inches (75 mm) <Insert dimension> thick.
- F. Heating Hot Water Supply and Return, above 200 deg. F (93 deg. C):
 - 1. NPS 3/4 (DN 20) and Smaller: Insulation shall be:
 - a. Fiberglass, Preformed Pipe, Type I or Type IV: 2-1/2 inches (63.5 mm) <Insert dimension> thick.
 - 2. NPS 1 (DN 25) and Larger: Insulation shall be:
 - a. Fiberglass, Preformed Pipe, Type I or Type IV: 3 inches (75 mm) <Insert dimension> thick.
- G. Steam and Steam Condensate, 350 deg. F (177 deg. C) and Below:
 - 1. NPS 3/4 (DN 20) and Smaller: Insulation shall be:
 - a. Fiberglass, Preformed Pipe, Type I or Type IV: 3 inches (75 mm) <Insert dimension> thick.
 - 2. NPS 1 (DN 25) and Larger: Insulation shall be:
 - a. Fiberglass, Preformed Pipe, Type I or Type IV: 4-1/2 inches (114.3 mm) <Insert dimension> thick.
 - b. Pipe and Tank Insulation: 5-1/2 inches (139.7 mm) <Insert dimension> thick.
- H. Steam and Steam Condensate, above 350 deg. F (177 deg. C):
 - 1. NPS 3/4 (DN 20) and Smaller: Insulation shall be:
 - a. Fiberglass, Preformed Pipe, Type I or Type IV: 4-1/2 inches (114.3 mm) <Insert dimension> thick.
 - 2. NPS 1 (DN 25) and Larger: Insulation shall be:
 - a. Fiberglass, Preformed Pipe, Type I or Type IV: 5 inches (127 mm) <Insert dimension> thick.
 - b. Pipe and Tank Insulation: 6 inches (152.4 mm) <Insert dimension> thick.
- I. Refrigerant Suction and Hot Gas Piping:
 - 1. All Pipe Sizes: Insulation shall be:

- a. Fiberglass, Preformed Pipe, Type I or Type IV: 1 inch (25 mm) <Insert dimension> thick.
- J. Dual Service Heating and Cooling, 40 to 200 deg. F (5 to 93 deg. C):
 - 1. NPS 12 (DN 300) and Smaller: Insulation shall be:
 - a. Fiberglass, Preformed Pipe, Type I or Type IV: 2 inches (50 mm) <Insert dimension> thick.
 - 2. NPS 14 (DN 350) and Larger: Insulation shall be:
 - a. Fiberglass, Preformed Pipe, Type I or Type IV: 3 inches (75 mm) <Insert dimension> thick.
 - b. Pipe and Tank Insulation: 4 inches (101.6 mm) <Insert dimension> thick.
- K. Heat Recovery Piping:
 - 1. All Pipe Sizes: Insulation shall be:
 - a. Fiberglass, Preformed Pipe, Type I or Type IV: 1 inch (25 mm) <Insert dimension> thick.
 - b. Pipe and Tank Insulation: 1-1/2 inches (38 mm) <Insert dimension> thick.

3.11 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

- A. Chilled Water and Brine:
 - 1. All Pipe Sizes: Insulation shall be:
 - a. Fiberglass, Preformed Pipe, Type I or Type IV: 3 inches (75 mm) <Insert dimension> thick.
- B. Condenser Water Supply and Return:
 - 1. All Pipe Sizes: Insulation shall be:
 - a. Fiberglass, Preformed Pipe, Type I or Type IV: 2 inches (50 mm) <Insert dimension> thick.
- C. Heating Hot Water Supply and Return, 200 deg. F (93 deg. C) and Below:
 - 1. All Pipe Sizes: Insulation shall be:
 - a. Fiberglass, Preformed Pipe, Type I or Type IV: 2 inches (50 mm) <Insert dimension> thick.
- D. Heating Hot Water Supply and Return, above 200 deg. F (93 deg. C):

1. All Pipe Sizes: Insulation shall be:
 - a. Fiberglass, Preformed Pipe, Type I, or Type IV: 3 inches (75 mm) <Insert dimension> thick.
 - E. Steam and Steam Condensate, 350 deg. F (177 deg. C) and Below:
 1. All Pipe Sizes: Insulation shall be:
 - a. Fiberglass, Preformed Pipe, Type I or Type IV: 4-1/2 inches (114 mm) <Insert dimension> thick.
 - F. Steam and Steam Condensate, above 350 deg. F (177 deg. C):
 1. All Pipe Sizes: Insulation shall be:
 - a. Fiberglass, Preformed Pipe, Type I or Type IV: 5 inches (127 mm) <Insert dimension> thick.
 - G. Refrigerant Suction and Hot Gas Piping:
 1. All Pipe Sizes: Insulation shall be:
 - a. Fiberglass, Preformed Pipe, Type I or Type IV: 2 inches (50 mm) <Insert dimension> thick.
 - H. Heat Recovery Piping:
 1. All Pipe Sizes: Insulation shall be:
 - a. Fiberglass, Preformed Pipe, Type I or Type IV: 2 inches (50 mm) <Insert dimension> thick.
 - I. Dual Service Heating and Cooling:
 1. All Pipe Sizes: Insulation shall be:
 - a. Fiberglass, Preformed Pipe, Type I or Type IV: 2 inches (50 mm) <Insert dimension> thick.
 - J. Fuel Oil Piping, Heated:
 1. All Pipe Sizes: Insulation shall be:
 - a. Fiberglass, Preformed Pipe, Type I or Type IV: 2 inches (50 mm) <Insert dimension> thick.
- 3.12 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. None.
2. **[PVC] [PVC, Color Coded by System]: [20 mil (0.5 mm)] [30 mil (0.8 mm)]** thick.
3. Aluminum, **[Smooth] [Corrugated] [Stucco Embossed]: [0.016 inch (0.41 mm)] [0.020 inch (0.51 mm)] [0.024 inch (0.61 mm)] [0.032 inch (0.81 mm)] [0.040 inch (1.0 mm)]** thick.
4. Painted Aluminum, **[Smooth] [Corrugated] [Stucco Embossed]: [0.016 inch (0.41 mm)] [0.020 inch (0.51 mm)] [0.024 inch (0.61 mm)] [0.032 inch (0.81 mm)]** thick.
5. Stainless Steel, **[Type 304] [or] [Type 316], [Smooth 2B Finish] [Corrugated] [Stucco Embossed]: [0.010 inch (0.25 mm)] [0.016 inch (0.41 mm)] [0.020 inch (0.51 mm)] [0.024 inch (0.61 mm)]** thick.
6. Self-Adhesive Outdoor Jacket
7. **<Insert jacket type>**.

D. Piping, Exposed:

1. None.
2. **[PVC] [PVC, Color Coded by System]: [20 mil (0.5 mm)] [30 mil (0.8 mm)]** thick.
3. Aluminum, **[Smooth] [Corrugated] [Stucco Embossed]: [0.016 inch (0.41 mm)] [0.020 inch (0.51 mm)] [0.024 inch (0.61 mm)] [0.032 inch (0.81 mm)] [0.040 inch (1.0 mm)]** thick.
4. Painted Aluminum, **[Smooth] [Corrugated] [Stucco Embossed]: [0.016 inch (0.41 mm)] [0.020 inch (0.51 mm)] [0.024 inch (0.61 mm)] [0.032 inch (0.81 mm)]** thick.
5. Stainless Steel, **[Type 304] [or] [Type 316], [Smooth 2B Finish] [Corrugated] [Stucco Embossed]: [0.010 inch (0.25 mm)] [0.016 inch (0.41 mm)] [0.020 inch (0.51 mm)] [0.024 inch (0.61 mm)]** thick.
6. Self-Adhesive Outdoor Jacket
7. **<Insert jacket type>**.

3.13 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. None.
2. **[PVC] [PVC, Color Coded by System]: [20 mil (0.5 mm)] [30 mil (0.8 mm)]** thick.

3. Aluminum, [Smooth] [Corrugated] [Stucco Embossed]: [0.016 inch (0.41 mm)] [0.020 inch (0.51 mm)] [0.024 inch (0.61 mm)] [0.032 inch (0.81 mm)] [0.040 inch (1.0 mm)] thick.
4. Painted Aluminum, [Smooth] [Corrugated] [Stucco Embossed]: [0.016 inch (0.41 mm)] [0.020 inch (0.51 mm)] [0.024 inch (0.61 mm)] [0.032 inch (0.81 mm)] thick.
5. Stainless Steel, Type [304] [316] [304 or 316], [Smooth 2B Finish] [Corrugated] [Stucco Embossed]: [0.010 inch (0.25 mm)] [0.016 inch (0.41 mm)] [0.020 inch (0.51 mm)] [0.024 inch (0.61 mm)] thick.
6. Self-Adhesive Outdoor Jacket
7. <Insert jacket type>.

D. Piping, Exposed:

1. PVC: [20 mil (0.5 mm)] [30 mil (0.8 mm)] [40 mil (1.0 mm)] thick.
2. [Painted]Aluminum, [Smooth] [Corrugated] [Stucco Embossed] [with Z-Shaped Locking Seam]: [0.016 inch (0.41 mm)] [0.020 inch (0.51 mm)] [0.024 inch (0.61 mm)] [0.032 inch (0.81 mm)] [0.040 inch (1.0 mm)] thick.
3. Stainless Steel, Type [304] [316] [304 or 316], [Smooth 2B Finish] [Corrugated] [Stucco Embossed] [with Z-Shaped Locking Seam]: [0.010 inch (0.25 mm)] [0.016 inch (0.41 mm)] [0.020 inch (0.51 mm)] [0.024 inch (0.61 mm)] thick.
4. Self-Adhesive Outdoor Jacket
5. <Insert jacket type>.

END OF SECTION 230719