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USACE / NAVFAC / AFCESA / NASA **UFGS-22 07 19.00 40 (June 2006)**

Preparing Activity: NASA **Superseding UFGS-22 07 19.00 40 (April 2006)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 19 March 2007

Latest change not indicated by CHG tags
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DIVISION 22 - PLUMBING

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PLUMBING PIPING INSULATION

06/06

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SECTION 22 07 19.00 40

PLUMBING PIPING INSULATION
06/06

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NOTE: This specification covers the requirements for insulation for hot and cold water and steam piping but does not cover cryogenic piping.

Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).
****

PART 1 GENERAL

1.1 REFERENCES

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NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the

Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B 209	(2004) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B 209M	(2004) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM C 1136	(2003a) Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
ASTM C 195	(2000) Standard Specification for Mineral Fiber Thermal Insulating Cement
ASTM C 449/C 449M	(2000) Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
ASTM C 533	(2004) Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
ASTM C 534	(2005) Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
ASTM C 547	(2003) Standard Specification for Mineral Fiber Pipe Insulation
ASTM C 552	(2003) Standard Specification for Cellular Glass Thermal Insulation
ASTM C 553	(2002) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C 592	(2000) Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)
ASTM C 795	(2003) Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel

ASTM C 916	(1985; R 2000e1) Standard Specification for Adhesives for Duct Thermal Insulation
ASTM C 920	(2005) Standard Specification for Elastomeric Joint Sealants
ASTM C 921	(2003a) Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation
ASTM D 579	(2004) Standard Specification for Greige Woven Glass Fabrics
ASTM E 84	(2005e1) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E 96	(2005) Standard Test Methods for Water Vapor Transmission of Materials

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 220	(2006) Standard on Types of Building Construction
NFPA 255	(2005 Ed) Standard Method of Test of Surface Burning Characteristics of Building Materials

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS 3779	(1990; R 1994a) Tape Adhesive, Pressure Sensitive Thermal Radiation Resistant
SAE AMS 3779/1A	(1990; R 1994a) Tape, Adhesive, Pressure-Sensitive Thermal Radiation Resistant, Aluminum Foil/Glass Cloth

1.2 SYSTEM DESCRIPTION

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NOTE: If Section 23 00 00.00 40 HEATING, VENTILATING, AND AIR-CONDITIONING is not included in the project specification, applicable requirements therefrom should be inserted and the following paragraph deleted.

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Section 23 00 00.00 40 HEATING, VENTILATING, AND AIR-CONDITIONING applies to work specified in this section.

1.3 PERFORMANCE REQUIREMENTS

Thermal-insulation system materials shall be noncombustible, as defined by NFPA 220. Adhesives, coatings, sealants, facings, jackets, and thermal-insulation materials, except cellular elastomers, shall have a flame-spread classification (FSC) of [25] [_____], and a smoke-developed classification (SDC) of [50] [_____]. These maximum values shall be determined in accordance with [ASTM E 84] [NFPA 255]. Coatings and

sealants shall be nonflammable in their wet state.

Adhesives, coatings, and sealants shall have published or certified temperature ratings suitable for the entire range of working temperatures normal for the surfaces to which they are to be applied.

1.4 SUBMITTALS

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NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.
****

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings for pipe insulation shall be submitted in accordance with paragraph entitled, "Installation," of this section.

SD-03 Product Data

Manufacturer's catalog data shall be submitted for the following items:

PART 2 PRODUCTS

2.1 MATERIALS

Materials shall be compatible and shall not contribute to corrosion, soften, or otherwise attack surfaces to which applied in either the wet or dry state. Materials to be used on stainless steel surfaces shall meet ASTM C 795 requirements. Materials shall be asbestos free and conform to the following.

2.1.1 Adhesives

2.1.1.1 Cloth Adhesives

Adhesives for adhering, sizing, and finishing lagging cloth, canvas, and open-weave glass cloth shall be a pigmented polyvinyl acetate emulsion and shall conform to the requirements of ASTM C 916, Type I.

2.1.1.2 Vapor-Barrier Material Adhesives

Adhesives for attaching laps of vapor-barrier materials and presized glass cloth and for attaching insulation to itself, to metal, and to various other substrates, shall be solvent-base, synthetic-rubber type and shall conform to the requirements of ASTM C 916, Type I, for attaching fibrous-glass insulation to metal surfaces. Solvent shall be nonflammable.

2.1.1.3 Cellular Elastomer Insulation Adhesive

Adhesive for cellular elastomer insulation shall be a solvent cutback chloroprene elastomer conforming to ASTM C 916, Type I, and shall be of a type approved by the manufacturer of the cellular elastomer for the intended use.

2.1.2 Coatings

2.1.2.1 Outdoor Vapor-Barrier Finishing

Coatings for outdoor vapor-barrier finishing of insulation surfaces such as fittings and elbows shall be a nonasphaltic, hydrocarbon polymer, solvent-base mastic containing a blend of nonflammable solvents. Coatings shall conform to the requirements of ASTM C 1136 and ASTM C 921.

2.1.2.2 Indoor Vapor-Barrier Finishing

Coatings for indoor vapor-barrier finishing of insulation surfaces shall be a pigmented resin and solvent compound and shall conform to ASTM C 1136, Type II.

2.1.2.3 Outdoor and Indoor Nonvapor-Barrier Finishing

Coatings for outdoor and indoor nonvapor-barrier finishing of insulation

surfaces shall be pigmented polymer-emulsion type recommended by the insulation material manufacturer for the surface to be coated and shall be applied to specified dry-film thickness.

2.1.2.4 Cellular-Elastomer Insulation Coating

Finish coating for cellular-elastomer insulation shall be a polyvinylchloride lacquer approved by the manufacturer of the cellular elastomer.

2.1.2.5 Coating Color

Coating color shall [be white] [conform to the color code specified] [blend with background of surrounding area] [be as specified by the Contracting Officer.]

2.1.3 Insulating Cement

2.1.3.1 General Purpose Insulating Cement

General purpose insulating cement shall be [diatomaceous silica] [mineral fiber] and shall conform to ASTM C 195. Composite shall be rated for 982 degrees C 1800 degrees F service and shall have a thermal-conductivity maximum of [.123] [0.85] [_____] watt per meter per degree Kelvin [_____] Btu by inch per hour per square foot for each degree F temperature differential at 93 degrees C 200 degrees F mean temperature for 25 millimeter 1 inch thickness.

2.1.3.2 Finishing Insulating Cement

Finishing insulating cement shall be mineral-fiber, hydraulic-setting type conforming to ASTM C 449/C 449M.

2.1.4 Calking

Calking used with specified insulation materials shall be an elastomeric joint sealant in accordance with ASTM C 920, Type S, Grade NS, Class 25, Use A.

2.1.5 Corner Angles

Corner angle piping insulation shall be nominal 0.41 millimeter 0.016 inch aluminum 25 by 25 millimeter 1 by 1 inch with factory applied kraft backing. Aluminum shall be in accordance with ASTM B 209M ASTM B 209, Alloy [3003] [3105] [5005].

2.1.6 Insulation Materials

Insulation conductances shall be maximum values, as tested at any point, not an average. Insulation conductance found by test to exceed the specified maximum shall either be replaced or augmented by an additional thickness to bring it to the required maximum conductance and a complete finishing system.

2.1.6.1 Mineral Fiber

Mineral fiber shall conform to [ASTM C 592] [ASTM C 553] [ASTM C 547], shall be suitable for surface temperatures up to 188 degrees C 370 degrees F, and shall be of not less than [_____] [64.1] kilograms per cubic meter

[_____] [4]-pound per cubic foot density. Thermal conductivity shall be not greater than [0.037] watt per meter per degree Kelvin [0.26] Btu per hour per square foot square per degree F [_____] at 66 degrees C 150 degrees F mean.

2.1.6.2 Pipe Barrel

Pipe barrel insulation shall be Type II, Molded, Grade A or Type III, Precision V-Groove, Grade A for use at temperatures up to and including 650 degrees C 1200 degrees F.

2.1.6.3 Pipe Fittings

Pipe fitting insulation shall be molded pipe fitting covering for use at temperatures up to and including 650 degrees C 1200 degrees F.

2.1.6.4 Flexible Blankets

Flexible blankets shall be blankets and felts for use at temperatures up to and including 177 degrees C 350 degrees F minimum 16 kilogram per cubic meter 1 pound per cubic foot density. Thermal conductivity shall be not greater than [_____] [0.26] [0.038] watt per meter per degree K Btu per hour per square foot per degree F at24 degrees C 75 degrees F mean.

2.1.6.5 Cellular Elastomer

Cellular elastomer shall conform to ASTM C 534, except that the water-vapor permeability shall not exceed [_____] [0.44] nanogram per meter per second per pascal [_____] [0.30] perms per foot per inch per hour per square foot mercury pressure difference for 25 millimeter 1 inch thickness.

2.1.6.6 Cellular Glass

Cellular glass shall conform to ASTM C 552, Type II, Grade 2, pipe covering. Substitutions for this material shall not be permitted. Minimum thickness shall be 38 mm.1-1/2 inches

2.1.6.7 Calcium Silicate

Calcium silicate shall conform to ASTM C 533. Apparent thermal conductivity shall be not greater than [0.078] watt per meter per degree K [0.54] Btu-inch per hour per square foot per degree F [_____] at 93 degrees C 200 degrees F mean.

2.1.7 Jacketing

****
NOTE: Select the following aluminum jackets for all weather exposed piping insulation, except system T-3. Stainless steel jackets should be considered for corrosive atmospheres. Aluminum or pvc should be specified for mechanical equipment rooms.
****

2.1.7.1 Aluminum Jackets

Aluminum sheet shall be in accordance with ASTM B 209M ASTM B 209 and shall be 0.41 millimeter 0.016 inch thick with factory-applied vapor barrier on the insulation side. Aluminum shall be made from smooth, polished, Temper

[H14] [H16], Alloy [3003] [5005] [3105]. Straps shall be AISI 300 series corrosion-resistant steel, 0.381 millimeter 15 mils thick, 13 millimeter 1/2 inch wide, for pipe under DN300 12 inch diameter and 20 millimeter 3/4 inch wide for pipe over DN300 12 inch diameter.

Elbow jackets shall be 0.41 millimeter 0.016 inch thick, deep-drawn, die-shaped, two-piece components for long-radius, butt-weld elbows manufactured from the same materials as specified for jackets, with factory-attached vapor-seals on underside of the aluminum. Preinsulated, voidless, jacketed components conforming to these specifications shall be used. Preinsulated fittings shall have a 50 millimeter 2 inch overlay beyond route for weld bead.

Vapor barrier shall be [30-60-30 laminated-asphalt paper] [3 kilogram per square meter60 pound per 100 square foot kraft paper] with 0.5 kilogram per square meter 10 pound per 100 square foot polyethylene coating.

Pipe jackets shall have not less than [50] millimeter [2] inch [_____] longitudinal and circumferential lap.

Sealant for longitudinal and butt joints of aluminum jacketing shall be an aluminum-pigmented, butyl, polymer sealant with high-butyl solids.

2.1.7.2 Glass Cloth Jackets

Glass cloth shall be plain-weave glass cloth conforming to ASTM D 579, Style 141 and shall weigh not less than 0.25 kilogram/square meter [7.23] ounces per square yard [_____] before sizing. Cloth shall be factory applied wherever possible.

Glass reinforcing cloth shall be a leno weave, 26-end and 12-pick thread conservation, with a warp and fill tensile strength of 7.9 and 5.3 kilonewton per meter 45 and 30 pounds per inch of width, respectively, and with a weight of not less than [_____] 0.51 kilogram per square meter [_____] [1.5] ounces per square yard. [At the Contractor's option, Style 191 leno-weave glass cloth conforming to ASTM D 579 may be provided.]

2.1.7.3 PVC Jackets

Polyvinylchloride (PVC) shall be a 0.010 inch 0.25 millimeter thick, factory-premolded, [one-piece fitting] [pipe-barrel sheeting vapor-barrier jacketing]. Material shall be self-extinguishing, high-impact strength, moderate chemical resistance. Permeability rating shall be 0.574 nanogram per pascal per second per square meter 0.01 grain per hour per square foot per inch of mercury pressure difference, determined in accordance with ASTM E 96. Vapor-barrier joint adhesive shall be the manufacturer's standard solvent-weld type.

Vapor barrier shall conform to ASTM C 1136, Type I, low-vapor transmission, high-puncture resistance for use on insulation for piping, ducts, and equipment.

2.1.7.4 3-Ply Laminate

Jacketing shall be a 3-ply laminate of 1.7 kilogram per square meter 35-pound per 100 square foot white-bleached kraft, bonded to not less than 0.018 millimeter 0.0007 inch thick aluminum foil and reinforced with glass fiber.

Water-vapor permeance rating of the composite shall be 1.15 nanogram per pascal per second per square meter 0.02 perm or grain per hour per square foot, per inch of mercury pressure differential, determined in accordance with ASTM E 96.

2.1.8 Tape

Glass lagging shall be a knitted elastic cloth specifically suitable for continuous spiral wrapping of insulated pipe bends and fittings and shall produce a smooth, tight, wrinkle-free surface. Tape shall conform to requirements of SAE AMS 3779, SAE AMS 3779/1A, ASTM D 579, and ASTM C 921, and shall weigh not less than [_____] 0.339 kilogram per square meter [_____] [10] ounces per square yard.

2.2 PIPING SYSTEMS

Insulation thickness and pipe sizes are in millimeter inches. Pipe size is inclusive dimensionally, and includes pipe nominal pipe size (NPS) and tubing outside diameter.

2.2.1 Dual-Temperature (Hot- and Chilled-) Water Piping

Insulation shall be [mineral fiber with vapor barrier jacket, Type T-1] [cellular class with vapor barrier jacket, Type T-4.] Thickness shall be not less than that given in the following list. Aboveground pipes, valve bodies, fittings, unions, and flanges shall be insulated.

****
NOTE: The following thickness covers chilled-water temperatures 35 to 50 degrees F 2 to 10 degrees C.
****

PIPE SIZE (MILLIMETER)	INSULATION THICKNESS (MILLIMETER)
32	38
32 to 75	38
75 and larger	50

PIPE SIZE (INCH)	INSULATION THICKNESS (INCH)
Up to 1-1/4	1-1/2
1-1/4 to 3	1-1/2
3 and larger	2

2.2.2 Hot-Water, Steam, and Condensate-Return Piping

Insulation shall be mineral fiber with glass cloth jacket, Type T-2. Thickness shall be not less than that given in the following list. Aboveground pipes, valve bodies, fittings, unions, flanges, and miscellaneous surfaces shall be insulated.

10 to 12	2

PIPE SIZE (MILLIMETER)	INSULATION THICKNESS (MILLIMETER)
Up to 100	25
100 to 250	38
250 to 300	50

PIPE SIZE (INCH)	INSULATION THICKNESS (INCH)
Up to 4	1
4 to 10	1-1/2

2.2.3 Cold-Water and Condensate-Drain Piping

Aboveground pipes, valve bodies, fittings, unions, flanges, and miscellaneous surfaces shall be insulated

[Insulation shall be 10 millimeter 3/8 inch mineral fiber with glass cloth jacket, Type T-2.]

[Insulation shall be cellular-elastomer conforming to ASTM C 534. Water-vapor permeability shall not exceed 5.74 nanograms per pascal per second per square meter 0.1 grain per square foot per hour per inch mercury pressure-differential for 25 millimeter 1 inch thickness.]

[Cold-water piping insulation shall be flexible unicellular-elastomeric thermal insulation, Type T-3. Pipe insulation thickness shall be [10] [15] millimeter [3/8] [1/2] inch per calculation. Expanded, closed-cell pipe insulation shall be used only aboveground, not for underground piping.]

2.2.4 Refrigerant Suction Piping

Insulation shall be cellular-elastomer, Type T-3. Thickness shall be nominal 20 millimeter 3/4 inch. Surfaces, including valve, fittings, unions, and flanges, shall be insulated.

2.2.5 Cooling-Tower Circulating Water Piping

****
NOTE: Normally, cooling-tower circulating water piping will not require insulation.
****

Insulation shall be cellular-elastomer, Type T-3. Thickness shall be not less than that given in the following list. Aboveground pipes, valve bodies, fittings, unions, flanges, and miscellaneous surfaces shall be insulated.

PIPE SIZE (MILLIMETER)	INSULATION THICKNESS (MILLIMETER)
Up to 50	15

PIPE SIZE (MILLIMETER)	INSULATION THICKNESS (MILLIMETER)
50 to 150	20
150 and larger	25

PIPE SIZE (INCH)	INSULATION THICKNESS (INCH)
Up to 2	1/2
2 to 6	3/4
6 and larger	1

Thickness inside buildings shall be 10 millimeter 3/8 inch for all pipe sizes.

****
NOTE: Type T-6 is normally specified for exterior use.
****

Insulation shall be mineral fiber with aluminum jacket, Type T-6. Thickness shall be not less than that indicated. Aboveground pipes, valve bodies, fittings, unions, flanges, and miscellaneous surfaces shall be insulated.

2.2.6 Steam and Condensate Piping, 350 psig

Insulation shall be calcium silicate with glass cloth jacket, Type T-5. Thickness shall be not less than indicated in following list which is based on an 27 degrees C 80 degrees F ambient temperature in still air with an insulation "K" factor of 0.37 at 93 degrees C 200 degrees F mean temperature:

PIPE SIZE (MILLIMETER)	INSULATION THICKNESS (MILLIMETER)
Up to 40	89
40 to 100	102
100 to 200	102
200 to 300	102

PIPE SIZE (INCH)	INSULATION THICKNESS (INCH)
Up to 1-1/2	3-1/2
1-1/2 to 4	4
4 to 8	4
8 to 12	4

2.2.7 Hot Water Heating Converter

Insulation shall be calcium silicate with glass cloth jacket, Type T-7. Thickness shall be 40 millimeter 1-1/2 inches.

2.2.8 Chilled-Water and Dual-Temperature Pumps

Insulation shall be cellular elastomer, Type T-9. Thickness shall be 25 millimeter 1 inch. Surfaces subject to condensation shall be covered, and a vapor-barrier coating shall be supplied.

2.2.9 Low-Pressure Steam and Condensate, Weather-Exposed

Insulation shall be calcium silicate with weatherproof jacket, Type T-17. Thickness shall be not less than that indicated in the following list. All systems shall be insulated.

CONDUIT SIZE (MILLIMETER)	INSULATION THICKNESS (MILLIMETER)
Up to 100	38
100 to 250	51
250 and larger	64

CONDUIT SIZE (INCH)	INSULATION THICKNESS (INCH)
Up to 4	1-1/2
4 to 10	2
10 and larger	2-1/2

2.2.10 Steam & Condensate, Weather-Exposed, 861 kilopascal 125 psig

Insulation shall be calcium silicate with weatherproof jacket, Type T-17. Thickness shall be not less than that indicated in the following list. All system surfaces shall be insulated.

CONDUIT SIZE (MILLIMETER)	INSULATION THICKNESS (MILLIMETER)
38	38
100	50
250 and larger	75

CONDUIT SIZE (INCH)	INSULATION THICKNESS (INCH)
1-1/2	1-1/2
4	2
10 and larger	3

2.2.11 Steam & Condensate, Weather-Exposed, 2.4 Megapascal 350 psig

Insulation shall be calcium silicate with weatherproof jacket, Type T-17. Thickness shall be not less than that indicated in the following list. All

system surfaces shall be insulated.

8 to 12	4

PIPE SIZE (MILLIMETER)	INSULATION THICKNESS (MILLIMETER)
Up to 40	89
40 to 100	102
100 to 200	102
200 to 300	102

PIPE SIZE (INCH)	INSULATION THICKNESS (INCH)
Up to 1-1/2	3-1/2
1-1/2 to 4	4
4 to 8	4

PART 3 EXECUTION

3.1 INSTALLATION OF INSULATION SYSTEMS

Contours on exposed work shall be smooth and continuous. Cemented laps, flaps, bands, and tapes shall be smoothly and securely pasted down. Adhesives shall be applied on a full-coverage basis.

Insulation shall be applied only to system or component surfaces that have been tested and approved.

Joints shall be tight with insulation lengths tightly butted against each other. Where lengths are cut, cuts shall be smooth and square and without breakage of end surfaces. Where insulation terminates, ends shall be neatly tapered and effectively sealed, or finished as specified. Longitudinal seams of exposed insulation shall be directed away from normal view.

Materials shall be applied in conformance with the recommendations of the manufacturer.

Surfaces shall be clean and free of oil and grease before insulation adhesives or mastics are applied. Solvent cleaning required to bring metal surfaces to such condition shall be provided.

Installation Drawings for pipe insulation shall be in accordance with the adhesive manufacturer's written instructions for installation.

3.2 SYSTEM TYPES

3.2.1 Type T-1, Mineral Fiber with Vapor-Barrier Jacket

Piping shall be covered with mineral-fiber pipe insulation with factory-and field-attached vapor-barrier jacket. Vapor seal shall be maintained. Jackets, jacket laps, flaps, and bands shall be securely cemented in place

with vapor-barrier adhesive. Jacket overlap shall be not less than [40] millimeter [1-1/2] inches [_____]. Jacketing bands for butt joints shall be 75 millimeter 3 inches wide.

Exposed-to-view fittings and valve bodies shall be covered with preformed mineral-fiber pipe-fitting insulation of the same thickness as the pipe-barrel insulation. Fitting insulation shall be temporarily secured in place with light cord ties. A 1.52 millimeter 60-mil coating of white indoor vapor-barrier coating shall be applied and, while still wet, wrapped with glass lagging tape with 50 percent overlap, and shall be smoothly blended into the adjacent jacketing. Additional coating shall be applied as needed and rubber-gloved to smooth fillet or contour coating, then allowed to fully cure before the finish coating is applied. On-the-job fabricated insulation for concealed fittings and special configurations shall be built up from mineral fiber and a special mastic consisting of a mixture of insulating cement and lagging adhesive diluted with 3 parts water. Where standard vapor-barrier jacketing cannot be used, the surfaces shall be made vapor tight by using coating and glass lagging cloth or tape as previously specified.

In lieu of materials and methods previously specified, fittings may be wrapped with a twine-secured, mineral-wool blanket to the required thickness and covered with premolded polyvinylchloride jackets. Seams shall be made vapor tight with a double bead of manufacturer's standard vapor-barrier adhesive applied in accordance with the manufacturer's instructions. All jacket ends shall be held in place with AISI 300 series corrosion-resistant steel straps, [0.381] millimeter [15] mils[_____] thick by 15 millimeter [1/2] inch [_____] wide.

Pipe insulation shall be set into an outdoor vapor-barrier coating for a minimum of [150] millimeter [6] inches [_____] at maximum [3500]-millimeter [12]-foot [_____] spacing and the ends of the insulation sealed to the jacketing with the same material to provide an effective vapor-barrier stop.

Staples shall not be used in applying insulation. Vapor-barrier materials shall be continuous over all surfaces, including areas inside pipe sleeves, hangers, and other concealments.

Piping insulation at hangers shall consist of 208 kilogram per cubic meter 13-pounds per cubic foot density, fibrous-glass inserts or expanded, rigid, closed-cell, polyvinylchloride. Junctions shall be sealed with vapor-barrier jacket where required, glass-cloth mesh tape, and vapor-barrier coating.

White-bleached kraft paper side of the jacketing shall be on the side exposed to view.

Exposed-to-view insulation shall be finished with not less than a [0.152]-millimeter [6]-mil [_____] dry-film thickness of nonvapor-barrier coating suitable for painting.

3.2.2 Type T-2, Mineral Fiber with Glass Cloth Jacket

Piping shall be covered with a mineral-fiber, pipe insulation with factory-attached, presized, white, glass cloth. Jackets, jacket laps, flaps, and bands shall be securely cemented in place with vapor-barrier adhesive. Jacket overlap shall be not less than 40 millimeter 1-1/2 inches. Jacketing bands for butt joints shall be 75 millimeter 3 inches wide.

Exposed-to-view fittings shall be covered with preformed mineral-fiber fitting insulation of the same thickness as the pipe insulation and temporarily secured in place with light cord ties. Impregnated glass lagging tape shall be installed with indoor vapor-barrier on 50 percent overlap basis and the tape shall be blended smoothly into the adjacent jacketing. Additional coating shall be applied as needed, and rubber gloved to a smooth contour. Ends of insulation shall be taped to the pipe at valves DN50 2 inches and smaller. On-the-job fabricated insulation for concealed fittings and special configurations shall be built up from mineral fiber and a mixture of insulating cement and lagging adhesive, diluted with 3 parts water. Surfaces shall be finished with glass cloth or tape lagging.

[Valves 65 millimeter 2-1/2 inches and larger and all flanges shall be covered with preformed insulation of the same thickness as the adjacent insulation.]

[Exposed-to-view insulation shall be finished with a minimum [0.152]-millimeter [6]-mil [_____] dry-film thickness of nonvapor-barrier coating suitable for painting.]

[In lieu of materials and methods specified above, fittings may be wrapped with a twine-secured, mineral-wool blanket to the required thickness and covered with premolded polyvinylchloride jackets. All jacket ends shall be held in place with AISI 300 series corrosion-resistant steel straps, [0.381] millimeter [15] mils [_____] thick by 15 millimeter [1/2] inch [_____] wide. Fitting insulation shall be thermally equivalent to pipe-barrel insulation to preclude surface temperatures detrimental to polyvinylchloride.]

3.2.3 Type T-3, Cellular Elastomer

Piping-system surfaces shall be covered with flexible cellular-elastomer sheet or preformed insulation. Vapor seal shall be maintained. Insulation shall be cemented into continuous material with a solvent cutback chloroprene adhesive recommended by the manufacturer for the specific purpose. Adhesive shall be applied to both of the surfaces on a 100-percent coverage basis to a minimum thickness of 0.254 millimeter 10 mils wet or approximately 4 square meter per liter 150 square feet per gallon of undiluted adhesive.

Insulation on cold water piping shall be sealed to the pipe for a minimum of 150 millimeter [6] inches [_____] at maximum intervals of 3500 millimeter 12 feet to form an effective vapor barrier. At piping supports, insulation shall be continuous through using outside-carrying type clevis hangers with insulation shield. [Cork] [Wood dowel] load-bearing inserts shall be installed between the pipe and insulation shields to prevent insulation compression.

Hot-water, cold-water, and condensate drain pipes shall be insulated to the extent shown with nominal [10] [15] millimeter [3/8] [1/2] inch thick, fire retardant (FR), cellular elastomer, preformed pipe insulation. Joints shall be sealed with adhesive.

At pipe hangers or supports where the insulation rests on the pipe hanger strap, the insulation shall be cut with a brass cork borer and a No. 3 superior grade cork inserted. Seams shall be sealed with approved adhesive. Sweat fitting shall be insulated with miter-cut pieces of cellular elastomer insulation of the same nominal pipe size and thickness

as the insulation on the adjacent piping or tubing. Miter-cut pieces shall be joined with approved adhesive. Covers shall be slit and snapped over the fitting, and joints shall be sealed with approved adhesive.

Screwed fittings shall be insulated with sleeve-type covers formed from miter-cut pieces of cellular elastomer thermal insulation having an inside diameter large enough to overlap adjacent pipe insulation. Pipe insulation shall be butted against fittings. Overlap shall be not less than [25] millimeter [1] inch [_____]. Adhesive shall be used to join cover pieces and cement the cover to the pipe insulation.

Surfaces exposed to view or ultraviolet light shall be finished with a [0.051] millimeter [2]-mil [_____] minimum dry-film thickness application of a polyvinylchloride lacquer recommended by the manufacturer, and applied in not less than [two] [_____] coats.

3.2.4 Type T-4, Cellular Glass with Vapor-Barrier Jacket

Piping shall be covered with cellular glass insulation and factory- and field-attached vapor-barrier jacket. Vapor seal shall be maintained. Jackets, jacket laps, flaps, and bands shall be securely cemented in place with vapor-barrier adhesive. Jacket overlap shall be not less than [40] millimeter [1-1/2] inches [_____]. Jacket bands for butt joints shall be not less than [75] millimeter [3] inches [_____] wide. Insulation shall be continuous through hangers. Insulation shall be bedded in an outdoor vapor-barrier coating applied to all piping surfaces.

Flanges, unions, valves, anchors, and fittings shall be insulated with factory premolded or prefabricated or field fabricated segments of insulation of the same material and thickness as the adjoining pipe insulation. When segments of insulation are used, elbows shall be provided with not less than three segments. For other fittings and valves, segments shall be cut to the required curvature or nesting size.

Segments of the insulation shall be secured in place with twine or copper wire. After the insulation segments are firmly in place, a vapor-barrier coating shall be applied over the insulation in two coats with glass tape imbedded between coats. First coat shall be tinted, the second shall be white to ensure application two coats. Coating shall be applied to a total dry-film thickness of 1.6 millimeter 1/16 inch minimum. Glass tape seams shall overlap not less than [25] millimeter [1] inch [_____] and the tape end not less than [100] millimeter [4] inches [_____].

In lieu of materials and methods specified above, fittings may be wrapped with 10 millimeter 3/8 inch thick, vapor-barrier, adhesive-coated strips of cellular elastomer insulation. Insulation shall be under tension, compressed to 25 percent of original thickness, and wrapped until overall thickness is equal to adjacent insulation. Cellular elastomer shall be secured in place with twine and sealed with vapor-barrier coating applied to produce not less than [1.6] millimeter [1/16] inch [_____] dry-film thickness. Fittings shall then be covered with premolded polyvinylchloride jackets. Seams shall be made vapor-tight with a double bead of manufacturer's standard vapor-barrier adhesive applied in accordance with the manufacturer's instructions. Jacket ends shall be held in place with AISI 300 series corrosion-resistant steel straps, [0.381] millimeter [15] mils [_____] thick by [15] millimeter [1/2] inch [_____] wide.

Anchors secured directly to piping shall be insulated, to prevent condensation, for not less than [150] millimeter [6] inches [_____] from

the surface of the pipe insulation.

White-bleached kraft paper side of jacketing shall be on the side exposed to view. Exposed-to-view insulation shall be finished with not less than a [0.152] millimeter [6]-mil [_____] dry-film thickness of nonvapor-barrier coating suitable for painting.

3.2.5 Type T-5, Calcium Silicate with Glass Cloth Jacket (Piping)

Piping shall be covered with a calcium-silicate pipe insulation with factory attached and presized, white, glass cloth. Jackets shall be field applied when required. Jackets, jacket laps, flaps, and bands shall be securely cemented in place with vapor-barrier adhesive. Jacket overlap shall be not less than [40] millimeter [1-1/2] inches [_____]. Jacketing bands for butt joints shall be 100 millimeter 4-inches wide. Fittings shall be fabricated from segmented pipe barrel sections bedded in general purpose insulating cement and wired in place. Voids shall be filled with general purpose insulating cement with not less than [6] millimeter [1/4] inch [_____] thick, final coating. Glass lagging tape shall be impregnated with lagging adhesive, wrapped with a 50-percent overlap, and be blended smoothly into adjacent jacketing. Additional adhesive shall be applied as needed and rubber-gloved to a smooth contour.

3.2.6 Type T-6, Mineral Fiber with Aluminum Jacket

Piping shall be covered with mineral-fiber pipe insulation with factory-attached or field-applied aluminum jacketing.

Fittings and valve bodies shall be covered with preformed mineral-fiber pipe-fitting insulation of the same thickness as the pipe-barrel insulation. Fitting insulation shall be secured temporarily in place with light cord ties. A 1.52 millimeter 60-mil coating of vapor-barrier mastic shall be applied, and while still tacky, wrapped with glass lagging tape.

Additional mastic shall be applied as needed and rubber-gloved to smooth fillets or contours. On-the-job fabricated insulation for special configurations shall be built up from mineral fiber and a mixture of insulating cement and lagging adhesive diluted with 3 parts water. Only where standard aluminum jacketing cannot be used, the surfaces shall be made vapor-tight by using mastic and glass lagging cloth or tape as specified above with an added finish coat of mastic.

Pipe insulation shall be set into outdoor vapor-barrier coating for a minimum of [150] millimeter [6] inches [_____] at maximum [3500] millimeter [12]-foot [_____] spacing. Ends of the insulation shall be sealed to the jacketing with the same material to provide effective vapor barrier stops.

Vapor barrier shall be continuous over all surfaces, including areas inside pipe sleeves, hangers, and other concealment.

Piping insulation shall be applied to both sides of pipe hangers. Junctions shall be insulated with a special mastic mixture, glass cloth mesh tape, and mastic as previously specified.

Jacket laps, flaps, and bands shall be securely cemented in place with aluminum jacket sealant. Jacketing bands for butt joints shall be 150 millimeter 6 inches wide.

Joints, wherever possible, shall be lapped against the weather so that the

water will run off the lower edge. Laps shall be in accordance with the pipe drainage pitch. Longitudinal laps on horizontal lines shall be located 45 degrees below the horizontal centerline and alternately staggered 25 millimeter 1 inch. Jacketing material shall be lapped a minimum of [50] millimeter [2] inches [_____], circumferentially sealed with mastic, and strapped to provide a waterproof covering throughout. Straps shall be located 200 millimeter 8 inches on center and shall be pulled up tight to hold jacketing securely in place. Screws shall be used in addition to straps when necessary to obtain a waterproof covering. Extra straps shall be placed on each side of supporting devices and at openings. Where flanging access occurs, a chamfer sheet shall be strapped to the pipe at jacketing.

Exposed longitudinal edges of aluminum jacketing shall be stiffened by bending a 25 millimeter 1 inch hem on one edge.

Expansion joints shall provide for maximum and minimum dimensional fluctuations.

To prevent corrosion, the aluminum jacketing shall not come in direct contact with other types of metal.

At openings in jacket, an outdoor vapor-barrier coating shall be applied for [50] millimeter [2] inches [_____] in all directions. Jacketing shall be applied while waterproofing is tacky.

Screws shall be used at each corner of each sheet, at fitting jackets, and as necessary for the service. Number 7, 10 millimeter 3/8 inch long, binding-head aluminum sheet metal screws shall be placed through the mastic seal.

3.2.7 Type T-7, Calcium Silicate with Glass Cloth Jacket (Surfaces)

Surfaces shall be covered with insulation block bedded in an insulating cement and covered with glass cloth jacketing.

Surfaces shall be cleaned with a chlorinated solvent. General purpose insulating cement shall be mixed with 3 parts water to 1 part nonvapor-barrier adhesive to bring to application consistency. Block shall be set into bedding and joints and spaces shall be filled with a bedding mix and wrapped with galvanized chicken wire mesh well laced into an envelope. A 10 millimeter 3/8 inch thick coating of bedding mix jacket shall be troweled on with nonvapor-barrier adhesive and glass cloth. Surfaces shall be finished with not less than a [0.152] millimeter [6]-mil [_____] dry-film thickness of nonvapor-barrier coating.

[At the Contractor's option, aluminum sheet jacketing may be used in lieu of glass cloth.]

3.2.8 Type T-9, Cellular Elastomer

Pump surfaces shall be solvent cleaned. Not less than 25 millimeter [1] inch [_____] of general purpose insulating cement shall be applied, mixed with nonvapor-barrier adhesive diluted with 3 parts water, to achieve smooth surface and configuration contours. After all water has been removed, surfaces shall be covered with 13 millimeter 1/2 inch thick cellular elastomer insulation attached and joined into a continuous sheet with an outdoor vapor-barrier coating recommended by the insulation manufacturer for the specific purpose. Coating shall be applied to both of

the surfaces on a 100-percent coverage basis with a minimum thickness of [0.254] millimeter [10] mils [_____] wet, or approximately 3.7 square meter per liter 150 square feet per gallon of undiluted coating. Coating shall be blended into the adjacent flange insulation and the joint covered with a band of cellular elastomer equal to the flange assembly width. Same coating shall be used to seal insulation to the casing at penetrations and terminations. Pumps shall be insulated in a manner that will permit insulation to be removed to repair or replace pumps.

Insulation shall be finished with a [0.051] millimeter [2]-mil [_____] minimum dry-film application of a polyvinylchloride lacquer coating recommended by the manufacturer and applied in not less than [two] [_____] coats.

3.2.9 Type T-10, Mineral-Fiber Fill

Voids surrounding pipe shall be packed with mineral-fiber fill.

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NOTE: Insulation system Type T-17 may be used as is written for drained shallow trenches or by modification to eliminate all thermoplastic references and requiring only standard aluminum jackets.
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3.2.10 Type T-17, Calcium Silicate Weatherproof Jacket

Piping system surfaces shall be covered with calcium silicate insulation. Fittings and valve bodies shall be covered with preformed insulation of the same material and thickness as the adjoining pipe insulation.

3.3 ACCEPTANCE

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NOTE: Following a minimum of 90 calendar days operation (or installation), but no later than one year, the Systems Engineer/Condition Monitoring Office/Predictive Testing Group should inspect the installation using Infrared Imaging. This technology can identify insulation voids, insulation settling, and areas of insufficient insulation. Identification of insulation materials and locations is required to effectively identify these types of problems. The Systems Engineer/Condition Monitoring Office/Predictive Testing Group needs to know the warranty expiration date, if there is a warranty, in order to perform the inspections within the prescribed time frame.
****

Final acceptance will depend upon providing construction (Record Drawings) details to the Contracting Officer. Construction details shall include, by building area, the insulation material type, amount, and installation method. An illustration or map of the duct routing locations may serve

this purpose. Data shall have a cover letter/sheet clearly marked with the system name, date, and the words "Record Drawings insulation/material." Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

-- End of Section --