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Preparing Activity: NASA Superseding
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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated October 2009

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DIVISION 22 - PLUMBING

SECTION 22 07 19

PLUMBING PIPING INSULATION

08/08

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SECTION 22 07 19

PLUMBING PIPING INSULATION 08/08

NOTE: This guide specification covers the requirements for field-applied insulation for hot and cold water and steam piping, exterior condensate piping including aboveground piping, piping on piers, piping under piers, piping in trenches on piers, piping in tunnels, and piping in manholes 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

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.

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 A 167	(1999; R 2009) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A 240/A 240M	(2009a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM B 209	(2007) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B 209M	(2007) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM C 1136	(2008) 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	(2007) Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
ASTM C 533	(2009) Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
ASTM C 534/C 534M	(2008) Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
ASTM C 547	(2008e1) Standard Specification for Mineral Fiber Pipe Insulation
ASTM C 552	(2007) Standard Specification for Cellular Glass Thermal Insulation

ASTM C 553	(2008) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C 591	(2008a) Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM C 592	(2008a) Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)
ASTM C 795	(2008) Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel
ASTM C 916	(1985; R 2007) Standard Specification for Adhesives for Duct Thermal Insulation
ASTM C 920	(2008) Standard Specification for Elastomeric Joint Sealants
ASTM C 921	(2009) Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation
ASTM D 226	(2006) Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
ASTM D 579	(2009) Standard Specification for Greige Woven Glass Fabrics
ASTM E 84	(2009c) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E 96/E 96M	(2005) Standard Test Methods for Water Vapor Transmission of Materials

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 220	(2008) Standard on Types of Building Construction
NFPA 255	(2005; Errata 2006) Standard Method of Test of Surface Burning Characteristics of Building Materials

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS 3779	(1990; Rev A; R 1994) Tape Adhesive, Pressure Sensitive Thermal Radiation Resistant, Aluminum Foil/Glass Cloth
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U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FED-STD-595	(Rev B; Am 1) Colors Used in Government
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Procurement

1.2 SYSTEM DESCRIPTION

NOTE: If Section 23 00 00 AIR SUPPLY, DISTRIBUTION, AND EXHAUST SYSTEMS is not included in the project specification, applicable requirements therefrom should be inserted and the following paragraph deleted.

Section 23 00 00 AIR SUPPLY, DISTRIBUTION, AND EXHAUST SYSTEMS applies to work specified in this section.

1.3 PERFORMANCE REQUIREMENTS

Provide noncombustible thermal-insulation system materials, as defined by NFPA 220. Adhesives, coatings, sealants, facings, jackets, and thermal-insulation materials, except cellular elastomers, with a flame-spread classification (FSC) of [25 or less] [____], and a smoke-developed classification (SDC) of [50 or less] [____]. Determine these maximum values in accordance with [ASTM E 84] [NFPA 255]. Provide coatings and sealants that are 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

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

Submit [Installation Drawings](#) for pipe insulation in accordance
with paragraph entitled, "Installation of Insulation Systems," of
this section.

SD-03 Product Data

Submit manufacturer's catalog data for the following items:

[Adhesives](#)
[Coatings](#)
[Insulating Cement](#)
[Insulation Materials](#)
[Jacketing](#)
[Tape](#)

SD-08 Manufacturer's Instructions

Installation manual for [Insulation Materials](#)

1.5 RECYCLED MATERIALS

Provide thermal insulation containing recycled materials to the extent
practicable, provided that the material meets all other requirements of
this section. The minimum recycled material content of the following
insulation are:

Rock Wool - 75 percent slag by weight
Fiberglass - 20-25 percent glass cullet by weight
Plastic Rigid Foam - 9 percent recovered material
Polyisocyanurate/Polyurethane - 9 percent recovered material
Rigid Foam - 9 percent recovered material

PART 2 PRODUCTS

Materials shall be compatible and not contribute to corrosion, soften, or
otherwise attack surfaces to which applied in either the wet or dry state.
Meet [ASTM C 795](#) requirements for materials to be used on stainless steel
surfaces. Provide materials that are asbestos free and conform to the
following.

2.1 INSULATION MATERIALS

Insulation conductances shall be maximum values, as tested at any point,
not an average. Replace or augment insulation conductance found by test to

exceed the specified maximum by an additional thickness to bring it to the required maximum conductance and a complete finishing system.

2.1.1.1 Mineral Fiber Insulation

Conform to [ASTM C 592] [ASTM C 553] [ASTM C 547] for Mineral Fiber Insulation and be suitable for surface temperatures up to 188 degrees C 370 degrees F, and not less than [_____] [64.1] kilograms per cubic meter [_____] [4]-pound per cubic foot density with thermal conductivity 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.

Mineral fiber pipe wrap insulation having an insulating efficiency not less than that of the specified thickness of fibrous glass pipe insulation may be provided in lieu of fibrous glass pipe insulation for pipe sizes 250 mm 10 inches and larger.

2.1.1.2 Cellular Elastomer Insulation

Conform to ASTM C 534/C 534M, except ensure the water vapor permeability does not exceed [_____] [0.44] nanogram 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 for Cellular Elastomer.

2.1.1.3 Cellular Glass Insulation

Conform to ASTM C 552, Type II, Grade 2, pipe covering for Cellular Glass. Substitutions for this material are not permitted. Ensure minimum thickness is not less than 38 mm. 1-1/2 inches.

2.1.1.4 Calcium Silicate Insulation

Conform to ASTM C 533. Ensure the apparent thermal conductivity does not exceed [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.

2.1.1.5 Fiberglass Insulation

Conform to ASTM C 547. Ensure the apparent thermal conductivity does not exceed [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.

Fiber glass pipe insulation having an insulating efficiency not less than that of the specified thickness of mineral fiber pipe insulation may be provided in lieu of mineral fiber pipe insulation for aboveground piping.

2.1.1.6 Polyisocyanurate Pipe Insulation

Conform to ASTM C 591 for polyisocyanurate, minimum density of 27.20 kilograms per cubic meter (kg/cu m) 1.7 pcf.

2.1.1.7 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.

2.1.8 Pipe Fittings

Provide molding pipe fitting insulation covering for use at temperatures up to and including 650 degrees C 1200 degrees F.

2.1.9 Flexible Blankets

Provide flexible 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 at 24 degrees C 75 degrees F mean.

2.2 ADHESIVES

2.2.1 Cloth Adhesives

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

2.2.2 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, must be solvent-base, synthetic-rubber type and conform to the requirements of ASTM C 916, Type I, for attaching fibrous-glass insulation to metal surfaces. Solvent shall be nonflammable.

2.2.3 Cellular Elastomer Insulation Adhesive

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

2.3 INSULATING CEMENT

2.3.1 General Purpose Insulating Cement

General purpose insulating cement shall be [diatomaceous silica] [mineral fiber] and conform to ASTM C 195. Composite shall be rated for 982 degrees C 1800 degrees F service and 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.

2.3.2 Finishing Insulating Cement

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

2.4 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.

2.5 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].

2.6 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.

2.6.1 Aluminum Jacket

NOTE: Use bracketed sentence for Naval Base Norfolk.

ASTM B 209M ASTM B 209, Temper H14, minimum thickness of 0.41 mm 0.016 inch, with factory-applied polyethylene and kraft paper moisture barrier on inside surface. Provide smooth surface jackets for jacket outside diameters less than 200 mm 8 inches. Provide corrugated surface jackets for jacket outside diameters 200 mm 8 inches and larger. Provide stainless steel bands, minimum width of 13 mm 0.5 inch. Provide factory prefabricated aluminum covers for insulation on fittings, valves, and flanges.[Aboveground jackets and bands shall have factory-applied baked-on semigloss brown color conforming to Federal Standard FED-STD-595, "Colors," color chip number 20062.]

2.6.2 Asphalt-Saturated Felt

ASTM D 226, without perforations, minimum weight of 0.49 kilograms per square meter 10 pounds per 100 square feet.

2.6.3 Stainless Steel Jacket

ASTM A 167 or ASTM A 240/A 240M; Type 304, minimum thickness of 0.25 mm 0.010 inch, smooth surface with factory-applied polyethylene and kraft paper moisture barrier on inside surface. Provide stainless steel bands, minimum width of 13 mm 0.5 inch. Provide factory prefabricated stainless steel covers for insulation on fittings, valves, and flanges.

2.6.4 Glass Cloth Jacket

Provide plain-weave glass cloth conforming to ASTM D 579, Style 141 and weigh not less than 0.25 kilogram/square meter [7.23] ounces per square yard [_____] before sizing. Factory apply cloth wherever possible.

Provide leno weave glass reinforcing cloth, 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.]

2.6.5 PVC Jacket

Provide 0.010 inch 0.25 millimeter thick, factory-premolded, [one-piece fitting] [pipe-barrel sheeting vapor-barrier jacketing]polyvinylchloride that is self-extinguishing, high-impact strength, moderate chemical resistance with a permeability rating of 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/E 96M. Provide manufacturer's standard solvent-weld type vapor-barrier joint adhesive.

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

2.7 COATINGS

2.7.1 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. Conform to the requirements of ASTM C 1136 and ASTM C 921 for coatings.

2.7.2 Indoor Vapor-Barrier Finishing

Provide pigmented resin and solvent compound coatings for indoor vapor-barrier finishing of insulation surfaces and conform to ASTM C 1136, Type II.

2.7.3 Outdoor and Indoor Nonvapor-Barrier Finishing

Provide pigmented polymer-emulsion type recommended by the insulation material manufacturer for outdoor and indoor nonvapor-barrier finish coating of insulation surfaces for the surface to be coated and applied to specified dry-film thickness.

2.7.4 Cellular-Elastomer Insulation Coating

Provide a polyvinylchloride lacquer approved by the manufacturer of the cellular elastomer finish coating.

2.7.5 Coating Color

[Provide white] [Conform to the color code specified] [Blend with background of surrounding area] [Provide as specified by the Contracting Officer]for the coating color.

2.8 TAPE

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

2.9 DUAL-TEMPERATURE (HOT- AND CHILLED-) WATER PIPING

Provide [mineral fiber with vapor barrier jacket, Type T-1] [cellular class with vapor barrier jacket, Type T-4] insulation, with a thickness of not less than []. Insulate aboveground pipes, valve bodies, fittings, unions, and flanges.

2.10 HOT-WATER, STEAM, AND CONDENSATE-RETURN PIPING

Provide mineral fiber insulation with glass cloth jacket, Type T-2, with a thickness of not less than [_____]. Insulate aboveground pipes, valve bodies, fittings, unions, flanges, and miscellaneous surfaces.

2.11 COLD-WATER AND CONDENSATE-DRAIN PIPING

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

[Provide 10 millimeter 3/8 inch mineral fiber insulation with glass cloth jacket, Type T-2, with a thickness of not less than [_____].]

[Provide cellular-elastomer insulation conforming to ASTM C 534/C 534M. 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, with a thickness of [10] [15] millimeter [3/8] [1/2] inch per calculation. Use expanded, closed-cell pipe insulation only aboveground, not for underground piping.]

2.12 REFRIGERANT SUCTION PIPING

Provide cellular-elastomer insulation, Type T-3, with a nominal thickness of 20 millimeter 3/4 inch. Insulate surfaces, including valve, fittings, unions, and flanges.

2.13 COOLING-TOWER CIRCULATING WATER PIPING

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

Provide cellular-elastomer insulation, Type T-3, with a thickness of not less than [_____]. Insulate aboveground pipes, valve bodies, fittings, unions, flanges, and miscellaneous surfaces.

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

Provide mineral fiber insulation with aluminum jacket, Type T-6, with a thickness of not less than [_____]. Insulate aboveground pipes, valve bodies, fittings, unions, flanges, and miscellaneous surfaces.

2.14 STEAM AND CONDENSATE PIPING, 2.4 MEGAPASCAL 350 PSIG

Provide calcium silicate insulation with glass cloth jacket, Type T-5, with a thickness of not less than [_____] 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:

2.15 HOT WATER HEATING CONVERTER

Provide calcium silicate insulation with glass cloth jacket, Type T-7, with a thickness of 40 millimeter 1-1/2 inches.

2.16 CHILLED-WATER AND DUAL-TEMPERATURE PUMPS

Provide cellular elastomer insulation, Type T-9, with a thickness of 25 millimeter 1 inch. Cover surfaces subject to condensation, and provide a vapor-barrier coating.

2.17 LOW-PRESSURE STEAM AND CONDENSATE, WEATHER-EXPOSED

Provide calcium silicate insulation with weatherproof jacket, Type T-17, with a thickness of not less than [_____] . Insulate all systems.

2.18 STEAM & CONDENSATE, WEATHER-EXPOSED, 861 KILOPASCAL 125 PSIG

Provide calcium silicate insulation with weatherproof jacket, Type T-17, with a thickness not less than [_____] . Insulate all system surfaces.

2.19 STEAM & CONDENSATE, WEATHER-EXPOSED, 2.4 MEGAPASCAL 350 PSIG

Provide calcium silicate insulation with weatherproof jacket, Type T-17, with a thickness not less than [_____] . Insulate all system surfaces.

PART 3 EXECUTION

3.1 INSTALLATION OF INSULATION SYSTEMS

Install smooth and continuous contours on exposed work. Smoothly and securely paste down cemented laps, flaps, bands, and tapes. Apply adhesives on a full-coverage basis.

Apply insulation only to system or component surfaces that have been tested and approved.

Install insulation lengths tightly butted against each other at joints. Where lengths are cut, provide smooth and square and without breakage of end surfaces. Where insulation terminates, neatly taper and effectively seal ends, or finish as specified. Direct longitudinal seams of exposed insulation away from normal view.

Apply materials in conformance with the recommendations of the manufacturer.

Clean surfaces free of oil and grease before insulation adhesives or mastics are applied. Provide solvent cleaning required to bring metal surfaces to such condition.

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

Cover piping with mineral-fiber pipe insulation with factory-and field-attached vapor-barrier jacket. Maintain vapor seal. Securely cement jackets, jacket laps, flaps, and bands in place with vapor-barrier adhesive. Provide jacket overlaps not less than [40] millimeter [1-1/2] inches [_____] and jacketing bands for butt joints 75 millimeter 3 inches wide.

Cover exposed-to-view fittings and valve bodies with preformed mineral-fiber pipe-fitting insulation of the same thickness as the pipe-barrel insulation. Temporarily secure fitting insulation in place with light cord ties. Apply a 1.52 millimeter 60-mil coating of white indoor vapor-barrier coating and, while still wet, wrap with glass lagging tape with 50 percent overlap, and smoothly blend into the adjacent jacketing. Apply additional coating 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, build 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, make the surfaces 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. Make seams vapor tight with a double bead of manufacturer's standard vapor-barrier adhesive applied in accordance with the manufacturer's instructions. Hold all jacket ends in place with AISI 300 series corrosion-resistant steel straps, [0.381] millimeter [15] mils[_____] thick by 15 millimeter [1/2] inch [_____] wide.

Set pipe insulation 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.

Do not use staples in applying insulation. Install continuous vapor-barrier materials 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. Seal junctions with vapor-barrier jacket where required, glass-cloth mesh tape, and vapor-barrier coating.

Expose white-bleached kraft paper side of the jacketing to view.

Finish exposed-to-view insulation 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

Cover piping with a mineral-fiber, pipe insulation with factory-attached, presized, white, glass cloth. Securely cement jackets, jacket laps, flaps,

and bands in place with vapor-barrier adhesive with jacket overlap not less than 40 millimeter 1-1/2 inches and jacketing bands for butt joints 75 millimeter 3 inches wide.

Cover exposed-to-view fittings with preformed mineral-fiber fitting insulation of the same thickness as the pipe insulation and temporarily secured in place with light cord ties. Install impregnated glass lagging tape with indoor vapor-barrier on 50 percent overlap basis and the blend tape smoothly into the adjacent jacketing. Apply additional coating as needed, and rubber gloved to a smooth contour. tape ends of insulation to the pipe at valves DN50 2 inches and smaller. Build up on-the-job fabricated insulation for concealed fittings and special configurations from mineral fiber and a mixture of insulating cement and lagging adhesive, diluted with 3 parts water. Finish surfaces with glass cloth or tape lagging.

[Cover all valves 65 millimeter 2-1/2 inches and larger and all flanges with preformed insulation of the same thickness as the adjacent insulation.]

[Finish exposed-to-view insulation 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. Hold all jacket ends in place with AISI 300 series corrosion-resistant steel straps, [0.381] millimeter [15] mils [_____] thick by 15 millimeter [1/2] inch [_____] wide. Provide fitting insulation, thermally equivalent to pipe-barrel insulation to preclude surface temperatures detrimental to polyvinylchloride.]

3.2.3 Type T-3, Cellular Elastomer

Cover piping-system surfaces with flexible cellular-elastomer sheet or preformed insulation. Maintain vapor seal. Cement insulation into continuous material with a solvent cutback chloroprene adhesive recommended by the manufacturer for the specific purpose. Apply adhesive 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.

Seal insulation on cold water piping 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. Install [Cork] [Wood dowel] load-bearing inserts between the pipe and insulation shields to prevent insulation compression.

Insulate hot-water, cold-water, and condensate drain pipes to the extent shown with nominal [10] [15] millimeter [3/8] [1/2] inch thick, fire retardant (FR), cellular elastomer, preformed pipe insulation. Seal joints with adhesive.

At pipe hangers or supports where the insulation rests on the pipe hanger strap, cut the insulation with a brass cork borer and a No. 3 superior grade cork inserted. Seal seams with approved adhesive. Insulate sweat fitting 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. Joint miter-cut pieces with approved adhesive. Slit and snap covers over the fitting, and seal joints with approved adhesive.

Insulate screwed fittings 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. Butt pipe insulation against fittings. Overlap shall be not less than [25] millimeter [1] inch [_____]. Use adhesive to join cover pieces and cement the cover to the pipe insulation.

Finish surfaces exposed to view or ultraviolet light 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

Cover piping with cellular glass insulation and factory- and field-attached vapor-barrier jacket. Maintain vapor seal. Securely cement jackets, jacket laps, flaps, and bands 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. Provide insulation continuous through hangers. Bed insulation in an outdoor vapor-barrier coating applied to all piping surfaces.

Insulate flanges, unions, valves, anchors, and fittings 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, provide elbows with not less than three segments. For other fittings and valves, cut segments to the required curvature or nesting size.

Secure segments of the insulation in place with twine or copper wire. After the insulation segments are firmly in place, apply a vapor-barrier coating over the insulation in two coats with glass tape imbedded between coats. First coat, tinted, the second, white to ensure application of two coats. Apply coating to a total dry-film thickness of 1.6 millimeter 1/16 inch minimum. Overlap glass tape seams 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. Secure cellular elastomer 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. Cover fittings with premolded polyvinylchloride jackets. Make seams vapor-tight with a double bead of manufacturer's standard vapor-barrier adhesive applied in accordance with the manufacturer's instructions. Hold jacket ends in place with AISI 300 series corrosion-resistant steel straps, [0.381] millimeter [15] mils [_____] thick by [15] millimeter [1/2] inch [_____] wide.

Insulate anchors secured directly to piping, to prevent condensation, for not less than [150] millimeter [6] inches [_____] from the surface of the pipe insulation.

Install white-bleached kraft paper side of jacket exposed to view. Finish exposed-to-view insulation 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)

Cover piping with a calcium-silicate pipe insulation with factory attached and presized, white, glass cloth. Field apply jackets when required. Securely cement jackets, jacket laps, flaps, and bands 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. Fabricate fittings from segmented pipe barrel sections bedded in general purpose insulating cement and wired in place. Fill voids with general purpose insulating cement with not less than [6] millimeter [1/4] inch [_____] thick, final coating. Impregnate glass lagging tape with lagging adhesive, wrapped with a 50-percent overlap, and be blended smoothly into adjacent jacketing. Apply additional adhesive as needed and rubber-gloved to a smooth contour.

3.2.6 Type T-6, Mineral Fiber with Aluminum Jacket

Cover piping with mineral-fiber pipe insulation with factory-attached or field-applied aluminum jacketing.

Cover fittings and valve bodies with preformed mineral-fiber pipe-fitting insulation of the same thickness as the pipe-barrel insulation. Temporarily secure fitting insulation in place with light cord ties. Apply a 1.52 millimeter 60-mil coating of vapor-barrier mastic, and while still tacky, wrapped with glass lagging tape.

Apply additional mastic as needed and rubber-gloved to smooth fillets or contours. Build up on-the-job fabricated insulation for special configurations 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, make the surfaces vapor-tight by using mastic and glass lagging cloth or tape as specified above with an added finish coat of mastic.

Set pipe insulation into outdoor vapor-barrier coating for a minimum of [150] millimeter [6] inches [_____] at maximum [3500] millimeter [12]-foot [_____] spacing. Seal ends of the insulation to the jacketing with the same material to provide effective vapor barrier stops.

Install continuous vapor barrier over all surfaces, including areas inside pipe sleeves, hangers, and other concealment.

Apply piping insulation to both sides of pipe hangers. Insulate junctions with a special mastic mixture, glass cloth mesh tape, and mastic as previously specified.

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

Lap joints, wherever possible, against the weather so that the water will run off the lower edge and in accordance with the pipe drainage pitch. Locate longitudinal laps on horizontal lines 45 degrees below the

horizontal centerline and alternately staggered 25 millimeter 1 inch. Lap jacketing material a minimum of [50] millimeter [2] inches [____], circumferentially sealed with mastic, and strapped to provide a waterproof covering throughout. Locate straps 200 millimeter 8 inches on center and pull up tight to hold jacketing securely in place. Use screws in addition to straps when necessary to obtain a waterproof covering. Place extra straps on each side of supporting devices and at openings. Where flanging access occurs, strap a chamfer sheet to the pipe at jacketing.

Stiffen exposed longitudinal edges of aluminum jacketing by bending a 25 millimeter 1 inch hem on one edge.

Provide expansion joints for maximum and minimum dimensional fluctuations.

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

At openings in jacket, apply an outdoor vapor-barrier coating for [50] millimeter [2] inches [____] in all directions. Apply jacketing while waterproofing is tacky.

Use screws at each corner of each sheet, at fitting jackets, and as necessary for the service. Place number 7, 10 millimeter 3/8 inch long, binding-head aluminum sheet metal screws through the mastic seal.

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

Cover surfaces with insulation block bedded in an insulating cement and covered with glass cloth jacketing.

Clean surfaces with a chlorinated solvent. Mix general purpose insulating cement with 3 parts water to 1 part nonvapor-barrier adhesive to bring to application consistency. Set block into bedding and joints and fill spaces with a bedding mix and wrap with galvanized chicken wire mesh well laced into an envelope. Trowel a 10 millimeter 3/8 inch thick coating of bedding mix jacket on with nonvapor-barrier adhesive and glass cloth. Finish surfaces 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

Clean pump surfaces with solvent. Apply not less than 25 millimeter [1] inch [____] of general purpose insulating cement, mixed with nonvapor-barrier adhesive diluted with 3 parts water, to achieve smooth surface and configuration contours. After all water has been removed, cover surfaces 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. Apply coating 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. Blend coating into the adjacent flange insulation and the joint covered with a band of cellular elastomer equal to the flange assembly width. Use same coating to seal insulation to the casing at penetrations and terminations. Insulate pumps in a manner that will permit insulation to be removed to repair or replace pumps.

Finish insulation 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

Pack voids surrounding pipe with mineral-fiber fill.

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.

3.2.10 Type T-17, Calcium Silicate Weatherproof Jacket

Cover piping system surfaces with calcium silicate insulation. Cover fittings and valve bodies with preformed insulation of the same material and thickness as the adjoining pipe insulation.

3.3 ACCEPTANCE

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. Include construction details, by building area, the insulation material type, amount, and installation method. An illustration or map of the duct routing locations may serve this purpose. With data provide 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 --