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USACE / NAVFAC / AFCEC **UFGS-23 07 00 (August 2024)**

Preparing Activity: USACE **Superseding**
UFGS-23 07 00 (February 2013)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2025
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DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

SECTION 23 07 00

THERMAL INSULATION FOR MECHANICAL SYSTEMS

08/24

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SECTION 23 07 00

THERMAL INSULATION FOR MECHANICAL SYSTEMS
08/24

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NOTE: This guide specification covers the requirements for field applied thermal insulation on HVAC and plumbing systems located within, on, under, and adjacent to buildings; above and below ground.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

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

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

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PART 1 GENERAL

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NOTE: Show the following information on project drawings:

1. Areas where pipe insulation differs from the "Typical;"

2. Areas where ductwork is to be internally insulated;

3. Areas where metal jackets or 8-ply vapor barrier jacket are to be used on interior piping;

4. Pumps to be insulated and encased in 20 gauge

boxes; and

5. Heat exchange temperatures.

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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 Reference Identifier (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. At the discretion of the Government, the manufacturer of any material supplied will be required to furnish test reports pertaining to any of the tests necessary to assure compliance with the standard or standards referenced in this specification.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 90.1 - IP	(2019) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 90.1 - SI	(2019) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 90.2	(2018; Addenda A-B 2021; Addenda C-K 2023; Addenda L 2024) Energy-Efficient Design of Low-Rise Residential Buildings

ASTM INTERNATIONAL (ASTM)

ASTM A240/A240M	(2024b) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A580/A580M	(2023) Standard Specification for Stainless Steel Wire
ASTM B209	(2014) Standard Specification for Aluminum

	and Aluminum-Alloy Sheet and Plate
ASTM B209M	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM C195	(2007; R 2024) Standard Specification for Mineral Fiber Thermal Insulating Cement
ASTM C450	(2008) Standard Practice for Fabrication of Thermal Insulating Fitting Covers for NPS Piping, and Vessel Lagging
ASTM C533	(2017; R 2023) Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
ASTM C534/C534M	(2024) Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
ASTM C547	(2022a) Standard Specification for Mineral Fiber Pipe Insulation
ASTM C552	(2022) Standard Specification for Cellular Glass Thermal Insulation
ASTM C553	(2024) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C585	(2010) Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing
ASTM C591	(2022) Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM C592	(2024) Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)
ASTM C610	(2017; R 2023) Standard Specification for Molded Expanded Perlite Block and Pipe Thermal Insulation
ASTM C612	(2014; R 2019) Standard Specification for Mineral Fiber Block and Board Thermal Insulation
ASTM C647	(2008; R 2013) Properties and Tests of Mastics and Coating Finishes for Thermal Insulation
ASTM C755	(2019b) Standard Practice for Selection of Water Vapor Retarders for Thermal Insulation

ASTM C795	(2008; R 2023) Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel
ASTM C916	(2020) Standard Specification for Adhesives for Duct Thermal Insulation
ASTM C920	(2018; R 2024) Standard Specification for Elastomeric Joint Sealants
ASTM C921	(2010; R 2015) Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation
ASTM C1126	(2024) Standard Specification for Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation
ASTM C1136	(2023) Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
ASTM C1290	(2016; R 2021) Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts
ASTM C1710	(2011) Standard Guide for Installation of Flexible Closed Cell Preformed Insulation in Tube and Sheet Form
ASTM D882	(2012) Tensile Properties of Thin Plastic Sheeting
ASTM D2863	(2019) Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)
ASTM D5590	(2017; R 2021) Standard Test Method for Determining the Resistance of Paint Films and Related Coatings to Fungal Defacement by Accelerated Four-Week Agar Plate Assay
ASTM E84	(2023) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E96/E96M	(2024) Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials
ASTM E2231	(2021) Standard Practice for Specimen Preparation and Mounting of Pipe and Duct Insulation Materials to Assess Surface Burning Characteristics
ASTM E2336	(2020) Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems

CALIFORNIA DEPARTMENT OF PUBLIC HEALTH (CDPH)

CDPH SECTION 01350	(2017; Version 1.2) Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide https://www.approvalguide.com/

GREEN SEAL (GS)

GS-36	(2013) Adhesives for Commercial Use

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 2758	(2014) Paper - Determination of Bursting Strength

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation

MIDWEST INSULATION CONTRACTORS ASSOCIATION (MICA)

MICA Insulation Stds	(8th Ed) National Commercial & Industrial Insulation Standards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(2024) Standard for the Installation of Air Conditioning and Ventilating Systems
NFPA 90B	(2024) Standard for the Installation of Warm Air Heating and Air Conditioning Systems
NFPA 96	(2024) Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations

SCIENTIFIC CERTIFICATION SYSTEMS (SCS)

SCS	SCS Global Services (SCS) Indoor Advantage

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT (SCAQMD)

SCAQMD Rule 1168	(2022) Adhesive and Sealant Applications

TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY (TAPPI)

TAPPI T403 OM	(2022) Bursting Strength of Paper

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-A-3316	(1987; Rev C; Am 2 1990) Adhesives, Fire-Resistant, Thermal Insulation
MIL-A-24179	(1969; Rev A; Am 2 1980; Notice 1 1987; Notice 2 2020) Adhesive, Flexible Unicellular-Plastic Thermal Insulation
MIL-PRF-19565	(1988; Rev C) Coating Compounds, Thermal Insulation, Fire- and Water-Resistant, Vapor-Barrier

UL SOLUTIONS (UL)

UL 94	(2023; Reprint Jan 2024) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 723	(2020) UL Standard for Safety Test for Surface Burning Characteristics of Building Materials
UL 2818	(2022) GREENGUARD Certification Program For Chemical Emissions For Building Materials, Finishes And Furnishings

1.2 SYSTEM DESCRIPTION

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NOTE: This guide specification is to be used for field applied insulation on mechanical systems; interior and exterior, above and below ground. Insulation for energy distribution systems covered by Sections 33 61 13 PRE-ENGINEERED UNDERGROUND HEAT DISTRIBUTION SYSTEM, 33 63 13.19 CONCRETE TRENCH HYDRONIC AND STEAM ENERGY DISTRIBUTION, 33 61 13.13 PREFABRICATED UNDERGROUND HYDRONIC ENERGY DISTRIBUTION, and 33 60 02 ABOVEGROUND HEAT DISTRIBUTION SYSTEM, are not within the scope of this guide specification. Heating, air conditioning, and evaporative cooling duct; equipment; and piping are included.

Pipe insulation covered in this specification is valid for between minus 34 and plus 204 degrees C minus 30 and plus 400 degrees F. Equipment insulation covered in this specification is valid for between minus 34 and plus 982 degrees C minus 30 and plus 1800 degrees F.

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1.2.1 General

Provide field-applied insulation and accessories on mechanical systems as specified herein; factory-applied insulation is specified under the piping, duct or equipment to be insulated. Provide insulation of heat distribution systems and chilled water systems outside of buildings as

specified in Section 33 61 13 PRE-ENGINEERED UNDERGROUND HEAT DISTRIBUTION SYSTEM, Section 33 63 13.19 CONCRETE TRENCH HYDRONIC AND STEAM ENERGY DISTRIBUTION, Section 33 60 02 ABOVEGROUND HEAT DISTRIBUTION SYSTEM, and Section 33 61 13.13 PREFABRICATED UNDERGROUND HYDRONIC ENERGY DISTRIBUTION. Provide field applied insulation materials required for use on Government-furnished items as listed in the SPECIAL CONTRACT REQUIREMENTS.

1.3 SUBMITTALS

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NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters 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 and Air Force projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

In SD-04, Designer will exclude ductwork insulation display samples for small, simple projects where the extent of duct insulation is not likely to cause a problem of enforcement with the requirements of the specification.

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

Submit the three SD types, SD-02 Shop Drawings, SD-03 Product Data, and SD-08 Manufacturer's Instructions at the same time for each system.

SD-02 Shop Drawings

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NOTE: For NAVFAC LANT projects, delete the requirement for this SD-02 Shop Drawing Submittal.
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MICA Plates; G, [_____]

Pipe Insulation Systems and Associated Accessories

Duct Insulation Systems and Associated Accessories

Equipment Insulation Systems and Associated Accessories

Recycled content for insulation materials; S

SD-03 Product Data

Pipe Insulation Systems; G, [_____]

Duct Insulation Systems; G, [_____]

Equipment Insulation Systems; G, [_____]

SD-04 Samples

Thermal Insulation; G, [_____]

Display Samples; G, [_____]

SD-07 Certificates

Indoor air quality for adhesives; S

SD-08 Manufacturer's Instructions

Pipe Insulation Systems; G, [_____]

Duct Insulation Systems; G, [_____]

Equipment Insulation Systems; G, [_____]

1.4 CERTIFICATIONS

1.4.1 Adhesives and Sealants

Provide products certified to meet indoor air quality requirements by UL 2818 (Greenguard) Gold, SCS Global Services Indoor Advantage Gold or provide certification or validation by other third-party programs that products meet the requirements of this Section. Provide current product certification documentation from certification body. When product does not have certification, provide validation that product meets the indoor air quality product requirements cited herein.

1.5 QUALITY ASSURANCE

1.5.1 Installer Qualification

Qualified installers must have successfully completed three or more similar type jobs within the last 5 years.

1.6 DELIVERY, STORAGE, AND HANDLING

Deliver materials in the manufacturer's unopened containers. Protect materials delivered and placed in storage from weather, humidity, dirt, dust and other contaminants. The Contracting Officer may reject insulation material and supplies that become dirty, dusty, wet, or contaminated by some other means. Attach manufacturer's stamp or label giving the name of the manufacturer and brand, and a description of the material, date codes, and approximate shelf life (if applicable) to packages or standard containers of insulation, jacket material, cements, adhesives, and coatings delivered for use, and samples required for approval. Insulation packages and containers must be asbestos free.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide materials which are the standard products of manufacturers regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening and is an acceptable product per this specification. Submit a complete list of materials, including manufacturer's descriptive technical literature, performance data, catalog cuts, and installation instructions. Include the product number, k-value, thickness and furnished accessories including adhesives, sealants and jackets for each mechanical system requiring insulation. The product data must be copyrighted, have an identifying or publication number, and have been published prior to the issuance date of this solicitation. Submit materials furnished under this section together in a booklet and in conjunction with the MICA plates booklet (SD-02). Annotate the product data to indicate which MICA plate is applicable.

2.1.1 Insulation System

Provide insulation systems in accordance with the approved MICA National Insulation Standards plates as supplemented by this specification. Provide field-applied insulation for heating, ventilating, and cooling (HVAC) air distribution systems and piping systems that are located within, on, under, and adjacent to buildings; and for plumbing systems. Provide CFC and HCFC free insulation.

2.1.2 Surface Burning Characteristics

Unless otherwise specified, insulation must have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. Determine flame spread, and smoke developed indexes, by ASTM E84 or UL 723. Test insulation in the same density and installed thickness as the material to be used in the actual construction. Prepare and mount test specimens according to ASTM E2231.

2.2 MATERIALS

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NOTE: Tables 1, 2, 3, 4, and 5 are not inclusive of systems requiring insulation. Edit, modify, and add to the information contained in tables as required for your project requiring insulation. These tables must become a part of project specification.

For cryogenic equipment handling media between minus 34 and minus 18 degrees C minus30 and minus one degree F, use elastomeric closed cell or cellular glass.

Table 7 is primarily used for personnel safety where stacks or pipes are within reach, or if stacks or pipes run through conditioned spaces where heat losses may increase building energy usage.

ASHRAE 90.2 is for low-rise residential building. ASHRAE 90.1 is for all buildings except low-rise residential buildings. Low-rise building has one or two stories without elevators. High-rise building has multistory with elevators.

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Provide insulation that meets or exceed the requirements of ASHRAE 90.1 - SIASHRAE 90.1 - IP[ASHRAE 90.2]. Ensure insulation exterior is cleanable, grease resistant, non-flaking and non-peeling. Provide compatible materials that do not contribute to corrosion, soften, or otherwise attack surfaces to which applied in either wet or dry state. Use materials on stainless steel surfaces meeting ASTM C795 requirements. Do not use calcium silicate on chilled or cold water systems. Use asbestos free materials. Provide product recognized under UL 94 (if containing plastic) and listed in FM APP GUIDE.

2.2.1 Adhesives

Provide non-aerosol adhesive products used on the interior of the building (defined as inside of the weatherproofing system) that meet either emissions requirements of CDPH SECTION 01350 (limit requirements for either office or classroom spaces regardless of space type) or VOC content requirements of SCAQMD Rule 1168 (HVAC duct sealants must meet limit requirements of "Other" category within SCAQMD Rule 1168 sealants table). Provide aerosol adhesives used on the interior of the building that meet either emissions requirements of CDPH SECTION 01350 (use the office or classroom requirements, regardless of space type) or VOC content requirements of GS-36. Provide certification or validation of indoor air quality for adhesives.

2.2.1.1 Acoustical Lining Insulation Adhesive

Provide a nonflammable, fire-resistant adhesive conforming to ASTM C916, Type I.

2.2.1.2 Mineral Fiber Insulation Cement

Provide cement in accordance with ASTM C195.

2.2.1.3 Lagging Adhesive

Lagging is the material used for thermal insulation, especially around a cylindrical object. This may include the insulation as well as the cloth/material covering the insulation. [To resist mold/mildew, use lagging adhesive meeting ASTM D5590 with 0 growth rating.]Provide nonflammable and fire-resistant lagging adhesives that have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. Ensure adhesive is MIL-A-3316, Class 1, pigmented [white] [red] and suitable, as listed by the manufacturer,for bonding fibrous glass cloth to faced and unfaced fibrous glass insulation board; for bonding cotton brattice cloth to faced and unfaced fibrous glass insulation board; for sealing edges of and bonding glass tape to joints of fibrous glass board; for bonding lagging cloth to thermal insulation; or Class 2 for attaching fibrous glass insulation to metal surfaces. Apply lagging adhesives in strict accordance with the manufacturer's recommendations for pipe and duct insulation.

2.2.1.4 Contact Adhesive

Adhesives may be any of, but not limited to, the neoprene based, rubber based, or elastomeric type that have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. Ensure adhesive does not adversely affect, initially or in service, the insulation to which it is applied, nor cause any corrosive effect on metal to which it is applied. Ensure that any solvent dispersing medium or volatile component of the adhesive has no objectionable odor and does not contain any benzene or carbon tetrachloride. Ensure dried adhesive does not emit nauseous, irritating, or toxic volatile matters or aerosols when the adhesive is heated to any temperature up to 100 degrees C 212 degrees F. The dried adhesive must be nonflammable and fire resistant. Flexible Elastomeric Adhesive: Comply with MIL-A-24179, Type II, Class I. Provide product listed in FM APP GUIDE.

2.2.2 Caulking

ASTM C920, Type S, Grade NS, Class 25, Use A.

2.2.3 Corner Angles

Nominal 0.406 mm 0.016 inch aluminum 25 by 25 mm 1 by 1 inch with factory applied kraft backing. Aluminum must be ASTM B209M ASTM B209, Alloy 3003, 3105, or 5005.

2.2.4 Fittings

Fabricated Fittings are the prefabricated fittings for flexible elastomeric pipe insulation systems in accordance with ASTM C1710. Together with the flexible elastomeric tubes, they provide complete system integrity for retarding heat gain and controlling condensation drip from chilled-water and refrigeration systems. Flexible elastomeric, fabricated fittings provide thermal protection (0.25 k) and condensation resistance (0.05 Water Vapor Transmission factor). For satisfactory performance, use properly installed protective vapor retarder/barriers and vapor stops on high relative humidity and below ambient temperature applications to reduce movement of moisture through or around the insulation to the colder interior surface.

2.2.5 Finishing Cement

ASTM C450: Mineral fiber hydraulic-setting thermal insulating and finishing cement. All cements that may come in contact with Austenitic stainless steel must comply with ASTM C795.

2.2.6 Fibrous Glass Cloth and Glass Tape

Provide fibrous glass cloth, with 20X20 maximum mesh size, and glass tape with maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. Provide tape consisting of 100 mm 4 inch wide rolls. Provide Class 3 tape that is 0.15 kg/square m 4.5 ounces/square yard. Elastomeric Foam Tape: Black vapor-retarder foam tape with acrylic adhesive containing an anti-microbial additive.

2.2.7 Staples

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NOTE: For cold applications (cold water, chilled water, and brine systems), staples and tacks are not permitted to be installed on vapor retarder/barrier jackets or fitting covers.

Monel is a nickel rich alloy that has high strength, high ductility, and excellent resistance to corrosion.

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Outward clinching type [monel] [Type 304 or 316 stainless steel].

2.2.8 Jackets

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NOTE: The purpose of jacketing insulated pipes and vessels is to protect the vapor retarder system and the insulation. Protective jacketing is designed to be installed over the vapor retarder/vapor barrier and insulation to prevent weather and abrasion damage. The protective jacketing must be installed independently and in addition to any factory or field applied vapor retarder.

VAPOR BARRIER/VAPOR RETARDER. To determine which system is required, apply the following criteria: On ducts, piping and equipment operating below [select a temperature that is at least equal to the dry bulb temperature's median of extreme highs from the region's weather data] or located outside must be equipped with a vapor barrier. Whereas ducts, pipes and equipment that are located inside and that always operate above [use the same temperature selected earlier in this paragraph which is based on the region's median of extreme highs dry bulb temperature] must be installed with a vapor retarder where required as stated in "Vapor Retarder Required."

A vapor barrier should be installed where there is a possiblity of condensation. Therefore, the designer

must require a vapor barrier where the temperature in the system may be below the ambient temperature. If the application operates at times above the selected temperature and other times below the selected temperature, the application must be equipped with a vapor barrier.

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2.2.8.1 Aluminum Jackets

Provide aluminum jackets consisting of corrugated, embossed or smooth sheet, 0.406 mm 0.016 inch nominal thickness; ASTM B209M ASTM B209, Temper H14, Temper H16, Alloy 3003, 5005, or 3105. Do not use corrugated aluminum jacket outdoors. Aluminum jacket securing bands must be Type 304 stainless steel, 0.396 mm 0.015 inch thick, 13 mm 1/2 inch wide for pipe under 300 mm 12 inch diameter and 19 mm 3/4 inch wide for pipe over 300 mm 12 inch and larger diameter. Aluminum jacket circumferential seam bands must be 50.8 by 0.406 mm 2 by 0.016 inch aluminum matching jacket material. Ensure bands for insulation below ground are 19 by 0.508 mm 3/4 by 0.020 inch thick stainless steel, or fiberglass reinforced tape. The jacket may, at the option of the Contractor, be provided with a factory fabricated Pittsburgh or "Z" type longitudinal joint. When the "Z" joint is used, use bands at the circumferential joints that are designed by the manufacturer to seal the joints and hold the jacket in place.

2.2.8.2 Polyvinyl Chloride (PVC) Jackets

Polyvinyl chloride (PVC) jacket and fitting covers must have high impact strength, ultraviolet (UV) resistant rating or treatment and moderate chemical resistance. The minimum thickness for a Standard jacket is 0.508mm0.020 inch and where high abuse resistance is required use Heavy Duty PVC jacket 0.762 mm0.030 inch. Standard PVC fittings will have an initial core thickness (before thermoforming) of 0.635 mm0.025 inch and heavy duty fittings will have an initial core thickness of 0.762 mm0.030 inch.

2.2.8.3 Vapor Barrier/Weatherproofing Jacket

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NOTE: Do not provide this material on Navy projects. Only material greater than 8 ply is to be used for Army projects.

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Provide laminated self-adhesive vapor barrier/weatherproofing jacket, greater than 3 plies standard grade, silver, white, black and embossed or greater than 8 ply (minimum 0.072 mm 2.9 mils adhesive); with less than 0.02 permeability when tested in accordance with ASTM E96/E96M, using the water transmission rate test method; heavy duty, white or natural; and UV resistant. Flexible Elastomeric exterior foam with factory applied, UV Jacket made with a cold weather acrylic adhesive. Construction of laminate designed to provide UV resistance, high puncture, tear resistance and excellent Water Vapor Transmission (WVT) rate.

2.2.8.4 Vapor Barrier/Vapor Retarder

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NOTE: Where there is a possibility of condensation install a vapor barrier. Therefore, the designer

must require a vapor barrier where the temperature in the system may be below the ambient temperature. If the application operates at times above the selected temperature and other times below the selected temperature, the application must be equipped with a vapor barrier.

****

Apply the following criteria to determine which system is required.

****

NOTE: Fill in the brackets a temperature that is at least equal to the dry bulb temperature's median of extreme highs from the region's weather data

****

a. On ducts, equip piping and equipment operating below [_____] degrees C degrees F or located outside with a vapor barrier.

****

NOTE: Use the same temperature selected earlier in this paragraph which is based on the region's median of extreme highs dry bulb temperature

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b. Install ducts, pipes and equipment that are located inside and that always operate above [_____] degrees C degrees F with a vapor retarder where required as stated in paragraph VAPOR RETARDER REQUIRED.

2.2.9 Vapor Retarder Required

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NOTE: The functions of a vapor retarder/vapor barrier are to keep out water, water vapor, and to prevent water vapor infiltration, in order to keep the insulation dry. Type I is a vapor barrier for use over insulation on pipes, ducts, or equipment operating at temperatures below ambient at least part of the time or wherever a vapor barrier is required. Type II vapor retarder is water vapor permeable and for use over pipes, ducts, or equipment operating above ambient temperatures or wherever a vapor barrier is not required.

****

ASTM C921, Type I, minimum puncture resistance 50 Beach units on all surfaces except concealed ductwork, where a minimum puncture resistance of 25 Beach units is acceptable. Minimum tensile strength, 6.1 N/mm 35 pounds/inch width. ASTM C921, Type II, minimum puncture resistance 25 Beach units, tensile strength minimum 3.5 N/mm 20 pounds/inch width. Use jackets on insulation exposed in finished areas that have white finish suitable for painting without sizing. Based on the application, insulation materials that require manufacturer or fabricator applied pipe insulation jackets are cellular glass, when all joints are sealed with a vapor barrier mastic, and mineral fiber. Ensure all non-metallic jackets have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. Flexible elastomerics require (in addition to vapor barrier skin) vapor retarder jacketing for high relative humidity and below ambient temperature

applications.

2.2.9.1 White Vapor Retarder All Service Jacket (ASJ)

ASJ is for use on hot/cold pipes, ducts, or equipment indoors or outdoors if covered by a suitable protective jacket. Provide product which meets all physical property and performance requirements of ASTM C1136, Type I, except a minimum burst strength of 585 kPa 85 psi. ASTM D2863 Limited Oxygen Index (LOI) is a minimum of 31.

In addition, do not use paper or other moisture-sensitive material for the outer exposed surface or the inner-most surface contacting the insulation. Ensure the outer exposed surface is white and has an emittance no less than 0.80.

2.2.9.2 Vapor Retarder/Vapor Barrier Mastic Coatings

2.2.9.2.1 Vapor Barrier

The vapor barrier must be self adhesive (minimum 0.05 mm 2 mils adhesive, 0.075 mm 3 mils embossed) greater than 3 plies standard grade, silver, white, black and embossed white jacket for use on hot/cold pipes. Ensure permeability is less than 0.02 when tested in accordance with ASTM E96/E96M. Provide products meeting UL 723 or ASTM E84 flame and smoke requirements and that are UV resistant.

2.2.9.2.2 Vapor Retarder

Provide fire and water resistant vapor retarder coating appropriately selected for either outdoor or indoor service. Color must be white. Ensure the water vapor permeance of the compound is in accordance with ASTM C755. Provide nonflammable, fire resistant coating. [To resist mold/mildew, provide coating meeting ASTM D5590 with 0 growth rating.]Ensure coating meets MIL-PRF-19565 Type II (if selected for indoor service) and is Qualified Products Database listed. Determine all other application and service properties pursuant to ASTM C647.

2.2.9.3 Laminated Film Vapor Retarder

ASTM C1136, Type I, maximum moisture vapor transmission 0.02 perms, minimum puncture resistance 50 Beach units on all surfaces except concealed ductwork; where Type II, maximum moisture vapor transmission 0.02 perms, a minimum puncture resistance of 25 Beach units is acceptable. Provide vapor retarder with a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. Flexible Elastomeric exterior foam with factory applied UV Jacket. Construction of laminate designed to provide UV resistance, high puncture, tear resistance and an excellent WVT rate.

2.2.9.4 Polyvinylidene Chloride (PVDC) Film Vapor Retarder

Provide PVDC film vapor retarder with a maximum moisture vapor transmission of 0.02 perms, minimum puncture resistance of 150 Beach units, a minimum tensile strength in any direction of 5.3 kN/m 30 lb/inch when tested in accordance with ASTM D882, and a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84.

2.2.9.5 Polyvinylidene Chloride Vapor Retarder Adhesive Tape

Requirements must meet the same as specified for Laminated Film Vapor Retarder above.

2.2.9.6 Vapor Barrier/Weather Barrier

Ensure the vapor barrier is greater than 3 ply self adhesive laminate -white vapor barrier jacket- superior performance (permeability less than 0.02 when tested in accordance with ASTM E96/E96M). Provide vapor barrier meeting UL 723 or ASTM E84 25 flame and 50 smoke requirements; and UV resistant. Minimum burst strength 1.3 MPa 185 psi in accordance with [TAPPI T403 OM] [ISO 2758]. Tensile strength 0.12 kg/m 68 lb/inch width (PSTC-1000). Provide tape as specified for laminated film vapor barrier above.

2.2.10 Vapor Retarder Not Required

ASTM C921, Type II, Class D, minimum puncture resistance 50 Beach units on all surfaces except ductwork, where Type IV, maximum moisture vapor transmission 0.10, a minimum puncture resistance of 25 Beach units is acceptable. Provide jacket with a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84.

2.2.11 Wire

Soft annealed ASTM A580/A580M Type 302, 304 or 316 stainless steel, 16 or 18 gauge.

2.2.12 Insulation Bands

Provide 13 mm 1/2 inch wide; 26 gauge stainless steel insulation bands.

2.2.13 Sealants

Choose sealants from the butyl polymer type, the styrene-butadiene rubber type, or the butyl type of sealants. Provide sealants with a maximum permeance of 0.02 perms based on Procedure B for ASTM E96/E96M, and a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84.

2.3 PIPE INSULATION SYSTEMS

****

NOTE: Where the temperature of cold water entering a building is below the average dew point of the indoor ambient air or below 15 degrees C60 degrees F, and where condensate drip will cause damage or create a hazard, the piping should be insulated to limit or minimize condensation and a vapor barrier added per manufacturer's recommendations, if needed, whether piping is above or below ceilings. Insulation that may absorb moisture will see a reduction in effectiveness even with a slight amount of infiltration. Moisture on the interior of certain metal jackets may lead to corrosion and pitting.

Flexible elastomeric and cellular glass are very

suitable for chilled water applications. Calcium silicate can not be used on chilled or cold water systems. Minimum thickness recommended for cellular glass insulation is 40 mm 1.5 inches. The reason is that the breakage rate during shipment of 25 mm 1 inch thick cellular insulation is too high to be economical. Design the insulation thickness based on worst case ambient conditions, such as a humid environment. Vapor Barrier Jacket for elastomeric and cellular glass are very suitable for chilled water.

For NAVFAC LANT projects, delete the option of 13 mm 1/2 inch from line 4 of the following paragraph.

ASHRAE 90.2 is for low-rise residential building. ASHRAE 90.1 is for all buildings except low-rise residential buildings. Low-rise building has one or two stories without elevators. High-rise building has multistory with elevators.

****

Conform insulation materials to Table 1 and minimum insulation thickness as listed in Table 2 and meet or exceed the requirements of ASHRAE 90.1 - SIASHRAE 90.1 - IP[ASHRAE 90.2]. Limit pipe insulation materials to those listed herein and meeting the following requirements:

2.3.1 Recycled Materials

Provide insulation materials containing the following minimum percentage of recycled material content by weight:

Rock Wool: 75 percent slag of weight
Fiberglass: 20 percent glass cullet
Rigid Foam: 9 percent recovered material
Phenolic Rigid Foam: 9 percent recovered material

Provide data identifying percentage of recycled content for insulation materials.

2.3.2 Aboveground Cold Pipeline (-34 to 16 deg. C -30 to 60 deg. F)

****

NOTE: When it is necessary to insulate existing cold water systems or systems that must remain in operation, the Designer may consider using a mineral fiber insulation that meets ASTM C547, with an integral wicking material designed to remove condensed water. The Designer should not consider using a mineral fiber integral wicking material when ambient conditions at the pipe location can be expected to be exposed to any high humidity conditions. High humidity areas are as identified in ASHRAE 90.1 as climate zones 0A, 1A, 2A, 3A, 3C, 4C and 5C. Follow manufacturer's recommendations for installation.

****

Provide insulation for outdoor, indoor, exposed or concealed applications,

as follows:

2.3.2.1 Cellular Glass

ASTM C552, Type II, and Type III. Supply the insulation from the fabricator with (paragraph WHITE VAPOR RETARDER ALL SERVICE JACKET (ASJ)) ASJ vapor retarder and installed with all longitudinal overlaps sealed and all circumferential joints ASJ taped or supply the insulation unfaced from the fabricator and install with all longitudinal and circumferential joints sealed with vapor barrier mastic.

2.3.2.2 Flexible Elastomeric Cellular Insulation

Closed-cell, foam- or expanded-rubber materials containing anti-microbial additive, complying with ASTM C534/C534M, Grade 1, Type I or II. Type I, Grade 1 for tubular materials. Type II, Grade 1, for sheet materials. Ensure Type I and II have vapor retarder/vapor barrier skin on one or both sides of the insulation, and require an additional exterior vapor retarder covering for high relative humidity and below ambient temperature applications.

2.3.2.3 Mineral Fiber Insulation with Integral Wicking Material (MFIWM)

ASTM C547. Install in accordance with manufacturer's instructions. Do not use in applications exposed to outdoor ambient conditions in climatic zones 1 through 4.

2.3.2.4 Polyisocyanurate Insulation

ASTM C591, Type I. Polyisocyanurate insulation may only be used on systems operating at temperatures not to exceed 60 degrees C 140 degrees F. Supply the insulation with a factory applied vapor retarder/barrier that complies with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. The insulation and all covering must pass the flame spread index of 25 and the smoke developed index of 50 when tested in accordance with ASTM E84.

2.3.3 Aboveground Hot Pipeline (Above 16 deg. C 60 deg. F)

Provide insulation for outdoor, indoor, exposed or concealed applications meeting the following requirements. Supply the insulation with manufacturer's recommended factory-applied jacket/vapor barrier.

2.3.3.1 Mineral Fiber

ASTM C547, Types I, II or III, supply the insulation with manufacturer's recommended factory-applied jacket.

2.3.3.2 Calcium Silicate

ASTM C533, Type I indoor only, or outdoors above 121 degrees C 250 degrees F pipe temperature. Supply insulation with the manufacturer's recommended factory-applied jacket/vapor barrier.

2.3.3.3 Cellular Glass

ASTM C552, Type II and Type III. Supply the insulation with manufacturer's recommended factory-applied jacket.

2.3.3.4 Flexible Elastomeric Cellular Insulation

Closed-cell, foam- or expanded-rubber materials containing anti-microbial additive, complying with ASTM C534/C534M, Grade 1, Type I or II to 105 degrees C 220 degrees F service. Type I for tubular materials. Type II for sheet materials.

2.3.3.5 Phenolic Insulation

ASTM C1126 Type III to 121 degrees C 250 degrees F service must comply with ASTM C795. Supply the insulation with manufacturer's recommended factory-applied jacket/vapor barrier.

2.3.3.6 Perlite Insulation

ASTM C610

2.3.3.7 Polyisocyanurate Insulation

ASTM C591, Type I. Supply the insulation with a factory applied vapor retarder/barrier that complies with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. The insulation and all covering must pass the flame spread index of 25 and the smoke developed index of 50 when tested in accordance with ASTM E84.

2.3.4 Aboveground Dual Temperature Pipeline

****

NOTE: The use of multiple layered systems, i.e., a flexible form of insulation, surrounded by a rigid form and sealed with mastics, sealants and vapor retarders/vapor barrier, may provide the most advantageous form of insulation system for this piping configuration. This is due to the pipe expansion and contraction associated with the change from hot to cold temperatures.

****

Select insulation for use over a dual temperature pipeline system (Outdoor, Indoor - Exposed or Concealed) in accordance with the most limiting/restrictive case. Find an allowable material from paragraph PIPE INSULATION MATERIALS and determine the required thickness from the most restrictive case. Use the thickness listed in paragraphs INSULATION THICKNESS for cold & hot pipe applications.

2.3.5 Below-ground Pipeline Insulation

For below-ground pipeline insulation, use cellular glass, ASTM C552, type II.

2.4 DUCT INSULATION SYSTEMS

****

NOTE: For NAVFAC ML projects, delete option of the following paragraph.

****

2.4.1 Factory Applied Insulation

Provide factory-applied [ASTM C552, cellular glass thermal] [ASTM C534/C534M Grade 1, Type II, flexible elastomeric closed cell] insulation according to manufacturer's recommendations for insulation with insulation manufacturer's standard reinforced fire-retardant vapor barrier[, with identification of installed thermal resistance (R) value and out-of-package R value].

2.4.2 Field Applied Insulation

2.4.2.1 General

****
NOTE: ASHRAE 90.2 is for low-rise residential building. ASHRAE 90.1 is for all buildings except low-rise residential buildings. Low-rise building has one or two stories without elevators. High-rise building has multistory with elevators.
****

Calculate the minimum thickness in accordance with [ASHRAE 90.2] ASHRAE 90.1 - SIASHRAE 90.1 - IP.

2.4.3 Rigid Insulation

Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type IA or Type IB; 3.0 pcf. Provide insulation with [factory applied ASJ][and][factory-applied FSK] jacket. Minimum thickness in accordance with ASHRAE 90.1 - SIASHRAE 90.1 - IP[ASHRAE 90.2][Tables 3 and 4]

2.4.4 Blanket Insulation

****
NOTE: For NAVFAC ML, delete this paragraph.
****

Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type II and ASTM C1290, Type III with factory-applied FSK jacket; [3/4][1.5] pcf. Minimum thickness in accordance with ASHRAE 90.1 - SIASHRAE 90.1 - IP[ASHRAE 90.2][Tables 3 and 4].

2.4.5 Kitchen Exhaust Ductwork Insulation

****
NOTE: If kitchen exhaust hood has outside air connection to cold outdoor, provide vapor barrier for outside air connection to prevent dissolution of calcium silicate.
****

Ensure insulation thickness is a minimum of 50 mm 2 inches, blocks or boards, either mineral fiber conforming to ASTM C612, Class 5, 320 kg/m3 20 pcf average [or calcium silicate conforming to ASTM C533, Type II. Provide vapor barrier for outside air connection to kitchen exhaust hood]. Provide enclosure materials and grease duct enclosure systems which meet testing requirements of ASTM E2336 for noncombustibility, fire

resistance, durability, internal fire, and fire-engulfment with a through-penetration fire stop.

2.4.6 Acoustical Duct Lining

2.4.6.1 General

For ductwork indicated or specified in Section 23 30 00 HVAC AIR DISTRIBUTION to be acoustically lined, provide external insulation in accordance with this specification section and in addition to the acoustical duct lining if R-value would not be met as required in Table 3 and 4. The installation of internal acoustical duct insulation is prohibited.

2.4.6.2 Duct Liner

Flexible Elastomeric Acoustical and Conformable Duct Liner Materials: Flexible Elastomeric Thermal, Acoustical and Conformable Insulation Compliance with ASTM C534/C534M Grade 1, Type II; and NFPA 90A or NFPA 90B as applicable.

2.4.7 Duct Insulation Jackets

2.4.7.1 All-Purpose Jacket

Provide insulation with insulation manufacturer's standard reinforced fire-retardant jacket with or without integral vapor barrier as required by the service. In exposed locations, provide jacket with a white surface.

2.4.7.2 Metal Jackets

2.4.7.2.1 Aluminum Jackets

ASTM B209M ASTM B209, Temper H14, minimum thickness of 27 gauge (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 dimension 200 mm 8 inches and larger. Provide corrugated surface jackets for jacket outside dimension 200 mm 8 inches and larger. Provide stainless steel bands, minimum width of 13 mm 1/2 inch.

2.4.7.2.2 Stainless Steel Jackets

ASTM A240/A240M; Type 304, minimum thickness of 33 gauge (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 1/2 inch.

2.4.7.3 Vapor Barrier/Weatherproofing Jacket

Provide vapor barrier/weatherproofing jacket that is laminated self-adhesive (minimum 0.05 mm 2 mils adhesive, 0.075 mm 3 mils embossed) less than 0.02 permeability, (greater than 3 ply, standard grade, silver, white, black and embossed or greater than 8 ply (minimum 0.072 mm 2.9 mils adhesive), heavy duty white or natural).

2.4.8 Weatherproof Duct Insulation

Provide [ASTM C552, cellular glass thermal insulation] [ASTM C534/C534M Grade 1, Type II, flexible elastomeric cellular insulation], and

weatherproofing as specified in manufacturer's instruction. Multi-ply, Polymeric Blend Laminate Jacketing: Construction of laminate designed to provide UV resistance, high puncture, tear resistance and an excellent WVT rate.

2.5 EQUIPMENT INSULATION SYSTEMS

Insulate equipment and accessories as specified in Tables 5 and 6. In outside locations, provide insulation 13 mm 1/2 inch thicker than specified. Increase the specified insulation thickness for equipment where necessary to equal the thickness of angles or other structural members to make a smooth, exterior surface. Submit a booklet containing manufacturer's published installation instructions for the insulation systems in coordination with the submitted MICA Insulation Stds plates booklet. Annotate their installation instructions to indicate which product data and which MICA plate are applicable. The instructions must be copyrighted, have an identifying or publication number, and have been published prior to the issuance date of this solicitation. A booklet is also required by paragraphs titled: Pipe Insulation Systems and Duct Insulation Systems.

PART 3 EXECUTION

****

NOTE: Project specifications will contain only the specific pipe or duct systems and equipment in a particular project that require insulation. Lists are not inclusive of systems requiring insulation. Edit, modify, and add to the information contained in the lists as required.

****

3.1 APPLICATION - GENERAL

Apply insulation to unheated and uncooled piping and equipment. Do not compress flexible elastomeric cellular insulation at joists, studs, columns, ducts, and hangers. The insulation must not pull apart after a one hour period; replace any insulation found to pull apart after one hour.

3.1.1 Display Samples

Submit and display, after approval of materials, actual sections of installed systems, properly insulated in accordance with the specification requirements. Such actual sections must remain accessible to inspection throughout the job and will be reviewed from time to time for controlling the quality of the work throughout the construction site. Identify each material used by indicating on an attached sheet the specification requirement for the material and the material by each manufacturer intended to meet the requirement. The Contracting Officer will inspect display sample sections at the jobsite. Keep approved display sample sections on display at the jobsite during the construction period. Upon completion of construction, the display sample sections will be closed and sealed.

3.1.1.1 Pipe Insulation Display Sections

Include as a minimum an elbow or tee, a valve, dielectric waterways and flanges, a hanger with protection shield and insulation insert, or dowel as required, at support point, method of fastening and sealing insulation

at longitudinal lap, circumferential lap, butt joints at fittings and on pipe runs, and terminating points for each type of pipe insulation used on the job, and for hot pipelines and cold pipelines, both interior and exterior, even when the same type of insulation is used for these services.

3.1.1.2 Duct Insulation Display Sections

Display sample sections for rigid and flexible duct insulation used on the job. Use a temporary covering to enclose and protect display sections for duct insulation exposed to weather

3.1.2 Installation

Except as otherwise specified, install material in accordance with the manufacturer's written instructions. Do not apply insulation materials until [tests] [tests and heat tracing] specified in other sections of this specification are completed. Remove material such as rust, scale, dirt and moisture from surfaces to receive insulation. Keep insulaton clean and dry. Do not remove insulation from its shipping containers until the day it is ready to use and return to like containers or equally protect from dirt and moisture at the end of each workday. Thoroughly clean insulation that becomes dirty prior to use. If insulation becomes wet or if cleaning does not restore the surfaces to like new condition, reject the insulation, and immediately remove from the jobsite. Stagger joints on multi layer insulation. Mix mineral fiber thermal insulating cement with demineralized water when used on stainless steel surfaces. Install insulation, jacketing and accessories in accordance with MICA Insulation Stds plates except where modified herein or on the drawings.

3.1.3 Firestopping

Where pipes and ducts pass through fire walls, fire partitions, above grade floors, and fire rated chase walls, seal the penetration with fire stopping materials as specified in Section 07 84 00 FIRESTOPPING. The protection of ducts at point of passage through firewalls must be in accordance with NFPA 90A and NFPA 90B. All other penetrations, such as piping, conduit, and wiring, through firewalls must be protected with a material or system of the same hourly rating that is listed by UL, FM, or a NRTL.

3.1.4 Installation of Flexible Elastomeric Cellular Insulation

Install flexible elastomeric cellular insulation with seams and joints sealed with rubberized contact adhesive. Do not use flexible elastomeric cellular insulation on surfaces greater than 105 degrees C 220 degrees F. Stagger seams when applying multiple layers of insulation. Protect insulation exposed to weather with metal jacketing as recommended by the manufacturer after the adhesive is dry and cured.

3.1.4.1 Adhesive Application

Apply a brush coating of adhesive to both butt ends to be joined and to both slit surfaces to be sealed. Allow the adhesive to set until dry to touch but tacky under slight pressure before joining the surfaces. Ensure insulation seals at seams and joints are not capable of being pulled apart one hour after application. Replace insulation that can be pulled apart one hour after installation.

3.1.4.2 Adhesive Safety Precautions

Use natural cross-ventilation, local (mechanical) pickup, or general area (mechanical) ventilation to prevent an accumulation of solvent vapors, keeping in mind the ventilation pattern must remove any heavier-than-air solvent vapors from lower levels of the workspaces. Gloves and spectacle-type safety glasses are recommended in accordance with safe installation practices.

3.1.5 Welding

Welding is not permitted on piping, duct or equipment without written approval of the Contracting Officer. The capacitor discharge welding process may be used for securing metal fasteners to duct.

3.1.6 Pipes/Ducts/Equipment That Require Insulation

Insulation is required on all pipes, ducts, or equipment, except for omitted items as specified.

3.2 PIPE INSULATION SYSTEMS INSTALLATION

Install pipe insulation systems in accordance with the approved MICA Insulation Stds plates as supplemented by the manufacturer's published installation instructions.

3.2.1 Pipe Insulation

3.2.1.1 General

Install pipe insulation on aboveground hot and cold pipeline systems as specified below to form a continuous thermal retarder/barrier, including straight runs, fittings and appurtenances unless specified otherwise. Install full length units of insulation using a single cut piece to complete a run. Do not use cut pieces or scraps abutting each other. Omit pipe insulation on the following:

a. Air chambers.

b. Adjacent insulation.

c. ASME stamps.

d. Access plates of fan housings.

3.2.1.2 Pipes Passing Through Walls, Roofs, and Floors

****
NOTE: Exterior wall and roof penetration details will be shown on the drawings. See Section 22 00 00 PLUMBING, GENERAL PURPOSE for additional information.
****

Provide continuous pipe insulation through the sleeve.

Provide an aluminum jacket or vapor barrier/weatherproofing self adhesive jacket (minimum 0.05 mm 2 mils adhesive, 0.075 mm 3 mils embossed) less than 0.0000 permeability, greater than 3 ply standard grade, silver, white, black and embossed with factory applied moisture retarder over the

insulation wherever penetrations require sealing.

3.2.1.2.1 Penetrate Interior Walls

Provide aluminum jacket or vapor barrier/weatherproofing - self adhesive jacket (minimum 0.05 mm 2 mils adhesive, 0.075 mm 3 mils embossed) less than 0.02 permeability, greater than 3 plies standard grade, silver, white, black and embossed which extends 50 mm 2 inches beyond either side of the wall and secure on each end with a band.

3.2.1.2.2 Penetrating Floors

Extend the aluminum jacket from a point below the backup material to a point 250 mm 10 inches above the floor with one band at the floor and one not more than 25 mm 1 inch from the end of the aluminum jacket.

3.2.1.2.3 Penetrating Waterproofed Floors

Extend the aluminum jacket from below the backup material to a point 50 mm 2 inches above the flashing with a band 25 mm 1 inch from the end of the aluminum jacket.

3.2.1.2.4 Penetrating Exterior Walls

Continue the aluminum jacket required for pipe exposed to weather through the sleeve to a point 50 mm 2 inches beyond the interior surface of the wall.

3.2.1.2.5 Penetrating Roofs

Insulate pipe as required for interior service to a point flush with the top of the flashing and sealed with flashing sealant. Tightly butt the insulation for exterior application to the top of flashing and interior insulation. Extend the exterior aluminum jacket 50 mm 2 inches down beyond the end of the insulation to form a counter flashing. Seal the flashing and counter flashing underneath with metal jacketing/flashing sealant.

3.2.1.2.6 Hot Water Pipes Supplying Lavatories or Other Similar Heated Service

Terminate the insulation on the backside of the finished wall. Protect the insulation termination with two coats of vapor barrier coating with a minimum total thickness of 2.0 mm 1/16 inch applied with glass tape embedded between coats (if applicable). Extend the coating out onto the insulation 50 mm 2 inches and seal the end of the insulation. Overlap glass tape seams 25 mm 1 inch. Caulk the annular space between the pipe and wall penetration with approved fire stop material. Cover the pipe and wall penetration with a properly sized (well fitting) escutcheon plate. Ensure the escutcheon plate overlaps the wall penetration at least 10 mm 3/8 inches.

3.2.1.2.7 Domestic Cold Water Pipes Supplying Lavatories or Other Similar Cooling Service

Terminate the insulation on the finished side of the wall (i.e., insulation must cover the pipe throughout the wall penetration). Protect the insulation with two coats of weather barrier mastic (breather emulsion type weatherproof mastic impermeable to water and permeable to air) with a

minimum total thickness of 2 mm 1/16 inch. Extend the mastic out onto the insulation 50 mm 2 inches and seal the end of the insulation. Caulk the annular space between the outer surface of the pipe insulation and the wall penetration with an approved fire stop material having vapor retarder properties. Cover the pipe and wall penetration with a properly sized (well fitting) escutcheon plate. Ensure the escutcheon plate overlaps the wall penetration by at least 10 mm 3/8 inches.

3.2.1.3 Pipes Passing Through Hangers

Ensure insulation, whether hot or cold application, is continuous through hangers. Support all horizontal pipes 50 mm 2 inches and smaller on hangers with the addition of a Type 40 protection shield to protect the insulation in accordance with MSS SP-58. Whenever insulation shows signs of being compressed, or when the insulation or jacket shows visible signs of distortion at or near the support shield, install insulation inserts as specified below for piping larger than 50 mm 2 inches, or factory insulated hangers (designed with a load bearing core) can be used.

3.2.1.3.1 Horizontal Pipes Larger Than 50 mm 2 Inches at 16 Degrees C 60 Degrees F and Above

Supported on hangers in accordance with MSS SP-58, and Section 22 00 00 PLUMBING, GENERAL PURPOSE.

3.2.1.3.2 Horizontal Pipes Larger Than 50 mm 2 Inches and Below 16 Degrees C 60 Degrees F

Supported on hangers with the addition of a Type 40 protection shield in accordance with MSS SP-58. Install an insulation insert of cellular glass, prefabricated insulation pipe hangers, or perlite above 27 degrees C 80 degrees F above each shield. Ensure insert covers no less than the bottom 180-degree arc of the pipe. Provide inserts that are the same thickness as the insulation, and extend 50 mm 2 inches on each end beyond the protection shield. When insulation inserts are required in accordance with the above, and the insulation thickness is less than 25 mm 1 inch, wooden or cork dowels or blocks may be installed between the pipe and the shield to prevent the weight of the pipe from crushing the insulation, as an option to installing insulation inserts. Ensure the insulation jacket is continuous over the wooden dowel, wooden block, or insulation insert.

3.2.1.3.3 Vertical Pipes

Supported with either Type 8 or Type 42 riser clamps with the addition of two Type 40 protection shields in accordance with MSS SP-58 covering the 360-degree arc of the insulation. Install an insulation insert of cellular glass or calcium silicate between each shield and the pipe. Ensure the insert covers the 360-degree arc of the pipe. Provide inserts that are the same thickness as the insulation, and extend 50 mm 2 inches on each end beyond the protection shield. When insulation inserts are required in accordance with the above, and the insulation thickness is less than 25 mm 1 inch, wooden or cork dowels or blocks may be installed between the pipe and the shield to prevent the hanger from crushing the insulation, as an option instead of installing insulation inserts. Ensure the insulation jacket is continuous over the wooden dowel, wooden block, or insulation insert. Support the vertical weight of the pipe with hangers located in a horizontal section of the pipe. When the pipe riser is longer than 9 m 30 feet, support the weight of the pipe additionally with hangers in the vertical run of the pipe that are directly clamped to

the pipe, penetrating the pipe insulation. Use insulated hangers and seal the insulation jacket as indicated herein for anchors in a similar service.

3.2.1.3.4 Inserts

Covered with a jacket material of the same appearance and quality as the adjoining pipe insulation jacket, overlap the adjoining pipe jacket 38 mm 1-1/2 inches, and seal as required for the pipe jacket. Use jacket material to cover inserts in flexible elastomeric cellular insulation conforming to ASTM C1136, Type 1, and is allowed to be of a different material than the adjoining insulation material.

3.2.1.4 Flexible Elastomeric Cellular Pipe Insulation

Use tubular form flexible elastomeric cellular pipe insulation for pipe sizes 150 mm 6 inches and less. Grade 1, Do not stretch Type II sheet insulation used on pipes larger than 150 mm 6 inches around the pipe. On pipes larger than 300 mm 12 inches, adhere the insulation directly to the pipe on the lower 1/3 of the pipe. Stagger seams when applying multiple layers of insulation. Insulate sweat fittings with miter-cut pieces the same size as on adjacent piping. Insulate screwed fittings with sleeved fitting covers fabricated from miter-cut pieces and overlap and seal to the adjacent pipe insulation. Type II requires an additional exterior vapor retarder/barrier covering for high relative humidity and below ambient temperature applications.

3.2.1.5 Pipes in High Abuse Areas

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NOTE: In high abuse areas such as janitor closets and traffic areas in equipment rooms and kitchens, aluminum jackets will be shown. Normally, pipe insulation to the 2 m 6 feet level will be protected in high abuse areas. The designer will specifically indicate the high abuse areas.

****

In high abuse areas such as janitor closets and traffic areas in equipment rooms, kitchens, and mechanical rooms, utilize [welded PVC] [stainless steel], aluminum or flexible laminate cladding (comprised of elastomeric, plastic or metal foil laminate) laminated self-adhesive (minimum 0.05 mm 2 mils adhesive, 0.075 mm 3 mils embossed) vapor barrier/weatherproofing jacket, - less than 0.02 permeability; (greater than 3 ply, standard grade, silver, white, black and embossed) [aluminum] jackets. Protect pipe insulation to the 2 m 6 foot level. [Other areas that specifically require protection to the 2 m 6 foot level are [_____].]

3.2.1.6 Pipe Insulation Material and Thickness

****

NOTE: Where the temperature of cold water entering a building is below average dew point of the indoor ambient air and where condensate drip will cause damage or create a hazard, insulate piping with vapor barrier to prevent condensation, regardless to whether piping is above or below ceilings.

Flexible elastomeric and cellular glass are very suitable for chilled water applications. Minimum

thickness recommended for cellular glass insulation is 40 mm 1.5 inches. The reason is that the breakage rate during shipment of 25 mm 1 inch thick cellular insulation is too high to be economical. Flexible elastomeric recommended minimum thickness is 25 mm 1 inch.

For cryogenic equipment handling media between minus 34 and minus 18 degrees C minus 30 and minus 1 degree F, use cellular glass insulation.

In Tables 1 and 3, state if a vapor barrier is required. Pipes and equipment with a temperature below 27 degrees C 80 degrees F should generally be provided with a vapor barrier jacket to prevent sweating. However, engineering judgment should be exercised to determine if a vapor barrier jacket is required. Reference paragraph ABOVEGROUND COLD PIPELINE (-34 TO 16 DEG. C -30 TO 60 DEG. F) for Vapor Retarder/Vapor Barrier requirements.

In Tables 1 and 2, when it is necessary to insulate existing cold water systems or systems that must remain in operation, the Designer may consider using a mineral fiber insulation that meets ASTM C547, with an integral wicking material designed to remove condensed water. The Designer should not consider using a mineral fiber integral wicking material when ambient conditions at the pipe location can be expected to be exposed to any high humidity conditions. High humidity areas are as identified in ASHRAE 90.1 as climate zones 0A, 1A, 2A, 3A, 3C, 4C and 5C. Follow manufacturer's recommendations for installation.

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NOTE: ASHRAE 90.2 is for low-rise residential building. ASHRAE 90.1 is for all buildings except low-rise residential buildings. Low-rise building has one or two stories without elevators. High-rise building has multistory with elevators.

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NOTE: In project locations with Environmental Severity Classification (ESC) of C3, C4 or C5, or high humidity areas as identified in ASHRAE 90.1 as climate zones 0A, 1A, 2A, 3A, 3C, 4C and 5C, use cellular glass in lieu of fiberglass materials to insulate all chilled water, refrigerant and condensate drain lines, including valves, strainers, and fittings when possible. Provide vapor barrier and coatings for all cold piping 60 degrees F and lower. See UFC 1-200-01 for determination of ESC for project locations.

****

Pipe insulation materials must be as listed in Table 1 and must meet or

exceed the requirements of ASHRAE 90.1 - SI ASHRAE 90.1 - IP[ASHRAE 90.2].

TABLE 1					
Insulation Material for Piping					
Service					
	Material	Specification	Type	Class	VR/VB Req'd
Chilled Water (Supply & Return, Dual Temperature Piping, 4.44 C 40 F nominal)					
	Cellular Glass	ASTM C552	II	2	Yes
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		Yes
	[Mineral Fiber with Wicking Material][Do not use in applications exposed to outdoor ambient conditions in climatic zones 1 through 4.]	[ASTM C547]	[I]		[Yes]
	Polyisocyanurate	ASTM C591	I	2	Yes
Heating Hot Water Supply & Return, Heated Oil (Max 121 C 250 F)					
	Mineral Fiber	ASTM C547	I	1	No
	Calcium Silicate	ASTM C533	I		No
	Cellular Glass	ASTM C552	II	2	No
	Faced Phenolic Foam	ASTM C1126	III		Yes
	Flexible Elastomeric Cellular	ASTM C534/C534M	I	2	No
	Polyisocyanurate Max temp 60C 140F	ASTM C591	I	2	Yes
Cold Domestic Water Piping, Makeup Water, and Condenser Water Piping					
	Cellular Glass	ASTM C552	II	2	No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Hot Domestic Water Supply & Recirculating Piping (Max 93 C 200 F)					
	Mineral Fiber	ASTM C547	I	1	No
	Cellular Glass	ASTM C552	II	2	No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
	Faced Phenolic Foam	ASTM C1126	III		Yes
Refrigerant Suction Piping (1.67 degrees C35 degrees F nominal)					
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No

TABLE 1

Insulation Material for Piping

Service					
	Material	Specification	Type	Class	VR/VB Req'd
	Cellular Glass	ASTM C552	II	1	Yes
Compressed Air Discharge, Steam and Condensate Return (94 to 121 Degrees C201 to 250 Degrees F					
	Cellular Glass	ASTM C552	II		No
	Mineral Fiber	ASTM C547	I	1	No
	Calcium Silicate	ASTM C533	I		No
	Faced Phenolic Foam	ASTM C1126	III		Yes
	Perlite	ASTM C610			No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I	2	No
Exposed Lavatory Drains, Exposed Domestic Water Piping & Drains to Areas for Handicapped Personnel					
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Condensate Drain Located Inside Building					
	Cellular Glass	ASTM C552	II	2	No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Medium Temperature Hot Water, Steam and Condensate (122 to 176 Degrees C251 to 350 Degrees F)					
	Mineral Fiber	ASTM C547	I	1	No
	Calcium Silicate	ASTM C533	I		No
	Cellular Glass	ASTM C552	I or II		No
High Temperature Hot Water & Steam (177 to 371 Degrees C351 to 700 Degrees F)					
	Mineral Fiber	ASTM C547	I	2	No
	Calcium Silicate	ASTM C533	I		No
	Cellular Glass	ASTM C552			No
Brine Systems Cryogenics (-34 to -18 Degrees C-30 to 0 Degrees F)					
	Cellular Glass	ASTM C552	II	2	No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Brine Systems Cryogenics (-18 to 1.11 Degrees C0 to 34 Degrees F)					
	Cellular Glass	ASTM C552	II	2	No

TABLE 1					
Insulation Material for Piping					
Service					
	Material	Specification	Type	Class	VR/VB Req'd
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Note: VR/VB = Vapor Retarder/Vapor Barrier					

****

NOTE: Table 2 is not inclusive of all systems requiring insulation. Pipe insulation thicknesses must meet or exceed the requirements of ASHRAE 90.2 for low-rise residential buildings, and ASHRAE 90.1 for all other buildings except low-rise residential. Edit, modify, and add to the information contained in Tables 1 and 2 as required for the project. Use Table 6.8.3-1 and Table 6.8.3-2 in ASHRAE 90.1 for minimum thickness in buildings other than low-rise residential. Insulation thicknesses listed in Table 2 are calculated based on ASHRAE 90.1 using the referenced conductivity (K-value) shown for the insulation material (except as noted below for cellular glass) and the upper limit of the given temperature range. Insulation thicknesses may be reduced from listed table values based on engineering calclulations. Required insulation thickness should be similarly calculated for different materials if the K-value is outside the ranges listed in ASHRAE 90.1 Table 6.8.3-1 and 6.8.3-2. For low-rise residential buildings, refer to Table 6-4 of ASHRAE 90.2 for Minimum Pipe Insulation. These tables will become a part of the project specifications.

Where the temperature of cold water entering a building is below average dew point of the indoor ambient air and where condensate drip will cause damage or create a hazard, insulate piping with vapor barrier to prevent condensation, regardless to whether piping is above or below ceilings.

Flexible elastomeric and cellular glass are very suitable for chilled water applications. Minimum thickness recommended for cellular glass insulation is 40 mm 1.5 inches. The reason is that the breakage rate during shipment of 25 mm 1 inch thick cellular insulation is too high to be economical. Flexible elastomeric recommended minimum thickness is 25 mm 1 inch

For cryogenic equipment handling media between minus 34 and minus 18 degrees C 30 and minus 1 degree F, use cellular glass.

****

TABLE 2

Piping Insulation Thickness (mminch)

For flexible cellular foam the thickness should be 13mm instead of 15mm. Economic thickness or prevention of condensation is the basis of these tables. If prevention of condensation is the criterion, the ambient temperature and relative humidity must be stated. Do not use integral wicking material in Chilled water applications exposed to outdoor ambient conditions in climatic zones 1 through 4.

Service	Material	Conductivity K-value (W/m^2-K) (Btu-in/ hr-ft^2-deg F)	Tube And Pipe Size (mm) (inch)				
			<25 <1	25-<40 1-<1.5	40-<100 1.5-<4	100-<200 4-<8	> or = 200>8
[Chilled Water (Supply & Return, Dual Temperature Piping, 4.44 Degrees C 40 Degrees F nominal)]							
	Cellular Glass	0.043 0.30	40 1.5	401.5	401.5	401.5	502
	Flexible Elastomeric Cellular	0.034 0.235	251	251	251	N/A	N/A
	Mineral Fiber with Wicking Material	0.032 0.22	251	401.5	401.5	502	502
	Polyisocyanurate	0.026 0.18	13 0.5	25 1	25 1	25 1	40 1.5
Heating Hot Water Supply & Return, Heated Oil (Max 121 C 250 F)							
	Mineral Fiber	0.039 0.27	65 2.5	652.5	652.5	75 3	75 3
	Calcium Silicate	0.053 0.37	100 4	100 4	100 4	100 4	1004
	Cellular Glass		90 3.5	90 3.5	90 3.5	100 4	100 4
	Faced Phenolic Foam	0.035 0.24	65 2.5	65 2.5	65 2.5	75 3	75 3
	Polyisocyanurate Max temp 60C 140F	0.033 0.23	25 1	25 1	40 1.5	40 1.5	40 1.5

TABLE 2

Piping Insulation Thickness (mminch)
For flexible cellular foam the thickness should be 13mm instead of 15mm. Economic thickness or prevention of condensation is the basis of these tables. If prevention of condensation is the criterion, the ambient temperature and relative humidity must be stated. Do not use integral wicking material in Chilled water applications exposed to outdoor ambient conditions in climatic zones 1 through 4.

Service	Material	Conductivity K-value (W/m^2-K) (Btu-in/ hr-ft^2-deg F)	Tube And Pipe Size (mm) (inch)				
			<25 <1	25-<40 1-<1.5	40-<100 1.5-<4	100-<200 4-<8	> or = 200>8
Cold Domestic Water Piping, Makeup Water, and Condenser Water							
	Cellular Glass	0.043 0.30	40 1.5	401.5	401.5	401.5	401.5
	Flexible Elastomeric Cellular	0.034 0.235	251	251	251	N/A	N/A
Hot Domestic Water Supply & Recirculating Piping (Max 93 C 200 F)							
	Mineral Fiber	0.037 0.26	40 1.5	40 1.5	50 2	50 2	50 2
	Cellular Glass	0.049 0.34	50 2	50 2	65 2.5	65 2.5	65 2.5
	Flexible Elastomeric Cellular	0.043 0.30	40 1.5	40 1.5	50 2	N/A	N/A
Refrigerant Suction Piping (1.67 degrees C35 degrees F nominal)							
	Flexible Elastomeric Cellular	0.034 0.235	251	251	251	N/A	N/A
	Cellular Glass	0.042 0.29	40 1.5	401.5	401.5	401.5	401.5
Compressed Air Discharge, Steam and Condensate Return (94 to 121 Degrees C201 to 250 Degrees F							
	Mineral Fiber	0.039 0.27	65 2.5	65 2.5	65 2.5	75 3	75 3
	Calcium Silicate	0.053 0.37	65 2.5	803	1004	1004	1154.5
	Cellular Glass	0.050 0.35	502	652.5	803	803	803

TABLE 2

Piping Insulation Thickness (mminch)
For flexible cellular foam the thickness should be 13mm instead of 15mm. Economic thickness or prevention of condensation is the basis of these tables. If prevention of condensation is the criterion, the ambient temperature and relative humidity must be stated. Do not use integral wicking material in Chilled water applications exposed to outdoor ambient conditions in climatic zones 1 through 4.

Service	Material	Conductivity K-value (W/m^2-K) (Btu-in/ hr-ft^2-deg F)	Tube And Pipe Size (mm) (inch)				
			<25 <1	25-<40 1-<1.5	40-<100 1.5-<4	100-<200 4-<8	> or = 200>8
Exposed Lavatory Drains, Exposed Domestic Water Piping & Drains to Areas for Handicapped Personnel							
	Flexible Elastomeric Cellular		13 0.5	130.5	130.5	130.5	130.5
Condensate Drain Located Inside Building							
	Cellular Glass	0.043 0.30	40 1.5	401.5	401.5	401.5	401.5
	Flexible Elastomeric Cellular	0.034 0.235	251	251	251	N/A	N/A
Medium Temperature Hot Water, Steam and Condensate (122 to 176 Degrees C251 to 350 Degrees F)							
	Mineral Fiber	0.042 0.29	65 2.5	90 3.5	100 4	115 4.5	115 4.5
	Calcium Silicate	0.056 0.39	125 5	165 6.5	165 6.5	165 6.5	165 6.5
High Temperature Hot Water & Steam (177 to 371 Degrees C351 to 700 Degrees F)							
	Mineral Fiber	0.046 0.32	115 4.5	125 5	125 5	125 5	125 5
	Calcium Silicate	0.059 0.41	115 4.5	125 5	1506	1506	1506
Brine Systems Cryogenics (-34 to -18 Degrees C-30 to 0 Degrees F)							
	Cellular Glass	0.036 0.25	65 2.5	652.5	803	803	903.5

TABLE 2

Piping Insulation Thickness (mminch)
For flexible cellular foam the thickness should be 13mm instead of 15mm. Economic thickness or prevention of condensation is the basis of these tables. If prevention of condensation is the criterion, the ambient temperature and relative humidity must be stated. Do not use integral wicking material in Chilled water applications exposed to outdoor ambient conditions in climatic zones 1 through 4.

Service							
	Material	Conductivity K-value (W/m^2-K) (Btu-in/ hr-ft^2-deg F)	Tube And Pipe Size (mm) (inch)				
			<25 <1	25-<40 1-<1.5	40-<100 1.5-<4	100-<200 4-<8	> or = 200>8
	Flexible Elastomeric Cellular	0.35 0.24	251	251	N/A	N/A	N/A
Brine Systems Cryogenics (-18 to 1.11 Degrees C0 to 34 Degrees F)							
	Cellular Glass	0.042 0.29	502	502	502	652.5	803
	Flexible Elastomeric Cellular	0.039 0.26	251	251	251	N/A	N/A

3.2.2 Aboveground Cold Pipelines

Insulate the following cold pipelines for minus 34 to plus 16 degrees C minus 30 to plus 60 degrees F in accordance with Table 2 except those piping listed in subparagraph Pipe Insulation in PART 3 as to be omitted. This includes but is not limited to the following:

a. Make-up water.

b. Horizontal and vertical portions of interior roof drains.

c. Refrigerant suction lines.

d. Chilled water.

e. Dual temperature water, i.e. HVAC hot/chilled water.

f. Air conditioner condensate drains.

g. Brine system cryogenics.

h. Condenser water piping where pipe temperature may fall below ambient dew point.

i. Exposed lavatory drains and domestic water lines serving plumbing fixtures for handicap persons.

[
j. Domestic cold and chilled drinking water.]

3.2.2.1 Insulation Material and Thickness

****

NOTE: Table 1 is not all inclusive of service insulation requirements. Edit, modify, and add to the tables as required for your project. Consideration may be given to increasing or decreasing the thickness of insulation required if, in the judgment of the designer, the situation warrants. For example, hot water piping in conditioned spaces may not require the tabulated thickness; or extremely cold systems in a high humidity climate may require additional insulation.

The designer should take into consideration the dew point temperature of the area in which the system is to be built. This is separate from the design dry bulb and design wet bulb temperatures, and should not be confused with the information provided in UFC 3-400-02. When accounting for the dew point for design of the insulation thickness, consider using a relative humidity range of 80 to 90 percent unless you are in unusual circumstances. In very dry environments (Denver) consider using a relative humidity less than 80 percent, and remember to meet the requirements of the energy budget. In lower humidity environments, use the lower end of this range outdoors (80 to 85 percent). In high humidity environments use 90 percent. Indoors, where the humidity is to be controlled at 50 percent, it is more appropriate to design to 70 percent.

ASHRAE 90.1 insulation standard is a reference the designer should use to introduce a different material, or utilize an existing material type for an application that is not listed, or is outside the temperature range listed in Table 2. Table 2 may be modified for regions that meet one of the following conditions from UFC 3-410-01 or UFC 3-410-02. A wet bulb temperature of 19 degrees C 67 degrees F or higher and the outside design relative humidity is 50 percent or higher (dew point temperature greater than 16 C 60 F) for 3,000 hours or more. A wet bulb temperature of 22.8 degrees C 73 degrees F or higher and the outside design relative humidity is 50 percent or higher (dew point temperature greater than 19 C 67 F) for 1,500 hours or more. (Outside design relative humidity based on the 2.5 percent dry bulb and 5.0 percent wet bulb temperatures.) (Weather data obtained from UFC 3-400-02.)

Further references for recommended thickness includes the International Mechanical Code and manufacturers recommended thickness tables. The refrigerant suction piping thickness was determined for 1 degree C 35 degrees F service and the chilled

water supply and return and dual temperature piping thickness was determined for 4 degrees C 40 degrees F nominal service temperature.

****

Determine insulation thickness for cold pipelines using Table 2.

3.2.2.2 Factory or Field applied Jacket

****

NOTE: In high abuse areas such as janitor closets and traffic areas in equipment rooms and kitchens, aluminum jackets or PVC jackets and fittings will be shown. Normally, pipe insulation to the 2 m 6 foot level will be protected in high abuse areas. The designer will specifically indicate what pipes are to be provided with aluminum jackets, PVC jackets, and fittings (see paragraph 2.3.8.2 for PVC selection criteria). On overseas projects, designer to verify availability of labor at locale for insulation trade; if not available delete option for field applied jacket. If stateside, option for field applied jacket to remain.

****

Cover insulation with a factory applied vapor retarder jacket/vapor barrier or [field applied] seal welded PVC jacket or greater than 3 ply laminated self-adhesive (minimum 0.05 mm 2 mils adhesive, 0.075 mm 3 mils embossed) vapor barrier/weatherproofing jacket - less than 0.02 permeability, standard grade, sliver, white, black and embossed for use with Mineral Fiber, Cellular Glass, and Phenolic Foam Insulated Pipe. For insulation inside the building, to be protected with an aluminum jacket, PVC jacket or fittings (installed over a vapor retarder jacket), or greater than 3 ply vapor barrier/weatherproofing self-adhesive (minimum 0.05 mm 2 mils adhesive, 0.075 mm 3 mils embossed) product, less than 0.02 permeability, standard grade, Embossed Silver, White & Black, install the insulation and vapor retarder jacket as specified herein. Install the aluminum jacket, PVC jacket or fittings (installed over a vapor retarder jacket), or greater than 3 ply vapor barrier/weatherproofing self-adhesive (minimum 0.05 mm 2 mils adhesive, 0.075 mm 3 mils embossed) product, less than 0.02 permeability, standard grade, embossed silver, White & Black, as specified for piping exposed to weather, except sealing of the laps of the aluminum jacket is not required. In high abuse areas such as janitor closets and traffic areas in equipment rooms, kitchens, and mechanical rooms, provide aluminum jackets, PVC jacket or fittings (installed over a vapor retarder jacket), or greater than 3 ply vapor barrier/weatherproofing self-adhesive (minimum0.05 mm 2 mils adhesive, 0.075 mm 3 mils embossed) product, less than 0.02 permeability, standard grade, embossed silver, white & black, for pipe insulation to the 1.8 m 6 ft level. Other areas that specifically require protection to the 1.8 m 6 ft level are [_____].

3.2.2.3 Installing Insulation for Straight Runs Hot and Cold Pipe

Apply insulation to the pipe with tight butt joints. Seal all butted joints and ends with joint sealant and seal with a vapor retarder coating, greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape or PVDC adhesive tape.

3.2.2.3.1 Longitudinal Laps of the Jacket Material

Overlap not less than 38 mm 1-1/2 inches. Provide butt strips 75 mm 3 inches wide for circumferential joints.

3.2.2.3.2 Laps and Butt Strips

Secure with adhesive and staple on 100 mm 4 inch centers if not factory self-sealing. If staples are used, seal in accordance with paragraph STAPLES below. Note that staples are not required with cellular glass systems.

3.2.2.3.3 Factory Self-Sealing Lap Systems

May be used when the ambient temperature is between 4 and 50 degrees C 40 and 120 degrees F during installation. Install the lap system in accordance with manufacturer's recommendations. Use a stapler only if specifically recommended by the manufacturer. Where gaps occur, replace the section or repair the gap by applying adhesive under the lap and then stapling.

3.2.2.3.4 Staples

Coat all staples, including those used to repair factory self-seal lap systems, with a vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - 0.0000 perm adhesive tape. Coat all seams, except those on factory self-seal systems, with vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape.

3.2.2.3.5 Breaks and Punctures in the Jacket Material

Patch by wrapping a strip of jacket material around the pipe and secure it with adhesive, staple, and coat with vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape. Extend the patch not less than 38 mm 1-1/2 inches past the break.

3.2.2.3.6 Penetrations Such as Thermometers

Fill the voids in the insulation and seal with vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape.

3.2.2.3.7 Flexible Elastomeric Cellular Pipe Insulation

Install by slitting the tubular sections and applying them onto the piping or tubing. Alternately, whenever possible slide un-slit sections over the open ends of piping or tubing. Secure all seams and butt joints and seal with adhesive. When using self seal products, secure only the butt joints with adhesive. Push insulation on the pipe, never pulled. Stretching of insulation may result in open seams and joints. Clean cut all edges. Rough or jagged edges of the insulation are not be permitted. Use proper tools such as sharp knives. Do not stretch Grade 1, Type II sheet insulation around the pipe when used on pipe larger than 150 mm 6 inches. On pipes larger than 300 mm 12 inches, adhere sheet insulation directly to the pipe on the lower 1/3 of the pipe.

3.2.2.4 Insulation for Fittings and Accessories

a. Butt pipe insulation tightly to the insulation of the fittings and accessories. Seal the butted joints and ends with joint sealant and seal with a vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape.

b. Place precut or preformed insulation around all fittings and accessories and conform to MICA plates except as modified herein: 5 for anchors; 10, 11, and 13 for fittings; 14 for valves; and 17 for flanges and unions. Insulation must be the same insulation as the pipe insulation, including same density, thickness, and thermal conductivity. Where precut/preformed is unavailable, rigid preformed pipe insulation sections may be segmented into the shape required. Use insulation of the same thickness and conductivity as the adjoining pipe insulation. If nesting size insulation is used, overlap the insulation 50 mm 2 inches or one pipe diameter. Elbows insulated using segments must conform to MICA Tables 12.20 "Mitered Insulation Elbow'. Submit a booklet containing completed MICA Insulation Stds plates detailing each insulating system for each pipe, duct, or equipment insulating system, after approval of materials and prior to applying insulation.

(1) Ensure MICA plates detail the materials to be installed and the specific insulation application. Submit all MICA plates required showing the entire insulating system, including plates required to show insulation penetrations, vessel bottom and top heads, legs, and skirt insulation as applicable. Present all variations of insulation systems including locations, materials, vaporproofing, jackets and insulation accessories.

(2) If the Contractor elects to submit detailed drawings instead of edited MICA Plates, ensure the detail drawings are technically equivalent to the edited MICA Plate submittal.

c. Upon completion of insulation installation on flanges, unions, valves, anchors, fittings and accessories, terminations, seams, joints and insulation not protected by factory vapor retarder jackets or PVC fitting covers must be protected with PVDC or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape or two coats of vapor retarder coating with a minimum total thickness of 2 mm 1/16 inch, applied with glass tape embedded between coats. Overlap tap seams 25 mm 1 inch. Extend the coating out onto the adjoining pipe insulation 50 mm 2 inches. Protect fabricated insulation with a factory vapor retarder jacket with either greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape, standard grade, silver, white, black and embossed or PVDC adhesive tape or two coats of vapor retarder coating with a minimum thickness of 2 mm 1/16 inch and with a 50 mm 2 inch wide glass tape embedded between coats. Where fitting insulation butts to pipe insulation, seal the joints with a vapor retarder coating and a 100 mm 4 inch wide ASJ tape which matches the jacket of the pipe insulation.

d. Insulate anchors attached directly to the pipe for a sufficient distance to prevent condensation but no less than 150 mm 6 inches from the insulation surface.

e. Mark insulation to show the location of unions, strainers, and check valves.

3.2.2.5 Optional PVC Fitting Covers

At the option of the Contractor, premolded, one or two piece PVC fitting covers may be used in lieu of the vapor retarder and embedded glass tape. Factory precut insulation inserts or premolded insulation segments must be used under the fitting covers for elbows, tees and other miscellaneous configurations. Insulation inserts must be the same installed insulation thickness. One insert must be installed for each inch of pipe insulation. The installed and compressed insert must have the same thermal performance as the pipe insulation. Premolded insulation segments must be the same insulation as the pipe insulation including same density, thickness, and thermal conductivity. PVC fitting covers must be secured by PVC vapor retarder tape, adhesive, seal welding or with tacks made for securing PVC covers. For above ambient pipe temperatures, secure PVC covers using tacks. As an option circumferential joints can be covered with PVC vapor retarder tape. For below ambient conditions seal system using PVC vapor retarder tape, and vapor retarder mastic with vapor dams. Longitudinal seams may be sealed with vapor retarder mastic, PVC vapor retarder tape or solvent weld adhesive to obtain a continuous vapor seal. For severe service conditions install PVC jackets over the existing ASJ jacket and seal using a solvent weld adhesive.

3.2.3 Aboveground Hot Pipelines

3.2.3.1 General Requirements

Insulate all hot pipe lines above 16 degrees C 60 degrees F, except those piping listed in subparagraph Pipe Insulation in PART 3 as to be omitted, in accordance with Table 2. This includes but is not limited to the following:

a. Domestic hot water supply & re-circulating system.

b. Steam.

c. Condensate & compressed air discharge.

d. Hot water heating.

e. Heated oil.

f. Water defrost lines in refrigerated rooms.

Cover insulation, in accordance with manufacturer's recommendations, with a factory applied Type I jacket or field applied aluminum where required or seal welded PVC.

3.2.3.2 Insulation for Fittings and Accessories

Butt pipe insulation tightly to the insulation of the fittings and accessories. Seal butted joints and ends with joint sealant. Mark insulation to show the location of unions, strainers, check valves and other components that would otherwise be hidden from view by the insulation.

3.2.3.2.1 Precut or Preformed

Place precut insulation inserts or preformed insulation inserts around all

fittings and accessories. Insulation inserts must be the same installed insulation thickness as the pipe insulation. One insert must be installed for each inch of pipe insulation thickness. The installed and compressed insert must have the same thermal performance as the pipe insulation. Preformed insulation inserts must be the same insulation as the pipe insulation including same density, thickness, and thermal conductivity.

3.2.3.2.2 Rigid Preformed

Where precut/preformed is unavailable, rigid preformed pipe insulation sections may be segmented into the shape required. Use insulation that is the same thickness and conductivity as the adjoining pipe insulation. If nesting size insulation is used, do not overlap insulation 50 mm 2 inches or one pipe diameter. Elbows insulated using segments must conform to MICA Tables 12.20 "Mitered Insulation Elbow".

3.2.4 Piping Exposed to Weather

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NOTE: In project locations with Environmental Severity Classification (ESC) of C4 or C5 or high humid areas as identified in ASHRAE 90.1 as climate zones 0A, 0B, 1A, 1B, 2A, 2B, 3A, 3B, 3C, 4A, 4B, 4C, 5A, 5B, and 5C, provide aluminum or stainless steel jacket on piping exposed to weather. See UFC 1-200-01 for determination of ESC for project locations. Polymer jacketing is not recommended as it can experience degradation in UV light in any ASHRAE zone.

****

Insulate and jacket piping exposed to weather as specified for the applicable service inside the building. After this procedure, apply a laminated self-adhesive (minimum 0.05 mm 2 mils adhesive, 0.075 mm 3 mils embossed) vapor barrier/weatherproofing jacket - less than 0.02 permeability (greater than 3 ply, standard grade, silver, white, black and embossed aluminum jacket, stainless steel or PVC jacket.

PVC jacketing requires no factory-applied jacket beneath it, however apply an all service jacket if factory applied jacketing is not furnished.

3.2.4.1 Aluminum Jacket

The jacket for hot piping may be factory applied. Overlap the jacket no less than 50 mm 2 inches at longitudinal and circumferential joints and secure with bands at no more than 300 mm 12 inch centers. Overlap longitudinal joints down to shed water and locate at 4 or 8 o'clock positions. Seal joints on piping 16 degrees C 60 degrees F and below with metal jacketing/flashing sealant while overlapping to prevent moisture penetration. Where jacketing on piping 16 degrees C 60 degrees F and below abuts an un-insulated surface, caulk joints to prevent moisture penetration. Seal joints on piping above 16 degrees C 60 degrees F with a moisture retarder.

3.2.4.2 Insulation for Fittings

Insulate and finish flanges, unions, valves, fittings, and accessories as specified for the applicable service. Apply two coats of breather emulsion type weatherproof mastic (impermeable to water, permeable to air)

recommended by the insulation manufacturer with glass tape embedded between coats. Overlap tap no less than 25 mm 1 inch and the adjoining aluminum jacket no less than 50 mm 2 inches. Factory preformed aluminum jackets may be used in lieu of the above. Provide molded PVC fitting covers when PVC jackets are used for straight runs of pipe.PVC fitting covers must be sealed based upon the pipe temperature in combination with ambient conditions and if the pipe insulation will be exposed to severe service conditions. For below ambient conditions, the pipe insulation and insulation fittings must be covered and sealed with a vapor barrier or weatherproofing jacket with a minimum 0.02 permeability as defined per ASTM C1136 before installing the PVC jacket and fitting cover. When in doubt as to the pipe temperature or service conditions, secure the PVC jacket using a weld adhesive using the manufacturer's recommended adhesive.

3.2.4.3 PVC Jacket

Provide ultraviolet resistant PVC jacket that is adhesive welded weather tight with manufacturer's recommended adhesive. Include provision for thermal expansion.

3.2.4.4 Stainless Steel Jackets

ASTM A240/A240M; Type 304, minimum thickness of 33 gauge (0.25 mm0.010 inch), smooth surface with factory-applied polyethylene and kraft paper moisture barrier on inside surface. Provide stainless steel bands, minimum width of 13 mm1/2 inch.

3.2.5 Below Ground Pipe Insulation

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NOTE: Where significant amounts (approximately 8 meters 25 feet) of below grade piping is to be insulated, a separate specification section will be developed to allow factory pre-insulated systems as an alternate to field applied systems. Portions of the underground piping that are to be insulated using this paragraph will be indicated on the drawings.

****

Insulate below ground pipes in accordance with Table 2, except as precluded in paragraph PIPE INSULATION in PART 3. This includes, but is not limited to the following:

a. Heated oil.

b. Domestic hot water.

c. Heating hot water.

d. Dual temperature water.

e. Steam.

f. Condensate.

3.2.5.1 Type of Insulation

Insulate below ground pipe with Cellular Glass insulation, in accordance

with manufacturer's instructions for application with thickness as determined from Table 2 (whichever is the most restrictive).

3.2.5.2 Installation of Below ground Pipe Insulation

a. Coat bore surfaces of the insulation with a thin coat of gypsum cement of a type recommended by the insulation manufacturer. Ensure coating thickness is sufficient to fill surface cells of insulation. Do not use mastic type materials for this coating. Note that unless this is for a cyclic application (i.e., one that fluctuates between high and low temperature on a daily process basis) there is no need to bore coat the material.

b. Use stainless steel bands, 19 mm 3/4 inch wide by 0.508 mm 0.020 inch thick to secure insulation in place. Apply a minimum of two bands per section of insulation. As an alternate, fiberglass reinforced tape may be used to secure insulation on piping up to 300 mm 12 inches in diameter. Apply a minimum of two bands per section of insulation.

c. Terminate insulation at anchor blocks but continue through sleeves and manholes.

d. At point of entry to buildings, terminate underground insulation 50 mm 2 inches inside the wall or floor, butt tightly against the aboveground insulation and seal the butt joint with high temperature silicone sealant and cover with fibrous glass tape.

e. Make provision for expansion and contraction of the insulation system in accordance with the insulation manufacturer's recommendations.

f. Insulate flanges, couplings, valves, and fittings with factory pre-molded, prefabricated, or field-fabricated sections of insulation of the same material and thickness as the adjoining pipe insulation. Secure insulation sections as recommended by the manufacturer.

g. Finish insulation, including fittings, with three coats of asphaltic mastic, with 6 by 5.5 mesh synthetic reinforcing fabric embedded between coats. Overlap fabric a minimum of 50 mm 2 inches at joints. Ensure total film thickness is a minimum of 4.7 mm 3/16 inch. As an alternate, apply a prefabricated bituminous laminated jacket, reinforced with internal reinforcement mesh, to the insulation. Use jacketing material and application procedures that match manufacturer's written instructions. Vapor barrier - less than 0.02 permeability self adhesive (minimum 0.05 mm 2 mils adhesive, 0.075 mm 3 mils embossed) jacket greater than 3 ply, standard grade, silver, white, black and embossed or greater than 8 ply (minimum 0.072 2.9 mils adhesive), heavy duty, white or natural). Use application procedures that match the manufacturer's written instructions.

h. At termination points, other than building entrances, use mastic and cloth or tape to cover the ends of insulation and extend 50 mm 2 inches along the bare pipe.

3.3 DUCT INSULATION SYSTEMS INSTALLATION

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NOTE: Insulation may be omitted on heating duct in heated spaces. Designer will determine if internally lined ducts are comparable in insulating

value to those unlined ducts to be insulated. If not, field insulation will be added.

The designer must maintain conditioned space control under cooling and heating conditions - meet the energy budget, and not allow condensation formation. The following do not require insulation: factory fabricated double wall internally insulated duct, glass fiber duct, site-erected air conditioning casings and plenums constructed of factory-insulated sheet metal panels, ducts internally lined with insulation or sound absorbing material, unless indicated otherwise, return ducts in ceiling spaces or as indicated, supply ducts in ceiling spaces which are used as return air plenums (or as indicated), factory pre-insulated flexible ducts, ducts within HVAC equipment, exhaust air ducts unless noted, and duct portions inside walls or floor-ceiling space in which both sides of the space are exposed to conditioned air and the space is not vented or exposed to unconditioned air.

In humid locations identified in ASHRAE 90.1 as Climate Zones 0A, 1A, 2A, 3A, 3C, 4C and 5C, exposed outdoor duct must be factory fabricated double wall internally insulated duct.

Ceiling spaces are defined as those spaces between the ceiling and bottom of floor deck or roof deck inside the air-conditioned space insulated envelope, and ceilings that form plenums.

ASHRAE 90.2 is for low-rise residential building. ASHRAE 90.1 is for all buildings except low-rise residential buildings. Low-rise building has one or two stories without elevators. High-rise building has multistory with elevators.

****

Install duct insulation systems in accordance with the approved MICA Insulation Stds plates as supplemented by the manufacturer's published installation instructions. Duct insulation minimum thickness and insulation level must be as listed in Table 3 at the discretion of the designer and must meet or exceed the requirements of ASHRAE 90.1 - SI ASHRAE 90.1 - IP[ASHRAE 90.2].

Except for oven hood exhaust duct insulation, install corner angles on external corners of insulation on ductwork in exposed finished spaces before covering with jacket. [Omit duct insulation on exposed supply and return ducts in air conditioned spaces [where the difference between supply air temperature and room air temperature is less than 9 degrees C 15 degrees F] unless otherwise shown.] Air conditioned spaces are defined as those spaces directly supplied with cooled conditioned air (or provided with a cooling device such as a fan-coil unit) and heated conditioned air (or provided with a heating device such as a unit heater, radiator or convector).

3.3.1 Duct Insulation Minimum Thickness

****

NOTE: The following tables are adapted from ASHRAE 90.1. They may be used to modify the thicknesses listed in Table 4. The thicknesses listed are recommended, and may be changed at the discretion of the designer. Duct insulation thicknesses must meet or exceed the requirements of ASHRAE 90.2 for low-rise residential buildings, and ASHRAE 90.1 for all other buildings except low-rise residential.

Use Table 6.8.2 Minimum Duct Insulation R-Value in ASHRAE 90.1 R-value for buildings other than low-rise residential. For low-rise residential buildings use minimum duct insulation requirements included in ASHRAE 90.2.

****

Table 3				
Minimum Duct Insulation				
	Cooling		Heating	
Duct Location	Annual Cooling Degree Days Base 18 C 65 F	Insulation R-Value (sm K)/W (h sf F)/Btu	Annual Heating Degree Days Base 18 C 65 F	Insulation R-Value (sm K)/W (h sf F)/Btu
Exterior of Building	<260 500	0.58 3.3	<816 1500	0.58 3.3
	260 - 621500 - 1150	0.88 5.0	816 - 24821500 - 4500	0.88 5.0
	622 - 10931151 - 2000	1.14 6.5	2483 - 41494501 - 7500	1.14 6.5
	>10932000	1.41 8.0	>41497500	1.41 8.0
	Temperature Difference	Insulation R-Value (sm K)/W (h sf F)/Btu	Temperature Difference degrees C degrees F	Insulation R-Value (sm K)/W (h sf F)/Btu
Inside building envelope or in unconditioned spaces	<815	None required	<815	None required
	8 <TD <2215 <TD <40	0.58 3.3	8 <TD <2215 <TD <40	0.58 3.3
	22 <TD40 <TD	0.88 5.0	22 <TD40 <TD	0.88 5.0

Table 3		
Minimum Duct Insulation		
	Cooling	Heating
These R-values do not include the film resistances. The required minimum thicknesses do not consider water vapor transmission and condensation. Additional insulation, vapor retarders, or both, may be required to limit vapor transmission and condensation. Where ducts are designed to convey both heated and cooled air, provide duct insulation as required by the most restrictive condition. Where exterior walls are used as plenum walls, provide wall insulation as required by the most restrictive condition of this section or the insulation for the building envelope. Cooling ducts are those designed to convey mechanically cooled air or return ducts in such systems. Heating ducts are those designed to convey mechanically heated air or return ducts in such systems. Thermal resistance will be measured in accordance with ASTM C518 at a mean temperature of 24 degrees C 75 degrees F. The Temperature difference is at design conditions between the space within which the duct is located and the design air temperature in the duct. Resistance for runouts to terminal devices less than 3 m 10 feet in length need not exceed 0.58 (sm K)/W 3.3 (h sf F)/Btu. Unconditioned spaces include crawlspaces and attics.		

Duct insulation minimum thickness in accordance with Table 4.

Table 4 - Minimum Duct Insulation (mm) (inches)	
Cold Air Ducts	50 2.0
Relief Ducts	40 1.5
Fresh Air Intake Ducts	40 1.5
Warm Air Ducts	50 2.0
Relief Ducts	40 1.5
Fresh Air Intake Ducts	40 1.5

3.3.2 Insulation and Vapor Retarder/Vapor Barrier for Cold Air Duct

****

NOTE: Cold air ducts needing insulation are ducts that handle air at or below 16 degrees C 60 degrees F. Mixing boxes, relief air ducts, and filter boxes should not be insulated unless condensation is a problem. Insulation may be omitted on that portion of return air ducts installed in the ceiling spaces where condensation is not a problem, and on that portion of supply ducts installed in ceiling spaces used as a return air plenum where condensation is not a problem. The designer is required to provide

calculations to prove, if insulation is not provided for ducts or equipment, the space will be properly cooled and condensation will not form on ductwork or equipment. For ducts to be used for both heating and cooling, the requirements for cold ducts will govern.

****

****

NOTE: Insulate all supply and return ductwork in humid locations. Humid locations are those in ASHRAE climate zones 0A, 1A, 2A, 3A, 3C, 4C and 5C (as identified in ASHRAE 90.1).

****

Provide insulation and vapor retarder/vapor barrier for the following cold air ducts and associated equipment.

a. Supply ducts.

b. Return air ducts.

c. Relief ducts.

d. Flexible run-outs (field-insulated).

e. Plenums.

f. Duct-mounted coil casings.

g. Coil headers and return bends.

h. Coil casings.

i. Fresh air intake ducts.

j. Filter boxes.

k. Mixing boxes (field-insulated).

l. Supply fans (field-insulated).

m. Site-erected air conditioner casings.

n. Ducts exposed to weather.

o. Combustion air intake ducts.

p. Exhaust ducts passing through concealed spaces, unconditioned spaces, or semi-heated spaces exhausting conditioned air.

Use insulation for rectangular ducts that is flexible type where concealed, minimum density 12 kg/cubic m 3/4 pcf, and rigid type where exposed, minimum density 48 kg/cubic m 3 pcf. Provide insulation for both concealed or exposed round/oval ducts that is flexible type, minimum density 12 kg/cubic m 3/4 pcf or a semi rigid board, minimum density 48 kg/cubic m 3 pcf, formed or fabricated to a tight fit, edges beveled and joints tightly butted and staggered. Provide insulation for all exposed ducts with either a white, paint-able, factory-applied Type I jacket or a

field applied vapor retarder/vapor barrier jacket coating finish as specified. Ensure the total field applied dry film thickness is approximately 2 mm 1/16 inch. Provide insulation on all concealed duct with a factory-applied Type I or II vapor retarder/vapor barrier jacket. Continue duct insulation through sleeves and prepare openings except firewall penetrations. Duct insulation terminating at fire dampers, must be continuous over the damper collar and retaining angle of fire dampers, which are exposed to unconditioned air and which may be prone to condensate formation. Provide duct insulation and vapor retarder/vapor barrier to cover the collar, neck, and un-insulated surfaces of diffusers, registers and grills. Apply vapor retarder/vapor barrier materials to form a complete unbroken vapor seal over the insulation. Seal sheet metal duct in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

3.3.2.1 Installation on Concealed Duct

a. For rectangular, oval or round ducts, attach flexible insulation by applying adhesive around the entire perimeter of the duct in 150 mm 6 inch wide strips on 300 mm 12 inch centers.

b. For rectangular and oval ducts, 600 mm 24 inches and larger, additionally secure insulation to bottom of ducts using mechanical fasteners. Space fasteners on 400 mm 16 inch centers and no more than 400 mm 16 inches from duct corners.

c. For rectangular, oval and round ducts, provide mechanical fasteners on sides of duct risers for all duct sizes. Space fasteners on 400 mm 16 inch centers and no more than 400 mm 16 inches from duct corners.

d. Impale insulation on the mechanical fasteners (self stick pins) where used and press thoroughly into the adhesive. Take care to ensure vapor retarder/vapor barrier jacket joints overlap 50 mm 2 inches. Do not compress insulation to a thickness less than that specified. Carry insulation over standing seams and trapeze-type duct hangers.

e. Where mechanical fasteners are used, install self-locking washers and trim and bend the pin over.

f. Secure jacket overlaps with staples and tape as necessary to ensure a secure seal. Coat staples, tape and seams with a brush coat of vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate (minimum 0.05 mm 2 mils adhesive, 0.075 3 mils embossed) - less than 0.0000 perm adhesive tape.

g. Cover breaks in the jacket material with patches of the same material as the vapor retarder jacket. Do not extend patches less than 50 mm 2 inches beyond the break or penetration in all directions and secure with tape and staples. Seal staples and tape joints with a brush coat of vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate (minimum 0.05 mm 2 mils adhesive, 0.075 mm 3 mils embossed) - less than 0.0000 perm adhesive tape.

h. At jacket penetrations such as hangers, thermometers, and damper operating rods, fill voids in the insulation and seal the penetration with a brush coat of vapor retarder coating or PVDC adhesive tape greater than 3 ply laminate (minimum 0.05 mm 2 mils adhesive, 0.075 mm 3 mils embossed) - less than 0.0000 perm adhesive tape.

i. Seal insulation terminations and pin punctures and flash with a

reinforced vapor retarder coating finish or tape with a brush coat of vapor retarder coating.. Ensure the coating overlaps the adjoining insulation and un-insulated surface 50 mm 2 inches. Extend pin puncture coatings 50 mm 2 inches from the puncture in all directions.

j. Where insulation standoff brackets occur, extend insulation under the bracket and terminate the jacket at the bracket.

3.3.2.2 Installation on Exposed Duct Work

a. For rectangular ducts, secure rigid insulation to the duct by mechanical fasteners on all four sides of the duct, space no more than 300 mm 12 inches apart and no more than 75 mm 3 inches from the edges of the insulation joints. Provide a minimum of two rows of fasteners for each side of duct 300 mm 12 inches and larger. Provide one row for each side of duct less than 300 mm 12 inches. Provide mechanical fasteners that are corrosion resistant as G60 coated galvanized steel, and indefinitely sustain a 22.7 kg 50 lb tensile dead load test perpendicular to the duct wall.

b. Form duct insulation with minimum jacket seams. Fasten each piece of rigid insulation to the duct using mechanical fasteners. When the height of projections is less than the insulation thickness, bring insulation up to standing seams, reinforcing, and other vertical projections and do not carry over. Continue vapor retarder/barrier jacket across seams, reinforcing, and projections. When height of projections is greater than the insulation thickness, carry over insulation and jacket . Apply insulation with joints tightly butted. Neatly bevel insulation around name plates and access plates and doors.

c. Impale insulation on the fasteners; install self-locking washers and trim and bend the pin over.

d. Seal joints in the insulation jacket with a 100 mm 4 inch wide strip of tape. Seal taped seams with a brush coat of vapor retarder coating.

e. Cover breaks and ribs or standing seam penetrations in the jacket material with a patch of the same material as the jacket. Do not extend patches less than 50 mm 2 inches beyond the break or penetration and secure with tape and staple. Seal staples and joints with a brush coat of vapor retarder coating.

f. At jacket penetrations such as hangers, thermometers, and damper operating rods, fill the voids in the insulation and seal the penetrations with a flashing sealant.

g. Seal and flash insulation terminations and pin punctures with a reinforced vapor retarder coating finish. Ensure coating overlaps the adjoining insulation and un-insulated surface 50 mm 2 inches. Extend pin puncture coatings 50 mm 2 inches from the puncture in all directions.

h. Insulation for both concealed or exposed round or oval ducts must be flexible type, minimum density 12 kg/cubic m 3/4 pcf or a semi rigid board, minimum density 48 kg/cubic m 3 pcf, formed or fabricated to a tight fit, edges beveled and joints tightly butted and staggered. Insulation for all exposed ducts must be provided with either a white, factory-applied Type I jacket or a field applied vapor retarder or vapor barrier jacket coating finish as specified, the total field

applied dry film thickness must be approximately 2 mm 1/16 inch.

i. Insulate oval and round ducts, flexible type, with factory Type I jacket insulation with minimum density of 12 kg per cubic meter 3/4 pcf, attach in accordance with MICA standards.

3.3.3 Insulation for Warm Air Duct

****
NOTE: Warm air ducts needing insulation are ducts that handle air above 16 degrees C 60 degrees F. Mixing boxes, relief air ducts, and filter boxes should not be insulated unless condensation is a problem. Factory fabricated double-walled internally insulated duct exposed to the weather should be externally insulated on long runs of duct in cold climates. If insulation is required for unique building design, indicate on the drawings the locations the insulation is to be installed. Ducts for dual purposes will be as required for cold duct.

In humid locations, exhaust ducts passing through concealed spaces which exhaust conditioned air must be insulated and a vapor barrier provided. Humid locations are those in ASHRAE climate zones 0A, 1A, 2A, 3A, 3C, 4C and 5C (as identified in ASHRAE 90.1). Include item below relating to exhaust ducts where this condition occurs in project.

Delete items below as required.
****

Provide insulation and vapor barrier for the following warm air ducts and associated equipment:.

a. Supply ducts.

b. Return air ducts.

c. Relief air ducts

d. Flexible run-outs (field insulated).

e. Plenums.

f. Duct-mounted coil casings.

g. Coil-headers and return bends.

h. Coil casings.

i. Fresh air intake ducts.

j. Filter boxes.

k. Mixing boxes.

l. Supply fans.

m. Site-erected air conditioner casings.

n. Ducts exposed to weather.

o. Exhaust ducts passing through concealed spaces, unconditioned spaces, or semi-heated spaces exhausting conditioned air.

Provide insulation for rectangular ducts that is flexible type where concealed, and rigid type where exposed. Provide insulation on exposed ducts with a white, paint-able, factory-applied Type II jacket, or finish with adhesive finish. Use flexible type insulation for round ducts, with a factory-applied Type II jacket. Provide insulation on concealed duct with a factory-applied Type II jacket. Accomplish adhesive finish where indicated to be used by applying two coats of adhesive with a layer of glass cloth embedded between the coats. Ensure total dry film thickness is approximately 2.0 mm 1/16 inch. Continue duct insulation through sleeves and prepare openings. Terminate duct insulation at fire dampers and flexible connections.

3.3.3.1 Installation on Concealed Duct

a. For rectangular, oval and round ducts, attach insulation by applying adhesive around the entire perimeter of the duct in 150 mm 6 inch wide strips on 300 mm 12 inch centers.

b. For rectangular and oval ducts 600 mm 24 inches and larger, secure insulation to the bottom of ducts using mechanical fasteners. Space fasteners on 450 mm 18 inch centers and no more than 450 mm 18 inches from duct corner.

c. For rectangular, oval and round ducts, provide mechanical fasteners on sides of duct risers for all duct sizes. Space fasteners on 450 mm 18 inch centers and no more than 450 mm 18 inches from duct corners.

d. Impale insulation on the mechanical fasteners where used. Do not compress insulation to a thickness less than that specified. Carry insulation over standing seams and trapeze-type hangers.

e. Install self-locking washers where mechanical fasteners are used and trim and bend the pin over.

f. Do not overlap insulatio jacket less than 50 mm 2 inches at joints and secure the lap and staple on 100 mm 4 inch centers.

3.3.3.2 Installation on Exposed Duct

a. For rectangular ducts, secure the rigid insulation to the duct using mechanical fasteners on all four sides of the duct, space no more than 400 mm 16 inches apart and no more than 150 mm 6 inches from the edges of the insulation joints. Provide a minimum of two rows of fasteners for each side of duct 300 mm 12 inches and larger and a minimum of one row for each side of duct less than 300 mm 12 inches.

b. Form duct insulation with factory-applied jacket with minimum jacket seams, and fasten each piece of rigid insulation to the duct using mechanical fasteners. When the height of projection is less than the insulation thickness, bring insulation up to standing seams, reinforcing, and other vertical projections and do not carry over the projection. Continue jacket across seams, reinforcing, and

projections. Where the height of projections is greater than the insulation thickness, carry insulation and jacket over the projection.

c. Impale insulation on the fasteners; install self-locking washers and trim and bend the pin over.

d. Seal joints on jacketed insulation with a 100 mm 4 inch wide strip of tape and brush with vapor retarder coating.

e. Cover breaks and penetrations in the jacket material with a patch of the same material as the jacket. Extend patches no less than 50 mm 2 inches beyond the break or penetration and secure with adhesive and staple.

f. Seal insulation terminations and pin punctures with tape and brush with vapor retarder coating.

g. Insulate oval and round ducts, flexible type, with factory Type I jacket insulation, minimum density of 12 kg per cubic meter 3/4 pcf attach by staples spaced no more than 400 mm 16 inches and no more than 150 mm 6 inches from the degrees of joints. Seal joints in accordance with item "d." above.

3.3.4 Ducts Handling Air for Dual Purpose

For air handling ducts for dual purpose below and above 16 degrees C 60 degrees F, insulate ducts as specified for cold air duct.

3.3.5 Insulation for Evaporative Cooling Duct

Insulate evaporative cooling supply duct located in spaces not evaporatively cooled. Use material and installation requirements as specified for duct insulation for warm air duct.

3.3.6 Duct Test Holes

After duct systems have been tested, adjusted, and balanced, repair breaks in the insulation and jacket in accordance with the applicable section of this specification for the type of duct insulation to be repaired. After the insulation is repaired, identify on the outside of the insulation with marker, sticker, or other means "TAB test ports."

3.3.7 Duct Exposed to Weather

3.3.7.1 Installation

Insulate and finish ducts exposed to weather as specified for the applicable service for exposed duct inside the building. After the above is accomplished, further finish the insulation as detailed in the following subparagraphs.

3.3.7.2 Round Duct

Laminated self-adhesive (minimum 0.05 mm 2 mils adhesive, 0.075 mm 3 mils embossed) vapor barrier/weatherproofing jacket - Less than 0.02 permeability, (greater than 3 ply, standard grade, silver, white, black and embossed or greater than 8 ply, heavy duty, white and natural) membrane must be applied overlapping material by 75 mm 3 inches no bands or caulking needed - see manufacturer's recommended installation

instructions. Aluminum jacket with factory applied moisture retarder must be applied with the joints lapped no less than 75 mm 3 inches and secured with bands located at circumferential laps and at no more than 300 mm 12 inch intervals throughout. Lap horizontal joints down to shed water and located at 4 or 8 o'clock position. Seal joints with metal jacketing sealant to prevent moisture penetration. Where jacketing abuts an un-insulated surface, seal joints with metal jacketing sealant.

3.3.7.3 Fittings

Finish fittings and other irregular shapes as specified for rectangular ducts.

3.3.7.4 Rectangular Ducts

Apply two coats of weather barrier mastic reinforced with fabric or mesh for outdoor application to the entire surface. Ensure each coat of weatherproof mastic has a minimum thickness of 2 mm 1/16 inch. Ensure exterior is a metal jacketing applied for mechanical abuse and weather protection, and secure with screws or vapor barrier/weatherproofing jacket less than 0.02 permeability greater than 3 ply, standard grade, silver, white, black, and embossed or greater than 8 ply, heavy duty white and natural. Apply membrane overlapping material by 75 mm 3 inches. No bands or caulking needed-see manufacturing recommend installation instructions.

3.3.8 Kitchen Exhaust Duct Insulation

NFPA 96 for [ovens,] [griddles,] [deep fat fryers,] [steam kettles,] [vegetable steamers,] [high pressure cookers,] [and] [mobile serving units]. Provide insulation with 19 mm 3/4 inch wide, minimum 4 mm 0.15 inch thick galvanized steel bands spaced not over 305 mm 12 inches o.c.; or 16 gauge galvanized steel wire with corner clips under the wire; or with heavy welded pins spaced not over 305 mm 12 inches apart each way. Do not use adhesives.

3.4 EQUIPMENT INSULATION SYSTEMS INSTALLATION

Install equipment insulation systems in accordance with the approved MICA Insulation Stds plates as supplemented by the manufacturer's published installation instructions.

3.4.1 General

Provide removable insulation sections to cover parts of equipment that must be opened periodically for maintenance including vessel covers, fasteners, flanges and accessories. Omit equipment insulation on the following:

a. Hand-holes.

b. Boiler manholes.

c. Cleanouts.

d. ASME stamps.

e. Manufacturer's nameplates.

f. Duct Test/Balance Test Holes.

3.4.2 Insulation for Cold Equipment

****
NOTE: Special cold equipment including Government-furnished equipment that requires field-applied insulation will be inserted in the appropriate paragraph.
****

Cold equipment below 16 degrees C 60 degrees F: Furnish insulation on equipment handling media below 16 degrees C 60 degrees F including the following:

a. Pumps.

b. Refrigeration equipment parts that are not factory insulated.

c. Drip pans under chilled equipment.

d. Cold water storage tanks.

e. Water softeners.

f. Duct mounted coils.

g. Cold and chilled water pumps.

h. Pneumatic water tanks.

i. Roof drain bodies.

j. Air handling equipment parts that are not factory insulated.

k. Expansion and air separation tanks.

3.4.2.1 Insulation Type

****
NOTE: Additional data on insulation thickness may be found in manufacturers catalogs and computer sizing programs and from individual calculations. Care should be taken in the selection of an insulating material for high temperature equipment. If the equipment rises to high operating temperature in a short period of time, thermal stresses may occur in rigid insulations that may lead to cracking and subsequent deterioration of the insulation.
****

Provide insulation suitable for the temperature encountered. Provide material and thicknesses as shown in Table 5:

TABLE 5		
Insulation Thickness for Cold Equipment (mm) (inches)		
Equipment handling media at indicated temperature		
	Material	Thickness (mm) (inches)
2 to 16 degrees C35 to 60 degrees F		
	Cellular Glass	401.5
	Flexible Elastomeric Cellular	251
Minus 18 to 1 degree C1 to 34 degrees F		
	Cellular Glass	753
	Flexible Elastomeric Cellular	401.5
Minus 34 to minus 17 degrees CMinus 30 to 0 degrees F		
	Cellular Glass	903.5
	Flexible Elastomeric Cellular	451.75

3.4.2.2 Pump Insulation

a. Insulate pumps by forming a box around the pump housing. Construct the box by forming the bottom and sides using joints that do not leave raw ends of insulation exposed. Join joints between sides and between sides and bottom by adhesive with lap strips for rigid mineral fiber and contact adhesive for flexible elastomeric cellular insulation. Ensure box conforms to the requirements of MICA Insulation Stds plate No. 49 when using flexible elastomeric cellular insulation. Ensure joints between top cover and sides fit tightly forming a female shiplap joint on the side pieces and a male joint on the top cover, thus making the top cover removable.

b. Protect exposed insulation corners with corner angles.

c. Upon completion of installation of the insulation, including removable sections, apply two coats of vapor retarder coating with a layer of glass cloth embedded between the coats. The total dry thickness of the finish must be 2 mm 1/16 inch. Provide a parting line between the box and the removable sections allowing the removable sections to be removed without disturbing the insulation coating. Apply flashing sealant to parting line, between equipment and removable section insulation, and at all penetrations.

3.4.2.3 Other Equipment

a. Form or fabricate insulation to fit the equipment. To ensure a tight fit on round equipment, bevel edges and tightly butt and stagger joints.

b. Secure insulation in place with bands or wires at intervals as recommended by the manufacturer but no more than 300 mm 12 inch centers except adhere flexible elastomeric cellular with contact adhesive. Protect insulation corners under wires and bands with suitable corner angles.

c. Install cellular glass in accordance with manufacturer's instructions. Seal joints and ends with joint sealant, and seal with a vapor retarder coating.

d. Use removable insulation on heads of heat exchangers. Fabricate removable section joints using a male-female shiplap type joint. Finish the entire surface of the removable section by applying two coats of vapor retarder coating with a layer of glass cloth embedded between the coats. The total dry thickness of the finish must be 2 mm 1/16 inch.

e. Protect exposed insulation corners with corner angles.

f. Apply insulation on equipment with ribs over 150 by 150 mm 6 by 6 inches by 12 gauge welded wire fabric which has been cinched in place, or if approved by the Contracting Officer, spot weld to the equipment over the ribs. Secure insulation to the fabric with J-hooks and 50 by 50 mm 2 by 2 inches washers or securely band or wire in place on 300 mm 12 inch centers.

3.4.2.4 Vapor Retarder/Vapor Barrier

Upon completion of installation of insulation, caulk penetrations. Apply two coats of vapor retarder coating or vapor barrier jacket over insulation, including removable sections, with a layer of open mesh synthetic fabric embedded between the coats. Ensure the total dry thickness of the finish is 2 mm 1/16 inch. Apply flasing sealant or vapor barrier tape to parting line between equipment and removable section insulation.

3.4.3 Insulation for Hot Equipment

****
NOTE: Special hot equipment such as sterilizers, expansion tanks for high temperature water systems, process equipment, and special Government-furnished equipment that requires field-applied insulation will be inserted in the appropriate subparagraphs. Expansion tanks on hot water heating systems will not normally be insulated.
****

Furnish insulation on equipment handling media above 16 degrees C 60 degrees F including the following:

a. Converters.

b. Heat exchangers.

c. Hot water generators.

d. Water heaters.

e. Pumps handling media above 54 degrees C 130 degrees F.

f. Fuel oil heaters.

g. Hot water storage tanks.

h. Air separation tanks.

i. Surge tanks.

j. Flash tanks.

k. Feed-water heaters.

l. Unjacketed boilers or parts of boilers.

m. Boiler flue gas connection from boiler to stack (if inside).

n. Induced draft fans.

o. Fly ash and soot collectors.

p. Condensate receivers.

3.4.3.1 Insulation

****

NOTE: Additional data on insulation thickness may be found in manufacturers catalogs and computer sizing programs and from individual calculations. Care should be taken in the selection of an insulating material for high temperature equipment. If the equipment rises to high operating temperature in a short period of time, thermal stresses may occur in rigid insulations that may lead to cracking and subsequent deterioration of the insulation.

****

Provide insulation suitable for the temperature encountered. Insulate shell and tube-type heat exchangers for the temperature of the shell medium.

Determine insulation thickness for hot equipment using Table 6:

TABLE 6

Insulation Thickness for Hot Equipment (mm) (inches)

Equipment handling steam or media at indicated pressure or temperature limit		
	Material	Thickness (mm) (inches)
103 kPa or 121 degrees C15 psig or 250 degrees F		
	Rigid Mineral Fiber	502
	Flexible Mineral Fiber	502

TABLE 6		
Insulation Thickness for Hot Equipment (mm) (inches)		
Equipment handling steam or media at indicated pressure or temperature limit		
	Material	Thickness (mm) (inches)
	Calcium Silicate/Perlite	1004
	Cellular Glass	753
	Faced Phenolic Foam	401.5
	Flexible Elastomeric Cellular (<93 C<200 F)	251
1380 kPa or 204 degree C200psig or 400 degrees F		
	Rigid Mineral Fiber	753
	Flexible Mineral Fiber	753
	Calcium Silicate/Perlite	1004
	Cellular Glass	1004
316 degrees C600 degrees F		
	Rigid Mineral Fiber	1255
	Flexible Mineral Fiber	1506
	Calcium Silicate/Perlite	1506
	Cellular Glass	1506
316 degrees C600 degrees F: Thickness necessary to limit the external temperature of the insulation to 50 C 120 F. Submit heat transfer calculations to substantiate insulation and thickness selection.		

3.4.3.2 Insulation of Boiler Stack and Diesel Engine Exhaust Pipe

Inside [boiler House] [mechanical Room], bevel insulation neatly around openings and provide sheet metal insulation stop strips around such openings. Apply a skim coat of hydraulic setting cement directly to insulation. Apply a flooding coat of adhesive over hydraulic setting cement, and while still wet, press a layer of glass cloth or tape into adhesive and seal laps and edges with adhesive. Coat glass cloth with adhesive. When dry, apply a finish coat of adhesive at can-consistency so that when dry no glass weave is observed. Provide metal jackets for [stacks] [and] [exhaust pipes] that are located above finished floor and spaces outside [boiler house] [mechanical room]. Apply metal jackets directly over insulation and secure with 19 mm 3/4 inch wide metal bands spaced on 457 mm 18 inch centers. Do not insulate name plates. Provide insulation type and thickness in accordance with the following Table 7.

****

NOTE: Table 7 is primarily used for personnel safety where stacks or pipes are within reach, or if stacks or pipes run through conditioned spaces where heat losses may increase building energy usage.

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TABLE 7						
Insulation and Thickness for Boiler Stack and Diesel Engine Exhaust Pipe						
Service & Surface Temperature Range (Degrees CF)						
	Material	Outside Diameter (mm) (Inches)				
		6 - 32 0.25 - 1.25	25 - 80 1 - 1.67	90-125 3.5-5	150 - 250 6 - 10	> or = 280 - 90011 - 36
Boiler Stack (Up to 204 degrees C) (Up to 400 degrees F)						
	Mineral Fiber ASTM C585 Class B-3, ASTM C547 Class 1, or ASTM C612 Class 1	N/A	N/A	753	903.5	1004
	Calcium Silicate ASTM C533, Type 1	N/A	N/A	753	903.5	1004
	Cellular Glass ASTM C552, Type II	401.5	401.5	401.5	502	652.5
Boiler Stack (205 to 315 degrees C) (401 to 600 degrees F)						
	Mineral Fiber ASTM C547 Class 2, ASTM C592 Class 1, or ASTM C612 Class 3	N/A	N/A	1004	1004	1255
	Calcium Silicate ASTM C533, Type I or II	N/A	N/A	1004	1004	1004
	Mineral Fiber and Cellular Glass Assembly:					
	Mineral Fiber ASTM C547 Class 2, ASTM C592 Class 1, or ASTM C612 Class 3	251	251	251	251	502

TABLE 7

Insulation and Thickness for
Boiler Stack and Diesel Engine Exhaust Pipe

Service & Surface Temperature Range (Degrees CF)

	Material	Outside Diameter (mm) (Inches)				
		6 - 32 0.25 - 1.25	25 - 80 1 - 1.67	90-125 3.5-5	150 - 250 6 - 10	> or = 280 - 90011 - 36
	Cellular Glass ASTM C552, Type II	502	502	502	502	502
Boiler Stack (316 to 427 degrees C) (601 to 800 degrees F)						
	Mineral Fiber ASTM C547 Class 3, ASTM C592 Class 1, or ASTM C612 Class 3	N/A	N/A	1004	1004	1506
	Calcium Silicate ASTM C533, Type I or II	N/A	N/A	1004	1004	1506
	Mineral Fiber and Cellular Glass Assembly:					
	Mineral Fiber ASTM C547 Class 2, ASTM C592 Class 1, or ASTM C612 Class 3	502	502	502	803	803
	Cellular Glass ASTM C552, Type II	502	502	502	502	502
Diesel Engine Exhaust (Up to 371 degrees C) (Up to 700 degrees F)						
	Calcium Silicate ASTM C533, Type I or II	803	903.5	1004	1004	1004
	Cellular Glass ASTM C552, Type II	652.5	903.5	1004	1154.5	1506

TABLE 7						
Insulation and Thickness for Boiler Stack and Diesel Engine Exhaust Pipe						
Service & Surface Temperature Range (Degrees CF)						
	Material	Outside Diameter (mm) (Inches)				
		6 - 32 0.25 - 1.25	25 - 80 1 - 1.67	90-125 3.5-5	150 - 250 6 - 10	> or = 280 - 90011 - 36
Diesel Engine Exhaust (371 to 649 degrees C) (700 to 1200 degrees F)						
	Calcium Silicate ASTM C533, Type I or II	N/A	N/A	165 6.5	165 6.5	190 7.5

3.4.3.3 Insulation of Pumps

Insulate pumps by forming a box around the pump housing. Construct the box by forming the bottom and sides using joints that do not leave raw ends of insulation exposed. Band bottom and sides to form a rigid housing that does not rest on the pump. Ensure joints between top cover and sides fit tightly. The top cover must have a joint forming a female shiplap joint on the side pieces and a male joint on the top cover, making the top cover removable. Apply two coats of Class I adhesive over insulation, including removable sections, with a layer of glass cloth embedded between the coats. Provide a parting line between the box and the removable sections allowing the removable sections to be removed without disturbing the insulation coating. The total dry thickness of the finish must be 2 mm 1/16 inch. Apply caulking to parting line of the removable sections and penetrations.

3.4.3.4 Other Equipment

a. Form or fabricate insulation to fit the equipment. To ensure a tight fit on round equipment, bevel edges and tightly butt and stagger joints.

b. Secure insulation in place with bands or wires at intervals as recommended by the manufacturer but no greater than 300 mm 12 inch centers except adhere flexible elastomeric cellular. Protect insulation corners under wires and bands with suitable corner angles.

c. On high vibration equipment, set cellular glass insulation in a coating of bedding compound as recommended by the manufacturer, and seal joints with bedding compound. Fill mineral fiber joints with finishing cement.

d. Provide removable insulation on heads of heat exchangers. Fabricate the removable section joint using a male-female shiplap type joint. Finish the entire surface of the removable section as specified.

e. Protect exposed insulation corners with corner angles.

f. On equipment with ribs, such as boiler flue gas connection, draft fans, and fly ash or soot collectors, apply insulation over 150 by 150 mm 6 by 6 inch by 12 gauge welded wire fabric which has been cinched in place, or if approved by the Contracting Officer, spot weld to the equipment over the ribs. Secure insulation to the fabric with J-hooks and 50 by 50 mm 2 by 2 inch washers or securely band or wire in place on 300 mm 12 inch (maximum) centers.

g. On equipment handling media above 316 degrees C 600 degrees F, apply insulation in two or more layers with staggered joints.

h. Upon completion of installation of insulation, caulk penetrations. Apply two coats of adhesive over insulation, including removable sections, with a layer of glass cloth embedded between the coats. The total dry thickness of the finish must be 2 mm 1/16 inch. Apply caulking to parting line between equipment and removable section insulation.

3.4.4 Equipment Handling Dual Temperature Media

Below and above 16 degrees C 60 degrees F: insulate equipment handling dual temperature media as specified for cold equipment.

3.4.5 Equipment Exposed to Weather

3.4.5.1 Installation

Insulate equipment exposed to weather and finish in accordance with the requirements for ducts exposed to weather in paragraph DUCT INSULATION INSTALLATION.

3.4.5.2 Optional Panels

At the option of the Contractor, prefabricated metal insulation panels may be used in lieu of the insulation and finish previously specified. Thermal performance must be equal to or better than that specified for field applied insulation. Provide panels that are the standard catalog product of a manufacturer of metal insulation panels. Provide fastenings, flashing, and support system conforming to published recommendations of the manufacturer for weatherproof installation and that prevent moisture from entering the insulation. Design panels to accommodate thermal expansion and to support a 1112 N 250 pound walking load without permanent deformation or permanent damage to the insulation. Exterior metal cover sheet must be aluminum and exposed fastenings must be stainless steel or aluminum.

-- End of Section --