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USACE / NAVFAC / AFCEA UFGS-15080N (September 1999)

Preparing Activity: NAVFAC

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Replacing without revision  
NFGS of same number and date

## UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 25 June 2004

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### SECTION TABLE OF CONTENTS

#### DIVISION 15 - MECHANICAL

#### SECTION 15080N

#### MECHANICAL INSULATION

09/99

#### PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 QUALITY ASSURANCE
  - 1.2.1 Calculation of Insulation Thickness
  - 1.2.2 Packaging and Labeling
  - 1.2.3 Surface Burning Characteristics
- 1.3 SUBMITTALS
- 1.4 RECYCLED MATERIALS

#### PART 2 PRODUCTS

- 2.1 PIPING INSULATION
  - 2.1.1 Piping Insulation Jackets
    - 2.1.1.1 All-Purpose Jacket
    - 2.1.1.2 Metal Jackets
- 2.2 HEATING, VENTILATING, AND AIR CONDITIONING SYSTEMS INSULATION
  - 2.2.1 Duct Insulation
    - 2.2.1.1 Rigid Insulation
    - 2.2.1.2 Blanket Insulation
  - 2.2.2 Kitchen Exhaust Ductwork Insulation
  - 2.2.3 Acoustical Duct Lining
  - 2.2.4 Duct Insulation Jackets
    - 2.2.4.1 All-Purpose Jacket
    - 2.2.4.2 Metal Jackets
  - 2.2.5 Weatherproof Duct Insulation
- 2.3 BOILER STACKS AND DIESEL ENGINE EXHAUST PIPING INSULATION
- 2.4 EQUIPMENT
- 2.5 ADHESIVES, SEALANTS, AND COATING COMPOUNDS
  - 2.5.1 Insulation and Vapor Barrier Adhesive
  - 2.5.2 Lagging Adhesive
  - 2.5.3 Mineral Fiber Insulation Cement
  - 2.5.4 Vapor Barrier Coating
  - 2.5.5 Weatherproof Coating
- 2.6 ACCESSORY MATERIALS
  - 2.6.1 Staples

- 2.6.2 Insulation Bands
- 2.6.3 Metal Bands
- 2.6.4 Anchor Pins and Speed Washers
- 2.6.5 Fibrous Glass Cloth and Tape
- 2.6.6 Wire
- 2.6.7 PVC Pipe Fitting Cover and Its Vapor Barrier Tape
- 2.6.8 Vapor Barrier Materials

## PART 3 EXECUTION

- 3.1 PREPARATION
- 3.2 DUCTWORK, PLENUMS, CASINGS, AND ACCESSORIES INSULATION
  - 3.2.1 Rigid Insulation
  - 3.2.2 Flexible Blanket Insulation
  - 3.2.3 Metal Jackets for Ductwork Outside Building
  - 3.2.4 Kitchen Exhaust Duct Insulation
  - 3.2.5 Duct Sleeves and Pipe Sleeves
  - 3.2.6 Access Plates and Doors
  - 3.2.7 Insulation Finishes and Joint Sealing
  - 3.2.8 Moisture Seal
- 3.3 PIPE INSULATION
  - 3.3.1 Pipe Insulation (Except Cellular and Calcium Silicate Insulation)
  - 3.3.2 Flexible Cellular Insulation
  - 3.3.3 [Cellular Glass] [and] [Calcium Silicate] Insulation
  - 3.3.4 Hangers and Anchors
  - 3.3.5 Sleeves and Wall Chases
  - 3.3.6 Flanges, Unions, Valves and Fittings for Piping
  - 3.3.7 Piping Exposed to Weather
    - 3.3.7.1 Metal Jackets
    - 3.3.7.2 Flanges, Unions, Valves, Fittings, and Accessories
- 3.4 BOILER STACKS AND DIESEL ENGINE EXHAUST INSULATION
- 3.5 EQUIPMENT INSULATION
  - 3.5.1 Heating Equipment (Except Pumps)
  - 3.5.2 Cold Equipment (Except Pumps)
  - 3.5.3 Pumps
- 3.6 FIELD QUALITY CONTROL
  - 3.6.1 Air Distribution Systems
  - 3.6.2 Piping Systems

-- End of Section Table of Contents --

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References are in agreement with UMRL dated 25 June 2004

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### SECTION 15080N

#### MECHANICAL INSULATION 09/99

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NOTE: This guide specification covers the requirements for mechanical insulation including field-applied insulation for heating, ventilating, and cooling (HVAC) air distribution systems and piping systems which are located within, on, under, and adjacent to buildings; and for plumbing piping systems.

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

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

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

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NOTE: This guide specification is intended for HVAC systems, plumbing systems, and piping systems which are located within, on, under, and adjacent to buildings. The following information shall be shown 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 are to be used on interior piping;
4. Pumps to be insulated and encased in 20 gage

boxes; and

## 5. Heat exchange temperatures.

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### PART 1 GENERAL

#### 1.1 REFERENCES

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NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest guide specification. Use of SpecsIntact automated reference checking is recommended for projects based on older guide specifications.

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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.

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

ASHRAE 90.1 (2001; various Errata) Energy Standard for Buildings Except Low-Rise Residential Buildings

ASHRAE 90.2 (2001) Energy Efficient Design of Low-Rise Residential Buildings

#### ASTM INTERNATIONAL (ASTM)

ASTM A 167 (1999) Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

ASTM A 240/A 240M (2003c) Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels for General Applications

ASTM B 209 (2002a) Aluminum and Aluminum-Alloy Sheet and Plate

ASTM B 209M (2002a) Aluminum and Aluminum-Alloy Sheet and Plate (Metric)

ASTM C 1126 (2000) Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation

ASTM C 1136 (2003) Flexible, Low Permeance Vapor Retarders for Thermal Insulation

ASTM C 195 (2000) Mineral Fiber Thermal Insulating Cement

ASTM C 533 (1995; R 2001) Calcium Silicate Block and

#### Pipe Thermal Insulation

ASTM C 534	(2003) Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
ASTM C 547	(2003) Mineral Fiber Pipe Insulation
ASTM C 552	(2000e1) Cellular Glass Thermal Insulation
ASTM C 553	(2002) Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C 59/C 59M1	(2001) Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM C 59/C 59M2	(1980) Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)
ASTM C 612	(2000a) Mineral Fiber Block and Board Thermal Insulation
ASTM C 916	(1985; R 2001e1) Adhesives for Duct Thermal Insulation
ASTM E 84	(2003) Surface Burning Characteristics of Building Materials

#### NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 255	(2000) Method of Test of Surface Burning Characteristics of Building Materials
NFPA 96	(2001) Ventilation Control and Fire Protection of Commercial Cooking Operations

#### U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-A-3316	(Rev C; Am 2) Adhesives, Fire-Resistant, Thermal Insulation
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#### UNDERWRITERS LABORATORIES (UL)

UL 723	(2003) Test for Surface Burning Characteristics of Building Materials
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### 1.2 QUALITY ASSURANCE

Provide [new and modify existing] field-applied insulation for heating, ventilating, and cooling (HVAC) air distribution systems and piping systems which are located within, on, under, and adjacent to buildings; and for plumbing systems.

#### [1.2.1 Calculation of Insulation Thickness

Calculation of insulation thickness shall be performed by designer and certified by professional engineer who is currently licensed in any State

or Washington D.C. Specific insulation thickness for services shall be indicated in Contractor's bid documents.

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NOTE: For LANTNAVFACENGCOM projects, delete  
following two paragraphs.  
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#### ]1.2.2 Packaging and Labeling

Every package or standard container of insulation, jackets, cements, adhesives, and coatings delivered to project site shall have manufacturer's stamp or label attached giving name of manufacturer, brand and description of material. Insulation packages and containers shall be asbestos-free.

#### 1.2.3 Surface Burning Characteristics

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NOTE: Other areas of the building may allow  
insulation with less performance values. Check with  
local building codes.  
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Materials shall have a flame-spread rating of not more than 25 and a smoke-developed rating of not more than 50, when tested in accordance with NFPA 255, ASTM E 84 or UL 723. Insulation materials located exterior to the building perimeter are not required to be fire-rated.

#### 1.3 SUBMITTALS

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NOTE: Submittals must be limited to those necessary  
for adequate quality control. The importance of an  
item in the project should be one of the primary  
factors in determining if a submittal for the item  
should be required.

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

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

Submittal items not designated with a "G" are considered as being for information only for Army projects and for Contractor Quality Control approval for Navy projects.

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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.] [for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Accessory materials

Adhesives, sealants, and coating compounds

Duct insulation

Duct insulation jackets

Piping insulation

Piping insulation jackets

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NOTE: CAUTION: If Government designer does not have necessary computer hardwares and softwares to perform and verify insulation calculation which shall be certified by professional engineer in Contractor's bid document, delete following submittal requirement.

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[ SD-05 Design Data

Calculation of Insulation Thickness; G]

1.4 RECYCLED MATERIALS

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

Rock Wool - 75 percent slag of weight  
Fiberglass - 20-25 percent glass cullet by weight  
Phenolic Rigid Foam - 5 percent recovered material  
Plastic Rigid Foam - 9 percent recovered material  
Polyisocyanurate/Polyurethane - 9 percent recovered material  
Rigid Foam - 9 percent recovered material

PART 2 PRODUCTS

2.1 PIPING INSULATION

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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 shall become a part of project specification.

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.

Cellular glass and faced rigid cellular phenolic foam 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 one inch thick cellular insulation is too high to be economical. For faced rigid cellular phenolic foam, recommended minimum thickness is 25 mm one inch.

For cryogenic equipment handling media between minus 34 degrees C and minus 18 degrees C 30 degrees F and minus one degree F, use cellular glass or faced rigid cellular phenolic foam insulation.

Table 5 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.

CAUTION: If Government designer does not have necessary computer hardwares and softwares to perform and verify insulation calculation which shall be certified by professional engineer in Contractor's bid document, delete third sentence of the following paragraph in its entirety.

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

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NOTE: For LANTNAVFACENGCOM projects, delete the option of 15 mm 1/2 inch from line 4 of the following paragraph.

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Insulation material shall conform to Table 1. Insulation thickness shall be as listed in Table 2. Except for flexible cellular insulation, insulation thickness as specified in Table 2 shall be [15] [25] mm [1/2] [1] inch greater for insulated piping systems located outside. [In lieu of Table 2, minimum thickness may be calculated in accordance with [Table 2A excerpted from ASHRAE 90.2] [ASHRAE 90.1, Section 9, Table 9-1 and Equation



9-1].] Insulation exterior shall be factory cleanable, grease resistant, non-flaking and non-peeling.

#### 2.1.1 Piping Insulation Jackets

##### 2.1.1.1 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. Provide jackets in exposed locations with a white surface suitable for field painting.

##### 2.1.1.2 Metal Jackets

- a. Aluminum Jackets: ASTM B 209M ASTM B 209, Temper H14, minimum thickness of 27 gage (0.41 mm0.016 inch), with factory-applied polyethylene and kraft paper moisture barrier on inside surface. Provide smooth surface jackets for jacket outside diameters less than 200 mm 8 inches. Provide corrugated surface jackets for jacket outside diameters 200 mm 8 inches and larger. Provide stainless steel bands, minimum width of 15 mm 0.5 inch. Provide factory prefabricated aluminum covers for insulation on fittings, valves, and flanges. Covers shall be same thickness and material as jackets on adjacent piping.
- b. Stainless Steel Jackets: ASTM A 167 or ASTM A 240/A 240M; Type 304, minimum thickness of 33 gage (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 15 mm 0.5 inch. Provide factory prefabricated stainless steel covers for insulation on fittings, valves, and flanges. Covers shall be same thickness and material as jackets on adjacent piping.

#### 2.2 HEATING, VENTILATING, AND AIR CONDITIONING SYSTEMS INSULATION

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**NOTE: For NORTHNAVFACENGCOM projects, delete option of the following paragraph.**  
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##### 2.2.1 Duct Insulation

Provide factory-applied insulation with insulation manufacturer's standard reinforced fire-retardant vapor barrier jacket [, with identification of installed thermal resistance (R) value and out-of-package R value.]

##### 2.2.1.1 Rigid Insulation

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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 shall become a part of project specification.**

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.

Cellular glass and faced rigid cellular phenolic foam 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 one inch thick cellular insulation is too high to be economical. For faced rigid cellular phenolic foam, recommended minimum thickness is 25 mm one inch.

For cryogenic equipment handling media between minus 34 degrees C and minus 18 degrees C 30 degrees F and minus one degree F, use cellular glass or faced rigid cellular phenolic foam insulation.

Table 5 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.

CAUTION: If Government designer does not have necessary computer hardwares and softwares to perform and verify insulation calculation which shall be certified by professional engineer in Contractor's bid document, delete second sentence of the following two paragraphs in its entirety.

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

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Rigid mineral fiber in accordance with ASTM C 612, Class 2 (maximum surface temperature 204 degrees C 400 degrees F), 48 kg/m<sup>3</sup> 3 pcf average, 25 mm one inch thick. [Alternately, minimum thickness may be calculated in accordance with [ASHRAE 90.2] [ASHRAE 90.1].]

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NOTE: For NORTHNAVFACENGCOM, delete the following paragraph.

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#### 2.2.1.2 Blanket Insulation

Blanket flexible mineral fiber insulation conforming to ASTM C 553, Type 1, Class B-3, 12 kg per cubic meter (kg/m<sup>3</sup>) 3/4 pound per cubic foot (pcf) nominal, 50 mm 2.0 inches thick. [Alternately, minimum thickness may be calculated in accordance with [ASHRAE 90.2] [ASHRAE 90.1].]

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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.

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## 2.2.2 Kitchen Exhaust Ductwork Insulation

Minimum insulation thickness of 50 mm 2 inches, blocks or boards, either mineral fiber conforming to ASTM C 612, Class 5, 320 kg/m<sup>3</sup> 20 pcf average [or calcium silicate conforming to ASTM C 533, Type II. Provide vapor barrier for outside air connection to kitchen exhaust hood].

## 2.2.3 Acoustical Duct Lining

For ductwork indicated or specified in Section 15810N DUCTWORK AND DUCTWORK ACCESSORIES, to be acoustically lined, provide external insulation in accordance with this specification section and in addition to the acoustical duct lining.

## 2.2.4 Duct Insulation Jackets

### 2.2.4.1 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 suitable for field painting.

### 2.2.4.2 Metal Jackets

- a. Aluminum Jackets: ASTM B 209M ASTM B 209, Temper H14, minimum thickness of 27 gage (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 15 mm 0.5 inch.
- b. Stainless Steel Jackets: ASTM A 167 or ASTM A 240/A 240M; Type 304, minimum thickness of 33 gage (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 15 mm 0.5 inch.

## [2.2.5 Weatherproof Duct Insulation

Provide [ASTM C 59/C 59M1, polyurethane or polyisocyanate board insulation, minimum density of 27 kg/m<sup>3</sup> 1.7 pcf] [ASTM C 534, flexible cellular insulation], and weatherproofing as specified in manufacturer's instruction.

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**NOTE:** The following paragraph is not applicable for power plants and boiler plants. It is for diesel engine exhaust piping (See Military Handbook MIL-HDBK-1003/11, Diesel-Electric Generating Plants, Section 13, paragraph entitled "Insulation Applications) and small boiler (up to [1471 kW] [150 boiler horsepower]) stacks within buildings.

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 shall become a part of project specification.

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.

Cellular glass and faced rigid cellular phenolic foam 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 one inch thick cellular insulation is too high to be economical. For faced rigid cellular phenolic foam, recommended minimum thickness is 25 mm one inch.

For cryogenic equipment handling media between minus 34 degrees C and minus 18 degrees C 30 degrees F and minus one degree F, use cellular glass or faced rigid cellular phenolic foam insulation.

Table 5 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.

Calcium silicate insulation conforming to ASTM C 533 shall be either Type I, for temperatures up to 649 degrees C 1200 degrees F or Type II, for temperatures up to 871 degrees C 1600 degrees F.

Cellular glass may be used over a wide temperature range, depending on manufacturer's method of fabrications. When combined with mineral fiber, mineral fiber/cellular glass composite permits temperature services up to plus 649 degrees C 1200 degrees F.

Mineral fiber insulation conforming to ASTM C 533 shall be Class B-3 which is good for temperatures up to 204 degrees C 400 degrees F. Above 204 to 454 degrees C 400 to 850 degrees F use mineral fiber insulation conforming to ASTM C 59/C 59M2, Class 1, one side metal mesh covered. Classes of mineral fiber insulation conforming to ASTM C 612 are as follows:

Class	Maximum Surface Temperature, degrees C
1	204
2	204
3	454
4	538
5	982

Class	Maximum Surface Temperature, degrees F
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1	400
2	400
3	850
4	1000
5	1800

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## 2.3 BOILER STACKS AND DIESEL ENGINE EXHAUST PIPING INSULATION

ASTM C 59/C 59M2 Class I or ASTM C 612 Class 3 or ASTM C 533, Type I. Insulation and minimum thickness shall comply with Table 5. Fill joints in the block insulation with mineral wool or equivalent insulation cement. For equipment operating at surface temperatures above 316 degrees C 600 degrees F, apply block in double layer construction with staggered joints.

## 2.4 EQUIPMENT

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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 shall become a part of project specification.

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.

Cellular glass and faced rigid cellular phenolic foam 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 one inch thick cellular insulation is too high to be economical. For faced rigid cellular phenolic foam, recommended minimum thickness is 25 mm one inch.

For cryogenic equipment handling media between minus 34 degrees C and minus 18 degrees C 30 degrees F and minus one degree F, use cellular glass or faced rigid cellular phenolic foam insulation.

Table 5 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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Insulate equipment and accessories as specified in Table 3 and 4. In outside locations, provide insulation 15 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.

## 2.5 ADHESIVES, SEALANTS, AND COATING COMPOUNDS

### 2.5.1 Insulation and Vapor Barrier Adhesive

Provide ASTM C 916, Type I adhesive for securing insulation to metal surfaces and for vapor barrier lap only in building interior.

### 2.5.2 Lagging Adhesive

MIL-A-3316, Class 1, for bonding fibrous glass cloth to unfaced fibrous glass insulation; for bonding cotton brattice cloth to faced and unfaced fibrous glass insulation board; for sealing edges of and bounding fibrous glass tape to joints of fibrous glass board; or for bonding lagging cloth to thermal insulation, or Class 2, for attaching fibrous glass insulation to metal surfaces. Provide for pipe and duct insulation.

### 2.5.3 Mineral Fiber Insulation Cement

ASTM C 195.

### 2.5.4 Vapor Barrier Coating

Provide in accordance with insulation manufacturers' recommendations.

### 2.5.5 Weatherproof Coating

For outside applications provide in accordance with insulation and jacket manufacturer's recommendations.

## 2.6 ACCESSORY MATERIALS

### 2.6.1 Staples

ASTM A 167, Type 304 or 316 stainless steel outside-clinch type.

### 2.6.2 Insulation Bands

15 mm 1/2 inch wide; 26 gage stainless steel.

### 2.6.3 Metal Bands

9.50 mm 3/8 inch minimum width; [26 gage stainless steel] [or] [24 gage aluminum].

### 2.6.4 Anchor Pins and Speed Washers

Provide in accordance with insulation manufacturer's recommendations.

### 2.6.5 Fibrous Glass Cloth and Tape

Fibrous glass cloth and tape; 20 by 20 maximum size mesh. Tape shall be 100 mm 4 inch wide rolls. Class 3 tape shall be 0.15 kg per square meter 4.5 ounces per square yard. In lieu of glass cloth and tape, open weave glass membrane may be provided.

### 2.6.6 Wire

Soft annealed stainless steel, [16] [18] gage.

### 2.6.7 PVC Pipe Fitting Cover and Its Vapor Barrier Tape

Provide PVC fitting covers with insulation inserts of same material and thickness as pipe insulation.

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NOTE: For LANTNAVFACENGCOM, delete following  
paragraph.  
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### [2.6.8 Vapor Barrier Materials

ASTM C 1136. Resistant to flame, moisture penetration, and mold growth, color white.

## ]PART 3 EXECUTION

### 3.1 PREPARATION

Clean and test mechanical systems prior to application of insulation. Obtain Contracting Officer's written approval [of HVAC, water distribution systems, and air distribution systems under Section 15950N HVAC TESTING/ADJUSTING/BALANCING] before applying field-applied insulation to mechanical systems. Do not insulate the following:

- a. Adjacent insulation;
- b. ASME stamps;
- c. Access plates of fan housings;
- d. Cleanouts or handholes;
- e. Components within factory preinsulated HVAC equipment;
- f. Factory preinsulated flexible ductwork;
- g. Factory preinsulated HVAC equipment;
- h. Manufacturer's nameplates;
- i. Chrome plated pipes, and fire protection pipes;
- j. Vibration isolating connections;

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NOTE: For LANTNAVFACENGCOM, delete second sentence in its entirety. For NORTHNAVFACENGCOM, delete first sentence in its entirety. For other EFDs, either first or second sentence may be deleted or used as an option. Return ducts should be insulated in areas where there are more than 8 degrees C 14 degrees F difference from room temperature.  
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### 3.2 DUCTWORK, PLENUMS, CASINGS, AND ACCESSORIES INSULATION

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NOTE: Refer to ASHRAE 90.2, Table 6-2a, for Minimum  
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## Duct Insulation.

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[Provide rigid type duct insulation in mechanical rooms and where indicated; provide blanket type insulation in all other locations.] [Do not use blanket type insulation.] Provide field-applied insulation to exterior of supply ducts, [return ducts,] outside air intake ducts, duct plenums, and casings of HVAC units. Ensure full range of motion of equipment actuators. Modify insulation to avoid obstruction with valve handles, safety reliefs, and other such items. Install insulation with jackets drawn tight and cement down on longitudinal and end laps. Do not use scrap pieces where a full length section will fit.

### 3.2.1 Rigid Insulation

Secure rigid insulation by impaling over pins or anchors located not more than 80 mm 3 inches from joint edges of boards, spaced not more than 305 mm 12 inches o.c. and secure with washers and clips. Spot weld anchor pins or attach with a waterproof adhesive especially designed for use on metal surfaces. Apply insulation with joints tightly butted. Neatly bevel insulation around name plates and access plates and doors. Each pin or anchor shall be capable of supporting a 89 N 20 poundload. Cut off protruding ends of pins, after clips are sealed with coating compound for inside work or manufacturer's recommended weatherproof coating for outside work, and reinforced with open weave glass membrane.

### 3.2.2 Flexible Blanket Insulation

Apply insulation with joints tightly butted. Secure insulation to ductwork with adhesive in 150 mm 6 inch wide strips on 305 mm 12 inch centers. Staple laps of jacket with outward clinching staples on 100 mm 4 inch centers. Sealing shall be in accordance with paragraph entitled "Insulation Finishes and Joint Sealing." Provide pins, washers and clips at 450 mm 18 inches on center and not more than 100 mm 4 inches from duct edge for duct surfaces greater than 610 mm 24 inches across except for top surfaces of horizontal ducts. For vertical ducts with surfaces less than 610 mm 24 inches across, provide pins no more than 100 mm 4 inches from duct edge at 450 mm 18 inches on center. Carry insulation over standing seams and trapeze-type hangers. Install speed washers with pins and pin trimmed to washer. Sagging of flexible duct insulation shall not be permitted. Cut off protruding ends of pins after securing and sealing clips with coating compound for inside work. For warm air ducts, overlap insulation not less than 50 mm 2 inches at joints and secure laps with outward clinch staples on 100 mm 4 inch centers. In cold air ducts, vapor seal joints and staple as specified.

### 3.2.3 Metal Jackets for Ductwork Outside Building

Ensure longitudinal and circumferential joints overlap at least 50 mm 2 inches wide, with filed-cut edge of circumferential joint turned under 25 mm one inch to provide smooth edge. Place longitudinal joints to shed water. Seal joints with insulation manufacturer's recommended weatherproof coating. Secure jackets in place with [aluminum] [or] [stainless steel] bands on 230 mm 9 inch centers. Do not use dissimilar metals for direct duct connections. Where ducts penetrate exterior walls, continue increased thickness required for ductwork exposed to weather and metal jackets through sleeve to a point 50 mm 2 inches beyond interior wall surface. Where metal jacket abuts an uninsulated surface, seal joints with a weatherproof mastic recommended by insulation manufacturer. For



rectangular ducts, provide corner angles to exposed corners of insulation. Apply two coats of weatherproof coating recommended by insulation manufacturer to entire surface with a layer of glass cloth embedded between coats. Ensure glass cloth overlaps not less than 50 mm 2 inches at joints and adjoining surface. Each coat of weatherproof coating shall be 1.60 mm 1/16 inch minimum thickness.

#### 3.2.4 Kitchen Exhaust Duct Insulation

NFPA 96 for [ovens,] [griddles,] [deepfat 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 gage 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.

#### 3.2.5 Duct Sleeves and Pipe Sleeves

Insulation shall be continuous through sleeves, wall and ceiling openings, except at fire dampers in duct systems. Extend surface finishes to protect surfaces, ends, and raw edges of insulation. Apply coatings and adhesives at manufacturer's recommended coverage per liter gallon.

#### 3.2.6 Access Plates and Doors

On acoustically lined ducts, plenums, and casings, provide insulation on access plates and doors. On externally insulated ducts, plenums, and casings, bevel insulation around access plates and doors.

#### 3.2.7 Insulation Finishes and Joint Sealing

Fill breaks, punctures, and voids with vapor barrier coating compound for inside work or manufacturer's recommended weatherproof coating for outside work. Vapor seal joints by embedding a single layer of 80 mm 3 inch wide open weave glass membrane, maximum 20 by 20 mesh per linear 25 mm one inch between two 1.60 mm 1/16 inch wet film thickness coats of vapor barrier coating compound. Draw glass fabric smooth and tight with a 40 mm 1 1/2 inch overlap. At jacket penetrations such as hangers, thermometers, and damper operating rods, fill voids in insulation with vapor barrier coating.

Brush a coat of vapor barrier coating where required on HVAC ducts. Provide vapor barrier jacket continuous across seams, reinforcements, and projections. Where height of projections is greater than insulation thickness, carry insulation and jacket over projection. For joints for heating only systems, provide insulation with two coats of fire resistant adhesive with glass fabric mesh embedded between coats.

#### 3.2.8 Moisture Seal

Provide a vapor (moisture) seal where insulation terminates against metal hangers, anchors and other projections through insulation on surfaces for which a vapor seal is specified. Keep insulation dry during application of finish. Bevel and seal edges of exposed insulation.

### 3.3 PIPE INSULATION

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**NOTE: Refer to ASHRAE 90.2, Table 6-4 for Minimum  
Pipe Insulation.**

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### 3.3.1 Pipe Insulation (Except Cellular and Calcium Silicate Insulation)

Place sections of insulation around pipe and joints tightly butted into place. Draw jacket tight and smooth. Secure jacket with fire resistant adhesive, factory-applied self-sealing lap, or stainless steel outward clinching staples spaced not over 100 mm 4 inches on center (o.c.) and 15 mm 1/2 inch minimum from edge of lap. Cover circumferential joints with butt strips, not less than 80 mm 3 inches wide, of material identical to jacket material. Overlap longitudinal laps of jacket material not less than 40 mm 1 1/2 inches. Adhesive used to secure butt strip shall be same as that used to secure jacket laps. Apply staples to both edges of butt strips.

- a. Vapor Barrier Jacket: When a vapor barrier jacket is required, as indicated in Table 1, on ends of sections of insulation that butt against flanges, unions, valves, fittings, and joints, provide a vapor barrier coating or manufacturer's weatherproof coating for outside service unless pipe is supplied with factory-applied self-seal lap. Apply vapor barrier coating at longitudinal and circumferential laps. Patch damaged jacket material by wrapping a strip of jacket material around the pipe and cementing, stapling, and coating as specified for butt strips. Extend patch not less than 40 mm 1 1/2 inches past the break in both directions. At penetrations by pressure gages and thermometers, fill voids with vapor barrier coating for outside service. Seal with a brush coat of the same coating. Do not use staples to secure jacket laps on pipes carrying fluid medium at temperatures below 2 degrees C 35 degrees F.
- b. Roof: Where pipe penetrates, insulate piping to a point flush with top of flashing and seal with vapor barrier coating. Butt top of flashing and interior insulation tightly to exterior insulation. Extend exterior metal jacket 50 mm 2 inches to fold down beyond end of insulation. Seal flashing and counterflashing underneath with vapor barrier coating.

### [3.3.2 Flexible Cellular Insulation

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**NOTE: Do not use for pipes in pipe chases and fire walls. For LANTNAVFACENGCOM, delete this paragraph in its entirety.**

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Bond cuts, butt joints, ends, and longitudinal joints with adhesive. Miter 90-degree turns and elbows, tees, and valve insulation. Where pipes penetrate fire walls, provide mineral-fiber insulation inserts and sheet-metal sleeves. Insulate flanges, unions, valves, and fittings in accordance with manufacturer's published instructions. Apply two coats of [acrylic latex or equivalent] [finish as recommended by insulation manufacturers] to flexible unicellular insulation in outside locations. Do not use vinyl lacquer finish or equivalent. Use metal jackets on cellular insulation located outside.

### ]3.3.3 [Cellular Glass] [and] [Calcium Silicate] Insulation

Provide in accordance with manufacturer's printed instructions.

#### 3.3.4 Hangers and Anchors

Pipe insulation shall be continuous through pipe hangers. Where pipe is supported by insulation, provide galvanized steel shields and protection saddles. Where shields are used on pipes 50 mm 2 inches and larger, provide insulation inserts at points of hangers and supports. Insulation inserts shall be of calcium silicate, cellular glass, minimum 128 kg/m<sup>3</sup> 8 pcf, molded glass fiber, minimum 128 kg/m<sup>3</sup> 8 pcf, or other approved material of the same thickness as adjacent insulation. Insulation inserts shall cover bottom half of pipe circumference and be not less in length than the protection shield. Vapor-barrier facing of insert shall be of same material as facing on adjacent insulation. Seal inserts into insulation with vapor barrier coating or weatherproof coating as applicable. Where protection saddles are used, fill voids with same insulation material as used on adjacent pipe. Where anchors are secured to chilled piping that is to be insulated, insulate anchors same as piping for a distance not less than four times the insulation thickness to prevent condensation. Vapor seal insulation around anchors.

#### 3.3.5 Sleeves and Wall Chases

Where interior wall penetrates, extend a [stainless steel] [aluminum] jacket 50 mm 2 inches out on either side of wall and secure on each end with a band. Where floor penetrates, extend a metal jacket from a point below back-up material to a point 254 mm 10 inches above floor with one band at the floor and one not more than 25 mm one inch from end of metal jacket. Where exterior wall is penetrated, extend metal jacket through sleeve to a point 50 mm 2 inches beyond interior surface of wall.

#### 3.3.6 Flanges, Unions, Valves and Fittings for Piping

Provide insulation for cold piping and hot piping of 43 degrees C 110 degrees F or higher. Factory fabricated removable and reusable insulation covers may be used except with flexible cellular. When nesting size insulation is used, overlap 50 mm 2 inches or one pipe diameter, whichever is larger. Use insulating cement to fill voids. On pipe sizes larger than 65 mm 2 1/2 inches, elbows insulated using segments shall not have less than three segments per elbow. Place and joint segments with manufacturer's recommended water-vapor resistant, fire retardant, and adhesive appropriate for the temperature limit of the service. Overlap tape seams 25 mm one inch.

Extend adhesive onto adjoining insulation not less than 50 mm two inches. Total dry film thickness shall not be less than 1.60 mm 1/16 inch. Where unions are indicated not to be insulated, taper insulation to union at a 45 degree angle. Provide finish coating as follows:

- a. Coating with Embedded Glass Tape: Coat insulation and all purpose jacket with two coats of lagging adhesive and with glass tape embedded between coats. Total dry film thickness shall not be less than 1.60 mm 1/16 inch. Where unions are indicated not to be insulated, taper insulation to union at a 45 degree angle. For cold piping, seal insulation and jacket with two coats of vapor barrier coating with glass tape embedded between coats. Insulate anchors attached directly to cold pipe for a sufficient distance to prevent condensation but not less than 150 mm 6 inches from insulation surface.
- b. PVC Fitting Covers: Factory premolded one-piece PVC fitting covers may be provided in lieu of two coats of adhesive with tape embedded between coats. Provide factory premolded

field-fabricated segment or blanket insert insulation under fitting covers. Install factory premolded one-piece PVC fitting covers over insulation. Secure covers with stapling, taping with PVC vapor barrier tape, or with metal or plastic tacks made for securing PVC fitting covers. Do not provide PVC fitting covers where exposed to weather. Provide PVC fitting covers only in ambient temperatures below 66 degrees C 150 degrees F.

### 3.3.7 Piping Exposed to Weather

#### 3.3.7.1 Metal Jackets

Provide over insulation. Machine cut jacket to smooth edge of circumferential joints. Overlap jacket not less than 50 mm 2 inches at longitudinal and circumferential joints and secure with metal bands at not more than 230 mm 9 inch centers. Overlap longitudinal joints down to shed water. Seal joints with a coating recommended by insulation manufacturer for weatherproofing.

#### 3.3.7.2 Flanges, Unions, Valves, Fittings, and Accessories

Insulate and finish as specified hereinbefore for applicable service. Apply two coats of an emulsion type weatherproof mastic for hot service and vapor barrier mastic for cold service recommended by insulation manufacturer. Embed glass tape in the first coat. Overlap tape not less than 25 mm one inch and the adjoining metal jacket not less than 50 mm 2 inches.

### 3.4 BOILER STACKS AND DIESEL ENGINE EXHAUST INSULATION

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 shall be 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.

### 3.5 EQUIPMENT INSULATION

Apply equipment insulation suitable for temperature and service in rigid block or semi-rigid board or flexible form to fit as closely as possible to equipment. Groove or score insulation where necessary to fit contours of equipment. Stagger end joints where possible. Bevel edges of insulation for cylindrical surfaces to provide tight joints. Join sections of cellular glass insulation with bedding compound. After cellular glass insulation is in place on areas to be insulated, except where metal-encased, fill joints, seams, chipped edges, or depressions with bedding compound to form a smooth surface. Fill mineral fiber joints with insulating cement. Bevel insulation around name plates, ASME and access plates. For insulation on equipment that is opened periodically for inspection, cleaning, or repair, construct insulation to be removable and replaceable without damage. Protect exposed insulation corners with corner angles under wires and bands.

### 3.5.1 Heating Equipment (Except Pumps)

Insulate shell and tube heat exchangers for the temperature of shell medium as indicated. Insulation on heads of heat exchangers shall be removable. Fabricate a male-female shiplap type joint for removable section. [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 gage welded wire fabric spot welded to equipment over ribs. Secure insulation to the fabric with J hooks and 50 by 50 mm 2 by 2 inch washers or wire loop insulation to the fabric.] Provide 16 gage [galvanized steel] [stainless steel] [or] [copper] wire or 19 mm 3/4 inch wide 20 gage stainless steel bands spaced on 305 mm 12 inch centers. Seal joints with bedding compound for cellular glass or for mineral fiber with insulating cement and cover insulation with a smooth coat of insulating cement. Apply two coats of lagging adhesive with a layer of glass cloth embedded between coats. Dry film thickness of finish shall be 0.79 mm 1/32 inch minimum.

### 3.5.2 Cold Equipment (Except Pumps)

Secure insulation with 16 gage, galvanized steel or copper clad wire or with 19 mm 3/4 inch wide 20 gage stainless steel bands spaced on 305 mm 12 inch centers. Seal joints with joint sealer. Cover non-removable irregular surfaces such as corner angles with a smoothing coat of insulating cement. Provide removable heat exchanger head covers with a male-female shiplap type joint. Apply two coats of vapor barrier coating with a layer of glass cloth embedded between coats. Dry film thickness of finish shall be 0.79 mm 1/32 inch minimum.

### 3.5.3 Pumps

Insulate pumps used for hot service with preformed mineral fiber insulation and pumps used for chilled water and brine service with [cellular glass] [flexible cellular] insulation. Insulate pumps by forming a box around pump housing, drive shaft, and piping. Apply insulation to inside surfaces of 20 gage [galvanized] [stainless steel] sheet-metal boxes having openings for drive shaft and pipes. Construct box by forming bottom and sides using joints which do not leave raw ends of insulation exposed. Band bottom and sides to form a rigid housing that does not rest on pump. Between top cover and sides, fit joints tightly forming a female shiplap joint on side pieces and a male joint on top cover to make top cover removable. Secure insulation to box with adhesive. Allow clearance for draining and adjustment of pump shaft seal.

## 3.6 FIELD QUALITY CONTROL

Visually inspect to ensure that materials provided conform to specifications. Inspect installations progressively for compliance with requirements.

### 3.6.1 Air Distribution Systems

Obtain Contracting Officer's written approval of systems under Section 15950N HVAC TESTING/ADJUSTING/BALANCING before applying field insulation to air distribution systems.

### 3.6.2 Piping Systems

Obtain Contracting Officer's written approval of HVAC water distribution

systems under Section 15950N HVAC TESTING/ADJUSTING/BALANCING before applying field-applied insulation to HVAC water distribution systems. At Contractor's option and with Contracting Officer's written approval, piping systems may be insulated before systems are tested, adjusted, and balanced (TAB'd). Piping insulation shall terminate immediately adjacent to each flow control valve, automatic control valve, or device. For chilled water and chilled-hot water piping systems, seal ends of pipe insulation and space between ends of pipe insulation and piping with waterproof vapor barrier seating. After systems are TAB'd, insulate control valves and devices.

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NOTE: CAUTION: If Government designer does not have necessary computer hardwares and softwares to perform and verify insulation calculation which shall be certified by professional engineer in Contractor's bid document, delete following calculation requirement.

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NOTE: Tables 1 is 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 shall become a part of project specification.

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.

Cellular glass and faced rigid cellular phenolic foam 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 one inch thick cellular insulation is too high to be economical. For faced rigid cellular phenolic foam, recommended minimum thickness is 25 mm one inch.

For cryogenic equipment handling media between minus 34 degrees C and minus 18 degrees C 30 degrees F and minus one degree F, use cellular glass or faced rigid cellular phenolic foam 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.

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NOTE: For LANTNAVFACENGCOM projects, delete "Type"

and "Class" in its entirety from Table 1; delete "Flexible Cellular" from material column of Tables 1 and 2 except refrigerant suction piping; and provide vapor barriers for all services. Delete data from High Temperature Hot Water and Brine Systems.

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NOTE: For SOUTHNAVFACENGCOM projects, use only cellular glass with vapor barrier for chilled water piping.

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NOTE: For PACNAVFACENGCOM projects in high humidity (tropical) areas, delete use of mineral fiber on chilled water, refrigerant suction, and other cold piping.

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TABLE 1  
Insulation Material For Piping

Service	Material	Spec.	Type	Class	Vapor Barrier Required
Chilled Water (Supply & Return, Dual Temperature Piping, 4.44oC nominal)	Cellular Glass	ASTM C 552	II	2	No
	Urethane	ASTM C 59/C 59M1			Yes
	Mineral Fiber	ASTM C 547		1	Yes
	Flexible Cellular	ASTM C 534	I		No
	Faced Phenolic Foam	ASTM C 1126	III		Yes
Hot Domestic Water Supply and Recirculating Piping (Maximum 93oC)	Mineral Fiber	ASTM C 547		1	No
	Cellular Glass	ASTM C 552	II	2	No
	Urethane	ASTM C 59/C 59M1			Yes
Cold Domestic Water Piping	Mineral Fiber	ASTM C 547		1	Yes
	Cellular Glass	ASTM C 552	II	2	No
	Urethane	ASTM C 59/C 59M1			Yes
	Flexible Cellular	ASTM C 534	I		No
Heating Hot Water (Supply & Return, Maximum 121oC)	Mineral Fiber	ASTM C 547		1	No
	Calcium Silicate	ASTM C 533	I		No
	Cellular Glass	ASTM C 552	II	2	No
Refrigerant Suction Piping (1.67oC nominal)	Flexible Cellular	ASTM C 534	I		No
	Cellular Glass	ASTM C 552		1	Yes
	Faced Phenolic	ASTM C 1126	III		Yes
	Foam				
Compressed Air Discharge, Steam and	Cellular Glass	ASTM C 552	II		No
	Mineral Fiber	ASTM C 547		1	No
	Calcium Silicate	ASTM C 533	I		No

TABLE 1  
Insulation Material For Piping

Service	Material	Spec.	Type	Class	Vapor Barrier Required
Condensate Return (94 to 121oC)					
Drinking	Mineral Fiber	ASTM C 547		1	Yes
Fountain, Drain	Cellular Glass	ASTM C 552	II	2	No
Piping (to sewer tie in)	Flexible Cellular	ASTM C 534	I		No
Exposed Lavatory Drains, Exposed Domestic Water Piping & Drains to Areas for Handicap Personnel	Flexible Cellular	ASTM C 534	I		No
Horizontal Roof Drain Leaders (Including Underside of Roof Drain Fittings)	Mineral Fiber	ASTM C 547		1	Yes
	Flexible Cellular	ASTM C 534	I		No
A/C condensate Drain Located Inside Bldg.	Mineral Fiber	ASTM C 547		1	Yes
	Cellular Glass	ASTM C 552	II	2	No
	Flexible Cellular	ASTM C 534	I		No
	Faced Phenolic Foam	ASTM C 1126	III		Yes
Medium Tempera- ture Hot Water, Steam and Condensate (122 to 176oC)	Mineral Fiber	ASTM C 547		1	No
	Calcium Silicate	ASTM C 533	I		No
	Cellular Glass	ASTM C 552	I or II		No
High Temperature Hot Water and Steam (177 to 371oC)	Mineral Fiber	ASTM C 547		2	No
	Calcium Silicate	ASTM C 533	I		
	Mineral Fiber/ Cellular Glass	ASTM C 547 & ASTM C 552			
Brine Systems Cryogenics (Minus 34 to Minus 18oC)	Cellular Glass	ASTM C 552	II	2	No
	Flexible Cellular	ASTM C 534	I		No
	Faced Phenolic Foam	ASTM C 1126	III		Yes
Brine Systems Cryogenics (Minus 18 to 1.11oC)	Cellular Glass	ASTM C 552	II	2	No
	Flexible Cellular	ASTM C 534	I		No
	Faced Phenolic Foam	ASTM C 1126	III		Yes



\*\*\*\*\*  
 NOTE: For LANTNAVFACENGCOM projects, delete "Type"  
 and "Class" in its entirety from Table 1; delete  
 "Flexible Cellular" from material column of Tables 1  
 and 2 except refrigerant suction piping; and provide  
 vapor barriers for all services. Delete data from  
 High Temperature Hot Water and Brine Systems.  
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 NOTE: For SOUTHNAVFACENGCOM projects, use only  
 cellular glass with vapor barrier for chilled water  
 piping.  
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\*\*\*\*\*  
 NOTE: For PACNAVFACENGCOM projects in high humidity  
 (tropical) areas, delete use of mineral fiber on  
 chilled water, refrigerant suction, and other cold  
 piping.  
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TABLE 1  
 Insulation Material For Piping

Service	Material	Spec.	Type	Class	Vapor
Barrier					
Required					
Chilled Water (Supply & Yes Return, Dual Temperature Piping, 40oF nominal)	Cellular Glass Urethane	ASTM C 552 ASTM C 59/C	II 59M1	2	No
	Mineral Fiber	ASTM C 547		1	Yes
	Flexible Cellular	ASTM C 534	I		No
	Faced Phenolic Foam	ASTM C 1126	III		Yes
Hot Domestic Water Supply and Recirculating Yes Piping (Maximum 200oF)	Mineral Fiber	ASTM C 547		1	No
	Cellular Glass Urethane	ASTM C 552 ASTM C 59/C	II 59M1	2	No
	Faced Phenolic Foam	ASTM C 1126	III		Yes
Cold Domestic Water Piping Yes	Mineral Fiber	ASTM C 547		1	Yes
	Cellular Glass Urethane	ASTM C 552 ASTM C 59/C	II 59M1	2	No
	Flexible Cellular	ASTM C 534	I		No
Heating Hot	Mineral Fiber	ASTM C 547		1	No

TABLE 1  
Insulation Material For Piping

Service	Material	Spec.	Type	Class	Vapor
Barrier Required					
Water (Supply & Return, Maxi- mum 250oF)	Calcium Silicate	ASTM C 533	I	2	No
	Cellular Glass	ASTM C 552	II		No
	Faced Phenolic Foam	ASTM C 1126	III		Yes
Refrigerant Suction Piping (35oF nominal)	Flexible Cellular	ASTM C 534	I	1	No
	Cellular Glass	ASTM C 552			Yes
	Faced Phenolic Foam	ASTM C 1126	III		Yes
Compressed Air Discharge, Steam and Condensate Return (201 to 250oF)	Cellular Glass	ASTM C 552	II	1	No
	Mineral Fiber	ASTM C 547			No
	Calcium Silicate	ASTM C 533	I		No
Drinking Fountain, Drain Piping (to sewer tie in)	Mineral Fiber	ASTM C 547		1	Yes
	Cellular Glass	ASTM C 552	II	2	No
	Flexible Cellular	ASTM C 534	I		No
	Faced Phenolic Foam	ASTM C 1126	III		Yes
Exposed Lavatory Drains, Exposed Domestic Water Piping & Drains to Areas for Handicap Personnel	Flexible Cellular	ASTM C 534	I		No
Horizontal Roof Drain Leaders (Including Underside of Roof Drain Fittings)	Mineral Fiber	ASTM C 547		1	Yes
	Flexible Cellular	ASTM C 534	I		No
A/C condensate Drain Located Inside Bldg.	Mineral Fiber	ASTM C 547		1	Yes
	Cellular Glass	ASTM C 552	II	2	No
	Flexible Cellular	ASTM C 534	I		No
	Faced Phenolic	ASTM C 1126	III		Yes

TABLE 1  
Insulation Material For Piping

Service	Material	Spec.	Type	Class	Vapor
Barrier Required					
	Foam				
Medium Tempera- ture Hot Water, Steam and Condensate (251 to 350oF)	Mineral Fiber Calcium Silicate Cellular Glass	ASTM C 547 ASTM C 533 ASTM C 552	I I or II	1	No No No
High Temperature Hot Water and Steam (351 to 700oF) Composite	Mineral Fiber Calcium Silicate Mineral Fiber/ Cellular Glass	ASTM C 547 ASTM C 533 ASTM C 547 & ASTM C 552	I	2	No
Brine Systems Cryogenics (Minus 30 to Zero)	Cellular Glass Flexible Cellular Faced Phenolic Foam	ASTM C 552 ASTM C 534 ASTM C 1126	II I III	2	No No Yes
Brine Systems Cryogenics (Zero to 34)	Cellular Glass Flexible Cellular Faced Phenolic Foam	ASTM C 552 ASTM C 534 ASTM C 1126	II I III	2	No No Yes

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NOTE: Table 2 is 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 shall become a part of project specification. Refer to Table 6-4 of ASHRAE 90.2 for Minimum Pipe Insulation.

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.

Cellular glass and faced rigid cellular phenolic foam 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 one inch thick cellular insulation is too high to be economical. For faced rigid cellular phenolic foam, recommended minimum thickness is 25 mm one inch.

For cryogenic equipment handling media between minus 34 degrees C and minus 18 degrees C 30 degrees F and minus one degree F, use cellular glass or faced rigid cellular phenolic foam insulation.

Economic insulation thickness recommendations (EITR) are based on three factors: energy, economics, and environment. Design conditions are as follows:

1. Ambient Temperature: 27 degrees C 80 degrees F, Still Air
2. Jacket Surface Emissivity: 0.2 Metal, 0.9 All Purpose
3. Surface Temperatures: 29 degrees C 85 degrees F nominal for service temperatures under 176 degrees C 350 degrees F; maximum 60 degrees C 140 degrees F for high service temperatures at and above 177 degrees C 351 degrees F.
4. Average energy cost of six dollars per 1,055,000 kJ million Btu's.

EITR is a term used by North America Insulation Manufacturers Association (NAIMA), Commercial/Industrial Insulation Committee. Current member companies are: Knauf Fiber Glass, CertainTeed, Manville, Partek North America, Rock Wool Manufacturing, and Owen Corning Fiberglass. Data of mineral fiber and calcium silicate are supplied by NAIMA. Data of cellular glass are supplied by Pittsburgh Corning Corporation. Other data are obtained from manufacturers' published documents. Insulation thickness calculation was generated by manufacturers. Individual and precise calculation may be done by using computer programs such as NAIMA 3 E's Insulation Thickness Computer Program. These computer programs shall comply with ASTM C 680, 1989 "Determination of Heat Gain or Loss and the Surface Temperatures of Insulated Pipe and Equipment Systems by the Use of a Computer Program".

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NOTE: For LANTNAVFACENGCOM projects, when there are two rows of insulation thickness for calcium silicate and mineral fiber, delete first-row data and use only second-row data identified with an asterisk. For other EFDs, delete second-row data. Delete data from High Temperature Water and Brine Systems.

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NOTE: For SOUTHNAVFACENGCOM projects, select first option of "Chilled Water (Supply & Return) & Dual Temperature Piping, 4 degrees C 39 degrees F nominal" Service.

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NOTE: For PACNAVFACENGCOM projects in high humidity (tropical) areas, delete use of mineral fiber on chilled water, refrigerant section, and other cold piping.

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TABLE 2  
Piping Insulation Thickness (mm)

Service	Material	Tube And Pipe Size (mm)				
		6-32	40-80	90-125	150-250	280-900
[Chilled Water (Supply & Return, & Dual Temperature Piping) (4.44oC Nominal)]	Cellular Glass	40	50	50	65	80
	Faced Phenolic	25	25	25	40	50
	Foam					
[Chilled Water (Supply & Return, & Dual Temperature Piping) (4.44oC Nominal)]	Mineral Fiber	25	25	40	40	40
	Cellular Glass	40	40	40	40	40
	Urethane	20	20	20	25	25
	Flexible Cellular	20	20	20	25	25
	Faced Phenolic	25	25	25	40	40
Hot Domestic Water Supply and Recirculating Piping (Maximum 93oC)	Foam					
	Mineral Fiber	25	25	40	40	40
	Cellular Glass	40	40	40	40	40
Cold Domestic Water Piping	Urethane	20	20	25	25	25
	Mineral Fiber	20	25	25	25	25
	Cellular Glass	40	40	40	40	40
	Flexible	15	15	15	15	N/A
	cellular					
Heating Hot Water (Supply & Return, Maximun 121oC)	Urethane	20	20	20	25	25
	Faced Phenolic	25	25	25	25	25
	Foam					
	Mineral Fiber	40	40	50	65	80
	Calcium Silicate	40	40	65	65	65
		50*	50*	65*	65*	65*
	Cellular Glass	40	40	40	40	40
	Faced Phenolic	25	25	25	25	25
	Foam					

TABLE 2  
Piping Insulation Thickness (mm)

Service	Material	Tube And Pipe Size (mm)				
		6-32	40-80	90-125	150-250	280-900
Refrigerant Suction Piping (1.67oC nominal)	Flexible cellular	15	25	25	25	25
	Cellular Glass	40	40	40	40	40
	Faced Phenolic	25	25	25	25	25
	Foam					
Compressed Air Discharge, Steam, and Condensate Return (94 to 121oC)	Mineral Fiber	40	40	50	65	65
		40*	50*	65*	80*	90*
	Calcium Silicate	40	40	65	65	65
		50*	80	100*	100*	115*
	Cellular Glass	40	40	40	40	40
	Faced Phenolic	25	25	25	25	25
	Foam					
Exposed Lavatory Drains, Exposed Domestic Water Piping & Drains to Areas for Handicap Personnel	Flexible cellular	15	15	15	15	15
Horizontal Roof Drain Leaders (including Underside of Roof Drain Fitting)	Mineral Fiber	25	25	40	40	50
	Flexible Cellular	25	25	25	25	25
	Faced Phenolic	25	25	25	25	25
	Foam					
A/C condensate Drain Located Inside Bldg.	Mineral Fiber	20	25	25	25	25
	Cellular Glass	40	40	40	40	40
	Flexible cellular	15	15	15	15	15
	Faced Phenolic	25	25	25	25	25
	Foam					
Medium Temp- erature Hot Water and Steam (122 to 176oC)	Mineral Fiber	50	65	80	80	100
		65*	80*	90*	100*	100*
	Calcium Silicate	50	65	80	80	80
		65*	90*	115*	115	125*
	Cellular Glass	40	40	40	50	65
High Temperature Water (177 to 204oC) and Steam (177 to 260oC)	Mineral Fiber	80	100	100	100	100
	Calcium Silicate	65	80	100	100	100
	Mineral Fiber/ Cellular Glass	25	25	25	25	25
		50	50	50	50	50
	Composite					
Brine Systems Cryogenics	Cellular Glass	65	65	80	80	90
	Flexible Cellular	25	25	N/A	N/A	N/A

TABLE 2  
Piping Insulation Thickness (mm)

Service	Material	Tube And Pipe Size (mm)				
		6-32	40-80	90-125	150-250	280-900
(Minus 34 to Minus 18oC)	Faced Phenolic Foam	40	40	40	50	50
Brine Systems, Cryogenics (Minus 18 to 1.11oC)	Cellular Glass	50	50	50	65	80
	Flexible Cellular	20	25	25	25	25
	Faced Phenolic Foam	25	25	25	40	40

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NOTE: For LANTNAVFACENGCOM projects, change pipe sizes to read as follows: 0.25 to 1.25; 1.5 to 3; 3.5 to 5; 6 to 10; and 11 to 36 respectively. When there are two rows of insulation thickness for calcium silicate and mineral fiber, delete first-row data and use only second-row data identified with an asterisk. For other EFDs, delete second-row data. Delete data from High Temperature Water and Brine Systems.

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NOTE: For SOUTHNAVFACENGCOM projects, select first option of "Chilled Water (Supply & Return) & Dual Temperature Piping, 4.50 degrees C 40 degrees F nominal" Service.

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NOTE: For PACNAVFACENGCOM projects in high humidity (tropical) areas, delete use of mineral fiber on chilled water, refrigerant section, and other cold piping.

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TABLE 2  
Piping Insulation Thickness (inch)

Service	Material	Tube And Pipe Size (Inches)				
		1/4-1 1/4	1 1/2-3	3 1/2-5	6-10	11-36
[Chilled Water (Supply & Return, & Dual Temperature	Cellular Glass	1.5	2	2	2.5	3
	Faced Phenolic	1	1	1	1.5	1.5
	Foam					

TABLE 2  
Piping Insulation Thickness (inch)

Service	Material	Tube And Pipe Size (Inches)						
		1/4-1 1/4	1 1/2-3	3 1/2-5	6-10	11-36		
Piping) (40oF Nominal)]								
[Chilled Water (Supply & Return, & Dual Temperature Piping) (40oF Nominal)]	Mineral Fiber	1	1	1.5	1.5	1.5		
	Cellular Glass	1.5	1.5	1.5	1.5	1.5		
	Urethane	0.75	0.75	0.75	1	1		
	Flexible Cellular	0.75	0.75	0.75	1	1		
	Faced Phenolic Foam	1	1	1	1.5	1.5		
Hot Domestic Water Supply and Recirculating Piping (Maximum 200oF)	Mineral Fiber	1	1	1.5	1.5	1.5		
	Cellular Glass	1.5	1.5	1.5	1.5	1.5		
	Urethane	0.75	0.75	1	1	1		
	Faced Phenolic	1	1	1	1	1		
	Foam							
Cold Domestic Water Piping	Mineral Fiber	0.75	1	1	1	1		
	Cellular Glass	1.5	1.5	1.5	1.5	1.5		
	Flexible cellular	0.5	0.5	0.5	N/A	N/A		
	Urethane	0.75	0.75	0.75	1	1		
	Faced Phenolic Foam	1	1	1	1	1		
Heating Hot Water (Supply & Return, Maximum 250oF)	Mineral Fiber	1.5	1.5	2	2.5	3		
	Calcium Silicate	1.5	1.5	2.5	2.5	2.5		
		2*	2*	2.5*	2.5*	2.5*		
	Cellular Glass	1.5	1.5	1.5	1.5	1.5		
	Faced Phenolic Foam	1	1	1	1	1		
Refrigerant Suction Piping (35oF nominal)	Flexible cellular	0.5	1	1	1	1		
	Cellular Glass	1.5	1.5	1.5	1.5	1.5		
	Faced Phenolic	1	1	1	1	1		
	Foam							
Compressed Air Discharge, Steam, and Condensate Return (201oF to 250oF)	Mineral Fiber	1.5	1.5	2	2.5	2.5		
		1.5*	2*	2.5*	3*	3.5*		
	Calcium Silicate	1.5	1.5	2.5	2.5	2.5		
		2*	3*	4*	4*	4.5*		
	Cellular Glass	1.5	1.5	1.5	1.5	1.5		
Faced Phenolic	1	1	1.5	1.5	1.5			



TABLE 2  
Piping Insulation Thickness (inch)

Service	Material	Tube And Pipe Size (Inches)					
		1/4-1 1/4	1 1/2-3	3 1/2-5	6-10	11-36	
	Foam						
Exposed Lavatory Drains, Exposed Domestic Water Piping & Drains to Areas for Handicap Personnel	Flexible cellular	0.5	0.5	0.5	0.5	0.5	
Horizontal Roof Drain Leaders (including Underside of Roof Drain Fitting)	Mineral Fiber	1	1	1.5	1.5	2	
	Flexible Cellular	1	1	1	1	1	
	Faced Phenolic Foam	1	1	1	1	1	
A/C condensate Drain Located Inside Bldg.	Mineral Fiber	0.75	1	1	1	1	
	Cellular Glass	1.5	1.5	1.5	1.5	1.5	
	Flexible cellular	0.5	0.5	0.5	0.5	0.5	
	Faced Phenolic Foam	1	1	1	1	1	
Medium Temp-erature Hot Water and Steam (251o to 350oF)	Mineral Fiber	2	2.5	3	3	4	
		2.5*	3*	3.5*	4*	4*	
	Calcium Silicate	2	2.5	3	3	3	
		2.5*	3.5*	4.5*	4.5*	5*	
	Cellular Glass	1.5	1.5	1.5	2	2.5	
High Temperature Water (351o to 400oF) and Steam (351oF to 500oF)	Mineral Fiber	3	4	4	4	4	
	Calcium Silicate	2.5	3	4	4	4	
	Mineral Fiber/	1	1	1	1	1	
	Cellular Glass Composite	2	2	2	2	2	
Brine Systems Cryogenics (Minus 30 to ZerooF)	Cellular Glass	2.5	2.5	3	3	3.5	
	Flexible Cellular	1	1	N/A	N/A	N/A	
	Faced Phenolic Foam	1.5	1.5	2	2	2	
Brine Systems,	Cellular Glass	2	2	2	2.5	3	

TABLE 2  
Piping Insulation Thickness (inch)

Service	Material	Tube And Pipe Size (Inches)					
		1/4-1 1/4	1 1/2-3	3 1/2-5	6-10	11-36	
Cryogenics (Zero to 34oF)	Flexible Cellular	0.75	1	1	1	1	
	Faced Phenolic	1	1	1	1.5	1.5	
	Foam						

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NOTE: Tables 3 and 4 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 shall become a part of project specification.

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.

Cellular glass and faced rigid cellular phenolic foam 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 one inch thick cellular insulation is too high to be economical. For faced rigid cellular phenolic foam, recommended minimum thickness is 25 mm one inch.

For cryogenic equipment handling media between minus 34 degrees C and minus 18 degrees C 30 degrees F and minus one degree F, use cellular glass or faced rigid cellular phenolic foam insulation.

Economic insulation thickness recommendations (EITR) are based on three factors: energy, economics, and environment. Design conditions are as follows:

1. Ambient Temperature: 27 degrees C 80 degrees F, Still Air
2. Jacket Surface Emissivity: 0.2 Metal, 0.9 All Purpose
3. Surface Temperatures: 29 degrees C 85 degrees F nominal for service temperatures under 176 degrees C 350 degrees F; maximum 60 degrees C 140 degrees F for high service temperatures at and above 177 degrees C 351 degrees F.

4. Average energy cost of six dollars per 1,055,000 kJ million Btu's.

EITR is a term used by North America Insulation Manufacturers Association (NAIMA), Commercial/Industrial Insulation Committee. Current member companies are: Knauf Fiber Glass, CertainTeed, Manville, Partek North America, Rock Wool Manufacturing, and Owen Corning Fiberglass. Data of mineral fiber and calcium silicate are supplied by NAIMA. Data of cellular glass are supplied by Pittsburgh Corning Corporation. Other data are obtained from manufacturers' published documents. Insulation thickness calculation was generated by manufacturers. Individual and precise calculation may be done by using computer programs such as NAIMA 3 E's Insulation Thickness Computer Program. These computer programs shall comply with ASTM C 680, 1989 "Determination of Heat Gain or Loss and the Surface Temperatures of Insulated Pipe and Equipment Systems by the Use of a Computer Program".

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NOTE: Flexible Cellular ASTM C 534, Type II can only be used up to and including 20 mm thick.

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TABLE 3  
Insulation Materials for Equipment

Equipment	Spec	Type	Class
Flexible Mineral Fiber Surface Temperatures up to 204oC	ASTM C 553	I	B-3
Rigid Mineral Fiber ASTM C 612 Surface Temperatures up to 204oC			1 or 2
Surface Temperatures up to 454oC			3
Cellular Glass Surface Temperatures between Minus 204oC and Positive 427oC	ASTM C 552	1, 2 or 3	1 or 2
Flexible Cellular Service Temperature from minus 7oC to 49oC	ASTM C 534	II	
Phenolic Foam Surface temperature from minus 40 to positive 120oC	ASTM C 1126	III	

TABLE 3  
Insulation Materials for Equipment

Equipment	Spec	Type	Class
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**NOTE: Flexible Cellular ASTM C 534, Type II can only be used up to and including 3/4 inch thick.**  
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TABLE 3  
Insulation Materials for Equipment

Equipment	Spec	Type	Class
Flexible Mineral Fiber Surface Temperatures up to 400oF	ASTM C 553	I	B-3
Rigid Mineral Fiber ASTM C 612			
Surface Temperatures up to 400oF			1 or 2
Surface Temperatures up to 850oF			3
Cellular Glass Surface Temperatures between Minus 400oF and Positive 800oF	ASTM C 552	1, 2 or 3	1 or 2
Flexible Cellular Service Temperature from 20oF to 120oF	ASTM C 534		
Phenolic Foam Surface temperature from minus 40 to positive 250oF	ASTM C 1126	III	

TABLE 4  
Insulation Thickness for Equipment

Equipment	Recommended Thickness
Expansion Tanks or Pneumatic Water Tanks	15 mm
Air Separators	50 mm
Pumps	50 mm

TABLE 4  
Insulation Thickness for Equipment

Equipment	Recommended Thickness
Hot Water Storage Tanks	50 mm
Heat Exchangers, such as Steam to Hot Water Convectors	
Up to 120oC	50 mm
121 to 204oC	90 mm
205 to 315oC	150 mm
Hot Water Duct-Mounted Coils	25 mm
*Chilled Water Tanks 2 to 13oC	15 mm
*Cryogenic Equipment Minus 34 to minus 17oC	100 mm

NOTE: \* indicates where vapor barrier is required.

TABLE 4  
Insulation Thickness for Equipment

Equipment	Recommended Thickness
Expansion Tanks or Pneumatic Water Tanks	1/2"
Air Separators	2"
Pumps	2"
Hot Water Storage Tanks	2"
Heat Exchangers, such as Steam to Hot Water Convectors	
Up to 249oF	2"
250 to 400oF	3-1/2"
401 to 600oF	6"
Hot Water Duct-Mounted Coils	2"
*Chilled Water Tanks 35oF to 55oF	1"
*Cryogenic Equipment Minus 30oF to 1oF	4"

NOTE: \* indicates where vapor barrier is required.

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NOTE: Table 5 is 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 shall become a part of project specification.

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.

Cellular glass and faced rigid cellular phenolic foam 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 one inch thick cellular insulation is too high to be economical. For faced rigid cellular phenolic foam, recommended minimum thickness is 25 mm one inch.

For cryogenic equipment handling media between minus 34 degrees C and minus 18 degrees C 30 degrees F and minus one degree F, use cellular glass or faced rigid cellular phenolic foam insulation.

Table 5 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.

Calcium silicate insulation conforming to ASTM C 533 shall be either Type I, for temperatures up to 649 degrees C 1200 degrees F or Type II, for temperatures up to 871 degrees C 1600 degrees F.

Cellular glass may be used over a wide temperature range, depending on manufacturer's method of fabrications. When combined with mineral fiber, mineral fiber/cellular glass composite permits temperature services up to plus 649 degrees C 1200 degrees F.

Mineral fiber insulation conforming to ASTM C 533 shall be Class B-3 which is good for temperatures up to 204 degrees C 400 degrees F. Above 204 to 454 degrees C 400 to 850 degrees F use mineral fiber insulation conforming to ASTM C 59/C 59M2, Class 1, one side metal mesh covered. Classes of mineral fiber insulation conforming to ASTM C 612 are as follows:

Class	Maximum Surface Temperature, degrees C
1	204
2	204
3	454
4	538
5	982

Class      Maximum Surface Temperature, degrees F

1	400
2	400
3	850
4	1000
5	1800

Economic insulation thickness recommendations (EITR) are based on three factors: energy, economics, and environment. Design conditions are as follows:

1. Ambient Temperature: 27 degrees C 80 degrees F, Still Air
2. Jacket Surface Emissivity: 0.2 Metal, 0.9 All Purpose
3. Surface Temperatures: 29 degrees C 85 degrees F nominal for service temperatures under 176 degrees C 350 degrees F; maximum 60 degrees C 140 degrees F for high service temperatures at and above 177 degrees C 351 degrees F.
4. Average energy cost of six dollars per 1,055,000 kJ million Btu's.

EITR is a term used by North America Insulation Manufacturers Association (NAIMA), Commercial/Industrial Insulation Committee. Current member companies are: Knauf Fiber Glass, CertainTeed, Manville, Partek North America, Rock Wool Manufacturing, and Owen Corning Fiberglass. Data of mineral fiber and calcium silicate are supplied by NAIMA. Data of cellular glass are supplied by Pittsburgh Corning Corporation. Other data are obtained from manufacturers' published documents. Insulation thickness calculation was generated by manufacturers. Individual and precise calculation may be done by using computer programs such as NAIMA 3 E's Insulation Thickness Computer Program. These computer programs shall comply with ASTM C 680, 1989 "Determination of Heat Gain or Loss and the Surface Temperatures of Insulated Pipe and Equipment Systems by the Use of a Computer Program."

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TABLE 5  
Insulation and Thickness (mm) for  
Boiler Stack and Diesel Engine Exhaust Pipe

Service & Surface Temperature Range (Degrees C)	Material	Outside Diameter (mm)				
		6-32	40-80	90-125	150-250	280-900
Boiler Stack	Mineral Fiber	NA	NA	80	90	100

TABLE 5  
Insulation and Thickness (mm) for  
Boiler Stack and Diesel Engine Exhaust Pipe

Service & Surface Temperature Range (Degrees C)	Material	Outside Diameter (mm)				
		6-32	40-80	90-125	150-250	280-900
(Up to 204oC)	ASTM C 553 Class B-3, ASTM C 547 Class 1, or ASTM C 612 Class 1					
	Calcium Silicate ASTM C 533, Type 1	NA	NA	80	90	100
	Cellular Glass ASTM C 552,	40	40	40 Type II	50	65
Boiler Stack (205 to 315oC)	Mineral Fiber ASTM C 547, Class 2, ASTM C 59/C 59M2 Class 1, or ASTM C 612 Class 3	NA	NA	100	100	125
	Calcium Silicate ASTM C 533 Type I or II	NA	NA	100	100	100
	Mineral Fiber/ Cellular Glass Composite:					
	Mineral Fiber ASTM C 547, ASTM C 59/C 59M2 Class 1, or ASTM C 612 Class 3	25	25	25 Class 2,	25	50
	Cellular Glass ASTM C 552, Type II	50	50	50	50	50
Boiler Stack (316 to 427oC)	Mineral Fiber ASTM C 547 Class 3, ASTM C 59/C 59M2 Class 1, or ASTM C 612 Class 3	NA	NA	100	100	150



TABLE 5  
Insulation and Thickness (mm) for  
Boiler Stack and Diesel Engine Exhaust Pipe

Service & Surface Temperature Range (Degrees C)	Material	Outside Diameter (mm)				
		6-32	40-80	90-125	150-250	280-900
	Calcium Silicate ASTM C 533 Type I or II	NA	NA	100	100	150
	Mineral Fiber/ Cellular Glass Composite:					
	Mineral Fiber ASTM C 547, Class 2, ASTM C 59/C 59M2 Class 1, or ASTM C 612 Class 3	50	50	50	80	100
	Cellular Glass ASTM C 552, Type II	50	50	50	50	50
Diesel Engine Exhaust (Up to 371oC)	Calcium Silicate ASTM C 533 Type I or II	80	90	100	100	100
	Cellular Glass ASTM C 552, Type II	65	90	100	115	150

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**NOTE: For LANTNAVFACENGCOM projects, change pipe  
sizes to read as follows: 0.25 to 1.25; 1.5 to 3;  
3.5 to 5; 6 to 10; and 11 to 36 respectively.**  
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TABLE 5  
Insulation and Thickness (Inches) for  
Boiler Stack and Diesel Engine Exhaust Pipe

Service & Surface Temperature Range (Degrees F)	Material	Outside Diameter (Inches)				
		1/4-1-1/4	1-1/2-3	3-1/2-5	6-10	11-36
Boiler Stack (Up to 400o F)	Mineral Fiber ASTM C 553 Class B-3, ASTM C 547	NA	NA	3	3.5	4

TABLE 5  
Insulation and Thickness (Inches) for  
Boiler Stack and Diesel Engine Exhaust Pipe

Service & Surface Temperature Range (Degrees F)	Material	Outside Diameter (Inches)				
		1/4-1-1/4	1-1/2-3	3-1/2-5	6-10	11-36
	Class 1, or ASTM C 612 Class 1					
	Calcium Silicate ASTM C 533, Type 1	NA	NA	3	3.5	4
	Cellular Glass ASTM C 552,	1.5	1.5 Type II	1.5	2	2.5
Boiler Stack (401 to 600oF)	Mineral Fiber ASTM C 547, Class 2, ASTM C 59/C 59M2 Class 1, or ASTM C 612 Class 3	NA	NA	4	4	5
	Calcium Silicate ASTM C 533 Type I or II	NA	NA	4	4	4
	Mineral Fiber/ Cellular Glass Composite:					
	Mineral Fiber ASTM C 547, ASTM C 59/C 59M2 Class 1, or ASTM C 612 Class 3	1	1 Class 2,	1	1	2
	Cellular Glass ASTM C 552, Type II	2	2	2	2	2
Boiler Stack (601 to 800oF)	Mineral Fiber ASTM C 547 Class 3, ASTM C 59/C 59M2 Class 1, or ASTM C 612 Class 3	NA	NA	4	4	6
	Calcium Silicate ASTM C 533 Type I or II	NA	NA	4	4	6

TABLE 5  
Insulation and Thickness (Inches) for  
Boiler Stack and Diesel Engine Exhaust Pipe

Service & Surface Temperature Range (Degrees F)	Material	Outside Diameter (Inches)				
		1/4-1-1/4	1-1/2-3	3-1/2-5	6-10	11-36
	Mineral Fiber/ Cellular Glass Composite:					
	Mineral Fiber ASTM C 547, Class 2, ASTM C 59/C 59M2 Class 1, or ASTM C 612 Class 3	2	2	2	3	4
	Cellular Glass ASTM C 552, Type II	2	2	2	2	2
Diesel Engine Exhaust (Up to 700oF)	Calcium Silicate ASTM C 533 Type I or II	3	3.5	4	4	4
	Cellular Glass ASTM C 552, Type II	2.5	3.5	4	4.5	6

-- End of Section --