



Standard Practice for Selection and Application of Thermal Insulation for Piping and Machinery¹

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This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This practice ~~provides guidance in~~ covers the selection of types and thicknesses of thermal insulation materials for piping, machinery, and equipment for nonnuclear shipboard applications within the temperature ranges specified in **Tables 1-16**. Methods and materials for installation, including lagging, are also detailed.

1.2 This practice addresses operating temperatures from a low of ~~-20°F (-29°C) up to 1050°F (566°C)~~ -20°F (-29°C) up to 1200°F (649°C).

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents²

2.1 ASTM Standards:³

- [A240](#) Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
- [B209/B209M](#) Specification for Aluminum and Aluminum-Alloy Sheet and Plate
- [C168](#) Terminology Relating to Thermal Insulation
- [C195](#) Specification for Mineral Fiber Thermal Insulating Cement
- [C449/C449M](#) Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
- [C533](#) Specification for Calcium Silicate Block and Pipe Thermal Insulation
- [C534](#) Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form

¹ This practice is under the jurisdiction of ASTM Committee [F25](#) on Ships and Marine Technology and is the direct responsibility of Subcommittee [F25.02](#) on Insulation/Processes.

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² The latest revision of all referenced documents shall apply.

³ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

TABLE 1 Insulation and Lagging Materials for Pipe, Tubing, and Fittings Used for Interior Piping Systems^{A,B}

| Temperature Range °F (°C) | Insulation | Specification | Lagging ^{C,D} | Specification |
|------------------------------|--|---|--|--|
| -20 to +40 (-29 to +4) | cellular glass | ASTM C552 , Type II | Woven fibrous glass cloth | MIL-C-20079, Type I, Classes 3 through 9 |
| | elastomeric cellular ^A | MIL-PRF-32514, Type I, ASTM C534 | Knitted fibrous glass tape Table 12 materials | MIL-C-20079, Type II, Class 3 |
| | elastomeric cellular ^A | MIL-PRF-32514, Type I, (ASTM C534 , Grade 3), ASTM C534 , Grades 1, 2, and 3 | Woven fibrous glass cloth | MIL-C-20079, Type I, Classes 3 through 9 |
| | | | Knitted fibrous glass tape Table 12 materials | MIL-C-20079, Type II, Class 3 |
| 41 to 125 (5 to 51) | cellular glass | ASTM C552 , Type II | Woven fibrous glass cloth | MIL-C-20079, Type I, Classes 3 through 9 |
| | | | Knitted fibrous glass tape Table 12 materials | MIL-C-20079, Type II, Class 3 |
| | elastomeric cellular ^A | MIL-P-15280, Form T; MIL-PRF-32514, Type I, ASTM C534 | Woven fibrous glass cloth | MIL-C-20079, Type I, Classes 3 through 9 |
| | elastomeric cellular ^A | MIL-PRF-32514, Type I, (ASTM C534 , Grade 3), ASTM C534 , Grades 1, 2, and 3 | Woven fibrous glass cloth | MIL-C-20079, Type I, Classes 3 through 9 |
| | | | Knitted fibrous glass tape Table 12 materials | MIL-C-20079, Type II, Class 3 |
| | mineral fibers | ASTM C547 , Type I and II | Woven fibrous glass cloth | MIL-C-20079, Type I, Classes 3 through 9 |
| | mineral fibers | ASTM C547 , Types I through IV | Woven fibrous glass cloth | MIL-C-20079, Type I, Classes 3 through 9 |
| | | | Knitted fibrous glass tape Table 12 materials | MIL-C-20079, Type II, Class 3 |
| 126 to 450 (52 to 232) | cellular glass | ASTM C552 , Type II | Woven fibrous glass cloth | MIL-C-20079, Type I, Classes 3 through 9 |
| | | | Knitted fibrous glass tape Table 12 materials | MIL-C-20079, Type II, Class 3 |
| | elastomeric cellular 220°F (104°C) max | ASTM C534 | Woven fibrous glass cloth | MIL-C-20079, Type I, Classes 3 through 9 |
| | elastomeric cellular 220 °F (104 °C) max | MIL-PRF-32514, Type I (ASTM C534 , Grade 3), ASTM C534 Grades 1, 2, and 3 | Woven fibrous glass cloth | MIL-C-20079, Type I, Classes 3 through 9 |
| | | | Knitted fibrous glass tape Table 12 materials | MIL-C-20079, Type II, Class 3 |
| | calcium silicate | ASTM C533 , Type I | Woven fibrous glass cloth | MIL-C-20079, Type I, Classes 3 through 9 |
| | | | Knitted fibrous glass tape Table 12 materials | MIL-C-20079, Type II, Class 3 |
| | expanded perlite | ASTM C610 | Woven fibrous glass cloth | MIL-C-20079, Type I, Classes 3 through 9 |
| | | | Knitted fibrous glass tape Table 12 materials | MIL-C-20079, Type II, Class 3 |
| | mineral fiber | ASTM C547 , Type II, Grade A | Woven fibrous glass cloth | MIL-C-20079, Type I, Classes 3 through 9 |
| | mineral fiber | ASTM C547 , Types I through IV | Woven fibrous glass cloth | MIL-C-20079, Type I, Classes 3 through 9 |
| | | | Knitted fibrous glass tape Table 12 materials | MIL-C-20079, Type II, Class 3 |
| 451 to 1050 (233 to 566) | cellular glass, 800°F (427°C) max | ASTM C552 , Type II | Woven fibrous glass cloth | MIL-C-20079, Type I, Classes 3 through 9 |
| 451 to 1200 (233 to 649) | cellular glass, 800 °F (427 °C) max | ASTM C552 , Type II | Woven fibrous glass cloth | MIL-C-20079, Type I, Classes 3 through 9 |
| | | | Knitted fibrous glass tape Table 12 materials | MIL-C-20079, Type II, Class 3 |
| | mineral fiber | ASTM C547 , Type V, Grade A | Woven fibrous glass cloth | MIL-C-20079, Type I, Classes 3 through 9 |
| | mineral fiber | ASTM C547 , Types I to IV for up to 1000 °F (538 °C) | Woven fibrous glass cloth | MIL-C-20079, Type I, Classes 3 through 9 |
| | mineral fiber | ASTM C547 , Types II and III for up to 1200 °F (649 °C) | Knitted fibrous glass tape Table 12 materials | MIL-C-20079, Type II, Class 3 |
| | | | Woven fibrous glass cloth | MIL-C-20079, Type I, Classes 3 through 9 |
| | | | Knitted fibrous glass tape Table 12 materials | MIL-C-20079, Type II, Class 3 |

| Temperature Range °F (°C) | Insulation | Specification | Lagging ^{C,D} | Specification |
|------------------------------|------------------|---------------|---|---|
| | expanded perlite | ASTM C610 | Woven fibrous glass cloth Knitted fibrous glass tape Table 12 materials | MIL-C-20079, Type I, Classes 3 through 9 MIL-C-20079, Type II, Class 3 |

^A See 5.4.

^B Insulation and insulation covering materials are acceptable for the temperature ranges indicated; other materials are capable of being used provided the requirements of this practice are satisfied. Thermal insulating tape is capable of being used as allowed by Section 8 of this practice.

^C Lagging shall be used over insulation only.

^D Factory applied aluminum foil lagging may be used in areas not requiring a paintable surface, such as behind drop ceilings and joiner panels and the lagging meets all regulatory requirements.

TABLE 2 Insulation and Lagging Materials for Pipe, Tubing, and Fittings Used for Weather-Exposed Piping Systems^A

| Temperature Range °F (°C) | Insulation | Specification | Lagging | Specification |
|------------------------------|--|--|---|--|
| -20 to +40 (-29 to +15) | cellular glass | ASTM C552, Type II | Woven fibrous glass with outdoor mastic, Table 12 materials | MIL-C-20079, Type I Class 7, Class 9 |
| | elastomeric cellular | MIL-PRF-32514, Type I | Woven fibrous glass with outdoor mastic, Table 12 materials | MIL-C-20079, Type I Class 7, Class 9 |
| | elastomeric cellular | MIL-PRF-32514, Type I (ASTM C534, Grade 3), ASTM C534, Grades 1, 2, and 3 | Woven fibrous glass with outdoor mastic, Table 12 materials | MIL-C-20079, Type I Classes 3 through 9 |
| 41 to 100 (5 to 37) | cellular glass | ASTM C552, Type II | Woven fibrous glass with outdoor mastic, Table 12 materials | MIL-C-20079, Type I Class 7, Class 9 |
| | elastomeric cellular | MIL-PRF-32514, Type I (ASTM C534, Grade 3), ASTM C534, Grades 1, 2, and 3 | Woven fibrous glass cloth with outdoor mastic, Table 12 materials | MIL-C-20079, Type I, Classes 3 through 9 |
| | perlite | ASTM C610 | Woven fibrous glass with outdoor mastic, Table 12 materials | MIL-C-20079, Type I Class 7, Class 9 |
| | calcium silicate | ASTM C533, Type I | Woven fibrous glass with outdoor mastic, Table 12 materials | MIL-C-20079, Type I Class 7, Class 9 |
| | mineral fiber | ASTM C547, Class 2 and 3 | Woven fibrous glass with outdoor mastic, Table 12 materials | MIL-C-20079, Type I Class 7, Class 9 |
| | mineral fiber | ASTM C547, Types I through IV | Woven fibrous glass with outdoor mastic, Table 12 materials | MIL-C-20079, Type I Class 7, Class 9 |
| 101 to 450 (38 to 232) | cellular glass | ASTM C552, Type II | Woven fibrous glass with outdoor mastic, Table 12 materials | MIL-C-20079, Type I Class 7, Class 9 |
| | perlite | ASTM C610 | Woven fibrous glass with outdoor mastic, Table 12 materials | MIL-C-20079, Type I Class 7, Class 9 |
| | calcium silicate | ASTM C533, Type I | Woven fibrous glass with outdoor mastic, Table 12 materials | MIL-C-20079, Type I Class 7, Class 9 |
| | mineral fiber | ASTM C547, Type IV, Grade A | Woven fibrous glass with outdoor mastic, Table 12 materials | MIL-C-20079, Type I Class 7, Class 9 |
| | mineral fiber | ASTM C547, Types I to IV | Woven fibrous glass with outdoor mastic, Table 12 materials | MIL-C-20079, Type I Class 7, Class 9 |
| | elastomeric cellular 220°F (104°C) Max | MIL-PRF-32514, Type I | | |
| | elastomeric cellular 220 °F (104 °C) Max | MIL-PRF-32514, Type I, (ASTM C534, Grade 3), ASTM C534, Grades 1, 2, and 3 | Woven fibrous glass cloth with outdoor mastic, Table 12 materials | MIL-C-20079, Type I, Classes 3 through 9 |

^A Insulation and lagging materials listed are acceptable for the temperature ranges indicated; other materials are capable of being used provided the requirements of this practice are satisfied.

[C547 Specification for Mineral Fiber Pipe Insulation](#)

[C552 Specification for Cellular Glass Thermal Insulation](#)

[C553 Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications](#)

TABLE 3 Insulation and Lagging Materials for Machinery and Equipment^{A,B}

| Temperature Range °F (°C) | Insulation | Specification | Lagging ^C | Specification |
|------------------------------|---|---|--|--|
| -20 to +40 (-29 to +4) | elastomeric cellular ^A | MIL-PRF-32514, Type I, ASTM C534 | woven fibrous glass cloth, Table 12 materials | MIL-C-20079, Type I, Classes 3 through 9 |
| | elastomeric cellular ^A | MIL-PRF-32514, Type I, (ASTM C534 , Grade 3), ASTM C534 , Grades 1, 2, and 3 | woven fibrous glass cloth with outdoor mastic, Table 12 materials | MIL-C-20079, Type I, Classes 3 through 9 |
| -41 to +125 (5 to 51) | cellular glass | ASTM C552 , Type II | woven fibrous glass cloth, Table 12 materials | MIL-C-20079, Type I, Classes 3 through 9 |
| | elastomeric cellular ^A | woven fibrous glass cloth, Table 12 materials | woven fibrous glass cloth, Table 12 materials | woven fibrous glass cloth, Table 12 materials |
| | elastomeric cellular ^A | MIL-PRF-32514, Type I, (ASTM C534 , Grade 3), ASTM C534 , Grades 1, 2, and 3 | woven fibrous glass cloth with outdoor mastic, Table 12 mate- rials | MIL-C-20079, Type I, Classes 3 through 9 |
| | cellular glass | ASTM C552 , Type II | woven fibrous glass cloth, Table 12 materials | MIL-C-20079, Type I, Classes 1, 3, 5, 7, and 9 |
| 126 to 1200 (52 to 649) | cellular glass | ASTM C552 | woven fibrous glass cloth, Table 12 materials | MIL-C-20079, Type I, Classes 1, 3, 5, 7, and 9 |
| | mineral fiber blanket | ASTM C553 | woven fibrous glass cloth, Table 12 materials | MIL-C-20079, Type I, Classes 3 through 9 |
| | glass fiber felt | MIL-I-16411 | woven fibrous glass cloth, Table 12 materials | MIL-C-20079, Type I, Classes 3 through 9 |
| | High Temperature fiber blanket | ASTM C892 , Grade 6 or 8 | glass wire, reinforced woven fibrous glass cloth, Table 12 materials | HH-P-31, Type I MIL-C-20079, Type I, Classes 3 through 9 |
| | high-temperature insulating cement ^D | ASTM C195 | glass wire, reinforced | HH-P-31, Type I |
| | Mineral Fiber Hydraulic-Setting cement | ASTM C449/C449M | | |
| | calcium silicate insulating block | ASTM C533 , Type I | | |
| | mineral fiber blanket (1000°F (538°C) max) | ASTM C553 , C612 | woven fibrous glass cloth, Table 12 materials | MIL-C-20079, Type I, Classes 3 through 9 |
| | mineral fiber blanket (1000 °F (538 °C) max)) | ASTM C553 , Types V through VII; C612 , Types III, IV A, and IV B, and V | woven fibrous glass cloth, Table 12 materials | MIL-C-20079, Type I, Classes 3 through 9 |
| | mineral fiber blanket or board (1200 °F (649 °C) max)) | ASTM C553 , Type VII; C612 , Type IV A, IV B, and V | woven fibrous glass cloth, Table 12 materials | MIL-C-20079, Type I, Classes 3 through 9 |
| perlite | ASTM C610 | glass wire, reinforced woven fibrous glass cloth, Table 12 materials | HH-P-31, Type I MIL-C-20079, Type I, Classes 3 through 9 | |

^A See 5.4.

^B Insulation and lagging materials are acceptable for the temperature ranges indicated; other materials are capable of being used provided the requirements of this practice are satisfied.

^C Factory applied aluminum foil lagging may be used in areas not requiring a paintable surface, such as behind drop ceilings and joiner panels and the lagging meets all regulatory requirements.

^D When insulating cement is used, it shall be applied in successive layers, ½ in. to 1 in. (13 mm to 25 mm) in thickness, until the total thickness specified in **Table 6** has been reached. Galvanized iron wire netting, 4-in. (102 mm) 1 in. (25 mm) mesh, shall be installed between layers. A ½-in. (13 mm) in. (13 mm) thickness of finishing cement, in accordance with Specification **C449/C449M**, shall be applied over the last layer of insulating cement.

[C610 Specification for Molded Expanded Perlite Block and Pipe Thermal Insulation](#)

[C612 Specification for Mineral Fiber Block and Board Thermal Insulation](#)

[C680 Practice for Estimate of the Heat Gain or Loss and the Surface Temperatures of Insulated Flat, Cylindrical, and Spherical Systems by Use of Computer Programs](#)

[C892 Specification for High-Temperature Fiber Blanket Thermal Insulation](#)

[C1086 Specification for Glass Fiber Mechanically Bonded Felt Thermal Insulation](#)

[C1729 Specification for Aluminum Jacketing for Insulation](#)

[C1767 Specification for Stainless Steel Jacketing for Insulation](#)

[D962 Specification for Aluminum Powder and Paste Pigments for Paints](#)

2.2 *Federal Specifications:*⁴

[HH-P-31 Packing and Lagging Material, Fibrous Glass Metallic and Plain Cloth and Tape](#)

2.3 *Military Specifications:*⁴

[MIL-C-20079 Cloth, Glass, Tape, Textile Glass and Thread, Glass](#)

[MIL-C-22395 Compound, End Sealing, Thermal Insulation Pipe Covering—Fire, Water, and Weather Resistant](#)

[MIL-DTL-32585 Insulation, Thermal and Acoustic Fibrous Glass](#)

⁴ Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, <http://quicksearch.dla.mil>.

TABLE 4 Minimum Thickness of Cellular Glass Insulation for Piping, –20 to 800°F (–29 to 427°C)–20 °F to 800 °F (–29 °C to 427 °C)^A

| Nominal Pipe Size, in. (mm) | Maximum Temperature, °F (°C) × Thickness, in. (mm) | | | | | | | | |
|--------------------------------|--|-------------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| | –20 to 40 ^B (–29 to 4) | 41 to 125 ^C (5 to 52) | 250 (121) | 350 (177) | 450 (232) | 550 (288) | 650 (343) | 750 (399) | 850 (454) |
| ¼ (6) and above | 2½ (63) 1½ ^D (38) | 1½ (38) 1½ ^D (38) | ... | ... | ... | ... | ... | ... | ... |
| 1½ (38) and below | ... | ... | 1½ (38) | 1½ (38) | 1½ (38) | 2 (51) | 2½ (63) | 2½ (63) | 3 (76) |
| 2 (51) | ... | ... | 1½ (38) | 2 (51) | 1½ (38) | 2 (51) | 3 (76) | 3 (76) | 3½ (89) |
| 2½, 3 (63, 76) | ... | ... | 1½ (38) | 1½ (38) | 2 (51) | 2½ (63) | 3 (76) | 3½ (89) | 4 (102) |
| 4 (102) | ... | ... | 1½ (38) | 1½ (38) | 2 (51) | 2½ (63) | 3½ (89) | 3½ (89) | 4 (102) |
| 5, 6 (127, 152) | ... | ... | 1½ (38) | 1½ (38) | 2 (51) | 3 (76) | 3½ (89) | 3½ (89) | 4½ (114) |
| 8 (203) | ... | ... | 1½ (38) | 1½ (38) | 2 (51) | 3 (76) | 3½ (89) | 4 (102) | 5 (127) |
| 10 (254) | ... | ... | 1½ (38) | 1½ (38) | 2 (51) | 3 (76) | 4 (102) | 4 (102) | 5 (127) |
| 12 (305) | ... | ... | 1½ (38) | 1½ (38) | 2½ (63) | 3 (76) | 4 (102) | 4½ (114) | 5½ (140) |
| 14 (356) | ... | ... | 1½ (38) | 1½ (38) | 2½ (63) | 3½ (89) | 4 (102) | 4½ (114) | 5½ (140) |
| 16 (406) | ... | ... | 1½ (38) | 1½ (38) | 2½ (63) | 3½ (89) | 4½ (114) | 4½ (114) | 5½ (140) |
| 18 (457) | ... | ... | 1½ (38) | 1½ (38) | 2½ (63) | 3½ (89) | 4½ (114) | 4½ (114) | 5½ (140) |

^A Thickness of cellular glass, in accordance with Specification C552, Type II.

^B For refrigerant piping.

^C For antisweat applications.

^D Thickness for applications in air-conditioned spaces only.

TABLE 5 Minimum Thickness of Elastomeric Cellular Insulation Piping, –20 to +220°F (–29 to 104°C)–20 °F to +220 °F (–29 °C to 104 °C)^A

| Nominal Size, in. (mm) | Temperature Range, °F (°C) | Nominal Thickness, in. (mm) | |
|---------------------------|-----------------------------------|-----------------------------|--------------------------------|
| | | Non-conditioned spaces | Air conditioned spaces only |
| ¼ (6) and above | –20 to 60 (–29 to 4) ^B | 1½ (38) | 1 (25) |

^A Thickness of elastomeric cellular insulation, conforming with, MIL-PRF-32514, Type I or Type II or Specification C534.

^B For refrigerant piping.

[MIL-I-16411 Insulation, Felt, Thermal, Glass Fiber](#)

[MIL-P-15280 Plastic Material, Unicellular \(Sheets and Tubes\)](#)

[MIL-PRF-24596 Coating Compounds, Nonflaming, Fire-Protective \(Metric\)](#)

[MIL-PRF-32514 Insulation, Anti-Sweat, Refrigerant, and Thermal Foam](#)

[MIL-STD-769 Thermal Insulation Requirements for Machinery and Piping](#)

[MIL-STD-2118 Trap, Steam, Angle, Thermostatic](#)

2.4 Other Documents:

[Title 46 Code of Federal Regulations \(CFR\), Shipping \(Parts 164.009 and 164.012\)⁴](#)

[USCG Type Approval 164.109 IMO FTP Code Annex 1, Part 1⁵](#)

[USCG Type Approval 164.112 IMO FTP Code Annex 1, Parts 2 and 5⁵](#)

[Fire Test Procedures Code IMO Resolution MSC 307 \(88\) Annex 1 Part 1 and Part 5 and Annex 2⁵](#)

[IMO SOLAS 1974 as amended through 2014⁵](#)

3. Terminology

3.1 Definitions:

3.1.1 For definitions of terms relating to insulating materials used in this practice, refer to Terminology C168.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *lagging, n*—a covering installed over thermal insulation.

3.2.1.1 Discussion—

Lagging can consist of a sheet or film vapor retarder, metal jacket, a non-metallic jacket, or a woven or knitted fabric combined with a durable mastic.

⁵ Available from International Maritime Organization (IMO), 4, Albert Embankment, London SE1 7SR, United Kingdom, <http://www.imo.org>.

TABLE 6 Minimum Thickness of Mineral Fiber Insulation for Hot Piping, 850°F (454°C) Maximum^{A,B}

| Nominal Pipe Size, in. (mm) | Maximum Temperature, °F (°C) × Thickness, in. (mm) | | | | | | | |
|--------------------------------|--|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| | 150 (66) | 250 (121) | 350 (177) | 450 (232) | 550 (288) | 650 (343) | 750 (399) | 850 (454) |
| 1½ (38) and below | 1 (25) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2 (51) | 2½ (63) | 3 (76) |
| 2 (51) | 1 (25) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 2½ (63) | 3½ (89) |
| 2½, 3 (63, 76) | 1 (25) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 3 (76) | 3½ (89) | 3½ (89) |
| 4 (102) | 1 (25) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 3 (76) | 3½ (89) | 4 (102) |
| 5, 6 (127, 152) | 1 (25) | 1 (25) | 1 (25) | 2 (51) | 2½ (63) | 3 (76) | 3½ (89) | 4 (102) |
| 8 (203) | 1 (25) | 1 (25) | 1 (25) | 2 (51) | 2½ (63) | 3 (76) | 3½ (89) | 4½ (114) |
| 10 (254) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3½ (89) | 3½ (89) | 4½ (114) |
| 12 (305) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3½ (89) | 4½ (114) | 4½ (114) |
| 14, 16, 18 (356, 406, 457) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 3 (76) | 3½ (89) | 4½ (114) | 5 (127) |

^A Commercially known as glass fiber.

^B Thickness of mineral fiber insulation in accordance with Specification C547, Class 2.

TABLE 7 Minimum Thickness of Mineral Fiber Insulation for Hot Piping, 1050°F (566°C) Maximum^{A,B}

| Nominal Pipe Size, in. (mm) | Maximum Temperature, °F (°C) × Thickness, in. (mm) | | | | | | | | | |
|--------------------------------|--|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|
| | 150 (66) | 250 (121) | 350 (177) | 450 (232) | 550 (288) | 650 (343) | 750 (399) | 850 (454) | 950 (510) | 1050 (566) |
| 1½ (38) and below | 1 (25) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2 (51) | 2 (51) | 2½ (63) | 3 (76) | 3½ (89) |
| 2 (51) | 1 (25) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 2½ (63) | 3 (76) | 3½ (89) | 4 (102) |
| 2½, 3 (63, 76) | 1 (25) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3½ (89) | 3½ (89) | 4 (102) | 4½ (114) |
| 4 (102) | 1 (25) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3 (76) | 3½ (89) | 4 (102) | 4½ (114) |
| 5, 6 (127, 152) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3 (76) | 3 (76) | 3½ (89) | 4½ (114) | 5½ (140) |
| 8 (203) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3 (76) | 3 (76) | 4 (102) | 4½ (114) | 5½ (140) |
| 10 (254) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3 (76) | 3½ (89) | 4 (102) | 5 (127) | 6 (152) |
| 12 (305) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3½ (89) | 3½ (89) | 4 (102) | 5 (127) | 6 (152) |
| 14 (356) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3½ (89) | 3½ (89) | 4½ (114) | 5½ (140) | 6½ (165) |
| 16 (406) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 3 (76) | 3½ (89) | 3½ (89) | 4½ (114) | 5½ (140) | 6½ (165) |
| 18 (457) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 3 (76) | 3½ (89) | 4 (102) | 4½ (114) | 5½ (140) | 6½ (165) |

^A Commercially known as mineral wool.

^B Thickness of mineral fiber insulation, in accordance with Specification C547, Class 3.

TABLE 8 Minimum Thickness of Calcium Silicate Insulation (Specification C533) for Hot Piping, 1050°F (566°C) Maximum^A

| Nominal Pipe Size, in. (mm) | Maximum Temperature, °F (°C) × Thickness, in. (mm) | | | | | | | | | |
|--------------------------------|--|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|
| | 150 (66) ^B | 250 (121) | 350 (177) | 450 (232) | 550 (288) | 650 (343) | 750 (399) | 850 (454) | 950 (510) | 1050 (566) |
| 1½ (38) and below | 1 (25) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 2½ (63) | 2½ (63) | 3 (76) | 3½ (89) |
| 2 (51) | 1 (25) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 2½ (63) | 3 (76) | 3½ (89) | 4 (102) |
| 2½, 3, 4 (63, 76, 102) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3 (76) | 3 (76) | 3½ (89) | 4 (102) | 5 (127) |
| 5, 6 (127, 152) | 1½ (38) | 1½ (38) | 1½ (38) | 2 (51) | 2½ (63) | 3½ (89) | 3½ (89) | 4 (102) | 4½ (114) | 5½ (140) |
| 8 (203) | 1½ (38) | 1½ (38) | 1½ (38) | 2 (51) | 2½ (63) | 3½ (89) | 3½ (89) | 4 (102) | 5 (127) | 5½ (140) |
| 10 (254) | 1½ (38) | 1½ (38) | 1½ (38) | 2 (51) | 3 (76) | 3½ (89) | 3½ (89) | 4½ (114) | 5 (127) | 6 (152) |
| 12 (305) | 1½ (38) | 1½ (38) | 1½ (38) | 2 (51) | 3 (76) | 3½ (89) | 3½ (89) | 4½ (114) | 5½ (140) | 6 (152) |
| 14 (356) | 1½ (38) | 1½ (38) | 1½ (38) | 2½ (63) | 3 (76) | 4 (102) | 4 (102) | 4½ (114) | 5½ (140) | 6½ (165) |
| 16, 18 (406, 457) | 1½ (38) | 1½ (38) | 1½ (38) | 2½ (63) | 3 (76) | 4 (102) | 4 (102) | 5 (127) | 5½ (140) | 6½ (165) |

^A Thickness of calcium silicate insulation, in accordance with Specification C533.

^B For indoor use only.

3.2.2 *objectionable areas, n*—locations where the formation of condensation will be objectionable from at least one of the following standpoints; (a) personnel; (b) electrical and electronic equipment, ladder steps, and walkways; (c) stores or supplies; or (d) machinery, equipment, or painted surfaces of bulkheads or decks which are normally kept in ship shape condition.

3.2.3 *high traffic area, n*—an area subject to wear and damage during normal, routine operations.

4. Materials and Manufacture

4.1 *Insulation and Lagging Material Specifications*, as listed in Tables 1-16, describe those materials that are intended for use in the indicated temperature ranges. The specifications and requirements outlined herein are not intended to prevent the use of new test methods or materials, provided that sufficient technical data is submitted to demonstrate that the proposed test method or material is equivalent in quality, effectiveness, durability, and safety to that prescribed by this practice.

TABLE 9 Minimum Thickness of Perlite Insulation (Specification C610) for Hot Piping, 1050°F (566°C) 1050 °F (566 °C) Maximum^A

| Nominal Pipe Size, in. (mm) | Maximum Temperature, °F (°C) × Thickness, in. (mm) | | | | | | | | | |
|-----------------------------|--|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|
| | 150 (66) | 250 (121) | 350 (177) | 450 (232) | 550 (288) | 650 (343) | 750 (399) | 850 (454) | 950 (510) | 1050 (566) |
| 1½ (38) and below | 1 (25) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 2½ (63) | 2½ (63) | 3 (76) | 3½ (89) |
| 2 (51) | 1 (25) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 2½ (63) | 3 (76) | 3½ (89) | 4 (102) |
| 2½, 3, 4 (63, 76, 102) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3 (76) | 3 (76) | 3½ (89) | 4 (102) | 5 (127) |
| 5, 6 (127, 152) | 1½ (38) | 1½ (38) | 1½ (38) | 2 (51) | 2½ (63) | 3½ (89) | 3½ (89) | 4 (102) | 4½ (114) | 5½ (140) |
| 8 (203) | 1½ (38) | 1½ (38) | 1½ (38) | 2 (51) | 2½ (63) | 3½ (89) | 3½ (89) | 4 (102) | 5 (127) | 5½ (140) |
| 10 (255) | 1½ (38) | 1½ (38) | 1½ (38) | 2 (51) | 3 (76) | 3½ (89) | 3½ (89) | 4½ (114) | 5 (127) | 6 (152) |
| 12 (305) | 1½ (38) | 1½ (38) | 1½ (38) | 2 (51) | 3 (76) | 3½ (89) | 3½ (89) | 4½ (114) | 5½ (140) | 6 (152) |
| 14 (356) | 1½ (38) | 1½ (38) | 1½ (38) | 2½ (63) | 3 (76) | 4 (102) | 4 (102) | 4½ (114) | 5½ (140) | 6½ (163) |
| 16, 18 (406, 457) | 1½ (38) | 1½ (38) | 1½ (38) | 2½ (63) | 3 (76) | 4 (102) | 4 (102) | 5 (127) | 5½ (140) | 6½ (165) |

^A Thickness of perlite insulation, in accordance with Specification C610.

TABLE 10 Minimum Thickness of Antisweat Insulation for Machinery and Equipment

| Temperature Range, °F (°C) | Material Specification | Nominal Thickness, in. (mm) ^A | |
|----------------------------|--|--|----------------------|
| | | Unconditioned Spaces | Conditioned Spaces |
| -20 to +40 (-29 to +4) | elastomeric cellular, ASTM C534, Type II | 2 (51) | 1 (25) ^B |
| | cellular glass, ASTM C552, Type I | 3 (76) | 1½ (38) ^B |
| 41 to 125 (5 to 51) | elastomeric cellular, ASTM C534, Type II | ¾ (19) | ½ (13) ^B |
| | cellular glass, ASTM C552, Type I | 1 (25) | ½ (13) ^B |
| | mineral fiber blanket, ASTM C553, C612 | 1 (25) | ¾ (19) ^B |

^A Nominal thickness exclusive of vapor retarder.

^B Thickness for application in air-conditioned spaces only.

5. General Requirements

5.1 Piping, including valves, fittings, and flanges conveying vapors, gases, or liquids that attain temperatures outside the range from 55 to 125°F (13 to 52°C) 55 °F to 125 °F (13 °C to 52 °C) during normal operation, shall be insulated except as otherwise stated herein.

5.2 The insulation thicknesses specified in this practice are designed to maintain the surface temperature at or below 125°F (52°C) 125 °F (52 °C) for fluid temperatures up to 650°F (343°C) 650 °F (343 °C) with an ambient temperature of 85°F (29°C) 85 °F (29 °C). For fluid temperatures above 650°F, 650 °F, the surface will be maintained at a maximum of 133°F (56°C) 133 °F (56 °C).

5.2.1 Insulation thicknesses have been calculated in accordance with the computer programs in Practice C680.

5.3 Piping and units of equipment with designated internal temperatures of 300°F (149°C) 300 °F (149 °C) and over shall be insulated from their supports or the supports insulated from the structures to which they are attached where the heat transmitted is objectionable on the opposite side of the structure.

5.4 Insulated piping passing through accommodation, service, and control spaces must be covered with approved noncombustible materials, which meet 46 CFR, Sections 164.009 and 164.012, or USCG Type Approval 164.109 and 164.112 as issued by the USCG. Elastomeric cellular insulation shall not be used in these spaces except where allowed by SOLAS.

5.5 Special consideration shall be given to the insulation of integral piping supplied with and mounted on equipment or machinery. In these cases, alternative materials and methods of installation shall be considered provided that they comply with the performance requirements of this practice.

TABLE 11 Minimum Thickness of Insulating Materials for Hot Surfaces of Machinery and Equipment, 126 to 1200°F (52 to 649°C) 126 °F to 1050 °F (52 °C to 566 °C)

| Material | Maximum Temperature, °F (°C) × Thickness, in. (mm) ^A | | | | | | | | | |
|---|---|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|
| | 150 (66) | 250 (121) | 350 (177) | 450 (232) | 550 (288) | 650 (343) | 750 (399) | 850 (454) | 950 (510) | 1050 (566) |
| Woven glass fiber, MIL-DTL-32585 | 1 (25) | 1 (25) | 1½ (38) | 2½ (63) | 3 (76) | 4 (102) | 4 (102) | 5 (127) | 5½ (140) | 6½ (165) |
| Block calcium silicate, Specification C533, Type I | 1½ (38) | 1½ (38) | 2 (51) | 2½ (63) | 4 (102) | 4 (102) | 4 (102) | 5 (127) | 5 (127) | 5½ (140) |
| Block perlite, Specification C610 | 1½ (38) | 1½ (38) | 2 (51) | 2½ (63) | 4 (102) | 4 (102) | 4 (102) | 5 (127) | 5 (127) | 5½ (140) |
| High temperature fiber, Specification C892, Grade 6 | 1 (25) | 1 (25) | 2 (51) | 2½ (63) | 3½ (89) | 4½ (114) | 4½ (114) | 5½ (140) | 6 (152) | 7½ (191) |
| High temperature fiber, Specification C892, Grade 8 | 1 (25) | 1 (25) | 1½ (38) | 2½ (63) | 3 (76) | 4 (102) | 4 (102) | 5 (127) | 6 (152) | 7 (178) |
| Mineral fiber, ^B Specification C553 | 1½ (38) | 1½ (38) | 2 (51) | 2½ (63) | 3½ (89) | 3½ (89) | 3½ (89) | 4 (102) | 4½ (114) | 5 (127) |
| Elastomeric cellular, ^C Specification C534 | ½ (13) | ½ (13) | | | | | | | | |
| Insulating cement, Specification C195 | 2 (51) | 2 (51) | 2½ (63) | 3½ (89) | 5 (127) | 5 (127) | 5 (127) | 5½ (140) | | |

^A Does not include finishing cement.

^B 1000°F (537°C) 1000 °F (537 °C) maximum temperature.

^C 180°F (82°C) 180 °F (82 °C) maximum temperature.

TABLE 12 Metal and Non-Metallic Cladding Materials^A

| Material | Specification | Minimum Thickness, in. (mm) |
|-----------------------------------|---------------------------------|---------------------------------|
| Aluminum | ASTM C1729 ^C | 0.016 (0.40) |
| Corrosion-resistant steel | ASTM C1767 ^C | 0.010 (0.25) |
| Non-metallic systems ^B | In accordance with manufacturer | In accordance with manufacturer |

^A For use on piping and machinery insulation in locations where insulation is subject to abuse, except for uptake applications in which metal lagging shall be galvanized steel, Specification D962, Coating Designation G-115, not less than ½ in. (0.795 mm) thick.

^B For use on systems in the weather unless the product meets the flame, smoke and toxicity requirements of Ship Specifications and Regulatory Body.

^C These standard specifications incorporate by reference the appropriate metal alloy standards (Specifications B209/B209M for aluminum and A240 for stainless steel).

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<https://standards.iteh.ai/catalog/standards/sist/7d239d4d-6938-4cd2-b9b5-079778f4a479/astm-f683-23>

5.6 Minimum insulation requirements have not been established for those surfaces or applications in which insulations had not been specified in past practices. In effect, the following surfaces are excluded from insulation requirements:

5.6.1 Surfaces where application of insulation will affect proper operation.

5.6.2 Equipment, components, and systems designed for the dispersion of heat, except when located in areas in which personnel protection is required insulation, shall be installed per in accordance with the requirements identified in 5.2.

5.6.3 Thermostatic steam traps and 24 in. (620 mm) of piping upstream of traps, which shall not be insulated. When located in areas in which personnel protection is required, expanded metal shields or multilayer glass cloth shall be provided.

5.6.4 Mechanical joints exposed to sub-atmospheric pressures and those included in the fuel oil service piping from heaters to burners.

5.6.5 Fuel oil piping between headers and burners.

5.6.6 Piping above ~~125°F (52°C)~~ 125 °F (52 °C) in bilges, not within watertight enclosures.

5.6.7 Piping or equipment that will form condensation in non-objectionable areas.

5.6.8 Dead-end hot water piping ¾ in. (10 mm) and smaller.

TABLE 13 Minimum Thickness of Glass Fiber Felt for Removable/Reusable Insulation Blankets^A

| Nominal Pipe Size, in. (mm) | Maximum Temperature, °F (°C) × Thickness, in. (mm) | | | | | | | | | |
|--------------------------------|--|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|
| | 150 (66) | 250 (121) | 350 (177) | 450 (232) | 550 (288) | 650 (343) | 750 (399) | 850 (454) | 950 (510) | 1050 (566) |
| ½ (13) | 1 (25) | 1 (25) | 1½ (38) | 1½ (38) | 2 (51) | 2 (51) | 2½ (63) | 2½ (63) | 3 (76) | 3½ (89) |
| 1 (25) | 1 (25) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2 (51) | 2½ (63) | 3 (76) | 3 (76) | 3½ (89) |
| 1½ (38) | 1 (25) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 2½ (63) | 3 (76) | 3 (76) | 4 (102) |
| 2 (51) | 1 (25) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 2½ (63) | 3 (76) | 3½ (89) | 4 (102) |
| 3 (76) | 1 (25) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3 (76) | 3½ (89) | 4 (102) | 4½ (114) |
| 4 (102) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3 (76) | 3 (76) | 3½ (89) | 4 (102) | 5 (127) |
| 6 (152) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3 (76) | 3 (76) | 4 (102) | 4½ (114) | 5½ (140) |
| 8 (203) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3 (76) | 3½ (89) | 4 (102) | 5 (127) | 5½ (140) |
| 10 (254) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3½ (89) | 3½ (89) | 4 (102) | 5 (127) | 6 (152) |
| 12 (305) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3½ (89) | 3½ (89) | 4½ (114) | 5 (127) | 6 (152) |
| 14 (356) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3½ (89) | 3½ (89) | 4½ (114) | 5½ (140) | 6 (152) |
| 16 (406) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 3 (76) | 3½ (89) | 3½ (89) | 4½ (114) | 5½ (140) | 6½ (165) |
| 18 (457) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 3 (76) | 3½ (89) | 4 (102) | 4½ (114) | 5½ (140) | 6½ (165) |

^A Thickness of glass fiber felt, in accordance with MIL-DTM-32585 or Specification C1086.

TABLE 14 Minimum Thickness of Nominal 8-lb/ft³ (128 kg/m³) High Temperature Fiber Blanket for Removable/Reusable Insulation Blankets^A

| Nominal Pipe Size, in. (mm) | Maximum Temperature, °F (°C) × Thickness, in. (mm) | | | | | | | | | |
|--------------------------------|--|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|
| | 150 (66) | 250 (121) | 350 (177) | 450 (232) | 550 (288) | 650 (343) | 750 (399) | 850 (454) | 950 (510) | 1050 (566) |
| ½ (13) | 1 (25) | 1 (25) | 1 (25) | 1½ (38) | 1½ (38) | 2 (51) | 2 (51) | 2½ (63) | 3 (76) | 3 (76) |
| 1 (25) | 1 (25) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2 (51) | 2½ (63) | 3 (76) | 3 (76) | 3½ (89) |
| 1½ (38) | 1 (25) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 2½ (63) | 3 (76) | 3½ (89) | 4 (102) |
| 2 (51) | 1 (25) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 2½ (63) | 3 (76) | 3½ (89) | 4 (102) |
| 3 (76) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3 (76) | 3 (76) | 3½ (89) | 4 (102) | 4½ (114) |
| 4 (102) | 1 (25) | 1 (25) | 1½ (38) | 2 (50) | 2½ (63) | 3 (76) | 3 (76) | 3½ (89) | 4 (102) | 4½ (114) |
| 6 (152) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3 (76) | 3 (76) | 4 (102) | 4½ (114) | 5 (127) |
| 8 (203) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3½ (89) | 3½ (89) | 4 (102) | 4½ (114) | 5½ (140) |
| 10 (254) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 3 (76) | 3½ (89) | 3½ (89) | 4 (102) | 5 (127) | 5½ (140) |
| 12 (305) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 3 (76) | 3½ (89) | 3½ (89) | 4½ (114) | 5 (127) | 6 (152) |
| 14 (356) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 3 (76) | 3½ (89) | 3½ (89) | 4½ (114) | 5 (127) | 6 (152) |
| 16 (406) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 3 (76) | 3½ (89) | 3½ (89) | 4½ (114) | 5 (127) | 6 (152) |
| 18 (457) | 1 (25) | 1 (25) | 1½ (38) | 2½ (63) | 3 (76) | 3½ (89) | 4 (102) | 4½ (114) | 5½ (140) | 6 (152) |

^A Thickness of 8-lb/ft³ (128-kg/m³) high temperature fiber blanket in accordance with Specification C892, Grade 8.

TABLE 15 Minimum Thickness of Nominal 6-lb/ft³ (96 kg/m³) High Temperature Fiber Blanket for Removable/Reusable Insulation Blankets^A

| Nominal Pipe Size, in. (mm) | Maximum Temperature, °F (°C) × Thickness, in. (mm) | | | | | | | | | |
|--------------------------------|--|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|
| | 150 (66) | 250 (121) | 350 (177) | 450 (232) | 550 (288) | 650 (343) | 750 (399) | 850 (454) | 950 (510) | 1050 (566) |
| ½ (13) | 1 (25) | 1 (25) | 1 (25) | 1½ (38) | 1½ (38) | 2 (51) | 2 (51) | 2½ (63) | 2½ (63) | 3 (76) |
| 1 (25) | 1 (25) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 2½ (63) | 2½ (63) | 3 (76) | 3½ (89) |
| 1½ (38) | 1 (25) | 1 (25) | 1½ (38) | 1½ (38) | 2 (51) | 2½ (63) | 2½ (63) | 2½ (63) | 3 (76) | 4 (102) |
| 2 (51) | 1 (25) | 1 (25) | 1½ (38) | 1½ (38) | 2 (51) | 2½ (63) | 2½ (63) | 3 (76) | 3½ (89) | 4 (102) |
| 3 (76) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3 (76) | 3 (76) | 3½ (89) | 4 (102) | 4½ (114) |
| 4 (102) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3 (76) | 3 (76) | 3½ (89) | 4½ (114) | 5 (127) |
| 6 (152) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3½ (89) | 3½ (89) | 4 (102) | 4½ (114) | 5½ (140) |
| 8 (203) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3½ (89) | 3½ (89) | 4 (102) | 5 (127) | 5½ (140) |
| 10 (254) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 3 (76) | 3½ (89) | 3½ (89) | 4½ (114) | 5 (127) | 6 (152) |
| 12 (305) | 1 (25) | 1 (25) | 1½ (38) | 2½ (63) | 3 (76) | 3½ (89) | 4 (102) | 4½ (114) | 5½ (140) | 6 (152) |
| 14 (356) | 1 (25) | 1 (25) | 2 (51) | 2½ (63) | 3 (76) | 3½ (89) | 4 (102) | 4½ (114) | 5½ (140) | 6½ (165) |
| 16 (406) | 1 (25) | 1 (25) | 2 (51) | 2½ (63) | 3 (76) | 3½ (89) | 4 (102) | 4½ (114) | 5½ (140) | 6½ (165) |
| 18 (457) | 1 (25) | 1 (25) | 2 (51) | 2½ (63) | 3½ (89) | 3½ (89) | 4 (102) | 5 (127) | 6 (152) | 6½ (165) |

^A Thickness of 6-lb/ft³ (96-kg/m³) high temperature fiber blanket in accordance with Specification C892, Grade 6.

5.6.9 Pressure-gauge piping.

5.6.10 Soot-blower valve units and soot-blower flanges.

5.6.11 Piping in voids and cofferdams except where omitting insulation is detrimental to system operation, such as catapult steam.

5.6.12 Safety valve bodies, springs, and lifting gear.

TABLE 16 Minimum Thickness of Glass Fiber Blanket for Removable/Reusable Insulation Blankets^A

| Nominal Pipe Size, in. (mm) | Maximum Temperature, °F (°C) × Thickness, in. (mm) | | | | | | | |
|-----------------------------|--|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| | 150 (66) | 250 (121) | 350 (177) | 450 (232) | 550 (288) | 650 (343) | 750 (399) | 850 (454) |
| ½ (13) | ½ (13) | ½ (13) | 1 (25) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 3 (76) |
| 1 (25) | ½ (13) | ½ (13) | 1 (25) | 1½ (38) | 2 (51) | 2 (51) | 2½ (63) | 3 (76) |
| 1½ (38) | ½ (13) | ½ (13) | 1 (25) | 1½ (38) | 2 (51) | 2 (51) | 3 (76) | 3½ (89) |
| 2 (51) | ½ (13) | ½ (13) | 1 (25) | 1½ (38) | 2 (51) | 2 (51) | 3 (76) | 4 (102) |
| 3 (76) | ½ (13) | ½ (13) | 1 (25) | 1½ (38) | 2 (51) | 2 (51) | 3 (76) | 4 (102) |
| 4 (102) | ½ (13) | ½ (13) | 1 (25) | 1½ (38) | 2½ (63) | 2½ (63) | 3½ (89) | 4½ (114) |
| 6 (152) | ½ (13) | ½ (13) | 1 (25) | 2 (51) | 2½ (63) | 2½ (63) | 3½ (89) | 5 (127) |
| 8 (203) | ½ (13) | ½ (13) | 1 (25) | 2 (51) | 2½ (63) | 2½ (63) | 4 (102) | 5 (127) |
| 10 (254) | ½ (13) | ½ (13) | 1½ (38) | 2 (51) | 2½ (63) | 2½ (63) | 4 (102) | 5½ (140) |
| 12 (305) | ½ (13) | 1 (25) | 1½ (38) | 2 (51) | 2½ (63) | 2½ (63) | 4 (102) | 5½ (140) |
| 14 (356) | ½ (13) | 1 (25) | 1½ (38) | 2 (51) | 3 (76) | 4 (102) | 4 (102) | 5½ (140) |
| 16 (406) | ½ (13) | 1 (25) | 1½ (38) | 2 (51) | 3 (76) | 4 (102) | 4½ (114) | 5½ (140) |
| 18 (457) | ½ (13) | 1 (25) | 1½ (38) | 2 (51) | 3 (76) | 4 (102) | 4½ (114) | 6 (152) |

^A Thickness of fiberglass blanket, in accordance with Specification C612, Type II, C553, Type IV.

5.6.13 Piping over shower stalls and behind and under lavatories.

5.6.14 Valves or flanges in the collection holding tank (CHT) system.

5.7 Higher-temperature-type insulations are capable of being used where lower-temperature-type insulations are specified, provided that they are satisfactory in all other respects.

5.8 In “high traffic” locations in which the completed insulation and lagging is liable to abuse and within 4 ft (1.2 m) of the deck, such as shipping, unshipping, and maintenance areas, the insulation shall be suitably protected from mechanical damage.

NOTE 1—The following are suitable protection suggestions:

(1) In way of foot traffic insulation with high compressive strength with a durable jacketing such as heavy cloth or materials listed in Table 12 can be used. Examples include calcium silicate, cellular glass but are not limited to. If insulation with a high compressive strength is not used, then a jacketing material compliant with materials listed in Table 12 are recommended.

(2) In way of forklift or other machinery operations, guards or bumpers should be used to prevent contact. Installing mechanical protection on the insulation system will not protect it from this type of impact and will only increase the cost to repair.

5.9 Before installing insulation, surface preparation of the piping is to be accomplished in accordance with the ship’s painting schedule.

5.10 Fasteners shall be welded to the structure or equipment (with permission of the vendor of the equipment) for securing insulation to the equipment.

5.11 For bends, fittings, and so forth, where molded sections of pipe insulation cannot be used, mitered sections of the pipe insulation or pre-formed fittings and covers shall be used, provided that they are suitable for the temperature and that the requirements of this practice are satisfied (see 4.1 and 5.4). When using calcium silicate fittings in sizes under 2-in. (51-mm) 2 in. (51 mm) nominal pipe size (NPS) shall be insulated with insulating cement, in accordance with Specification C449/C449M or stuffed out with Type 1, Form 3, in accordance with MII-DTL-32585 and covered with hydraulic setting insulating cement

5.12 Where insulation specifications listed in Tables 1 and 3 provide for the use of nonmetal “jacketed”-type insulation, separate lagging material shall be omitted.

5.13 Single-layered insulation construction shall be permitted on all surfaces operating at temperatures below 600°F (316°C); 600 °F (316 °C). Double-layered insulation construction shall be used with all joints staggered on all surfaces operating at temperatures of 600°F 600 °F and above, except single-layered construction will be permitted when the total insulation thickness is 3 in. (75 mm) or less or the pipe size is NPS 2 in. (50 mm) or below.

6. Selection Requirements, Piping

6.1 *Interior Piping, Temperature Range from ~~-20 to +40°F (-29 to +4°C)~~ -20 °F to +40 °F (-29 °C to +4 °C)*—Use for air conditioning and ship's stores refrigerant piping and other services within the temperature range.

6.1.1 For insulation and lagging materials, see [Table 1](#).

6.1.2 For insulation thickness, see [Table 4](#) or [Table 5](#).

6.1.3 For installation details, see [Fig. 1](#) or [Fig. 2](#), as applicable.

6.2 *Interior Piping, Temperature Range from ~~41 to 60°F (15.6 to 52°C)~~ 41 °F to 60 °F (15.6 °C to 52 °C)*—Use for cold freshwater, plumbing drains, firemain, main and auxiliary, saltwater circulating, and saltwater cooling, piping, and other services within the temperature range.

6.2.1 For insulation and lagging materials, see [Table 1](#).

6.2.2 For insulation thickness, see [Table 2](#), [Table 3](#), or [Table 4](#).

6.2.3 For installation details, see [Fig. 1](#), [Fig. 2](#), or [Fig. 3](#) as applicable.

6.2.4 *Special Conditions:*

6.2.4.1 Piping systems operating in this temperature range including water closet drain piping do not require insulation except where damage or discomfort will result from condensation.

6.2.4.2 Dry firemain need only be insulated above ceilings and in areas in which damage or discomfort from condensation is a problem.

6.2.4.3 If cold, fresh, or potable water tanks (not having a side integral with the shell) are installed in a heated area, the piping to the pumps and therefore to the services need not be insulated. If this water is being used for flushing water closets, the drain piping need not be insulated.

6.2.4.4 Freshwater fill piping inside the ship shall be insulated.

6.2.4.5 Drains from drinking water chillers shall be insulated.

6.3 *Interior Piping, Temperature Range from ~~61 to 450°F (16.1 to 232°C)~~ 61 °F to 450 °F (16.1 °C to 232 °C)*—Use for hot freshwater, hot-water heating, fuel oil service discharge from heaters to headers, condensate, and air ejector piping, boiler feed, high- and low-pressure steam drain piping, and other services within the temperature range.

6.3.1 For insulation and lagging materials, see [Table 1](#).

6.3.2 For insulation thickness, see [Table 4](#), [Table 5](#), [Table 6](#), [Table 7](#), or [Table 8](#).

6.3.3 For installation details, see [Fig. 1](#), [Fig. 2](#), [Fig. 3](#), [Fig. 4](#), or [Fig. 5](#), as applicable.

6.3.4 *Special Conditions*—On piping, tubing, and fittings sized less than NPS $\frac{3}{8}$ in., insulation need be applied only where required for personnel protection.

6.4 *Interior Piping, Temperature Range from ~~451 to 1050°F (233 to 566°C)~~ 451 °F to 1050 °F (233 °C to 566 °C)*—Use for main steam, auxiliary steam, exhaust and bleed steam, gland seal steam and exhaust, high- and low-pressure steam drains, soot blower steam, boiler blow, safety and relief valve escape steam heating, diesel exhaust piping, and other services within the temperature range.

6.4.1 For insulation and lagging materials, see [Table 1](#).