

**MIL-STD-769C (SHIPS)
15 NOVEMBER 1967**

**SUPERSEDING
MIL-STD-769B (SHIPS)
3 JANUARY 1966**

MILITARY STANDARD

THERMAL INSULATION REQUIREMENTS

FOR

MACHINERY AND PIPING



FSC 5640

MIL-STD-769C(SHIPS)
15 November 1967

DEPARTMENT OF THE NAVY
NAVAL SHIP ENGINEERING CENTER
WASHINGTON, D.C. 20360

Thermal Insulation Requirements for Machinery and Piping
MIL-STD-769B(SHIPS)

1. This standard has been approved by the Naval Ship Engineering Center, and is published to establish the requirements for thermal insulation for machinery and piping on Naval ships.
2. Use of this standard by activities under the cognizance of the Naval Ship Engineering Center shall be mandatory effective on the date of issue.
3. Recommended corrections, additions, or deletions including improvements in the procedures described herein, and changes in this standard which can result in less costly installations without sacrificing the level of quality desired should be addressed to the Commander, Naval Ship Engineering Center, Department of the Navy, Washington, D. C. 20360.

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1. SCOPE

1.1 The purpose of this standard is to amplify the general requirements for insulation of piping, machinery, uptakes, and mechanical equipment covered in the General Specifications for Ships of the U. S. Navy or in ships specifications.

2. REFERENCED DOCUMENTS

2.1 The issues of the following documents in effect on the date of invitation for bids or request for proposal, form a part of this standard to the extent specified herein.

GOVERNMENTAL

SPECIFICATIONS

T-T-931	- Twine, Cotton, Mattress.
HH-C-466	- Cloth, Glass, Coated (for Membrane Waterproofing and Built-Up Roofing).
HH-I-551	- Insulation Block, Pipe Covering and Boards, Thermal (Cellular Glass).
QQ-S-775	- Steel Sheets, Carbon, Zinc-Coated.
QQ-W-343	- Wire-Electrical And Non-Electrical, Copper (Uninsulated).
QQ-W-390	- Wire, Nickel-Chromium-Iron Alloy.
SS-C-192	- Cement, Portland.
SS-C-466	- Cloth, Thread, and Tape, Asbestos.
TT-P-26	- Paint, Interior, White and Tints, Fire-Retardant.
TT-P-320	- Pigment, Aluminum; Powder and Paste, for Paint.
UU-B-790	- Building Paper, Vegetable Fiber: (Kraft, Waterproofed, Water Repellent and Fire Resistant).
UU-T-106	- Tape, Pressure-Sensitive Adhesive, Masking, Paper.
MIL-C-788	- Cloth, Brattice, Cotton, Fire-Resistant.
MIL-I-2781	- Insulation, Pipe, Thermal.
MIL-I-2818	- Insulation Blanket, Thermal, Fibrous Mineral.
MIL-I-2819	- Insulation Block, Thermal.
MIL-C-2861	- Cement, Insulation, High-Temperature.
MIL-C-2908	- Cements, Finishing, Insulation.
MIL-A-3316	- Adhesives, Fire-Resistant, Thermal Insulation.
MIL-I-15091	- Insulation Felt, Thermal, Asbestos Fiber.
MIL-A-15199	- Adhesive, Asbestos Cloth to Pipe, Insulation.
MIL-P-15280	- Plastic Foam, Unicellular, Sheet and Tubular Form, Elastomeric.
MIL-P-15328	- Primer, Pretreatment (Formula No. 117 for Metals).
MIL-I-15349	- Insulation Tape, Thermal.
MIL-I-15475	- Insulation Felt, Thermal, Fibrous Glass, Semirigid.
MIL-I-16411	- Insulation Felt, Thermal, Glass Fiber.
MIL-A-18065	- Adhesives, High Initial Bond.
MIL-B-19564	- Bedding Compound, Thermal Insulation Pipe Covering.
MIL-C-19565	- Coating Compounds, Thermal Insulation Pipe Covering - Fire-, and Water-Resistant, Vapor-Barrier and Weather-Resistant.
MIL-C-20079	- Cloth, Glass, Tape, Textile, Glass: and Thread, Glass.
MIL-I-22023	- Insulation Felt, Thermal and Sound Absorbing Felt, Fibrous Glass, Flexible.
MIL-I-22344	- Insulation, Pipe, Thermal, Fibrous Glass.
MIL-C-22395	- Compound, End Sealing, Thermal Insulation Pipe Covering - Fire-, Water-, and Weather-Resistant.
MIL-I-24244	- Insulation Materials, Thermal, With Special Corrosion and Chloride Requirements.
MIL-P-52350	- Paper, Asbestos.

General Specifications For Ship of the U.S. Navy.

DRAWING

5000-SS103-841336 - Piping, Boiler Soot Blower, Typical Installation.

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

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NONGOVERNMENTAL

SPECIFICATIONS

AMERICAN SOCIETY FOR TESTING AND MATERIALS

ASTM - A167 - Specification for Corrosion-Resisting Chromium-Nickel Steel Plate, Sheet and Strip.

ASTM - 209 - Specification for Seamless Carbon-Molybdenum Alloy-Steel Boiler and Superheater tubes.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103)

(Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

3. GENERAL REQUIREMENTS

3.1 General requirements such as definitions, basic applications, and reasons for insulating are covered in the General Specifications for Ships of the U. S. Navy or in ships specifications, Section 9390-2. Thermal insulation and acoustic absorptive treatment of compartments, ventilating ducts and trunks are covered in the appropriate sections of the above specifications.

3.2 Minor deviations in installation which meet the intent of the requirements specified herein may be approved by the cognizant Supervisor of Shipbuilding, U. S. Naval shipyard, or the Commander, Naval Ship Engineering Center. (Copy of all such changes shall be forwarded to the Commander, Naval Ship Engineering Center, SEC 6153.)

4. MATERIALS AND THICKNESSES

4.1 Minimum thicknesses. Tables I to X, inclusive specify materials for insulation and lagging and the minimum acceptable thicknesses for the temperature ranges listed.

4.2 Special conditions. The following special conditions supplement or modify the selection of materials or thicknesses specified, when applicable:

- (a) The insulation thickness on soot blower piping between the root valve and the soot blower heads shall be reduced from that indicated for a system normally operating at the same temperature as follows:
 - (1) Where double layer insulation is used, only the inner (high temperature) insulation thickness layer need be installed.
 - (2) Where the insulation consists of a single uniform thickness layer, only one-half the total specified thickness need be installed.
- (b) The insulation thickness for hot water systems operating at a normal maximum temperature of 150°F. may be 1/2 inch thick for pipe sizes up to 3/4 inch i.p.s., in accordance with MIL-I-2781.
- (c) Where double layer construction consisting of two classes of insulation is specified in table II, the higher temperature class insulation may be furnished in a uniform single thickness equal to the total thickness specified, if single layer construction is considered desirable. Where single layer construction is used in lieu of double layer construction, suitable expansion joints to permit thermal movement of the piping, without opening of insulation joints, must be provided.
- (d) Where considered desirable, higher temperature classes of insulation may be used where lower temperature classes are specified provided they are satisfactory in all other respects (e.g. where class b of MIL-I-2781 is specified, class d or e may be used or where class c is specified, class f may be used).
- (e) Compounded type insulation conforming to MIL-I-2781, grade I, (calcium silicate only) or cellular glass insulation conforming to MIL-I-551 shall be used on hot piping requiring insulation that will be exposed to the weather, and shall conform to the thicknesses specified in table X.
- (f) Elastomeric foamed plastic insulation, MIL-P-15280, may be used for machinery and equipment applications up to 180°F; 1/2 inch minimum thickness.

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- (g) Where HOT SURFACE insulation thicknesses are not specified, such as for refractory fiber insulation felt, MIL-I-23128, and special applications, the following shall be used as a guide in determining acceptable thicknesses.

Insulation thickness shall be sufficient to:

- (1) Reduce the insulation surface temperature to 150°F. or below, where personnel can normally contact these surfaces.
 - (2) Prevent the transfer of heat to surrounding areas which would be objectionable to personnel or adversely affect other components.
 - (3) Prevent transfer of heat which would otherwise reduce the efficiency or effectiveness of the system or component.
- (h) Where operating temperatures are normally between 125°F. and 150°F. and the omission of insulation will not adversely affect operating efficiency, non-metallic lagging only may be applied where necessary, to protect personnel from contact with hot metal surfaces.
- (i) Insulation on austenitic stainless steel piping and machinery shall meet the corrosion and chloride requirements of MIL-I-24244.
- (j) Adhesives containing halogenated solvents shall not be used on foam plastic conforming to MIL-P-15280 for submarine application.

4.3 Adhesives. The following adhesives shall be used for fastening cloth and tape lagging:

<u>Type of lagging</u>	<u>Specification</u>
Asbestos	MIL-A-15199 ^{1/} or MIL-A-3316, class 1
Fibrous glass	MIL-A-3316, class 1

^{1/} Not applicable for cementing to fibrous glass insulation or for use with asbestos lagging containing glass yarn. Lagging pretreated with compatible adhesive is acceptable providing the end result is equal to one of the above combinations.

4.4 Finishing cements. Where finishing cement is specified any of the following materials are acceptable subject to any material limitations for the proposed application:

- (a) Finishing cement, MIL-C-2908, type II.
- (b) High-temperature insulating cement, MIL-C-2861, when used under asbestos cloth.
- (c) A mixture of 80 percent high-temperature insulating cement, MIL-C-2861, and 20 percent portland cement, SS-C-192.

4.5 Metal lagging. Where metal lagging is required, any of the following materials are acceptable, except for uptake applications (see 6.1.4):

<u>Sheet material</u>	<u>Specification</u>	<u>Nominal thickness</u> Inch
Hot-dipped galvanized		
Steel	QQ-S-775	0.014
Aluminum	ASTM 209, alloy 6061	.030
Corrosion-resistant steel (CRES)	ASTM A167, AISI type 304	.014

4.6 Fasteners. Insulation shall be held in place by suitable wire or flat metal bands. The welding of fasteners to machinery, piping, pressure vessels or other related equipment is prohibited. Where fasteners are necessary they shall be attached during manufacture (prior to heat treatment, stress relief and testing) by a Naval Ship Engineering Center approved procedure.

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5. RE-USABLE COVERS

5.1 Hot-surface insulation covers. In order to insure that the pipe covering will not interfere with the servicing of a takedown joint where a re-usable cover is installed, the permanent insulation shall stop short of the takedown joint and a short removable and re-usable section of insulation shall be installed between the permanent insulation and the takedown joint. The insulation joint formed by the permanent and re-usable sections may be square, or at an angle of 45 degrees; the joint, however, shall be tight, without any gaps between the two sections and shall incorporate means to prevent dislodging the insulation sections. Re-usable covers are not required on systems insulated with elastomeric foamed plastic insulation (MIL-P-15280).

5.2 Construction. For sizes larger than 2 inches i.p.s., valve bonnets and valves having takedown joints at the ends shall be fitted with re-usable covers such that the bonnet joint may be removed independently of the valve covering. Valves 2 inches i.p.s. and under shall be fitted with separate covers as indicated above, or covers of a one-piece design such that they may be wrapped around the entire valve body and clipped or otherwise secured just below the handwheel.

5.3 Fabrication, piping components. For piping components except as otherwise specified, any one of the following methods of fabrication is acceptable:

5.3.1 Covers may be made in two halves of thermal insulating felt enclosed in asbestos cloth. Each half cover shall be sewn and quilted with wire-inserted asbestos yarn conforming to SS-C-466, form II, (for machine sewing, if desired, this yarn may be constructed with the three monel wires twisted together first, and the three asbestos threads twisted around the outside of the wire) or fastened with mechanical stapling in a manner to provide a uniform thickness, strength and rigidity.

5.3.1.1 Covers for use at temperatures of 850°F. and below shall be filled with insulation felt (see table I). Wire-inserted asbestos cloth, SS-C-466, grade AAA-M, shall be used on the inside surface of covers for valves larger than 2 inches i.p.s. For valves 2 inches i.p.s. and smaller, grade AAA shall be used on inside surface of covers. For 500°F. and below, asbestos cloth, SS-C-466, grade AA, shall be used on outside surface of covers; grade AAA cloth shall be used 500°F.

5.3.1.2 Covers for use at temperatures above 850°F. shall have filling consisting of inner layers of fiber-glass felt, MIL-I-16411, or refractory fiber felt, MIL-I-23128, and outer layers of asbestos felt, and shall be covered on the inside surface and on the ends with nickel-chromium alloy wire mesh, QQ-W-390 (or wire-inserted asbestos cloth, SS-C-466, grade AAA-M, for services up to 950°F.) and on the outside surface with grade AAA asbestos cloth. Asbestos paper MIL-P-52350, class 2, thickness 1/8 inch may be inserted between the asbestos felt and the asbestos cloth if considered necessary to retain the cylindrical shape of the cover.

5.3.1.3 Hard asbestos millboard, 1/4 inch thick, enclosed in asbestos cloth of the type used on the outside cover, shall be sewn on ends of covers for strength and rigidity. When a more flexible cover is desired, such as when space limitation would not permit installation of the more rigid type, the millboard will not be required. When the flange diameter is larger than the outside diameter of the adjacent pipe covering, build-up pieces made of asbestos felt encased in asbestos cloth, SS-C-466, grade AAA shall be stitched to inside of cover. Halves of covers shall be fastened together by 1/16-inch diameter galvanized, or other corrosion resistant wire rope laced through brass or galvanized steel hooks or rings, or fastened by brass snap fasteners. Fastenings shall be securely attached to cloth lagging.

5.3.1.4 Preformed fibrous glass valve or fitting covers may be used when temperatures are in the 125-370°F. range. These shall be of the same thickness as the adjacent pipe covering. Such covers, when used, shall be lagged independently of the pipe covering and in a manner which will facilitate removal and replacement.

Table I - Schedule of approved insulation and lagging materials. 1/

Service	Temperature Range (°F.)	Pipe and Tubing		Valves and Fittings		Flange Joints		Machinery	
		Insulation	Lagging	Insulation	Lagging	Insulation	Lagging	Insulation	Lagging
Gases Steam Hot Water Oil	125 to 1200	MIL-I-2781 MIL-I-15349 (750°F.Max.) MIL-I-22344 (370°F.Max.) MIL-P-15280 (180°F.Max.)	SS-C-466 MIL-C-20079	MIL-I-2781 MIL-I-2819 MIL-I-16411 MIL-I-15091, type A MIL-C-2861 MIL-I-22344 (370°F.Max.) MIL-P-15280 (180°F.Max.) MIL-I-23128	SS-C-466 MIL-C-20079	MIL-I-2781 MIL-I-2819 MIL-I-16411 MIL-I-15091, type A MIL-C-2861 MIL-I-22344 (370°F.Max.) MIL-P-15280 (180°F.Max.) MIL-I-23128	SS-C-466 MIL-C-20079	MIL-I-2819 MIL-I-16411 MIL-I-15091, type A MIL-I-2818 MIL-C-2861 MIL-I-22023 (370°F.Max.) MIL-I-23128 MIL-P-15280 (180°F.Max.)	SS-C-466 MIL-C-20079
Cold water Chilled Water	28 to 99	MIL-I-15091 MIL-I-2781 MIL-I-22344 MIL-P-15280 HH-I-551	SS-C-466 MIL-C-20079 UU-B-790, type III, grade F, style 10 MIL-C-788	MIL-I-15091 MIL-I-2781 MIL-I-22344 MIL-I-2819 MIL-P-15280 HH-I-551	SS-C-466 MIL-C-20079 UU-B-790, type III, grade F, style 10 MIL-C-788	MIL-I-15091 MIL-I-2781 MIL-I-22344 MIL-I-2819 MIL-P-15280 HH-I-551	SS-C-466 MIL-C-20079 UU-B-790, type III, grade F, style 10 MIL-C-788	MIL-I-15091 MIL-I-22023 MIL-I-2819 MIL-P-15280 HH-I-551	SS-C-466 MIL-C-20079 UU-B-790, type III, grade F, style 10 MIL-C-788
Refrigerant	-20 to 60	HH-I-551 MIL-P-15280	SS-C-466 MIL-C-20079 MIL-C-788	HH-I-551 MIL-P-15280	SS-C-466 MIL-C-20079 MIL-C-788	HH-I-551 MIL-P-15280	SS-C-466 MIL-C-20079 MIL-C-788	HH-I-551 MIL-P-15280	SS-C-466 MIL-C-20079 MIL-C-788

1/ Additional materials are covered in 4.5 (metal lagging); 6.1.4 (boiler uptakes); 6.2 (securing antisweat insulation); 6.4.1 (weather deck hot piping).

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Table II - Insulation thicknesses for hot piping, compounded and fibrous conforming to MIL-I-2781

Pipe size (inches i.p.s.)	Temperature range (degrees F.)	Class ^{1/}		Nominal thickness (inches)		
		Inner layer	Outer layer	Inner layer	Outer layer	Total
1/2, 1-1/2	125 - 388	b,c	---	1	---	1
	389 - 500	b,c	---	2	---	2
	501 - 750	c,d	---	2	---	2
	751 - 950	e,f	---	2	---	2
	951 - 1050	e,f	b,c	2	1-1/2	3-1/2
2, 2-1/2	125 - 338	b,c	---	1-1/2	---	1-1/2
	339 - 388	b,c	---	2	---	2
	389 - 500	b,c	---	3	---	3
	501 - 750	c,d	---	3	---	3
		c,d	b,c	1-1/2	1-1/2	3
	751 - 900	e,f	b,c	1-1/2	1-1/2	3
901 - 1050	e,f	b,c	2	1-1/2	3-1/2	
3 through 4-1/2	125 - 338	b,c	---	1-1/2	---	1-1/2
	339 - 388	b,c	---	2	---	2
	389 - 500	b,c	---	3	---	3
	501 - 750	c,d	---	3	---	3
		c,d	b,c	1-1/2	2	3-1/2
	751 - 900	e,f	b,c	1-1/2	2	3-1/2
901 - 950	e,f	b,c	2	1-1/2	3-1/2	
951 - 1050	e,f	b,c	2-1/2	1-1/2	4	
5, 6	125 - 338	b,c	---	1-1/2	---	1-1/2
	339 - 388	b,c	---	2	---	2
	389 - 500	b,c	---	3	---	3
	501 - 750	c,d	---	3	---	3
		c,d	b,c	1-1/2	2	3-1/2
	751 - 900	e,f	b,c	1-1/2	2	3-1/2
901 - 950	e,f	b,c	2	1-1/2	3-1/2	
951 - 1050	e,f	b,c	3	2	5	
7	125 - 338	b,c	---	1-1/2	---	1-1/2
	339 - 388	b,c	---	2-1/2	---	2-1/2
	389 - 500	b,c	---	3	---	3
	501 - 750	c,d	---	4	---	4
		c,d	b,c	1-1/2	2	3-1/2
	751 - 900	e,f	b,c	1-1/2	2	3-1/2
901 - 950	e,f	b,c	2	2	4	
951 - 1050	e,f	b,c	3	2	5	
8 and larger	125 - 338	b,c	---	1-1/2	---	1-1/2
	339 - 388	b,c	---	2-1/2	---	2-1/2
	389 - 500	b,c	---	3	---	3
	501 - 750	c,d	---	4	---	4
		c,d	b,c	2	2	4
	751 - 900	e,f	b,c	2	2	4
901 - 950	e,f	b,c	2-1/2	2	4-1/2	
951 - 1050	e,f	b,c	3	2	5	

^{1/} Does not include finishing cement.

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Table III - Thickness of insulation conforming to MIL-P-15280 and MIL-I-22344, for hot piping.

Temperature range (°F.)	Specification	Thickness
		Inch
125 to 180	MIL-P-15280 or MIL-I-22344	1/2
181 to 250	MIL-I-22344	1/2
251 to 300	MIL-I-22344	3/4
301 to 370	MIL-I-22344	1

Table IV - Thickness of insulating tape conforming to MIL-I-15349, for 1/4 to 3/4 inch size hot piping.

Temperature range (°F.)	Pipe size	Nominal thickness
		Inch
125 to 250	1/4, 3/8	3/8
251 to 750	1/4, 3/8	7/8
125 to 250	1/2, 3/4	3/4
251 to 388	1/2, 3/4	1

Table V - Thickness^{1/} of insulating materials for hot surfaces of machinery and equipment up to 850°F.

Temperature range (°F.)	Nominal thickness (inches)		
	Glass fiber felt MIL-I-16411, type II refractory fiber blanket MIL-I-23128 grade A	Asbestos felt MIL-I-15091 insulation block MIL-I-2819 mineral fiber blanket MIL-I-2818 glass fiber felt MIL-I-16411 type I	Insulating cement MIL-C-2861
125 - 338	1	1-1/2	1-1/2
339 - 388	1-1/2	2-1/2	2-1/2
389 - 500	2	3	3
501 - 750	2-1/2	3-1/2	4
751 - 850	3	4-1/2	5

^{1/} Does not include finishing cement.

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Table VI - Thickness^{1/} of insulating materials for hot surfaces of machinery and equipment over 850°F.

Temperature range (°F.)	Thickness (inches)				
	Single felt material	Combination of two felt materials			Block
	MIL-I-16411 Type II MIL-I-23128 Grade A	Inner layer MIL-I-16411 Type I or II	Outer layer MIL-I-15091 Type A	Total	MIL-I-2819
851 - 900	4	2	3	5	4-1/2
951 - 1050	4	2	3	5	5
1051 - 1200					

^{1/} Does not include finishing cement.

Table VII - Thickness of refrigerant insulation for piping.

Pipe size (inches)	Temperature range (°F.)	Cellular glass HH-I-551 Nominal ^{1/} thickness (inches)		Plastic foam, MIL-P-15280 thickness, (inches)	
Up to 1-1/4	-20 to -1	2-1/4	1-1/2*	1-1/2	1*
	0 to 40	2	1-1/4*	1	3/4*
1-1/2 to 2-1/2	-20 to -1	2-1/2	1-3/4*	1-1/2	1
	0 to 40	2-1/4	1-1/2*	1	3/4*
3 to 5	-20 to -1	3	2*	1-1/2	1*
	0 to 40	2-3/4	1-3/4*	1	3/4*

^{1/} By nominal thickness is meant a thickness which is approximate and should only be used as a guide in determining actual thickness requirements.

* Thickness for application in air-conditioned spaces only.

Table VIII - Thickness of refrigerant insulation for machinery and equipment (exclusive of vapor barrier).

Temperature range (°F.)	Thickness (inches)			
	Foam plastic MIL-P-15280		Cellular glass, HH-I-551	
0 to 35	3	1	5	1-1/2*

* Thickness for application in air conditioned spaces only.

Table IX - Thickness of antisweat insulation (exclusive of vapor barrier).

Temperature range (°F.)	Machinery and equipment		Piping			
	Material specification	Thickness (inches)	Material specification	Thickness (inches)		
28 to 99	MIL-I-15091	1-1/2	3/4*	MIL-I-15091	1	1/2*
	MIL-I-2819			MIL-I-2781		
	HH-I-551			MIL-I-2819		
	MIL-I-22023	1	1/2*	HH-I-551	3/4	1/2*
	MIL-P-15280	3/4	1/2*	MIL-I-15280		
			MIL-I-22344			

* Thickness for application in air-conditioned spaces only.

Table X - Nominal thicknesses of insulation for weather deck hot piping.

Pipe size (inches i.p.s.)	Calcium silicate, MIL-I-2781 Cellular glass, HH-I-551
	Inches
1/4 to 3	1-1/2
3-1/2 to 6	2
Over 6	2-1/2

5.3.2 Covers may be made of segments of block insulation or preformed pipe insulation, having the same thickness as that on the adjacent piping. Blocks shall be securely wired to frames of 1/2 inch square mesh, number 18 gage (0.049-inch diameter) galvanized steel wire. Wire mesh frames inside and outside of blocks shall have ends bent over and joints secured with number 18 gage black annealed iron wire woven through the mesh. Insulating cement compatible with the material of the blocks shall be troweled smoothly over all surfaces of the wire mesh. Asbestos roll felt may be used to build up covers when the flange diameter is larger than the outside diameter of the adjacent pipe covering. Cover shall be tightly and smoothly lagged to envelop the outside and ends. For temperatures of 500°F. and below asbestos cloth lagging conforming to SS-C-466, grade AA, shall be used; grade AAA cloth shall be used above 500°F. Lagging may be cemented or sewn on, except ends of covers shall always be sewn. Where double layer insulation is used the two sections of the cover shall be fitted together with scarfed joint. Such joints shall be straight and true to reduce heat loss. Bands, eyelets, or locks of galvanized steel, or lacing with hooks, rings, washers, and wire shall be used to secure the covers.

5.3.3 When installing the above covers, spaces between inner surfaces of covers for flanges and other irregular surfaces shall be filled with pieces of insulation felt. Asbestos felt may be used when temperatures are 850°F. or less. Fibrous glass felt in accordance with MIL-I-16411 or MIL-I-23128, grade A may be used when temperatures are 1200°F. or less. Felt shall be packed loosely enough to preserve air cell structure and tightly enough to prevent air circulation.

5.4 Fabrication, machinery and equipment. For re-usable covers for machinery and equipment, either of the following methods of fabrication is acceptable.

5.4.1 Covers may be similar to the flexible asbestos felt or fiber-glass felt type described for piping components.

5.4.2 Covers may be made in sections formed of insulating block held together with wire and adhesive cement, covered with 1/2-inch thickness of finishing cement, and lagged. Lacing with hooks, rings, washers, and wire, or brass snap fasteners shall be used to secure the covers.

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5.4.3 Semi-removable turbine casing flange covers may be installed as an alternate for removable covers specified above. The permanent insulation shall be run to the casing flange allowing bolt removal space. The flange and bolts are then covered with asbestos cloth, wire inserted asbestos cloth or incolene wire mesh, as required by operating temperature, which shall be secured to the bolts with wire. The flange may now be insulated with fibrous glass felt MIL-I-16411, asbestos felt MIL-I-15091, mineral wool felt MIL-I-2818 or insulation block MIL-I-2819 to the required thickness and shape; the insulation is then lagged with asbestos cloth. This cloth shall be carried over the outer edge of the permanent insulation and secured with adhesive. The semi-removable cover shall then be sealed and painted.

6. INSTALLATION

6.1 Hot surface insulation.

6.1.1 Pipe and tubing. Each layer of molded insulation shall be installed with joints butted together. Where two layers are used all joints shall be staggered. Not less than three fastenings shall be used for securing each 3-foot section of insulation. Fastening shall be number 18 gage minimum (0.049-inch diameter) annealed black or hot-dipped galvanized iron wire or flat steel bands. Except as otherwise specified, lagging shall be installed over the insulation.

6.1.1.1 The installation of soot blower piping insulation shall be in accordance with drawing 5000-S5103-841336.

6.1.2 Piping components. For valves, fittings, and accessories, welded and brazed fittings including unions may be insulated and lagged similarly to adjacent piping.

6.1.2.1 Block, felt, blanket insulating materials, or molded pipe insulation secured with hot-dipped galvanized iron wire, may be used. When insulating felts are used above 850°F. the inner layer shall be fiber-glass felt conforming to MIL-I-16411 or refractory fiber felt, MIL-I-23128. Galvanized iron wire netting, number 18 gage minimum (0.049-inch diameter), shall be spread over the insulating material and secured with wire. Insulating cement shall be used to fill all crevices, smooth all surfaces, and completely cover the wire netting. A 1/2-inch thickness of finishing cement shall then be applied. Insulating material shall be the same thickness as that on adjacent piping.

6.1.2.2 For components 3-1/2 inch i.p.s. and smaller, insulating cement only conforming to MIL-C-2861, may be applied to a thickness 1/2-inch less than the adjacent pipe insulation. A 1/2-inch thickness of finishing cement shall be applied over the insulating cement.

6.1.2.3 Re-usable covers shall be fitted where required.

6.1.3 Machinery and equipment. For machinery and equipment, block, felt, or blanket insulating materials of the required thickness shall be secured with hot-dipped galvanized iron wire. Galvanized iron wire netting 1-inch mesh and number 18 gage minimum (0.049-inch diameter) shall be spread over the surface and secured by wire. Insulating cement shall be used to fill all crevices, smooth all surfaces, and completely cover the wire netting.

6.1.3.1 When no insulating cement has been specified, a 1/2-inch thickness of finishing cement shall be applied.

6.1.3.2 When an insulating cement has been specified it shall be applied in successive layers, 1/2-inch to 1-inch in thickness, until the total thickness specified has been reached. Wire netting, similar to that used for covering the insulating materials shall be installed between layers. A 1/2-inch thickness of finishing cement shall be applied over the last layer of insulating cement.

6.1.3.3 Lagging shall be installed over finishing cement. Re-usable covers shall be installed where required.

6.1.3.4 Clips, hooks, or other fastenings for securing insulation or lagging shall not be brazed or welded to nonferrous parts of distilling plants or deaerating feed tanks.

6.1.4 Boiler uptakes. For boiler uptakes the thermal insulation shall be 2-inches thick. Either mineral wool felt, MIL-I-2818, or fibrous glass sheet, MIL-I-15475, may be used. If acoustic absorptive treatment is found to be necessary to decrease the noise level the insulation thickness shall be increased accordingly.

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6.1.4.1 Metal lagging for uptakes shall be galvanized sheet steel conforming to QQ-S-775, not less than 1/32-inch thick.

6.1.4.2 Insulation and lagging is not required on uptakes above the weather deck, except where the transfer of heat, to spaces adjacent to the uptake area, would be objectional.

6.1.5 Unfired pressure vessels. Unfired pressure vessels including catapult wet accumulators shall be covered with block insulation MIL-I-2319 in accordance with table V. Block insulation shall be covered with 1/2-inch cement, MIL-C-2861, lagged with asbestos cloth, grade U.G. or SS-C-466, and painted in accordance with 6.6. Insulation in the way of vessel supports shall be metal faced to prevent insulation from wedging between the vessel and its support.

6.1.5.1 Removable and re-usable covers shall be installed over butt welded shell inserts for which periodic radiographic inspection of the joint is required. These covers shall extend 4 inches beyond the welded joint.

6.2 Antisweat insulation (cold and chilled water service).

6.2.1 ~~Molded pipe covering, cellular glass, water repellent asbestos felt, or fibrous glass insulation shall be secured with number 18 gage minimum (0.049-inch diameter) hot-dipped galvanized iron wire, soft annealed copper wire, QQ-W-343, wire inserted asbestos yarn, or glass thread, MIL-C-20079, spirally wound on 1-inch centers. One layer of water repellent and fire resistant paper, UU-B-790, shall be wrapped tightly around the insulation and secured with cotton twine, T-T-931, glass thread, MIL-C-20079, or 1-inch wide tape, UU-T-106. All joints of the paper shall be lapped and sealed with adhesive cement, MIL-A-3316, class 1. The compatible lagging shall then be installed and completely covered with vapor barrier compound, MIL-C-19565, type II. The water repellent paper may be eliminated on cellular glass where the insulation surface is suitable for the effective application of vapor barrier compound MIL-C-19565.~~

6.2.2 Application of a vapor barrier is not required on elastomeric foamed plastic insulation, MIL-P-15280, nor is lagging required except in areas where such insulation would be subject to damage.

6.3 Refrigerant insulation.

6.3.1 Cellular glass insulation shall be coated on all surfaces with vapor barrier compound, MIL-C-19565, type II at the time of installation. Insulation shall be installed with staggered end joints. On horizontal pipes the longitudinal joints shall be at the top and bottom. Insulation shall be secured with number 18 gage minimum (0.049-inch diameter) copper-covered steel wire or 1-inch wide tape, UU-T-106, on 9-inch centers. The compatible lagging shall then be installed and completely covered with vapor barrier compound, MIL-C-19565, type II.

6.3.2 Elastomeric foamed plastic, MIL-P-15280 may be applied in 1/4-inch minimum thickness layers as necessary to build up the required thickness (type II, form 1 or 2). All longitudinal and butt joints shall be staggered. All joints and lagging, if required (see 6.2.2), shall be secured with adhesive cement in accordance with paragraph 3.7 of MIL-P-15280.

6.4 Weather deck hot piping insulation.

6.4.1 Calcium silicate or cellular glass insulation for piping exposed to the weather shall be installed as follows:

(a) Preliminary preparation of piping.

- (1) All surfaces to be clean, dry, and free of scale and grease.
- (2) Fittings, valves, flanges, pipe supporting clamp, and at least 3 inches of adjacent pipe shall be painted as follows: Apply one coat pretreatment formula 117, MIL-C-15328. After this coat dries, apply two coats of aluminum paint made by mixing two pounds of aluminum paste, TT-P-320, type II, class B, with each gallon of phenolic varnish.

(b) Installation on pipes.

- (1) The bore, butt ends, and longitudinal joint surfaces of cellular glass insulating material shall be coated not more than 1/16 inch thick with commercial bedding compound, in accordance with MIL-I-19564, at time of

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- installation. Bedding compound is not required with calcium silicate pipe covering.
- (2) Longitudinal joints on horizontal piping shall be on top and bottom of pipe.
 - (3) Insulation shall be secured tightly to pipe with 1/2-inch wide U.S. Standard 22 gage galvanized steel bands on 9-inch centers. Steel bands shall be placed over a layer of fibrous glass tape, MIL-C-20079, class c, which has been dipped in the commercial finishing compound in accordance with MIL-C-19565 type I. Steel bands shall be wrapped with a layer of masking tape, UU-T-106, type II.
 - (4) Completely coat insulation with commercial finishing compound, in accordance with MIL-C-19565, using about 2 gallons per 100 square feet. Wrap on tightly one layer of open weave fibrous glass cloth, MIL-C-466, or knitted fibrous glass tape, MIL-C-20079, and then apply another coating of above-specified finishing compound, using about 4 gallons per 100 square feet. After this coat has set apply a second coat of finishing compound using the same quantities.
 - (5) Where insulation is stopped off on the piping, sufficient mineral wool, MIL-I-2818, shall be tightly tied in place with galvanized iron wire over a heavy coating of the above-specified commercial bedding compound, to provide a tapered portion from insulation surface to pipe surface. The ends of the insulation shall be tapered at a 30-degree angle with the pipe. The tapered ends of the insulation shall be smoothed with insulation cement in accordance with MIL-C-2861. The cement covered tapered ends, after drying thoroughly, shall be coated with approximately a 1/8-inch thick tack coat of end sealing compound in accordance with MIL-C-22395. The sealer compound shall extend onto the pipe for at least 3 inches. A single layer of grade D, class 2, asbestos cloth lagging, in accordance with SS-C-466, shall be applied over the insulation and secured at longitudinal lap joint with class 1 adhesive cement in accordance with MIL-C-3316. The asbestos lagging cloth shall be tailored to fit the contour of the ends of the insulation by cutting and removing wedge-shaped sections of the cloth. The remaining ends of the cloth shall be embedded in the tack coating of sealer compound and shall be attached to the pipe with a single 1/2-inch wide galvanized steel band. A 3/16-inch layer (approximately) of sealer compound shall be troweled to a smooth finish over the cloth covered ends of the assembly. A smooth finish may be obtained by brush coating or hand rubbing the sealer compound with a suitable solvent. After 72 hours of drying at ambient temperature, the asbestos cloth of the assembly shall be given two brush coats of water- and weather-resistant coating compound in accordance with MIL-C-19565. The waterproofing compound shall extend halfway down the tapered ends of the assembly. The waterproofing compound shall be air dried 24 hours between applications.
- (c) Installation on fittings, flanges, and valves.
- (1) Before applying flange insulation weather deck piping shall be tested and secured in the following manner: After specified tests are completed, weather deck piping shall be subjected to alternate periods of full operating pressure, allowing pipe to come to maximum temperature; and then to zero gage pressure allowing pipe to come to ambient temperature. These cycles shall be repeated a sufficient number of times tightening and adjusting flanges where necessary until no leaks can be detected.
 - (2) Fittings, flanges, and valve covers shall be ship-fabricated from sections of molded pipe covering or cellular glass block cemented together with adhesive cement, MIL-A-18065, class 1.
 - (3) Permanent covers for fittings and valves shall be fitted snugly to fittings and adjacent pipe covering using the same materials and methods as outlined for pipe covering. Voids between insulation and fitting shall be filled with tightly packed mineral wool, MIL-I-2818.
 - (4) Where specified, rigid-type portable flange covers shall extend over the adjacent pipe covering 1-1/2 times the thickness of the insulation. The two halves of the cover should be coated and lagged separately, using the same materials and procedure as outlined for pipe covering. The galvanized steel bands used to secure the two halves together and to the adjacent pipe covering shall be applied over the lagging and then coated with the above-specified finishing compound.

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(d) Installation around supports and hangers.

- (1) Remove only enough installation from butt edges to provide a snug fit around support brackets or hanger rods. Fill all voids between insulation and support with tightly packed mineral wool, MIL-I-2818, to within 1/4 inch from insulation surface. Fill remainder of space with end sealing compound in accordance with MIL-C-22395 overlapping generously both the support member and the adjacent insulation. Lag and coat with the same method and materials as adjacent piping.

6.5 Metal lagging. Metal lagging shall be installed with lap joints, secured with hardened self-tapping screws or metal bands. Joints shall be arranged in a manner which will facilitate run-off of impinging liquids.

6.6 Painting. All cloth and tape laggings shall be painted after installation with one coat of fire-retardant white paint, TT-P-26, if necessary for appearance. Elastomeric foamed plastic insulation MIL-P-15280 shall not be painted except where necessary for appearance. (For material and application requirements, see Section 9190-1 of the General Specifications for Ships of the U.S. Navy or ships specifications.)

7. NOTES

(Copies of this standard for military use may be obtained as indicated in the foreword to, or the general provisions of, the Index of Military Specifications and Standards.)

Both the title and the identifying number should be stipulated when requesting copies of Military Standards.

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