

MIL-I-2781E  
 7 October 1975  
 SUPERSEDING  
 MIL-I-2781D  
 13 June 1963  
 (See 6.6)

MILITARY SPECIFICATION  
 INSULATION, PIPE, THERMAL

# This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

# 1.1 Scope. This specification covers preformed thermal insulation for use on pipes at surface temperatures up to 1200° Fahrenheit (°F).

2. APPLICABLE DOCUMENTS

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

SPECIFICATIONS

FEDERAL

SS-C-160 - Cements, Insulation, Thermal.  
 PPP-B-636 - Boxes, Shipping, Fiberboard.

MILITARY

MIL-C-2861 - Cement, Insulation, High Temperature.

STANDARDS

MILITARY

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.  
 MIL-STD-125 - Marking for Shipment and Storage.  
 MIL-STD-769 - Thermal Insulation Requirements for Machinery and Piping.  
 MIL-STD-1623 - Fire Performance Requirements and Approved Specifications for Interior Finish Materials and Furnishings (Naval Shipboard Use).

(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.)

# 2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

UNIFORM CLASSIFICATION COMMITTEE

Uniform Freight Classification Rules.

(Application for copies should be addressed to the Uniform Classification Committee, Room 1106, 222 South Riverside Plaza, Chicago, Illinois 60606.)

NATIONAL MOTOR FREIGHT TRAFFIC ASSOCIATION INCORPORATED, AGENT  
 National Motor Freight Classification Rules.

(Application for copies should be addressed to the National Motor Freight Traffic Association, Inc., 1616 P Street, N.W., Washington, D.C. 20036.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

C 302 - Density of Preformed Pipe-Covering-Type Thermal Insulation, Test for.  
 C 335 - Thermal Conductivity of Pipe Insulation, Test for.  
 C 356 - Linear Shrinkage of Preformed High-Temperature Thermal Insulation Subject to Soaking Heat, Test for.  
 C 411 - Hot-Surface Performance of High-Temperature Thermal Insulation, Test for.  
 C 421 - Mechanical Stability of Preformed Thermal Insulation by Tumbling, Test for.  
 C 446 - Breaking Load and Calculated Modulus of Rupture of Preformed Insulation for Pipes, Test for.

FSC 5640

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(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. REQUIREMENTS

3.1 Qualification. The thermal pipe insulation furnished under this specification shall be products which are qualified for listing on the applicable qualified products list at the time set for opening of bids (see 4.3 and 6.3).

# 3.2 Material. The thermal pipe insulation shall be composed of asbestos-free, heat-resisting compounds suitable for the temperature conditions and the purpose intended. A certification of compliance shall be required (see 6.2.2).

#### 3.3 Form and dimensions.

# 3.3.1 Form and length. Thermal pipe insulation in nominal pipe sizes up to and including 10 inches shall be furnished in sections 3 feet long, split in half lengthwise. Pipe insulation for nominal pipe sizes larger than 10 inches may be furnished in semi-cylindrical sections or as curved segments, 3 feet in length. Each section or segment shall be generally true to shape and roundness and capable of fitting standard iron pipe sizes. A tolerance of plus or minus 1/4 inch in length will be permitted.

3.3.2 Inner diameter. The inner diameter of the pipe insulation shall be as specified in table I.

# Table I - Inner diameter of pipe insulation.

Pipe size		Inner diameter <sup>1/</sup>	Tolerance	
Nominal	Outer diameter	Nominal	Minus	Plus
Inches	Inches	Inches	Inch	Inch
1/2	0.840	0.856	0	} 1/16
3/4	1.050	1.066	0	
1	1.315	1.331	0	
1-1/4	1.660	1.676	0	
1-1/2	1.900	1.916	0	} 3/32
2	2.375	2.406	1/64	
2-1/2	2.875	2.906	1/64	
3	3.500	3.531	1/64	
3-1/2	4.000	4.031	1/64	} 3/32
4	4.500	4.531	1/64	
4-1/2	5.000	5.031	1/64	
5	5.563	5.641	1/32	
6	6.625	6.703	1/32	} 3/32
7	7.625	7.703	1/32	
8	8.625	8.703	1/32	
9	9.625	9.703	1/32	
10	10.750	10.828	1/32	} 5/32
11	11.750	11.828	3/64	
12	12.750	12.844	3/64	
14	14.000	14.094	3/64	
15 thru 32	0.000	0.094	3/64	} 5/32
33	33.000	33.094	3/64	

<sup>1/</sup> Inner diameter measurement shall consist of the average of six readings on each section; three readings of diameter near the ends and at the center of each section in a horizontal direction, and three vertical measurements of leg height multiplied by two.

3.3.3 Thickness. Pipe insulation shall be furnished in the thickness specified in table II, as specified (see 6.2). A tolerance of plus 1/8-inch or minus 1/16-inch in actual thicknesses specified in table II will be permitted.

Table II - Thickness.

Pipe size		Nominal thickness									
Nominal	Outer diameter	1	1-1/2	2	2-1/2	3	3-1/2	4	4-1/2	5	
Inches	Inches	inch	inches	inches	inches	inches	inches	inches	inches	inches	inches
		Actual thickness	Actual thickness	Actual thickness	Actual thickness	Actual thickness	Actual thickness	Actual thickness	Actual thickness	Actual thickness	Actual thickness
1/2	0.840	1	1- 9/16	2- 1/16	2- 7/8	3- 3/8	3- 7/8	4- 3/8	4- 15/16	5- 7/16	Inches
3/4	1.050		1- 7/16	1-15/16	2- 3/4	3- 1/4	3- 3/4	4- 1/4	4-13/16	5- 5/16	Inches
1	1.315		1- 9/16	2- 3/32	2- 5/8	3- 1/8	3- 5/8	4- 1/8	4-11/16	5- 3/16	Inches
1- 1/4	1.660		1- 5/8	1-29/32	2- 7/16	2-15/16	3- 7/16	3-15/16	4-17/32	5- 1/32	Inches
1- 1/2	1.900		1- 1/2	2- 5/16	2-13/16	3- 5/16	3-13/16	4- 3/8	4-29/32	5-13/32	Inches
2	2.375		1- 9/16	2- 3/32	2-19/32	3- 3/32	3-19/32	4- 5/32	4-21/32	5- 5/32	Inches
2- 1/2	2.875		1- 1/32	2-11/32	2-27/32	3-11/32	3-29/32	4- 1/32	4-29/32	5-17/32	Inches
3	3.500		1-27/32	2- 1/32	2-17/32	3- 1/32	3-19/32	4- 3/32	4-19/32	5- 7/32	Inches
3- 1/2	4.000		1-17/32	2- 9/32	2-25/32	3-1/32	3-27/32	4- 1/32	4-11/32	5- 7/32	Inches
4	4.500		1-25/32	2- 1/32	2-17/32	3-1/32	3-19/32	4- 3/32	4-23/32	5- 7/32	Inches
4- 1/2	5.000		1-17/32	2- 9/32	2-27/32	3-11/32	3-27/32	4- 1/32	4-15/32	5- 7/32	Inches
5	5.563		1-25/32	2- 9/32	2-27/32	3-11/32	3-27/32	4- 1/32	4-15/32	5- 7/32	Inches
6	6.625		1- 1/2	2	2- 9/16	3- 1/16	3- 9/16	4- 3/16	4-11/16	5- 3/16	Inches
7	7.625		1-15/32	2- 1/32	2-17/32	3- 1/32	3-21/32	4- 5/32	4-21/32	5- 7/32	Inches
8	8.625		1-17/32	2- 1/32	2-17/32	3- 5/32	3-21/32	4- 5/32	4-21/32	5- 7/32	Inches
9	9.625		1-17/32	2- 1/32	2-21/32	3- 5/32	3-21/32	4- 5/32	4-21/32	5- 5/32	Inches
10	10.750		1-17/32	2- 5/32	2-21/32	3- 5/32	3-21/32	4- 5/32	4-21/32	5- 5/32	Inches
11	11.750		1-19/32	2- 3/32	2-19/32	3- 3/32	3-19/32	4- 3/32	4-19/32	5- 3/32	Inches
12	12.750		1-19/32	2- 3/32	2-19/32	3- 3/32	3-19/32	4- 3/32	4-19/32	5- 3/32	Inches
14	14.000		1- 9/16	2- 1/16	2- 9/16	3- 1/16	3- 9/16	4- 1/16	4-19/32	5- 3/32	Inches
Over 14 up to and including 33			1- 7/16	1-15/16	2- 7/16	2-15/16	3- 7/16	3-15/16	4- 7/16	4-15/16	Inches

Note: The inner diameter of pipe insulation listed in table I approximates the outer diameter of iron pipe sizes. The insulation can be applied either to a pipe or as a second layer to a smaller layer of pipe insulation.

1/2 Pipe insulation may be furnished in two layers to form total required thickness in conformance with MIL-STD-769.

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- # 3.4 Physical requirements. Pipe insulation shall conform to the requirements specified in table III.

Table III - Physical requirements.

Characteristic	Test paragraph	Physical requirements
Density average, lb/ft <sup>3</sup> maximum	4.5.2	14.0
Thermal conductivity (average) Btu/hr. ft. deg F at mean temperature of:	4.5.3	
200°F		.42
300°F		.45
400°F		.50
500°F		.60
600°F		.65
700°F		.70
Weight loss by tumbling Loss in weight (average), percent max.	4.5.4	
After first 10 minutes		20
After second 10 minutes		40
Modulus of rupture (average), lb/in <sup>2</sup> minimum	4.5.5	<u>1</u>
Changes under soaking heat for 6 hours at 1200°F Linear shrinkage (average) percent, max.	4.5.6	2.0

1 Three times density (lbs/ft<sup>3</sup>) of the sample tested.

- # 3.5 Simulative service. Thermal pipe insulation shall not warp, crack, or show other visible changes upon completion of the test specified in 4.5.7. Minor surface cracks on the hot face surface of the pipe insulation shall be disregarded. Test duration at specified temperature shall be 30 days.

- # 3.6 Fire resistance and smoke density. The finished material shall conform to the fire resistance and smoke density requirements set forth in MIL-STD-1623 (see 4.5.8).

3.7 Compatibility. The piping insulation shall be compatible with thermal insulation cement of SS-C-160 type III, grade F and high temperature thermal cement of MIL-C-2861. Without the application of a primer, the cements must readily adhere to the insulation segments and form a smooth, protective surface which will not separate under force of gravity, vibration, or accidental mechanical force, such as bumping or jarring.

#### 4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

- # 4.2 Classification of inspections. The inspection requirements specified herein are classified as follows:

- (a) Qualification inspection (see 4.3).  
(b) Quality conformance inspection (see 4.4).

- # 4.3 Qualification tests. Qualification tests shall be conducted at a laboratory satisfactory to the Naval Ship Engineering Center. Qualification tests shall consist of all the tests specified in 4.5.

- # 4.3.1 Sampling for qualification tests. Three samples shall be selected and subjected to the tests of 4.5.2, 4.5.4, 4.5.5, and 4.5.6; two samples for the tests of 4.5.3 and

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4.5.8 and one sample for the test of 4.5.7. The average test results shall be within the limits prescribed in table III and the individual test results shall not exceed these limits by more than 10 percent.

# 4.4 Quality conformance inspection.

# 4.4.1 Sampling for quality conformance inspection. For purposes of sampling, an inspection lot shall consist of all pipe insulation of the same form, size, and thickness produced under similar conditions and procured at one time.

4.4.1.1 Examination of the end item. Examination of the end item shall be made in accordance with 4.4.1.1.1 through 4.4.1.1.3. The lot size, for purpose of determining the sample size in accordance with MIL-STD-105, shall be in units of pipe insulation sections or segments (see 4.4.1.1.1 and 4.4.1.1.2) and units of shipping containers (see 4.4.1.1.3).

# 4.4.1.1.1 Examination of the end item for defects in appearance and workmanship. The sample unit for the following examination shall be one section or segment. The inspection level for determining the sample size shall be level I with an Acceptable Quality Level (AQL) of 2.5 percent defective.

Category	Defects
Critical	None defined
Major	
101	Appearance and workmanship
102	Cracked, broken or damaged.
103	Crumbly, surface not smooth.
104	Not true to form or roundness.
105	Bad edges.
106	Longitudinal cut surfaces not plane.
107	Excessive voids.
	Warped.
108	Form
	Form not as required; not furnished in sections or segments as specified, fail to properly encase pipe of the required diameter.
Minor	None defined

# 4.4.1.1.2 Examination of the end item for defects in dimensions. The sample unit for the following examination shall be one section or segment. The inspection level for determining the sample size, shall be level I with an AQL of 2.5 percent defective.

Categories	Defects
Critical	None defined
Major	
101	Length Not within limits or tolerance specified or by contract requirement.
102	Inner diameter Clearance not within specified limits (see footnote under table I).
103	Size Not within conformance with the simplified dimensional or nesting system.
104	Thickness Not within specified limits and tolerances.
Minor	None defined

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4.4.1.1.3 Examination of preparation for delivery. An examination shall be made to determine that the packing and markings comply with the requirements of section 5 of this specification. The sample unit for the following examination shall be one shipping container, selected just prior to the closing operation. The inspection level for determining the sample size, shall be level I, with an AQL of 2.5 percent defective. Shipping containers, fully prepared for delivery, shall be examined for closure defects.

Categories	Defects
Critical	None defined
Major	
101	Packing Not as specified.
102	Container not as specified, closures not accomplished by specified or required methods of material.
103	Any nonconforming component, component missing, damaged or otherwise defective, affecting serviceability.
104	Inadequate application of components; such as, incomplete closures, inadequate taping of joints, bulged or distorted containers.
105	Count Number of sections or segments per container less than specified or indicated quantity.
106	Weight Gross or net weight exceeds specified requirements.
107	Marking Omitted, illegible, incorrect, incomplete, or not as specified (see 5.2).
Minor	None defined

# 4.4.2 Sampling for tests. The lot size shall be the number of half sections or segments in the lot. A separate sample size of specimens shall be drawn for each test as specified in table IV. For tests of 4.5.2 and 4.5.5, the size shall be as specified by table IV. For tests of 4.5.4 and 4.5.6, the sample size shall consist of three specimens per lot for lots over 160 and the number of allowable test failures shall be zero. Lot sizes 160 or under shall be as specified in table IV.

# Table IV - Sampling for tests.

Lot size in half section or segments	Sample size = Number of test specimens for each test (4.5.2 and 4.5.5)	Number of specimen failures allowed for each test
Up to 63	None	--
64 to 160	2	0
161 to 400	3	0
401 to 1,000	5	0
1,001 to 2,500	8	0
2,501 to 6,300	13	1
6,301 to 16,000	20	2
16,001 to 40,000	32	3

# 4.4.2.1 Testing of end item. The end item shall be tested for applicable characteristics as specified in table V from each lot presented.



Table V - Instruction for testing.

Characteristic	Specification reference		Number determinations per unit	Results reported as
	Requirement	Test method		Numerically to nearest <sup>1/</sup>
Density	3.4	4.5.2	1	0.1 lb/ft <sup>3</sup>
Weight loss by tumbling	3.4	4.5.4	1	1 percent
Modulus or rupture	3.4	4.5.5	1	1 lb/in <sup>2</sup>
Changes under soaking heat	3.4	4.5.6	1	0.1 percent
Linear shrinkage	3.4	4.5.6	1	0.1 percent

<sup>1/</sup> Test reports shall include all values on which results are based.

#### 4.5 Test procedures.

4.5.1 Conditioning samples. Test specimens shall be conditioned by drying to constant weight in an oven at a temperature of 215°F to 250°F preceding a test.

4.5.2 Density. The density shall be determined in accordance with the method specified in ASTM C 302.

4.5.3 Thermal conductivity. Thermal conductivity shall be determined in accordance with the method specified in ASTM C 335.

4.5.4 Weight loss by tumbling. Weight loss by tumbling shall be determined in accordance with the method specified in ASTM C 421.

4.5.5 Modulus of rupture. Modulus of rupture shall be determined in accordance with the method specified in ASTM C 446.

4.5.6 Physical changes after heat soaking. Specimens shall be weighed and measured. The specimens shall then be placed in an electrically heated oven and subjected to 1200°F for 6 hours for linear shrinkage. The specimens shall then be removed from the oven, cooled to room temperature, and tested to determine linear shrinkage in accordance with method specified in ASTM C 356.

4.5.7 Simulative performance. Simulative performance shall be determined in accordance with the method specified in ASTM C 411 except the pipe shall be maintained at the specified temperature for 30 days.

4.5.8 Fire resistance and smoke density. Specimens shall be tested in accordance with test procedures and requirements set forth in MIL-STD-1623.

4.5.9 Compatibility. A six inch section of pipe insulation, 1-1/2 inches thick, shall be uniformly surface coated while at room temperature, with approximately a 1/4 inch layer of finishing cement in accordance with type III, grade F of SS-C-160. Drying time under ambient air temperature conditions shall be determined. This test shall be repeated with a second pipe section using a cement in accordance with MIL-C-2861. The drying time for this cement shall also be determined.

#### 5. PREPARATION FOR DELIVERY

(The preparation for delivery requirements specified herein apply only for direct Government procurements.)

5.1 Packing. Packing shall be level A, B, or C as specified (see 6.2).

5.1.1 Level A. Pipe insulation shall be packed in containers conforming to class weather-resistant of PPP-B-636, except that limitations on inside dimensions of box shall not apply. Boxes shall be closed, waterproofed, and reinforced in accordance with method V of the appendix to the box specification.

5.1.2 Level B. Pipe insulation shall be packed in containers conforming to class domestic of PPP-B-636, except that limitations on inside dimensions of box shall not apply. Box closure shall be in accordance with the appendix to the box specification.

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# 5.1.3 Level C. Pipe insulation shall be packed in containers, at the lowest rates, in a manner which will insure acceptance by common carrier and will afford protection against physical damage during direct shipment from the supply source to the first receiving activity for immediate use. This level in general shall conform to the Uniform Freight or National Motor Freight Classification Rules and Regulations or other carrier regulations as applicable to the mode of transportation.

5.2 Marking. In addition to any special marking required, shipping containers shall be marked in accordance with MIL-STD-129.

5.2.1 Special marking. Packages and shipping containers shall be marked "ASBESTOS-FREE", (see 6.2.1).

## 6. NOTES

# 6.1 Intended use. The thermal insulation is to provide for piping operating at surface temperatures up to 1200°F.

6.2 Ordering data. Procurement documents should specify:

### 6.2.1 Procurement requirements:

- (a) Title, number, and date of this specification.
- (b) Nominal iron pipe size, and nominal thickness (see 3.3.3).
- (c) Levels of packing required (see 5.1).
- (d) Special marking (see 5.2.1).

6.2.2 Contract data requirements. When this specification is used in a procurement invoking the data requirement clause of the Armed Services Procurement Regulations (ASPR) paragraph 7-104.9(n) and which incorporates a DD Form 1423 Contract Data Requirements List (CDRL), the data requirements identified below will be developed as specified in the cited Data Item Description (DID) and delivered in accordance with such CDRL. When the ASPR provisions are not invoked, the data specified below shall be delivered in accordance with the contract requirements.

<u>Specification paragraph</u>	<u>Data requirements</u>	<u>Service</u>	<u>Applicable DID</u>	<u>Options</u>
3.2	Certificate of compliance	SH	DI-E-2121	---

(Copies of DID's required by the supplier in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.)

6.3 With respect to products requiring qualification, awards will be made only for products which are at the time set for opening of bids, qualified for the inclusion in applicable Qualified Products List QPL-2781 whether or not such products have actually been listed that date. The attention of the suppliers is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the Qualified Products List is the Naval Ship Engineering Center, Prince George's Center, Center Building, Hyattsville, Maryland 20782, and information pertaining to qualification of products may be obtained from that activity. Application for Qualification tests shall be made in accordance with "Provisions Governing Qualification SD-6" (see 6.4).

6.4 Copies of "Provisions Governing Qualification SD-6" may be obtained upon application to Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.

# 6.5 Grades, classes, and types of MIL-I-2781D were consolidated as end items were identical.



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6.6 THE MARGINS OF THIS SPECIFICATION ARE MARKED "\*" TO INDICATE WHERE CHANGES (ADDITIONS, MODIFICATIONS, CORRECTIONS, DELETIONS) FROM THE PREVIOUS ISSUE HAVE BEEN MADE. THIS WAS DONE AS A CONVENIENCE ONLY AND THE GOVERNMENT ASSUMES NO LIABILITY WHATSOEVER FOR ANY INACCURACIES IN THESE NOTATIONS. BIDDERS AND CONTRACTORS ARE CAUTIONED TO EVALUATE THE REQUIREMENTS OF THIS DOCUMENT BASED ON THE ENTIRE CONTENT IRRESPECTIVE OF THE MARGINAL NOTATIONS AND RELATIONSHIP TO THE LAST PREVIOUS ISSUE.

**Custodians:**

Army - ME  
Navy - SH  
Air Force - 84

**Preparing activity:**

Navy - SH  
(Project 5640-0284)



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