Designation: C 547 – 07$^{\epsilon 1}$

Standard Specification for Mineral Fiber Pipe Insulation[1]

This standard is issued under the fixed designation C 547; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

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

ϵ[1] NOTE—Section 2 and 11.1.5.3 were editorially corrected in May 2008.

1. Scope

1.1 This specification covers mineral fiber insulation produced to form hollow cylinders for standard pipe and tubing sizes. The mineral fiber pipe insulation may be molded or precision v-grooved, with one or more walls split longitudinally for use on pipe temperatures up to 1400°F (760°C).

1.2 For satisfactory performance, properly installed protective vapor retarders or barriers should be used on sub-ambient temperature applications to reduce movement of moisture through or around the insulation to the colder surface. Failure to use a vapor barrier can lead to insulation and system damage. Refer to Practice C 921 to aid material selection.

1.3 Flexible mineral fiber wrap products such as perpendicular-oriented fiber insulation rolls, non-precision or manually scored block or board, or flexible boards or blankets used as pipe insulation, are not covered by this specification.

1.4 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.5 For Naval Sea Systems Command (NAVSEA) acceptance, materials must also comply with Supplemental Requirements. See Annex A1 of this standard.

1.6 The following safety hazards caveat applies to the test methods portion, Section 11, only: *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

C 167 Test Methods for Thickness and Density of Blanket or Batt Thermal Insulations
C 168 Terminology Relating to Thermal Insulation
C 177 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus
C 302 Test Method for Density and Dimensions of Preformed Pipe-Covering-Type Thermal Insulation
C 335 Test Method for Steady-State Heat Transfer Properties of Pipe Insulation
C 356 Test Method for Linear Shrinkage of Preformed High-Temperature Thermal Insulation Subjected to Soaking Heat
C 390 Practice for Sampling and Acceptance of Thermal Insulation Lots
C 411 Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation
C 447 Practice for Estimating the Maximum Use Temperature of Thermal Insulations
C 585 Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System)
C 612 Specification for Mineral Fiber Block and Board Thermal Insulation
C 795 Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel
C 921 Practice for Determining the Properties of Jacketing Materials for Thermal Insulation
C 1045 Practice for Calculating Thermal Transmission Properties Under Steady-State Conditions
C 1058 Practice for Selecting Temperatures for Evaluating and Reporting Thermal Properties of Thermal Insulation
C 1104/C 1104M Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation
E 84 Test Method for Surface Burning Characteristics of Building Materials

2.2 *Other Standards:*

UL 723 Tests for Surface Burning of Building Materials[3]

[1] This specification is under the jurisdiction of ASTM Committee C16 on Thermal Insulation and is the direct responsibility of Subcommittee C16.20 on Homogeneous Inorganic Thermal Insulations.

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[2] 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.

[3] Available from Underwriters Laboratories (UL), 333 Pfingsten Rd., Northbrook, IL 60062-2096, http://www.ul.com.

NFPA 255 Method of Tests of Surface Burning Characteristics of Building Materials[4]

CAN/ULC-S102 Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies [5]

3. Terminology

3.1 The definitions in Terminology C 168 shall apply to the terms used in this specification.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *molded*—refers to products preformed via a molding process to yield full-round cylindrical pipe insulation sections.

3.2.2 *precision v-groove*—refers to products fabricated from machined board via a precision cutting process. Machined segments are adhered to a backing to form a full-round cylindrical pipe insulation section. Due to the precision of the process, the product has no gaps when installed.

4. Classification

4.1 Products covered by this specification are classified according to maximum use temperature as follows:

4.1.1 *Type I*—Molded, for use to 850°F (454°C).

Grade A—Requires no heat-up schedule

Grade B—Heat-up schedule is required

4.1.2 *Type II*—Molded, for use to 1200°F (650°C).

Grade A—Requires no heat-up schedule

Grade B—Heat-up schedule is required

4.1.3 *Type III*—Precision v-groove, for use to 1200°F (650°C).

Grade A—Requires no heat-up schedule

Grade B—Heat-up schedule is required

4.1.4 *Type IV*—Molded, for use to 1000°F (538°C).

Grade A—Requires no heat-up schedule

Grade B—Heat-up schedule is required

4.1.5 *Type V*—Molded, for use to 1400°F (760°C)

Grade A—Requires no heat-up schedule

Grade B—Heat-up schedule is required

NOTE 1—**Warning:** Grade B may not be suitable for applications requiring hot installation capability at the maximum temperature indicated. Products having a Grade B designation are designed to be used with a heat-up schedule. Failure to use a heat-up schedule with Grade B products may lead to an exothermic reaction. This is dependent on thickness and temperature. Consult the manufacturer or manufacturer's literature for special heat rate considerations.

4.2 Binder decomposition at elevated temperature may be a limiting factor in certain applications. Consult the manufacturer regarding special heat rate considerations.

5. Materials and Manufacturer

5.1 *Composition*— The mineral fiber insulation for pipes shall be manufactured from mineral substance such as rock, slag, or glass, processed from a molten state into fibrous form with binder. Asbestos shall not be used as an ingredient or component part. Some products may also contain adhesive.

5.2 *Jackets (Facings)*—The user of this specification has the option to specify that the insulation be jacketed.

NOTE 2—The user is advised that the maximum use temperature of factory-applied facings and adhesives may be lower than the maximum use temperature of the insulation. The specifier shall ensure that sufficient insulation thickness is installed so none of these accessory items (facings and adhesives) are exposed to temperatures above their maximum use temperature. The products covered by this standard are predominantly inorganic in nature. Organic facings, adhesives and binders are also used in the construction of these products. The resulting composite therefore could have increased combustibility.

6. Physical Requirements

6.1 The product shall conform to the following requirements in addition to those specified in Table 1.

6.2 *Hot Surface Performance*:

6.2.1 The product shall not crack, warp, flame, or glow during hot surface exposure. No evidence of melting or fiber degradation shall be evident upon post test inspection.

6.2.2 The insulation's internal temperature rise (exotherm) shall not exceed the pipe temperature by more than 200°F (111°C).

6.3 *Non-fibrous (Shot) Content*:

6.3.1 The non-fibrous content of a rock- or slag-based product shall not exceed 30 % by weight.

6.4 For Naval Sea Systems Command (NAVSEA) acceptance, materials must also comply with Supplemental Requirements. See Annex A1 of this standard.

7. Standard Shapes, Sizes, and Dimensions

7.1 The basic shape of mineral fiber pipe insulation forms a right annular cylinder, which is radially slit on at least one side of the cylinder axis. It is furnished in sections or segments designed to fit standard sizes of pipe and tubing.

7.2 Typical available thicknesses range from nominal ½-in. (13 mm) to nominal 6-in. (152 mm), single or double layer, in ½-in. increments for most pipe and tubing sizes.

7.3 Individual dimensions for inner diameter and wall thickness shall conform to Practice C 585.

7.4 Standard section or segment length shall be 3 ft (0.91m) or as agreed upon between the buyer and seller.

8. Dimensional Tolerances

8.1 Length equals ±⅛-in. (3 mm).

8.2 When installed on a nominal pipe or tubing size as defined in Practice C 585, the insulation shall fit snugly and have tight longitudinal and circumferential joints.

8.3 The inner and outer bore of the insulation shall be concentric to the outer surface. The deviation from concentricity shall not exceed 3⁄16 in. (5 mm).

9. Workmanship

9.1 The insulation shall not have defects that will adversely affect installation or service quality.

[4] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, http://www.nfpa.org.

[5] Available from Underwriters Laboratories of Canada, 7 Crouse Road, Scarborough, Ontario MIR3A9.

TABLE 1 Requirements of Mineral Fiber Pipe Insulation (Grades A & B)

Property	Type I (Grades A andB)	Type II (Grades A and B)	Type III (Grades A and B)	Type IV (Grades A and B)	Type V (Grades A and B
Use temperature, max, °F (°C)	850 (454)	1200 (650)	1200 (650)	1000 (538)	1400 (760)
Sag resistance, max, % thickness change	5	5	5	5	5
Linear shrinkage (length), max, % change after change after soaking heat at maximum use temperature	2	2	2	2	2
Water vapor sorption, max, % by weight	5	5	5	5	5
Surface burning characteristics, max					
Flame spread index	25	25	25	25	25
Smoke developed index	50	50	50	50	50
Apparent thermal conductivity, max, Btu.in./h,ft^2, °F(W/m.K)					
Mean temperature[A] °F (°C)					
100 (38)	0.25 (0.036)	0.25 (0.036)	0.25 (0.036)	0.25 (0.036)	0.25 (0.036)
200 (93)	0.31 (0.045)	0.31 (0.045)	0.31 (0.045)	0.31 (0.045)	0.31 (0.045)
300 (149)	0.40 (0.058)	0.37 (0.053)	0.37 (0.053)	0.37 (0.053)	0.37 (0.053)
400 (204)	0.51 (0.074)	0.45 (0.065)	0.45 (0.065)	0.45 (0.065)	0.45 (0.065)
500 (280)	0.64 (0.092)	0.54 (0.078)	0.54 (0.078)	0.54 (0.078)	0.54 (0.078)
600 (316)		0.65 (0.094)	0.65 (0.094)	0.65 (0.094)	0.65 (0.094)
700 (371)		0.77 (0.111)	0.77 (0.111)	0.77 (0.111)	0.77 (0.111)

[A] The user is advised that retrofit applications (where new insulation is being applied over existing) could require knowing the thermal conductivity of the existing layer at mean temperatures above those shown. Consult a manufacturer for data at mean temperatures exceeding those listed.

TABLE 2 Requirements of Mineral Fiber Pipe Insulation (Grade A Only)

Property	Type I (Grade A)	Type II (Grade A)	Type III (Grade A)	Type IV (Grade A)	Type V (Grade A)
Maximum Internal Temp. Rise (Grade A Only), °F (°C)	200 (111)	200 (111)	200 (111)	200 (111)	200 (111)

10. Sampling

10.1 When specified in the purchase order or contract, sampling and acceptance shall be in accordance with Practice C 390.

11. Test Methods

11.1 The properties in this specification shall be determined in accordance with the following test methods, with jacketing excluded unless stated otherwise.

11.1.1 *Density and Dimensions*—Test Method C 302.

11.1.2 *Linear Shrinkage*— Test Method C 356.

11.1.3 *Thermal Conductivity*—Test Method C 335.

11.1.3.1 Thermal performance shall be characterized on a 3-in. NPS × 2-in. pipe insulation size. Thermal performance must be assessed on actual pipe insulation sections. Data obtained on flat samples, using Test Method C 177, shall not be used to state compliance with this specification.

11.1.3.2 Practice C 1058 may be used to obtain recommended test temperature combinations for testing purposes.

11.1.3.3 As specified in C 1045, the range of test conditions must include at least one test where the hot surface temperature is greater than, or equal to, the hot limit of the temperature range of desired data and at least one test where the cold surface temperature is less than, or equal to, the cold limit of the temperature range desired. At least two additional tests shall be distributed somewhat evenly over the rest of the temperature range.

11.1.3.4 Final analysis of the thermal data shall be conducted in accordance with C 1045 to generate a thermal conductivity versus temperature relationship for the specimen.

11.1.3.5 The final step of C 1045 analysis is to calculate the thermal conductivity using the equations generated at a set of mean temperatures for comparison to the specification.**Warning—**While it is recommended that the specification data be presented as thermal conductivity versus temperature, several existing specifications may contain mean temperature data from tests conducted at specific hot and cold surface temperatures. In these cases, the conductivity as a function of temperature from the C 1045 analysis may provide different results. To insure that the data is compatible, a C 680 analysis, using the thermal conductivity versus temperature relationship from C 1045 and the specific hot and cold surface temperatures, is required to determine the effective thermal conductivity for comparison to the specification requirements.

11.1.4 *Water Vapor Sorption*—Test Method C 1104/C 1104M.

11.1.5 *Surface Burning Characteristics*—Test Method E 84.

11.1.5.1 Flat specimens otherwise identical in composition to pipe insulation shall be used. This applies to plain and factory-jacketed products, with and without self-sealing longitudinal lap closure systems.

11.1.5.2 Test Methods UL 723 or NFPA 255 may be substituted for Test Method E 84. These methods are largely considered synonymous by most building officials.

11.1.5.3 For Canada, test in accordance with CAN/ULC-S102.

11.1.6 *Hot Surface Performance*—Test Method C 411 and Standard Practice C 447.

11.1.6.1 A 3-in. (75-mm) nominal pipe size or larger shall be used. A test specimen shall be at least 36-in. (914-mm) in length. All types shall be tested at 6-in. (150-mm) nominal thickness, in either single or multiple layer configurations.

11.1.6.2 All products shall be tested without jacketing, with the exception of products where the jacket is an integral part necessary to hold the insulation together such as precision v-groove. The test pipe shall be at the Type I, Type II, Type III, or Type IV temperature specified in 4.1, when the insulation is applied. For Class B material any special requirement for heat-up shall be specified by the manufacturer shall be used.

11.1.6.3 Immediately upon application to the pipe, the internal temperature rise shall be measured as prescribed in the Hot Surface Performance section of Standard Practice C 447.

11.1.7 *Sag Resistance*:

11.1.7.1 *Scope*—This procedure is used to determine thickness loss as a result of exposure to maximum service during the hot surface performance test.

11.1.7.2 *Significance and Use*—Products having excessive thickness loss at elevated temperature could yield less than expected in-service performance.

11.1.7.3 *Definition*—Sag is defined as the extent of thickness loss due to material fatigue or decomposition due to elevated temperature.

11.1.7.4 *Procedure*—For the sag determination, measure the thickness of the test length before and after 96-h hot surface exposure. A pin gage suitable for this is described by Test Methods C 167. The measurement shall be taken at the top longitudinal center of the horizontally mounted test specimen. The pin gage shall be vertically inserted through the insulation to obtain tip contact with the hot pipe surface. The pin gage shall be read with a steel rule to the nearest 1/32-in. (1 mm). Calculate the thickness sag as follows:

$$\% \text{ change} = ((t1 - t2)/t1) \times 100 \quad (1)$$

where:

$t1$ = starting thickness, and
$t2$ = thickness after 96 h.

11.1.7.5 *Precision and Bias*—See Method C 167, "Standard Test Methods for Thickness and Density of Blanket or Batt Thermal Insulations".

11.1.8 *Non-fibrous Content (Shot)*—For rock or slag based products non-fibrous content shall be determined in accordance with Test Method C 1335.

11.1.9 *Stress Corrosion Performance*—Compliance with Specification C 795 is necessary only when requested to assess corrosivity when the insulation is applied to austenitic stainless steel pipe.

12. Qualification Requirements

12.1 The following requirements shall be employed for the purpose of product qualification:

12.1.1 Density and dimensions,
12.1.2 Linear shrinkage,
12.1.3 Apparent thermal conductivity,
12.1.4 Surface burning characteristics,
12.1.5 Hot surface performance,
12.1.6 Sag resistance,
12.1.7 Water vapor sorption, and
12.1.8 Non-fibrous content (shot).

13. Inspection

13.1 When agreed upon between the purchaser and manufacturer or supplier, the inspection of material shall be made at either the point of shipment or the point of delivery. The following requirements are generally employed for the purposes of acceptance and sampling of lots, on shipments of qualified insulation:

13.1.1 Dimensional tolerances, and Workmanship.

13.2 *Rejection*—Material that fails to conform to the requirements of this specification may be rejected. Rejection should be reported to the manufacturer or supplier promptly and in writing. The manufacturer and supplier have the right to verify rejected products.

14. Packaging and Package Marking

14.1 *Packaging*—Mineral fiber preformed pipe insulation shall be packaged in the manufacturer's standard commercial container unless otherwise agreed upon between the buyer, seller, and the manufacturer.

14.2 Unless otherwise specified, each container shall be marked with the manufacturer's lot or date code identification, and facing, if any, on the material in the container. When specified in the purchase order or contract, each container shall also be marked with the appropriate Specification C 547 type and maximum use temperature.

15. Keywords

15.1 mineral fiber thermal insulation; molded; physical properties; pipe insulation; precision v-groove; thermal properties

ANNEX

(Mandatory Information)

A1. MINERAL FIBER PIPE INSULATION COMPRESSION RESILIENCY FOR NAVSEA

A1.1 Scope

A1.1.1 In addition to the requirements of this standard, additional compression resiliency testing is required for Naval Sea System Command (NAVSEA) acceptance.

A1.2 Background

A1.2.1 NAVSEA engineers, builds and supports America's Fleet of ships and combat systems. This test is only required if NAVSEA acceptance is desired.

A1.3 Test Overview

A1.3.1 Three 12-in. segments of half-round 3 by 2 in. (80 by 50 mm) thick mineral fiber pipe insulation are measured for initial thickness, then compressed 10 times to a maximum load of 200 lbs., then re-measured for thickness recovery after compression.

A1.4 Apparatus

A1.4.1 Universal testing machine,

A1.4.2 Pin gauge as specified in Test Methods C 167,

A1.4.3 Steel rule graduated in 1⁄32 in. (1 mm),

A1.4.4 A 12 in. (305 mm) length of schedule 40, 3-in. (80 mm) nominal pipe size (NPS),

A1.4.5 A 12 in. (305 mm) length of channel or I-beam for supporting the 3-in. pipe,

A1.4.6 A sample of 3-in. x 2-in. (80 mm by 50 mm) thick mineral fiber pipe insulation, and

A1.4.7 A 12-in. (305 mm) saddle conforming to the outside diameter of the insulation.

A1.5 Sample Preparation

A1.5.1 Three 12-in. (305 mm) long, half-round segments of 3×2-in. (80 mm by 50 mm) mineral fiber pipe insulation are cut from a full-round section.

A1.6 Thickness Determination

A1.6.1 A half-round 12-in. (305 mm) length of 3 × 2-in. (80 by 50 mm) pipe insulation is placed on a 3-in. (80 mm) NPS pipe and measured for thickness using the pin gauge and steel rule. The measurements are in the center of the insulation length and 3-in. (75 mm) from each end. These values are recorded as the initial thickness. The measurement points are marked as the re-measurement points after compression. See Fig. A1.1.

A1.7 Compression Saddle

A1.7.1 The sheet metal comprising the radius of the saddle shall be 1⁄32 in. (13 gauge) (2 mm) or greater. See Fig. A1.2.

A1.7.2 An alternative to metal is to use a half round of 8-in. nominal (280 mm) Schedule 80 PVC piping which has an average inside diameter of 7.565 in. (192 mm).

A1.7.3 The wooden portion shall be mechanically fastened to the radial portion with wood screws.

A1.8 Compression Resiliency Test

A1.8.1 The half round insulation segment is placed in the half-round compression saddle designed to test pipe insulation (See Fig. A1.3). The saddle may be placed on top of the half round segment, or the segment may rest in the saddle (upside down from the figures provided). If the saddle is placed on top, and is not fixed to the crosshead of the testing machine, then its

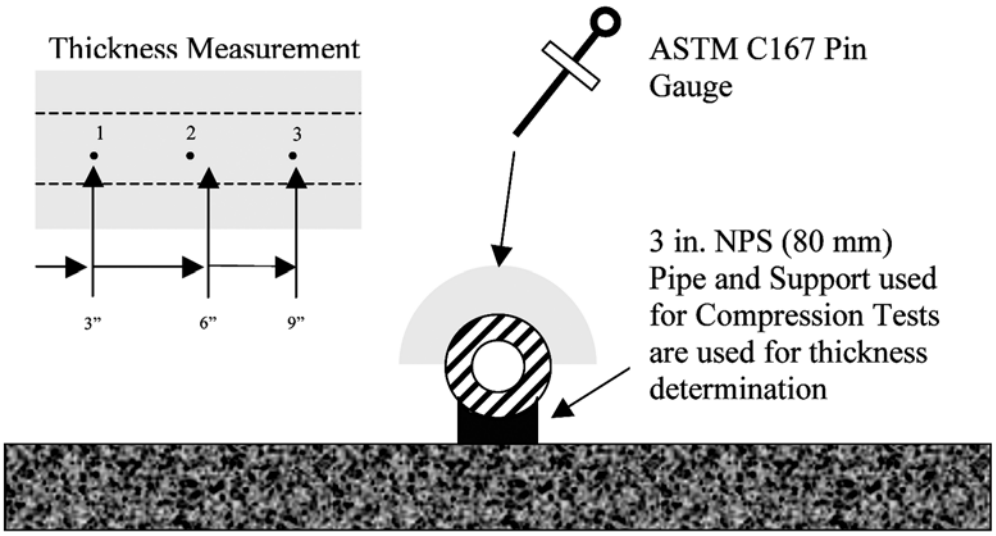

FIG. A1.1 Thickness Determination

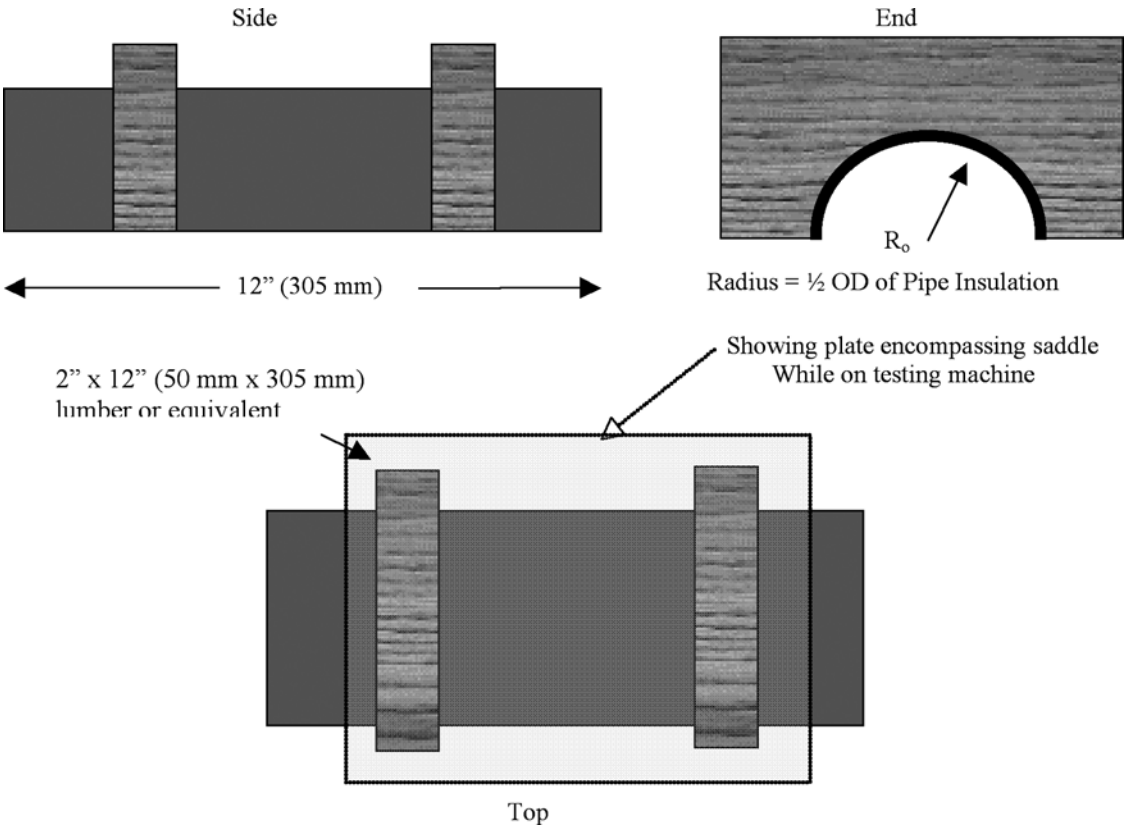

FIG. A1.2 Compression Saddle Configuration

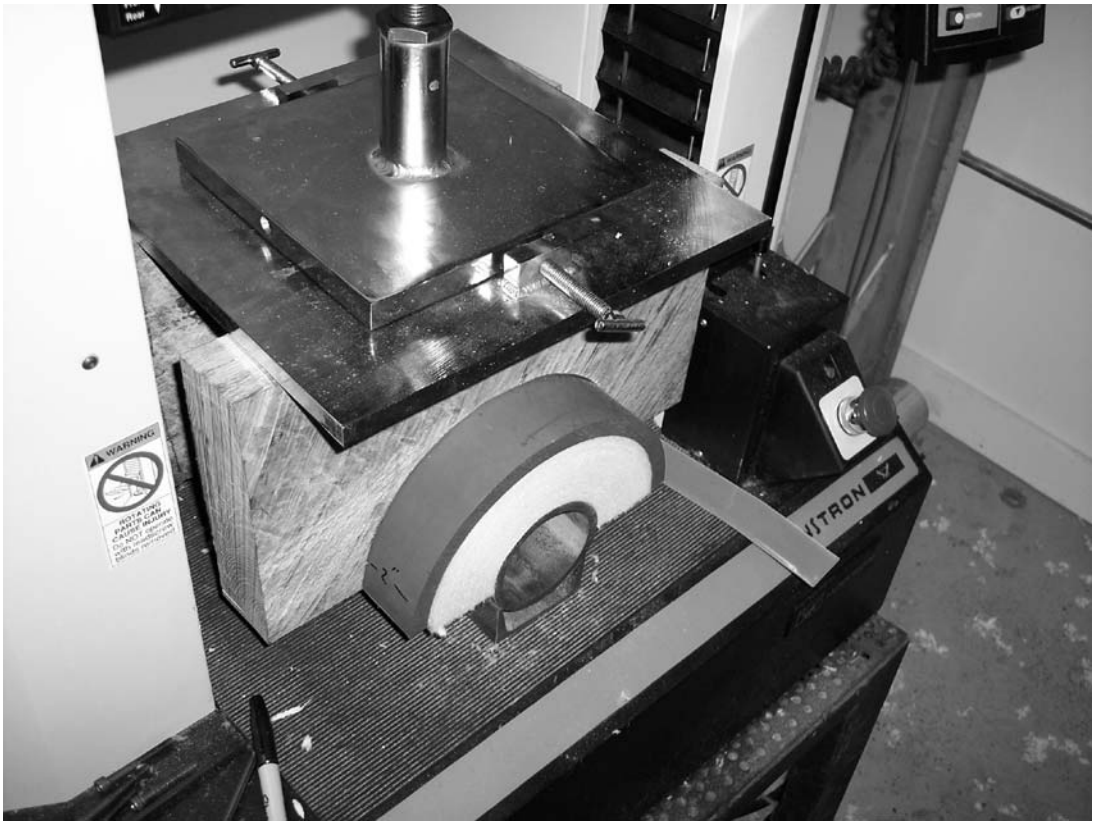

FIG. A1.3 Test Set-up for Compression Resiliency

mass shall be taken into account as part of the pounds force applied to the half round section. If the saddle is on the bottom, then the 3 in. (80 mm) NPS pipe shall be fixed to the cross-head of the universal testing machine. Hence there would be no apparatus mass to be accounted for.

A1.8.2 Using the universal testing machine, the half-round section shall be loaded to a force of 200 lbs. (90 kg) and released. This is repeated a total of ten times. The test speed shall be 0.5 in. (12 mm) per minute.

A1.8.3 The compressed sample is re-measured for thickness after 15 min rest after the last compression and recorded. (See Fig. A1.1),

A1.8.4 Three 12-in. (305 mm) long, half-sections shall be tested.

A1.9 Calculation

A1.9.1 The percent of thickness recovery after enduring ten loading of a force equal to 200 lbs. per lineal foot (90 kg per 0.305 m) is calculated as follows for the three tests:

$$\%\ Comp.\ Resiliency = \left(\frac{Average\ Recovered\ Thickness}{Average\ Initial\ Thickness}\right) x\ 100 \quad \text{(A1.1)}$$

A1.10 Requirement

A1.10.1 The average of three tests shall have a thickness recovery after compression of greater than or equal to 90 percent.

A1.11 Precision and Bias

A1.11.1 No precision or bias is presented for the C 547 Annex A1 Compression Resilience test since the test is a NAVSEA only requirement.