Designation: C534/C534M – 20a

Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form[1]

This standard is issued under the fixed designation C534/C534M; 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.

1. Scope

1.1 This specification covers preformed flexible elastomeric cellular-thermal insulation in sheet and tubular form. Grade 1 covers materials to be used on commercial or industrial systems with operating temperatures from –183 to 104°C [–297 to 220°F], Grade 2 covers material used on industrial systems with operating temperatures from –183 to 150°C [–297 to 300°F], and Grade 3 covers material used on industrial systems with operating temperatures from –183 to 120°C [–297 to 250°F] where halogens are not permitted.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.3 *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.*

1.4 *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 Documents

2.1 *ASTM Standards:*[2]

C168 Terminology Relating to Thermal Insulation

C177 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus

C390 Practice for Sampling and Acceptance of Thermal Insulation Lots

C335 Test Method for Steady-State Heat Transfer Properties of Pipe Insulation

C411 Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation

C447 Practice for Estimating the Maximum Use Temperature of Thermal Insulations

C518 Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus

C534 Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form

C585 Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing

C692 Test Method for Evaluating the Influence of Thermal Insulations on External Stress Corrosion Cracking Tendency of Austenitic Stainless Steel

C795 Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel

C871 Test Methods for Chemical Analysis of Thermal Insulation Materials for Leachable Chloride, Fluoride, Silicate, and Sodium Ions

C1045 Practice for Calculating Thermal Transmission Properties Under Steady-State Conditions

C1058 Practice for Selecting Temperatures for Evaluating and Reporting Thermal Properties of Thermal Insulation

C1114 Test Method for Steady-State Thermal Transmission Properties by Means of the Thin-Heater Apparatus

C1304 Test Method for Assessing the Odor Emission of Thermal Insulation Materials

C1427 Specification for Extruded Preformed Flexible Cellular Polyolefin Thermal Insulation in Sheet and Tubular Form

C1763 Test Method for Water Absorption by Immersion of Thermal Insulation Materials

D883 Terminology Relating to Plastics

D1622 Test Method for Apparent Density of Rigid Cellular Plastics

D1667 Specification for Flexible Cellular Materials—Poly (Vinyl Chloride) Foam (Closed-Cell)

[1] This specification is under the jurisdiction of ASTM Committee C16 on Thermal Insulation and is the direct responsibility of Subcommittee C16.22 on Organic and Nonhomogeneous 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.

E84 Test Method for Surface Burning Characteristics of Building Materials
E96/E96M Test Methods for Water Vapor Transmission of Materials
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E456 Terminology Relating to Quality and Statistics
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
E2231 Practice for Specimen Preparation and Mounting of Pipe and Duct Insulation Materials to Assess Surface Burning Characteristics

2.2 *Other Standards:*[3]
CAN/ULC-S102 Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies

3. Terminology

3.1 *Definitions*—Terms used in this specification are defined in Terminology C168 and in Terminology D883.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *cellular elastomeric foam*—a closed-cell foam made of natural or synthetic rubber, or a mixture of the two, and containing other polymers, other chemicals, or both, which is permitted to be modified by organic or inorganic additives. These foams have properties similar to those of vulcanized rubber, namely, (*1*) the ability to be converted from a thermoplastic to a thermosetting state by cross-linking (vulcanization) and (*2*) the ability to recover substantially its original shape when strained or elongated.

3.2.2 *flexible cellular*—a flexible cellular organic polymeric material shall not rupture within 60 s when a specimen 200 by 25 by 25 mm [8 by 1 by 1 in.] is bent around a 25-mm [1-in.] diameter mandrel at a uniform rate of one lap in 5 s in the form of a helix at a temperature between 18 and 29°C [65 and 85°F].

NOTE 1—The flexibility of these materials may decrease at lower temperatures.

4. Classification

4.1 When referencing Specification C534/C534M, type and grade shall always be specified.

4.2 The types are designated below:

4.2.1 *Type I*—Tubular.

Grade 1 Use temperature (minimum/maximum values) -183 to 104°C [-297 to 220°F].
Grade 2 Use temperature (minimum/maximum values) -183 to 150°C [-297 to 300°F].
Grade 3 Use temperature (minimum/maximum values) -183 to 120°C [-297 to 250°F].

4.2.2 *Type II*—Sheet.

Grade 1 Use temperature (minimum/maximum values) -183 to 104°C [-297 to 220°F].
Grade 2 Use temperature (minimum/maximum values) -183 to 150°C [-297 to 300°F].
Grade 3 Use temperature (minimum/maximum values) -183 to 120°C [-297 to 250°F].

4.3 Grade 1 is flexible elastomeric material for use on typical commercial systems.

4.4 Grade 2 is a high temperature flexible elastomeric material.

4.5 Grade 3 is an elastomeric material that does not contain any leachable chlorides, fluorides or polyvinyl chloride.

NOTE 2—Continuous long-term exposure at or above the upper use temperature may cause degradation in the form of loss of flexibility

5. Materials

5.1 These products shall be made of a homogeneous blend of natural or synthetic rubber that is permitted to be modified with various thermoplastic or thermosetting resins, plasticizers, modifiers, antioxidants, curatives, blowing agents and other additives. These products are thermoset and are not thermoplastic in nature.

5.2 These products are expanded with chemical blowing agents that decompose with the application of heat. The gases produced by these blowing agents are similar to those found in the atmosphere and thus the diffusion rate is not significant. These gases do not change over time and the thermal conductivity of the insulation is stable over time.

5.3 Flexible, elastomeric, cellular thermal insulations shall be of uniform core density and have closed cells. Even though these insulation materials are permitted to have a smooth skin surface on one or both sides, they are to be considered homogeneous for the purposes of determining thermal performance.

6. Physical Requirements

6.1 *Qualification Requirements*—Thermal conductivity, water vapor permeability and dimensional stability physical properties listed in Table 1, are defined as qualification requirements (refer to Practice C390, Section 5, Classification of Requirements and Section 6, Acceptance for Qualification Requirements).

6.2 *Inspection Requirements:*

6.2.1 The requirements for water absorption listed in Table 1 is defined as an inspection requirement (refer to Practice C390, Section 5, Classification of Requirements, and Section 7, Acceptance for Inspection Requirements).

6.2.2 All dimensional requirements shall be as described in Section 6 and Table 2.

6.2.3 All workmanship, finish and appearance requirements shall be as described in Section 9.

6.2.4 Compliance with inspection requirements shall be in accordance with Practice C390.

6.3 Both Type I and Type II insulations shall conform to the physical property requirements listed in Table 1.

6.4 The material shall be free of objectionable odors at all temperatures within the recommended use range when tested according to Test Method C1304.

6.5 *Surface Burning Characteristics*—The material shall be tested to assess its surface burning characteristics, at the thickness supplied, in accordance with Test Method E84 with

[3] Available from Underwriters Laboratories (UL), 2600 N.W. Lake Rd., Camas, WA 98607-8542, http://www.ul.com.

TABLE 1 Physical Requirements for Type I (Tubular) and Type II (Sheet)[A]

Property	Unit	Grade 1	Grade 2 (higher temperature)	Grade 3 (non-chloride/non-fluoride containing)
Apparent thermal conductivity, max., at a mean temperature of:	W/m·K [Btu·in./h·ft^2·°F]			
-150°C [-238°F]		0.023[0.16]	0.023 [0.16]	0.023 [0.16]
-100°C [-148°F]		0.028 [0.18]	0.028 [0.18]	0.028 [0.18]
-29°C [-20°F]		0.036 [0.25]	0.036 [0.25]	0.036 [0.25]
-18°C [0°F]		0.038 [0.26]	0.038 [0.26]	0.038 [0.26]
24°C [75°F]		0.040 [0.28]	0.043 [0.30]	0.040 [0.28]
50°C [120°F]		0.043 [0.30]	0.047 [0.32]	0.043 [0.30]
86°C [150°F]		0.045 [0.31]	0.049 [0.34]	0.045 [0.31]
150°C [300°F]		NA	0.061 [0.42]	NA
Water absorption, max.	% by volume	0.20	0.20	0.20
Water-vapor permeability, max.	g/Pa·s·m [perm-in.]	1.44×10^{-10} [0.10]	4.32×10^{-10} [0.30]	4.32×10^{-10} [0.30]
Linear shrinkage, max after soak at maximum use temperature	% linear change	7.0 %	7.0 %	7.0 %

[A] Table 1 describes two types of flexible elastomeric cellular thermal insulation. The values stated in Table 1 may not always be appropriate as design values. For specific design recommendations using a particular product and for supporting documentation, consult the manufacturer.

TABLE 2 Dimensional Tolerances, mm [in.]

	Tolerances
Type I—Tubular Material	
Inside diameter, mm [in.]:	
Up to 10 [⅜], incl.	+2.5 [3⁄32], -0
13 [½] to 22 [⅞], incl.	+3 [⅛], -0
25 [1] to 38 [1½], incl.	+5 [3⁄16], -0
41 [1-⅝] to 60 [2-⅜], incl.	+6 [¼], -0
Over 60 [2-⅜]	+10 [⅜], -0
Wall thicknesses, mm [in.]:	
Up to 19 [¾], incl.	+3 [⅛], -0
19 and over [¾]	+5 [3⁄16], -0
Length, mm [in.]	+75 [3], -25 [1]
Type II—Sheet Material	
Thickness, mm [in.]:	
Up to 13 [½], incl.	± 2 [± 1⁄16]
Over 13 [½]	± 3 [± 3⁄32]
Length and width, mm [in.]:	
Up to 150 [6], incl.	± 6 [± ¼]
Over 150 [6] to 300 [12], incl.	± 10 [± ⅜]
Over 300 [12]	± 3%

mounting according to Practice E2231. The results shall be reported. In Canada, use Test Method CAN/ULC-S102 and report the results.

6.5.1 This test method does not always define the hazard potentially presented by preformed flexible elastomeric cellular thermal insulation under actual fire conditions. It is retained for reference in this standard as test data are required by some codes.

6.5.2 Preformed flexible cellular elastomeric thermal insulation is an organic material and is combustible. Do not exposed it to flames or other ignition sources. In some applications, the fire test response characteristics of the material are addressed through requirements established by the appropriate governing documents.

6.6 *Leachable Chloride/Fluoride Content*—Grade 3 shall be below the detectable limit of the test procedure used for leachable chlorides or fluorides when tested according to Test Method C871.

7. Standard Shapes, Sizes and Dimensions

7.1 *Type I*—Tubular materials are manufactured in 1.83 m [72 in.] standard lengths, as well as in continuous lengths. Insulation is manufactured for diameters up to 200 mm [8 in. nominal pipe size (NPS)] with wall thickness up to 50 mm [2 in.].

7.2 *Type II*—Sheet material is manufactured in thicknesses up to 50 mm [2 in.]. Sheets are manufactured in sizes up to 1.22 m [48 in.] in width and in continuous lengths. Other sizes are available upon request. Individual dimensions shall conform to those specified by the manufacturer.

7.3 Actual dimensions shall be agreed upon between the manufacturer and the purchaser. The procedure section and the pipe and tubing diameter information of Practice C585 is beneficial in determining these actual dimensions.

7.4 The insulation tolerances shall conform to Table 2.

8. Surface

8.1 *Type I*—All surfaces (except ends and slits that are mechanically cut) shall have natural skins.

8.2 *Type II*—Sheet material is manufactured either with skin on one side or with skin on two sides. The surface shall be at the manufacturer's option, unless otherwise specified.

9. Workmanship, Finish, and Appearance

9.1 The insulation shall be free of visual defects that will adversely affect the service quality. For example, blisters, blow holes and tears when occurring to an excessive degree shall be judged to adversely affect the service quality of the material.

10. Sampling

10.1 The insulation shall be sampled in accordance with Practice C390. Details shall be agreed upon between the buyer and seller.

10.2 When possible, the insulation shall be tested in the form supplied. However, when Type I does not lend itself to testing or to making of test specimens because of its shape, standard test sheets shall be prepared from tubular material having equivalent physical characteristics to Type I (see 10.1 and 11.1.2).

11. Test Methods

11.1 *Test Conditions:*

11.1.1 The physical requirements enumerated in this specification shall be determined in accordance with the following test methods:

11.1.2 When standard test sheets are required for tubular material, they shall be prepared by longitudinally slitting the tubular specimens along one wall thickness, opening and laying the sample flat.

11.1.3 These products are produced with either skin on one side or skin on both sides. Testing shall be done in the final end use form.

11.2 *Apparent Thermal Conductivity:*

11.2.1 *Type I*—Choose from Test Methods C177, C518, C1114 or C335 in conjunction with Practice C1045. Use standard test sheet for C177, C518 or C1114.

NOTE 3—Test Method C335 may be used for below ambient conditions. The authors of this reference state, "the regression curves for sheet and pipe insulation agree with 1.5 and 2.5 % at mean temperatures of 25 and 10°C, respectively. The measured apparent thermal conductivites of both types of materials are well below the maxima allowed by C534.[4]

11.2.2 *Type II*—Choose from Test Methods C177, C518 or C1114 in conjunction with Practice C1045.

11.2.3 Tests shall be conducted with a temperature differential of 25 ± 5°C [50 ± 10°F] between the hot and cold plates of the testing apparatus in accordance with Table 3 of Practice C1058.

11.2.4 The mean apparent thermal conductivity for four samples of the material tested shall not be greater than the value stated in Table 1. The apparent thermal conductivity of an individual specimen shall not greater than 105 % of the value stated in Table 1.

11.3 *Water Vapor Permeability:*

11.3.1 *Type I and Type II*—Use standard test sheets for Type I. For Type II, use the desiccant method of Test Methods E96/E96M with the following conditions:

11.3.2 The desiccant method shall be performed at a 50 ± 5 % relative humidity at 23 ± 2°C [73 ± 4°F],

11.3.3 The preferred specimen thickness shall be 13 mm [½ in.] with skin on at least one side,

11.3.4 The specimen shall be tested so that the skin surface is toward the high humidity, and

11.3.5 All samples shall be run a minimum of three weeks (504 h) or longer to ensure that equilibrium conditions have been reached.

11.4 *Linear Shrinkage:*

11.4.1 *Scope*—This test method covers the evaluation of linear shrinkage of flexible cellular elastomeric thermal insulation.

11.4.2 *Significance and Use*—This test method provides a relatively simple and short-term evaluation of in-use performance with regard to linear shrinkage. This standard does not address ID or Wall dimensional changes.

11.4.3 Test at the upper temperature limit of the material as defined in the Scope and test at –101°C [–150°F].

11.4.4 *Apparatus:*

11.4.4.1 *Oven*—An air-circulating oven equipped with a temperature control to maintain a temperature of 175 ± 1.7°C [350 ± 3°F].

11.4.4.2 *Freezer*—An air-circulating freezer equipped with a temperature control to maintain a temperature of –101 ± 1.7°C [–150 ± 3°F].

11.4.4.3 *Steel Rule*—Graduated in millimeters [inches] capable of measuring to increments of 1.0 mm [0.05 in.]

11.4.5 *Test Specimens:*

11.4.5.1 *Type I*—Three 300 mm [12 in.] long specimens from each of the test samples.

11.4.5.2 *Type II*—Three specimens 300 by 75 mm [12 by 3 in.] cut from each of the test samples.

11.4.6 *Procedure:*

11.4.6.1 At each of two points 250 mm [10 in.] apart on the centerline of each specimen, place a benchmark.

11.4.6.2 Condition the specimen 24 h at a temperature of 23 ± 2°C [73.4 ± 3.6°F] and measure the distance between the Benchmarks to the nearest 1.0 mm [0.05 in.].

11.4.6.3 Place the specimens in the oven or freezer operating at the specified temperature. After 7 days remove the specimens from the oven, or freezer and condition for at least 2 h at 23°C ± 2°C [73.4°F ± 3.6°F] and re-measure.

11.4.7 *Report*—Report the average linear shrinkage of the three specimens from each lot as a change in length. Between the two benchmarks expressed as a percentage of the length measured originally.

11.4.8 *Precision and Bias Statement for Linear Shrinkage – Definitions and Additional Information:*

11.4.8.1 For precise definitions of statistical terms, refer to Terminology E456.

11.4.8.2 For more information on calculation methods relating to the use of statistical procedures, refer to Practices E177 and E691.

11.4.8.3 Standard C534 and Standard C1427 have identical linear shrinkage tests. This study included the three material types called out in standard C534 and the one type called out in standard C1427. Samples consisted of 7 different specimens (varying by size and manufacturer) for each of the 4 types called out. The specimens were tested according to their classified grade maximum temperature use. The testing was conducted at 6 laboratories. The results from all samples were used to develop the repeatability and reproducibility values. This was a very broad study considering the range of specimens used. It was felt that the data could be improved by working with the laboratories in their test procedures and data reporting.[5]

11.4.8.4 *Repeatability Statement*—The repeatability standard deviation has been determined to be 0.41 with a mean value of 4.23 %. for all materials tested. This corresponds to a 95 % repeatability value of ±26.9 %.

11.4.8.5 *Reproducibility Statement*—The reproducibility standard deviation has been determined to be 0.79 with a mean

[4] Wiles, K.E., Desjarlais, A.O., Stovall, T.K., McElroy, D.L., Childes, K.W., and Miller, W.A., "A Pipe Insulation Test Apparatus for Use Below Room Temperature," *Insulation Materials: Testing and Applications, 4th Volume, ASTM STP 1426* , A.O. Desjarlias and R.R. Zarr, Eds. ASTM International, West Conshohocken, PA, 2002.

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C16-1029.