INTERNATIONAL

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Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation[1]

This standard is issued under the fixed designation C591; 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.

1. Scope

1.1 This specification covers the types, physical properties, and dimensions of unfaced, preformed rigid cellular polyisocyanurate plastic material intended for use as thermal insulation on surfaces from ~~–297°F (–183°C)~~-297°F (-183°C) to 300°F ~~(150°C).~~(149°C). For specific applications, the actual temperature limits shall be agreed upon by the manufacturer and purchaser.

1.2 This specification only covers "polyurethane modified polyisocyanurate" thermal insulation which is commonly referred to as "polyisocyanurate" thermal insulation. This standard does not encompass all polyurethane modified materials. Polyurethane modified polyisocyanurate and other polyurethane materials are similar, but the materials will perform differently under some service conditions.

1.3 This standard is designed as a material specification, not a design document. Physical property requirements vary by application and temperature. At temperatures below -70°F (-51°C) the physical properties of the polyisocyanurate insulation at the service temperature are of particular importance. Below -70°F (-51°C) the manufacturer and the purchaser must agree on what additional cold temperature performance properties are required to determine if the material can function adequately for the particular application.

1.4 The tables~~s~~ in the Annex A1 addresses requirements of unfaced preformed rigid cellular polyisocyanurate thermal insulation manufactured with HCFC blowing agent.

1.5 When adopted by an authority having jurisdiction, codes that address fire properties in many applications regulate the use of the thermal insulation materials covered by this specification. Fire properties are controlled by job, project, or other specifications where codes or government regulations do not apply.

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

1.7 *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]

C165 Test Method for Measuring Compressive Properties of Thermal Insulations
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
C272 Test Method for Water Absorption of Core Materials for Structural Sandwich Constructions
C303 Test Method for Dimensions and Density of Preformed Block and BoardType Thermal Insulation
C335 Test Method for Steady-State Heat Transfer Properties of Pipe Insulation
C390 Practice for Sampling and Acceptance of Thermal Insulation Lots
C411 Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation
C518 Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
C550 Test Method for Measuring Trueness and Squareness of Rigid Block and Board Thermal Insulation

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[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.

C585 Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing
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
C1303 Test Method for Predicting Long-Term Thermal Resistance of Closed-Cell Foam Insulation
C1363 Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus
D883 Terminology Relating to Plastics
D1621 Test Method for Compressive Properties Of Rigid Cellular Plastics
D1622 Test Method for Apparent Density of Rigid Cellular Plastics
D1623 Test Method for Tensile and Tensile Adhesion Properties of Rigid Cellular Plastics
D2126 Test Method for Response of Rigid Cellular Plastics to Thermal and Humid Aging
D2856 Test Method for Open-Cell Content of Rigid Cellular Plastics by the Air Pycnometer
D6226 Test Method for Open Cell Content of Rigid Cellular Plastics
E84 Test Method for Surface Burning Characteristics of Building Materials
E96/E96M Test Methods for Water Vapor Transmission of Materials

3. Terminology

3.1 For descriptions of terms used in this specification, refer to Terminologies C168 and D883.

3.2 The term polyisocyanurate does not encompass all polyurethane containing materials (see 1.2).

3.3 The term "core specimen" refers to representative samples cut in accordance with the sampling procedure listed within each property test method.

4. Classification

4.1 Unfaced, preformed rigid cellular polyisocyanurate thermal insulation covered by this specification is classified into six types as follows:

4.1.1 *Type I*—Compressive resistance of 20 lb/in^2 (137 kPa), minimum.

4.1.2 *Type IV*—Compressive resistance of 22 lb/in^2 (150 kPa), minimum.

4.1.3 *Type II*—Compressive resistance of 35 lb/in^2 (240 kPa), minimum.

4.1.4 *Type III*—Compressive resistance of 45 lb/in^2 (310 kPa), minimum.

4.1.5 *Type V*—Compressive resistance of 80 lb/in^2 (550 kPa), minimum.

4.1.6 *Type VI*—Compressive resistance of 125 lb/in^2 (862 kPa), minimum.

~~4.2Unfaced, preformed rigid cellular polyisocyanurate thermal insulation covered by this specification is classified into two grades as follows:~~

~~4.2.1Grade 1–Service temperature range of -70°F (-51°C) and 300°F (150°C).~~

~~4.2.2Grade 2–Service temperature range of -297°F (-183°C) and 300°F (150°C).~~

4.2 Unfaced, preformed rigid cellular polyisocyanurate thermal insulation covered by this specification is classified into one grade as follows:

4.2.1 Grade 2–Service temperature range of -297°F (-183°C) to 300°F (149°C).

5. Ordering Information

5.1 Orders for materials purchased under this specification shall include the following:

5.1.1 Designation of this specification and year of issue,

5.1.2 Product name or grade/type, or both,

5.1.3 Apparent thermal conductivity and specific thickness required,

5.1.4 Product dimensions,

5.1.5 Quantity of material,

5.1.6 Special packaging or marking, if required, and

5.1.7 Special requirements for inspection or testing, or both.

6. Materials and Manufacture

6.1 Unfaced, preformed rigid cellular polyisocyanurate thermal insulation is produced by the polymerization of polymeric polyisocyanates in the presence of polyhydroxyl compounds, catalysts, cell stabilizers, and blowing agents.

6.2 The material covered by this specification shall be supplied in "bun" form or finished board stock or special shapes as agreed upon by the manufacturer and end-user.

7. Physical Properties

7.1 Unfaced, preformed rigid cellular polyisocyanurate thermal insulation shall conform to the requirements shown in Table 1~~or Table 2~~.

7.2 Polyisocyanurate thermal insulation is an organic material and is combustible. Do not expose this insulation to flames or other ignition sources. The fire performance of the material shall be addressed through fire test requirements established by the appropriate governing authority. The manufacturer shall be contacted for specific data as fire performance characteristic will vary with grade, type, and thickness.

7.3 Not all physical properties at temperature below -70°F (-51°C) have been fully tested. Where these properties are critical, the user shall consult the manufacturer for properties and performance at these lower temperatures.

TABLE ~~2~~ 1 Physical Property Requirements
Grade 2: Operating Temperature Range -297°F (-183°C) to 300°F (149°C)[A]

NOTE—Grade 1, which was specific to PIR for use at operating temperatures of -70°F (-51°C) to 300°F (149°C) , was deleted in 2009 because this material was no longer produced. Grade 2 was not renumbered to minimize conflict with various global engineering and end-user specifications which require the use of materials complying with, "ASTM C591, Grade 2".

Property	Type I	Type IV	Type II	Type III	Type V	Type VI
~~Density, min lb/ft^3(kg/m^3)~~		~~2.0 (32)~~	~~2.5 (40)~~	~~3.0 (48)~~	~~4.0 (60)~~	~~6.0 (96)~~
Density, min lb/ft^3(kg/m^3)	1.8 (29)	2.0 (32)	2.5 (40)	3.0 (48)	4.0 (60)	6.0 (96)
~~Compressive resistance at 10 % deformation or yield whichever occurs first, parallel to rise, min, lb/in^2(kPa)~~		~~22 (150)~~	~~30 (240)~~	~~45 (310)~~	~~80 (550)~~	~~125 (862)~~
Compressive resistance at 10 % deformation or yield whichever occurs first, parallel to rise, min, lb/in^2(kPa)	20 (137)	22 (150)	35 (240)	45 (310)	80 (550)	125 (862)
~~Apparent thermal conductivity, max Btu-in/h-ft^2°F (W/m-K), at a mean temperature of:~~						
Apparent thermal conductivity, max Btu-in/h-ft^2-°F (W/m-K), at a mean temperature of:						
~~-200°F (-129°C)~~	~~.13 (.019)~~	~~.13 (.019)~~		~~.14 (.020)~~	~~.14 (.020)~~	~~.15 (.022)~~
-200°F (-129°C)	.13 (.019)	.13 (.019)	.13 (.019)	.14 (.020)	.14 (.020)	.15 (.022)
~~-150°F (-101°C)~~	~~.15 (.022)~~	~~.15 (.022)~~		~~.16 (.023)~~	~~.16 (.023)~~	~~.17 (.025)~~
-150°F (-101°C)	.15 (.022)	.15 (.022)	.15 (.022)	.16 (.023)	.16 (.023)	.17 (.025)
~~-100°F (-73°C)~~		~~.17 (.025)~~	~~.17 (.025)~~	~~.18 (.026)~~	~~.18 (.026)~~	~~.19 (.027)~~
-100°F (-73°C)	.17 (.025)	.17 (.025)	.17 (.025)	.18 (.026)	.18 (.026)	.19 (.027)
~~-50°F (-46°C)~~		~~.19 (.027)~~	~~.19 (.027)~~	~~.20 (.029)~~	~~.20 (.029)~~	~~.21 (.030)~~
-50°F (-46°C)	.19 (.027)	.19 (.027)	.19 (.027)	.20 (.029)	.20 (.029)	.21 (.030)
~~0°F (-17°C)~~		~~.20 (.029)~~	~~.20 (.029)~~	~~.21 (.030)~~	~~.21 (.030)~~	~~.22 (.032)~~
0°F (-17°C)	.20 (.029)	.20 (.029)	.20 (.029)	.21 (.030)	.21 (.030)	.22 (.032)
~~50°F (10°C)~~		~~.19 (.027)~~	~~.19 (.027)~~	~~.20 (.029)~~	~~.20 (.029)~~	~~.21 (.030)~~
50°F (10°C)	.19 (.027)	.19 (.027)	.19 (.027)	.20 (.029)	.20 (.029)	.21 (.030)
~~75°F (24°C)~~		~~.20 (.029)~~	~~.20 (.029)~~	~~.21 (.030)~~	~~.21 (.030)~~	~~.22 (.032)~~
75°F (24°C)	.20 (.029)	.20 (.029)	.20 (.029)	.21 (.030)	.21 (.030)	.22 (.032)
~~150°F (66°C)~~		~~.24 (.035)~~	~~.24 (.035)~~	~~.25 (.036)~~	~~.25 (.036)~~	~~.26 (.037)~~
150°F (66°C)	.24 (.035)	.24 (.035)	.24 (.035)	.25 (.036)	.25 (.036)	.26 (.037)
~~200°F (93°C)~~		~~.27 (.039)~~	~~.27 (.039)~~	~~.28 (.040)~~	~~.28 (.040)~~	~~.30 (.044)~~
200°F (93°C)	.27 (.039)	.27 (.039)	.27 (.039)	.28 (.040)	.28 (.040)	.30 (.044)
~~Water absorption, max, % by volume~~		~~2.0~~	~~1.0~~	~~1.0~~	~~1.0~~	~~0.8~~
Water absorption, max, % by volume	2.0	2.0	1.0	1.0	1.0	0.8
~~Water vapor permeability, max, perm-in (ng/Pa-s-m)~~		~~4.0 (5.8)~~	~~3.5 (5.1)~~	~~3.0 (4.4)~~	~~2.5 (3.7)~~	~~2.0 (2.9)~~
Water vapor permeability, max, perm-in (ng/Pa-s-m)	4.0 (5.8)	4.0 (5.8)	3.5 (5.1)	3.0 (4.4)	2.5 (3.7)	2.0 (2.9)
Dimensional stability, max % linear change						
~~158 + 4°F (70 + 2°C), 97 + 3 % relative humidity~~		~~4~~	~~4~~	~~4~~	~~4~~	~~4~~
158 + 4°F (70 + 2°C), 97 + 3 % relative humidity	4	4	4	4	4	4
~~-40 + 6°F (-40+ 3°C), ambient relative humidity~~		~~1~~	~~1~~	~~1~~	~~1~~	~~1~~
-40 + 6°F (-40+ 3°C), ambient relative humidity	1	1	1	1	1	1
~~212 + 4°F (100 + 2°C), ambient relative humidity~~		~~2~~	~~2~~	~~2~~	~~2~~	~~2~~
212 + 4°F (100 + 2°C), ambient relative humidity	2	2	2	2	2	2
~~Closed cell content, min~~		~~90~~	~~90~~	~~90~~	~~90~~	~~90~~
Closed cell content, min	90	90	90	90	90	90
~~Hot-surface performance, at 300°F (149°C)[A]~~		~~Pass~~	~~Pass~~	~~Pass~~	~~Pass~~	~~Pass~~
Hot-surface performance, at 300°F (149°C)[B]	Pass	Pass	Pass	Pass	Pass	Pass

[A] ~~This specification does not purport to address all the performance issues associated with it's use. It is the responsibility of the user of this standard to establish~~ appropriate performance criteria.
[B] Pass/fail criteria found in 12.4.

8. Dimensions and Tolerances

8.1 The dimensions shall be as agreed upon by the purchaser and the supplier. Polyisocyanurate thermal insulation is commonly available in lengths up to 144 in. (3.66 ~~mm),~~m), widths up to 48 in. (1.22 m), and thicknesses from 0.5 in. (13 mm) to 24 in. (610 mm).

8.2 *Insulation Board*:

8.2.1 Dimensional tolerances for boards shall be as follows:

Dimension	Tolerance, in. (mm)
Length	±1⁄8 (3.2)
Width	±1⁄16 (1.6)
Thickness	±1⁄32 (0.8)

8.2.2 *Edge Trueness*—Determine in accordance with Test Method C550. The maximum deviation from the edge trueness shall not be greater than 1⁄32 in/ft (2.6 mm/m) of length or width.

8.2.3 *Face Trueness*—Determine in accordance with Test Method C550. The maximum deviation from flatness shall not be greater than 1⁄16 in/ft (5.2 mm/m) of length or width.

8.2.4 *Corner Squareness*—Determine in accordance with Test Method C550. The maximum deviation from corner squareness shall not be greater than 1⁄8 in. (3.2 mm) for all board thicknesses.

8.2.5 *Edge Squareness*—Determine in accordance with Test Method C550. The maximum deviation from edge squareness shall not be greater that 1⁄16 in. (1.6 mm) for all board thicknesses.

8.3 *Pipe Insulation*:

8.3.1 Material supplied for pipe insulation shall have dimensions and tolerances that are in accordance with Practice C585.

9. Workmanship and Appearances

9.1 The polyisocyanurate thermal insulation shall have no defects that will adversely affect its service qualities.

10. Sampling

10.1 Unless otherwise specified, the polyisocyanurate thermal insulation shall be sampled and inspected for acceptance of material in accordance with Practice C390.

10.2 *Inspection Requirements*:

10.2.1 The requirements for density shown in Table 1, the dimensional requirements described in Section 8, and the workmanship and appearance requirements described in Section 9 are defined as inspection requirements (refer to Practice C390).

10.3 *Qualification Requirements* :

10.3.1 The physical requirements shown in Table 1 ~~and Table 2~~ except density are defined as qualification requirements (refer to Practice C390). Density is defined as an inspection requirement.

11. Specimen Preparation

11.1 A period of at least 72 h shall elapse from the time of manufacture of the polyisocyanurate thermal insulation until cutting of any test specimens. The core test specimens shall be cut from the cores of the test samples as required for testing.

11.2 Unless otherwise specified, the test specimens shall be conditioned at 73 ± 4°F (23 ± 2°C) and 50 ± 5 % relative humidity for at least 12 h prior to testing.

12. Test Methods

12.1 *Density*—Determine in accordance with Test Method D1622 or C303.

12.2 *Compressive Resistance*—Determine in accordance with Test Method C165, Procedure A or Test Method D1621, Procedure A at a crosshead speed of 0.1 in/min (2.5 mm/min) for each 1 in. (25 mm) of specimen thickness. See Note 1.

NOTE 1—Polyisocyanurate insulation can be anisotropic and, therefore, strength properties can vary with direction. The manufacturer should be consulted if additional information is required.

12.3 *Apparent Thermal Conductivity* —Determine in accordance with either Test Methods C177, C518, C1114 or C1363 in accordance with Practice C1045 using the small temperature differences indicated in Practice C1058, Table 3. In some cases where this insulation is used in pipe applications, Test Method C335 is applicable. The core 1 in. (25mm) test specimens shall be conditioned at 73 ± 4°F (23 ± 2°C) and 50 ± 5% relative humidity for 180 ± 5 days from time of manufacture. In case of dispute, Test Method C177 shall be the referee method. The apparent thermal conductivity of the material tested shall not be greater than the maximum value identified in Table 1~~or Table 2~~. The apparent thermal conductivity of individual specimens tested shall not be greater than 110% of the maximum value identified in Table 1~~or Table 2~~. Compliance with qualification requirements shall be in accordance with Practice C390~~. For estimating long term changes in thermal resistance, Test Method~~ . It is possible that Test Method C1303 ~~may provide useful information. See~~ will provide useful information for estimating long term changes in thermal resistance. See Note 2.

NOTE 2—The core thickness has an impact on measured thermal resistance, as thickness increases the thermal resistance increases, as thickness decreases the thermal resistance decreases. The thermal resistance of polyisocyanurate thermal insulation may be significantly influenced by installation