Designation: C 591 – 00~~0~~1

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

This standard is issued under the fixed designation C 591; 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 − 29~~7~~0°F (−5~~1~~83°C) to 300°F (150°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. ~~Consult~~ At temperatures below - 70°F (- 51°C) the ~~manufacturer for specific recommendations and~~ physical properties ~~regarding applications, which include cryogenic service.~~ 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, may be required to determine if the material can function adequately for the particular application.

1.4 The use of thermal insulation material covered by this specification may be regulated by building codes that address fire performance.

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

~~1.6 Polyisocyanurate thermal insulation should be kept dry during storage, shipping, installation, start-up, and operation.~~

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1.6 *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:*

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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 Inorganic and Nonhomogeneous Inorganic Thermal Insulation.

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C 165 Test Method for Measuring Compressive Properties of Thermal Insulations[2]
C 168 Terminology Relating to Thermal Insulating Materials[2]
C 177 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus[2]
C 203 Test Method for Breaking Load and Flexural Properties of Block-Type Thermal Insulation[2]
C 236 Test Method for Steady-State Thermal Performance of Building Assemblies by Means of a Guarded Hot Box[2]
C 272 Test Method for Water Absorption of Core Materials for Structural Sandwich Constructions[2]
C 303 Test Method for Density of Preformed Block-Type Thermal Insulation[2]
C 335 Test Method for Steady-State Heat Transfer Properties of Horizontal Pipe[2]
C 390 Criteria for Sampling and Acceptance of Preformed Thermal Insulation Lots[2]
C 411 Test Method for Hot Surface Performance of High Temperature Thermal Insulation[2]
C 518 Test Method for the Steady State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus[2]
C 550 Practice for Measuring Trueness and Squareness of Rigid Block and Board Thermal Insulation[2]
C 585 Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System)[2]
C $\underline{871}$ Test Methods for Chemical Analysis of Thermal Insulation Materials for Leachable Chloride, Fluoride, Silicate, and Sodium Ions[2]
C $\underline{976}$ Test Method for Thermal Performance of Building Assemblies by Means of a Calibrated Hot Box[2]
C 1045 Practice for Calculating Thermal Transmission Properties from Steady-State Heat Flux Measurements[2]
C 1058 Practice for Selecting Temperatures for Evaluation and Reporting Thermal Properties of Thermal Insulation[2]
C 1114 Test Method for Steady-State Thermal Transmission Properties by Means of the Thin-Heater Apparatus[2]
C 1303 Test Method for Estimating the Long-Term Change in the Thermal Resistance of Unfaced Rigid Closed Cell Plastic Foams by Slicing and Sealing Under Controlled Laboratory Conditions[3]
D 883 Terminology Relating to Plastics[4]
D 1621 Test Method for Compressive Properties of Rigid Cellular Plastics[4]
D 1622 Test Method for Apparent Density of Rigid Cellular Plastics[4]
D $\underline{1623}$ Test Method for Tensile and Tensile Adhesion Properties of Rigid Cellular Plastics[4]
D $\underline{2126}$ Test Method for Response of Rigid Cellular Plastics to Humid Aging[4]
D 2856 Test Method for Open Cell Content of Rigid Cellular Plastics by the Air Pycnometer[5]
E 84 Test Method for Surface Burning Characteristics of Building Materials[6]
E 96 Test Methods for Water Vapor Transmission of Materials[2]

3. Terminology

3.1 For descriptions of terms used in this specification, refer to Terminologies C 168 and D 883.

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 16 lb/in^2 (110 kPa), minimum.
4.1.2 *Type IV*—Compressive resistance of 21 lb/in^2 (145 kPa), minimum.
4.1.3 *Type II*—Compressive resistance of 36 lb/in^2 (250 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 70 lb/in^2 (483 kPa), minimum.
4.1.6 *Type VI*—Compressive resistance of 125 lb/in^2 (862 kPa), minimum.

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

4.2.1 Grade 1–Service temperature range of - 70°F (- 51°C) and 300°F (150°C).
4.2.2 Grade 2–Service temperature range of - 297°F (- 183°C) and 300°F (150°C).

5. Ordering Information

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

[2] *Annual Book of ASTM Standards*, Vol 04.06.
[3] *Annual Book of ASTM Standards*, Vol 15.03.
[4] *Annual Book of ASTM Standards*, Vol 08.01.
[5] *Annual Book of ASTM Standards*, Vol 08.02.
[6] *Annual Book of ASTM Standards*, Vol 04.07.

TABLE 1 Physical Property Requirements[A]
Grade 1: Operating Temperature Range -70°F (-51°C) to 300°F (149°C)

Property	Type I	Type IV	Type II	Type III	Type V	Type VI
~~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)~~
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)	16 (110)	21 (145)	35 (240)	45 (310)	70 (483)	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:						
-100°F (-73°C)	.17 (.025)	.17 (.025)	.17 (.025)	.18 (.026)	.18 (.026)	.19 (.027)
-50°F (-46°C)	.19 (.027)	.19 (.027)	.19 (.027)	.20 (.029)	.20 (.029)	.21 (.030)
0°F (-17°C)	.18 (.026)	.18 (.026)	.18 (.026)	.19 (.027)	.19 (.027)	.20 (.029)
50°F (10°C)	.17 (.025)	.17 (.025)	.17 (.025)	.18 (.026)	.18 (.026)	.19 (.027)
75°F (24°C)	.18 (.026)	.18 (.026)	.18 (.026)	.19 (.027)	.19 (.027)	.20 (.029)
150°F (86°C)	.22 (.032)	.22 (.032)	.22 (.032)	.23 (.033)	.23 (.033)	.24 (.035)
200°F (93°C)	.24 (.035)	.24 (.035)	.24 (.035)	.26 (.037)	.26 (.037)	.28 (.040)
Water absorption, max, % by volume	0.5	0.5	0.7	0.8	0.8	0.8
~~Water vapor permeability, max, perm-in~~	~~4.0 (5.8)~~	~~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	4
−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	2
Closed cell content, min	90	90	90	90	90	90
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 defined in 12.4.

5.1.1 Designation of this specification and year of issue,
5.1.2 Product name or 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 may be supplied in "bun" form or finished board stock or special shapes.

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. It should not be exposed to flames or other ignition sources. The fire performance of the material should be addressed through fire test requirements established by the appropriate governing authority. The manufacturer should 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, and the user should consult the manufacturer for properties and performance at these lower temperatures.

8. Dimensions and Tolerances

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

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

Property	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)
Compressive resistance at 10 % deformation or yield whichever occurs first, parallel to rise, min, lb/in^2(kPa)	21 (145)	35 (240)	45 (310)	70 (483)	125 (862)
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)
-150°F (-101°C)	.15 (.022)	.15 (.022)	.16 (.023)	.16 (.023)	.17 (.025)
-100°F (-73°C)	.17 (.025)	.17 (.025)	.18 (.026)	.18 (.026)	.19 (.027)
-50°F (-46°C)	.19 (.027)	.19 (.027)	.20 (.029)	.20 (.029)	.21 (.030)
0°F (-17°C)	.18 (.026)	.18 (.026)	.19 (.027)	.19 (.027)	.20 (.029)
50°F (10°C)	.17 (.025)	.17 (.025)	.18 (.026)	.18 (.026)	.19 (.027)
75°F (24°C)	.18 (.026)	.18 (.026)	.19 (.027)	.19 (.027)	.20 (.029)
150°F (86°C)	.22 (.032)	.22 (.032)	.23 (.033)	.23 (.033)	.24 (.035)
200°F (93°C)	.24 (.035)	.24 (.035)	.26 (.037)	.26 (.037)	.28 (.040)
Water absorption, max, % by volume	0.5	0.7	0.8	0.8	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)
Dimensional stability, max % linear change					
158 + 4°F (70 + 2°C), 97 + 3 % relative humidity	4	4	4	4	4
−40 + 6°F (−40+ 3°C), ambient relative humidity	1	1	1	1	1
212 + 4°F (100 + 2°C), ambient relative humidity	2	2	2	2	2
Closed cell content, min	90	90	90	90	90
Hot-surface performance, at 300°F (149°C)[A]	Pass	Pass	Pass	Pass	Pass

[A] Pass/fail criteria found in 12.4.

8.2 *Insulation Board*:

8.2.1 Dimensional tolerances for boards shall be as follows:

Dimension	Tolerance, in. (mm)
Length	±⅛ (3.2)
Width	±1⁄16 (1.6)
Thickness	±1⁄32 (0.8)

8.2.2 *Edge Trueness*—Determine in accordance with Test Method C 550. 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 C 550. 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 C 550. The maximum deviation from corner squareness shall not be greater than ⅛ in. (3.2 mm) for all board thicknesses.

8.2.5 *Edge Squareness*—Determine in accordance with Test Method C 550. 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 C 585.

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 Criteria C 390.

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 Criteria C 390).

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 Criteria C 390). 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 D 1622 or C 303.

12.2 *Compressive Resistance*—Determine in accordance with Test Method C 165, Procedure A or Test Method D 1621, Procedure A at a crosshead speed of 0.1 in/min (2.5 mm/min) for each 1 in. (25 mm) of specimen thickness.

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 C 177, C 236, C 518, C 976, or C 1114 in accordance with Practice C 1045 using the small temperature differences indicated in Practice C 1058, Table 3. Test Method C 335 may also be applicable to insulation used in pipe applications. 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 C 177 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 Criteria C 390. For estimating long term changes in thermal resistance, Test Method C 1303 may provide useful information.

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 and service related variables such as age, encapsulation within gas-barrier materials, environmental conditions, and mechanical abuse and may be reduced from measured values after exposure to conditions of use. For specific design recommendations using a particular product, consult the manufacturer.

12.4 *Hot-Surface Performance*—Determine in accordance with Test Method C 411. Pass criteria defined as no warpage, cracking, flaming, glowing, smoldering, and smoking when tested with a white background.

12.5 *Water Absorption*— Determine in accordance with Test Method C 272, Procedure A.

12.6 *Water Vapor Permeability*—Determine in accordance with Test Methods E 96 using the desiccant procedure at 73 ± 2°F (23 ± 1°C).

NOTE 3—The application of a vapor retarder may be required in conjunction with the application of this insulation.

12.7 *Dimensional Stability*—Determine in accordance with Test Method D 2126.

12.8 *Closed-Cell Content*—Determine in accordance with Test Method D 2856.

12.9 *Surface Burning Characteristics*— Determine, if required, in accordance with Test Method E 84 at the thickness supplied and results are to be reported.

12.10 *Tensile Strength*— Determine in accordance with Test Method D 1623.

12.11 *Leachable Chloride, Fluoride, Silicate, and Sodium Ions*— Determine in accordance with Test Method C 871.

NOTE 4—It is the responsibility of the user of this standard to determine the technical requirements for their specific applications and to select an appropriate grade and type of material.

13. Inspection

13.1 Inspection of this material shall be agreed upon by the purchaser and the supplier as part of the purchase agreement.

14. Rejection and Rehearing

14.1 Material that fails to conform to the requirements of this specification may be rejected. Rejection shall be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with the results of the tests, the producer or supplier may request a rehearing. Retesting may be necessary.

14.2 At the agreement of the buyer and seller, the seller shall have the right to reinspect a rejected shipment and resubmit same after removal of the nonconforming portion.

15. Packaging and Marking

15.1 Unless otherwise agreed upon between the purchaser and the supplier, materials under this specification shall be packaged by the manufacturer's standard commercial practice.

15.2 Unless otherwise specified, shipping containers shall be marked with the name and designation of the manufacturer, grade , type, lot number, size thickness, product apparent thermal conductivity, and quantity of material in the container.

16. Supplementary Requirements

16.1 Polyisocyanurate thermal insulation should keep dry during storage, shipping and installation.

16.2 Unless otherwise specified, shipping containers shall be marked with the name and designation of the manufacturer, grade, type, lot number, size thickness, product apparent thermal conductivity, and quantity of material in the container.

17. Keywords

167.1 cellular plastic; polyisocyanurate; polyurethane modified polyisocyanurate; thermal insulation

APPENDIX

(Nonmandatory Information)

X1. END-USE CONSIDERATION

X1.1 *Extended Service Temperature Range:*

X1.1.1 Polyisocyanurate thermal insulation may be used on surfaces operating between -70°F (–51°C) and –290°F (–161°C). Additional test data such as tensile strength, compressive resistance, and dimensional stability may be helpful in determining the end use suitability. Consult the manufacturer for specific recommendations and properties.