Designation: C591 – 16

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 U.S. 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) to 300°F (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 This standard addresses requirements of unfaced preformed rigid cellular polyisocyanurate thermal insulation manufactured using blowing agents with an ozone depletion potential of 0 (ODP 0).

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/C272M Test Method for Water Absorption of Core Materials for Sandwich Constructions
C303 Test Method for Dimensions and Density of Preformed Block and Board–Type Thermal Insulation
C335/C335M 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
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

[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.

C1045 Practice for Calculating Thermal Transmission Properties Under Steady-State Conditions
C1058/C1058M 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/C1303M 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/D1622M Test Method for Apparent Density 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 (Withdrawn 2006)[3]
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.

3.4 *Definitions of Terms Specific to This Standard:*

3.4.1 *aged, v—in relation to thermal conductivity testing*, the act of delaying thermal conductivity testing for a specified time period after the final polymerization.

3.4.1.1 *Discussion*—Unfaced preformed rigid cellular polyisocyanurate thermal insulation samples are aged because the thermal conductivity of this material increases with time, primarily due to changes in the composition of the gas contained within the closed cells. The rate of this thermal conductivity increase diminishes with time so an aging time prior to testing is selected to reasonably represent the long-term performance of the material. The aging time for thermal conductivity test specimens of material covered by this standard is typically 180 days.

3.4.2 *conditioned, v*—the act of putting specimens in specified temperature and humidity conditions immediately prior to testing to allow the specimens to reach temperature and moisture content equilibrium.

3.4.2.1 *Discussion*—Samples are conditioned for a fairly short time period (typically 12 to 24 h) during which the test lab holds the sample at standard lab conditions (see 11.2) immediately prior to testing. If specimens are aged (see 3.4.1) for thermal conductivity testing at the same conditions specified for conditioning and kept at these conditions until the time of testing, then a separate conditioning period at the end of the aging period is not necessary.

3.4.3 *final polymerization, n*—the final chemical reaction and cooling that occurs immediately following primary manufacturing of unfaced preformed rigid cellular polyisocyanurate thermal insulation materials created using a simultaneous blowing and exothermic polymerization process.

3.4.3.1 *Discussion*—Unfaced preformed rigid cellular polyisocyanurate thermal insulation materials created using a simultaneous blowing and exothermic polymerization process are formed into a shape such as a bun during manufacture. This shape reaches its final form and size during primary manufacturing and is at a temperature substantially above ambient. This shape continues to undergo final polymerization and cooling for a time period ranging from a few hours to several days. This period of final polymerization and cooling is part of the manufacturing process and samples are not taken for testing or quality control until the end of this period is reached.

3.4.4 *ozone depletion potential (ODP), n*—a relative index indicating the extent to which a chemical product causes ozone depletion.

3.4.4.1 *Discussion*—The reference level of 1 is the potential of trichlorofluoromethane (R-11 or CFC-11) to cause ozone depletion. ODP 0 is an ozone depletion potential of zero.

3.4.5 *primary manufacturing, n*—the initial manufacturing step of unfaced preformed rigid cellular polyisocyanurate thermal insulation materials that begins with the mixing of the precursor chemicals and ends with the formation of the final bun shape.

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.

4.2 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).

[3] The last approved version of this historical standard is referenced on www.astm.org.

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, 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. See Note 1. For each physical property requirement, the average from testing the number of test specimen(s) required by 11.3 of this specification shall be used to determine compliance.

NOTE 1—It is the responsibility of the user of this standard to determine the technical requirements for their specific applications and to select an appropriate Type of material.

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 temperatures 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.

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 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:*

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

NOTE 1—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})	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)	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:						
-200°F (-129°C)	.13 (.019)	.13 (.019)	.13 (.019)	.14 (.020)	.14 (.020)	.15 (.022)
-150°F (-101°C)	.15 (.022)	.15 (.022)	.15 (.022)	.16 (.023)	.16 (.023)	.17 (.025)
-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)	.19 (.027)	.19 (.027)	.19 (.027)	.20 (.029)	.20 (.029)	.22 (.032)
50°F (10°C)	.18 (.026)	.18 (.026)	.18 (.026)	.19 (.027)	.19 (.027)	.21 (.030)
75°F (24°C)	.19 (.027)	.19 (.027)	.19 (.027)	.20 (.029)	.20 (.029)	.22 (.032)
150°F (66°C)	.23 (.033)	.23 (.033)	.23 (.033)	.24 (.035)	.24 (.035)	.26 (.037)
200°F (93°C)	.26 (.037)	.26 (.037)	.26 (.037)	.27 (.039)	.27 (.039)	.30 (.044)
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)	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 its use. It is the responsibility of the user of this standard to establish appropriate performance criteria.
[B] Pass ⁄fail criteria found in 12.4.

8.2.1 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*—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*—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*—The physical requirements shown in Table 1 except density are defined as qualification requirements (refer to Practice C390). Density is defined as an inspection requirement.

11. Specimen Selection and Preparation

11.1 Prior to the cutting of any test specimens, a period of at least 72 h shall elapse from the end of primary manufacturing to allow for final polymerization (see 3.4.5 and 3.4.3). The test specimens shall be cut from the buns of material as required by Annex A1 for the reasons described in Appendix X1.

11.2 Unless otherwise specified, the test specimens shall be conditioned (see 3.4.2) at 73 ± 4°F (23 ± 2°C) and 50 ± 5 % relative humidity for at least 24 h prior to testing.

11.3 Number of specimens to test for each required property for continuous bunstock PIR (see A1.2):

11.3.1 *Density*—Test three specimens.

11.3.2 *Compressive Resistance*—Test six specimens.

11.3.3 *Apparent Thermal Conductivity*—Test three specimens at mean temperature of 75°F (24°C) and one specimen at the other mean temperatures listed in Table 1.

11.3.4 *Hot Surface Performance*—Test one specimen.

11.3.5 *Water Absorption*—Test three specimens as prescribed in Test Method C272/C272M.

11.3.6 *Water Vapor Permeability*—Test three specimens as prescribed in Test Method E96/E96M.

11.3.7 *Dimensional Stability*—Test three specimens.

11.3.8 *Closed Cell Content*—Test three specimens.

11.4 Number of specimens to test for each bun tested for each required property for box-pour bunstock PIR. Due to the possible variability from bun to bun within a batch of box-pour bunstock PIR, it is necessary to test three buns from a given batch (see A1.3):

11.4.1 *Density*—Test three specimens.

11.4.2 *Compressive Resistance*—Test six specimens.

11.4.3 *Apparent Thermal Conductivity*—Test three specimens at mean temperature of 75°F (24°C) and one specimen at the other mean temperatures listed in Table 1.

11.4.4 *Hot Surface Performance*—Test one specimen.

11.4.5 *Water Absorption*—Test three specimens as prescribed in Test Method C272/C272M.

11.4.6 *Water Vapor Permeability*—Test three specimens as prescribed in Test Method E96/E96M.

11.4.7 *Dimensional Stability*—Test three specimens.

11.4.8 *Closed Cell Content*—Test three specimens.

12. Test Methods

12.1 *Density*—Determine in accordance with Test Method D1622/D1622M or C303.

12.2 *Compressive Resistance*—Determine in accordance with Test Method C165, Procedure A or Test Method D1621, at a crosshead speed of 0.1 in/min (2.5 mm/min) for each 1 in. (25 mm) of specimen thickness. See Note 2.

NOTE 2—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 Test Method C177, C518, C1114 or C1363 in accordance with Practice C1045 using the small temperature differences indicated in Practice C1058/C1058M, Table 3. In some cases where this insulation is used in pipe applications, Test Method C335/C335M is applicable. Core 1 in. (25 mm) thick test specimens shall be cut from buns after the final polymerization (see 3.4.3 and 11.1) is complete, be aged (3.4.1) at 73 ± 4°F (23 ± 2°C) and 50 ± 5 % relative humidity for 180 ± 5 days from time of specimen cutting, be conditioned if necessary (see 3.4.2), and then tested following these aging (and conditioning if present) periods. 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. The apparent thermal conductivity of individual specimens tested shall not be greater than 110 % of the maximum value identified in Table 1. Compliance with qualification requirements shall be in accordance with Practice C390. It is possible that Test Method

C1303/C1303M will provide useful information for estimating long term changes in thermal resistance. See Note 3.

NOTE 3—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 C411. Pass criteria is defined as ≤ 0.25 in. (6 mm) warpage, and no cracking, flaming, glowing, smoldering, and smoking when tested with a white background. Discoloration of the sample during this test is not an indication of failure.

12.5 *Water Absorption*—Report in units of % by volume determined by multiplying the water absorption % by weight obtained by testing in accordance with Test Method C272/C272M, Procedure A, by the specimen specific gravity.

12.6 *Water Vapor Permeability*—Determine in accordance with Test Methods E96/E96M using the desiccant procedure at 73 ± 2°F (23 ± 1°C). See Note 4.

NOTE 4—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 D2126.

12.8 *Closed-Cell Content*—Determine in accordance with Test Method D2856 or D6226.

12.9 *Surface Burning Characteristics*—Determine, if required, in accordance with Test Method E84 at the thickness supplied and results are to be reported.

12.10 *Leachable Chloride, Fluoride, Silicate, and Sodium Ions*—Determine in accordance with Test Method C871.

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 Failure to conform to the requirements of this specification shall be cause for rejection. Rejection shall be reported to the producer or supplier promptly and in writing.

14.2 In the case of rejection of a shipment, the producer shall have the right to resubmit the lot for inspection after the removal and replacement of that portion not conforming to requirements.

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 or thickness, product apparent thermal conductivity, and quantity of material in the container.

16. Supplementary Requirements

16.1 Polyisocyanurate thermal insulation shall be kept dry during storage, shipping, and installation.

17. Keywords

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

ANNEX

(Mandatory Information)

A1. SPECIMEN SAMPLING LOCATION FOR PROPERTY TESTING

A1.1 Background

A1.1.1 This annex describes where in the polyisocyanurate (PIR) bun specimens shall be taken for all property testing required by this standard for both continuous bunstock and box-pour PIR.

A1.1.2 Because the manufacturing process and sampling requirements differ so greatly between continuous bunstock and box-pour processes, each will be treated separately in this annex.

A1.1.3 Because of the cost and effort needed for testing and because the impact of bun location on performance is small, it is not feasible or necessary to test every possible location within a bun. This annex provides a systematic means of sampling from PIR buns so that the performance of all of the major bun areas are examined and the average of this performance is compared to the requirements of this standard to determine compliance.

A1.1.4 Because the test methods for each required property differ in complexity and nature and because each property behaves differently in response to bun location, there is not one sampling protocol for all properties. Instead, each property has its own sampling protocol.

A1.1.5 In all cases, the test methods and number of specimens to be tested are shown in Sections 12 and 11, respectively.

A1.2 Continuous Bunstock PIR

A1.2.1 Refer to X1.2.1 for a definition of the various bun locations for obtaining specimens for property testing.

A1.2.2 For any property, the right and left locations are interchangeable provided this is done for all specimens prepared for that property. This is permissible because of X1.2.2.3 which explains why the left and right sides of the bun are equivalent.

A1.2.3 *Density*—Test one specimen from each of the left/top, left/bottom, and center/equator locations. These are locations 1, 5, and 7, respectively as shown in Fig. A1.1.

A1.2.4 *Compressive Resistance*—Test two specimens from each of the left/top, left/bottom, and center/equator locations. These are locations 1, 5, and 7, respectively as shown in Fig. A1.1.

A1.2.5 *Apparent Thermal Conductivity*—Test one specimen from each of the left/top, left/bottom, and center/equator locations at a mean temperature of 75°F (24°C). These are locations 1, 5, and 7, respectively, in Fig. A1.1. For the other mean temperatures listed in Table 1, test one specimen from the left/equator location. This is location 4 in Fig. A1.1.

A1.2.6 *Water Absorption*—Test one specimen from each of the left/top, left/bottom, and center/equator locations. These are locations 1, 5, and 7, respectively as shown in Fig. A1.1.

A1.2.7 *Water Vapor Permeability*—Test one specimen from each of the left/top, left/bottom, and center/equator locations. These are locations 1, 5, and 7, respectively as shown in Fig. A1.1.

A1.2.8 *Dimensional Stability*—Test one specimen from each of the left/top, left/bottom, and center/equator locations. These are locations 1, 5, and 7, respectively as shown in Fig. A1.1.

A1.2.9 *Closed Cell Content*—Test one specimen from each of the left/top, left/bottom, and center/equator locations. These are locations 1, 5, and 7, respectively as shown in Fig. A1.1.

A1.2.10 *Hot Surface Performance*—Test one specimen from the center/equator location. This is location 5 as shown in Fig. A1.1.

A1.3 Box-Pour Bunstock PIR

A1.3.1 Refer to X1.3.1 for a definition of the various bun locations for obtaining specimens for property testing.

A1.3.2 For any property, the right and left locations are interchangeable provided this is done for all specimens prepared for that property. This is permissible because of X1.3.2.4 which explains why the left and right sides of the bun are equivalent.

A1.3.3 For any property, the front and back locations are interchangeable provided this is done for all specimens prepared for that property. This is permissible because of X1.3.2.3 which explains why the front and back sides of the bun are equivalent.

A1.3.4 Since there is a reasonable likelihood of variability from bun to bun within a batch of boxpour bunstock PIR, it is necessary to test three buns from a given batch. These buns shall be selected from early, middle, and late in the bun preparation from a single batch of ingredients. The number of specimens listed in A1.3.5 – A1.3.11 is the number from a single bun. This same number of specimens must be tested from each of the three buns sampled.

A1.3.5 *Density*—Test one specimen from each of the left/top/front, left/bottom/front, and center/equator/middle locations. These are locations 1-Front, 7-Front, and 5-Middle, respectively, as shown in Fig. A1.2.

A1.3.6 *Compressive Resistance*—Test two specimens from each of the left/top/front, left/bottom/front, and center/equator/middle locations. These are locations 1-Front, 7-Front, and 5-Middle, respectively, as shown in Fig. A1.2.

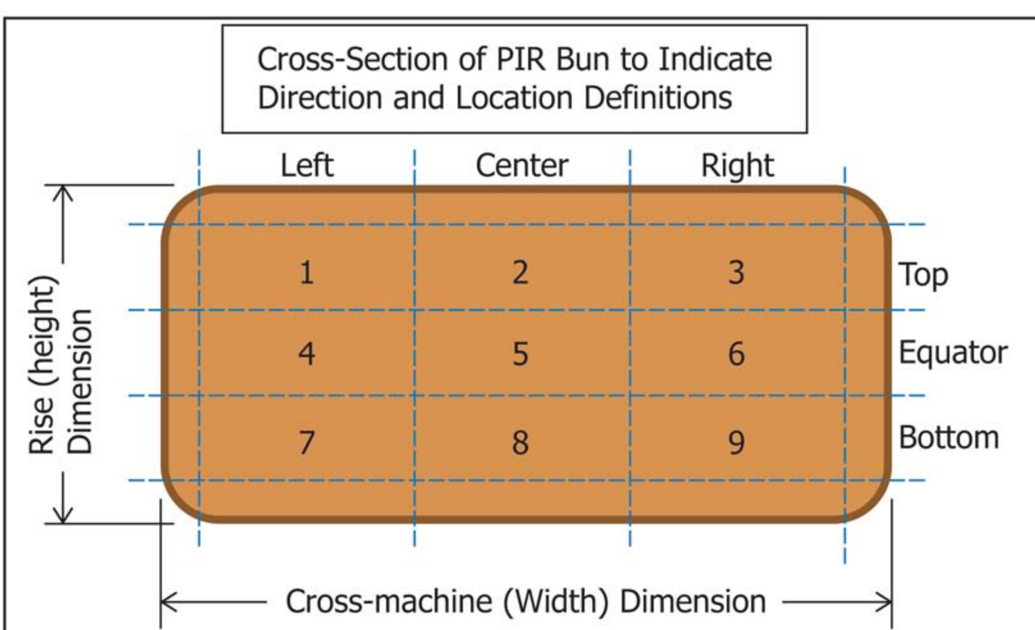

FIG. A1.1 Bun Position Definitions for Continuous Bunstock PIR

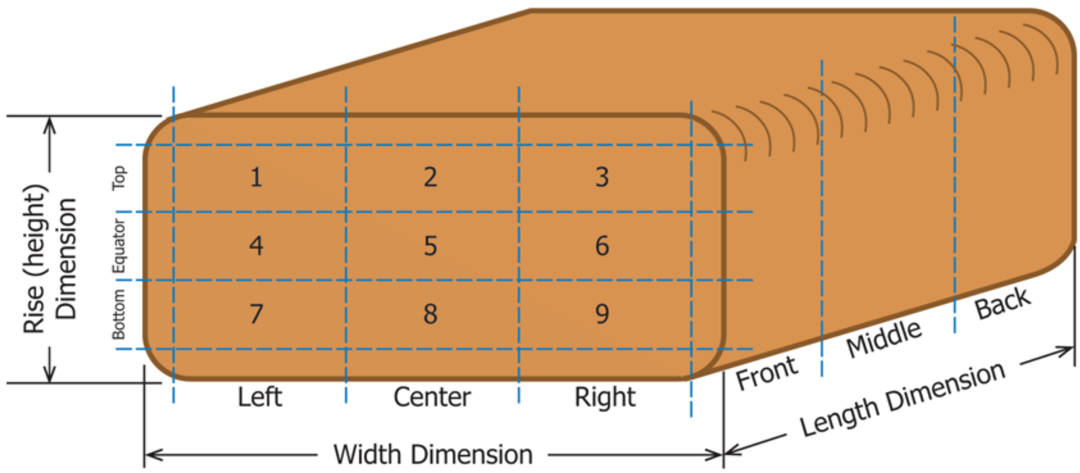

FIG. A1.2 Bun Position Definitions for Box-Pour PIR

A1.3.7 *Apparent Thermal Conductivity*—Test one specimen from each of the left/top/front, left/bottom/front, and center/equator/middle locations at a mean temperature of 75°F (24°C). These are locations 1-Front, 7-Front and 5-Middle, respectively, in Fig. A1.2. For the other mean temperatures listed in Table 1, test one specimen from the left/equator/middle location. This is location 4-Middle as shown in Fig. A1.2.

A1.3.8 *Water Absorption*—Test one specimen from each of the left/top/front, left/bottom/front, and center/equator/middle locations. These are locations 1-Front, 7-Front, and 5-Middle, respectively, as shown in Fig. A1.2.

A1.3.9 *Water Vapor Permeability*—Test one specimen from each of the left/top/front, left/bottom/front, and center/equator/middle locations. These are locations 1-Front, 7-Front, and 5-Middle, respectively, as shown in Fig. A1.2.

A1.3.10 *Dimensional Stability*—Test one specimen from each of the left/top/front, left/bottom/front, and center/equator/middle locations. These are locations 1-Front, 7-Front, and 5-Middle, respectively, as shown in Fig. A1.2.

A1.3.11 *Closed Cell Content*—Test one specimen from each of the left/top/front, left/bottom/front, and center/equator/middle. These are locations 1-Front, 7-Front, and 5-Middle, respectively, as shown in Fig. A1.2.

A1.3.12 *Hot Surface Performance*—Test one specimen from the center/equator/middle location. This is location 5-Middle as shown in Fig. A1.2.

APPENDIX

(Nonmandatory Information)

X1. DEFINITION OF BUN LOCATIONS AND RATIONALE FOR SELECTION OF SPECIMEN SAMPLING LOCATION FOR PROPERTY TESTING

X1.1 Background

X1.1.1 The material covered by this standard is produced in large buns using either a continuous bunstock or a box-pour bunstock process. For some properties, variability can exist based on location within the bun and from one box-pour bun to another. This appendix defines bun locations, describes some reasons why bun location influences properties, explains which bun locations have an influence on properties, and provides a rationale for why certain bun locations are selected for specimen sampling.

X1.1.2 Annex A1 uses the information in Appendix X1 to specify the sampling locations for the specimens used to determine compliance to the required properties in this standard.

X1.1.3 Because the manufacturing process and sampling requirements differ so greatly between continuous bunstock and box-pour processes, each will be treated separately in this appendix.

X1.2 Continuous Bunstock PIR

X1.2.1 *Definition of Bun Directions and Locations:*

X1.2.1.1 The PIR bun is produced in the shape of a continuous length rectangular prism with rounded corners and a high density skin on the sides, top, and bottom outer surfaces that is removed prior to final fabrication into desired shapes. The PIR buns are produced on a moving conveyer belt and each bun is cut to the desired length from the continuous length by a band saw. The three main orthogonal directions of the bun are called the conveyer (length), cross-machine (width), and rise (height). The typical sizes of PIR buns in each direction are listed in 8.1.

X1.2.1.2 For the purposes of defining specimen sampling locations, the following terminology is used.

(1) The conveyer (length) direction does not require any location terminology since the continuous bun-stock process is consistent enough that all length positions in a bun and all of the buns in a batch can be considered to have the same performance (see X1.2.2.2).

(2) The cross-machine (width) dimension of the bun is broken into three portions called left, center, and right. These will consist of roughly the left one-third, center one-third, and right one-third of the bun, respectively, in this dimension after removal of the outer skins.

(3) The rise (height) dimension of the bun is broken into three portions called bottom, equator, and top. These will consist of roughly the bottom one-third, equator one-third, and top one-third of the bun, respectively, in this dimension after removal of the outer skins.

(4) The above bun location terminology is illustrated in Fig. A1.1.

X1.2.2 *Influence of Bun Location on Properties:*

X1.2.2.1 The continuous bunstock PIR material covered by this standard is produced by pumping a pressurized pre-polymerized liquid onto a moving conveyer belt. This liquid simultaneously foams and polymerizes in an exothermic reaction. The combination of the geometry involved, the simultaneous foaming and exothermic polymerization reaction, and the insulating ability of the PIR can lead to differences in properties based on bun location. While these differences are small and have minimal impact on product performance, they are real and measureable.

X1.2.2.2 Since the bun is made in a continuous process, the material being produced is not considered prime until the process is running consistently. The very initial and very last portions of a continuous run of material are not considered prime so there is no significant variability in the conveyer (length) direction of the bun.

X1.2.2.3 Since the liquid pre-polymer is not typically applied across the entire conveyer width, the foaming process moves somewhat outwards from the center of the conveyor towards the left and right edges. In some cases, this yields a difference in properties between the center and the left or right of the bun. The left and right sides will not be different from one another but in some cases both will be similarly different from the center.

X1.2.2.4 Since the liquid pre-polymer is simultaneously polymerizing and foaming, the product rises from a liquid layer that is about ½ in. (13 mm) thick to a final bun height of up to about 24 in. (610 mm). In some cases, this yields a difference in properties between the bottom, equator, and top of the bun.

X1.2.2.5 Because the polymerization process is exothermic and because the PIR material is a good insulator, the interior of the bun will reach a higher temperature and will remain hotter for a longer period of time than will the edges of the bun. In some cases, this yields a difference in properties between the interior portions of the bun and the portions of the PIR bun nearer the edges.

X1.3 Box-Pour Bunstock PIR

X1.3.1 *Definition of Bun Directions and Locations:*

X1.3.1.1 The PIR bun is produced in the shape of a rectangular prism with rounded corners and a high density skin on the outer surface that is removed prior to final fabrication into desired shapes. The PIR buns are produced individually so, in addition to possible variability that may occur in the three orthogonal directions of an individual bun, there is also potential variability between buns. The three main orthogonal directions of a bun are called the length, width, and rise (height). The length will be the larger of the two orthogonal dimensions which are not the rise (height). The width will be the smaller of the two orthogonal dimensions which are not the rise (height).

X1.3.1.2 For the purposes of defining specimen sampling locations, the following terminology is used.

(1) Each discrete box-pour bun in a batch shall be assigned a unique identification number. Note that it is possible for there to be only a single box-pour bun in a batch.

(2) The length dimension of the bun is broken into three portions called front, middle, and back. These will consist of roughly the front one-third, middle one-third, and back one-third of the bun, respectively in this dimension after removal of the outer skins.

(3) The width dimension of the bun is broken into three portions called left, center, and right. These will consist of roughly the left one-third, center one-third, and right one-third of the bun, respectively in this dimension after removal of the outer skins.

(4) The rise (height) dimension of the bun is broken into three portions called bottom, equator, and top. These will consist of roughly the bottom one-third, equator one-third, and top one-third of the bun, respectively in this dimension after removal of the outer skins.

(5) This is illustrated in Fig. A1.2.

X1.3.2 *Influence of Bun Location on Properties:*

X1.3.2.1 The box-pour bunstock PIR material covered by this standard is produced by:

(1) Mixing the various ingredients together to form a pre-polymerized liquid. The main components are normally called an A-side and a B-side although in some cases additional components are added. It is critical that the ratio of these two or more components be consistent for each individual box-pour PIR bun in a batch.

(2) Pouring or pumping a specified amount of the pre-polymerized liquid into a box. In some cases, the box will have a lid but, in other cases, the top of the box remains uncovered. This liquid simultaneously foams and polymerizes in an exothermic reaction. The combination of the geometry involved, the simultaneous foaming and exothermic polymerization reaction, the insulating ability of the PIR, and variability in the processing can lead to differences in properties based

on bun location. While these differences are normally small and will have minimal impact on product performance, they are real and measureable.

X1.3.2.2 All of the box-pour PIR buns in a batch are made discretely from the single batch of prepolymerized liquid (see X1.3.2.1*(1)*) which begins polymerizing as soon as it is first mixed. Since it takes time to fill each box with an aliquot of chemicals from the batch, there can be variability between the buns in a single batch of box-pour PIR due to differences in the extent of the polymerization reaction that has occurred in the batch of pre-polymerized liquid as each successive box is filled. In some cases, there can even be variation within a single bun for this same reason.

X1.3.2.3 Since the liquid pre-polymer is not typically applied across the entire floor of the box, the foaming process moves somewhat outwards from the middle of the box towards the front and back edges. In some cases, this yields a difference in properties between the middle and the front or back of the bun. The front and back sides will not be different from each other but in some cases both will be similarly different from the middle.

X1.3.2.4 Since the liquid pre-polymer is not typically applied across the entire floor of the box, the foaming process moves somewhat outwards from the center of the box towards the left and right edges. In some cases, this yields a difference in properties between the center and the left or right of the bun. The left and right sides will not be different from each other but in some cases both will be similarly different from the center.

X1.3.2.5 Since the liquid pre-polymer is simultaneously foaming and polymerizing, the product rises from a liquid layer that is about ½ in. (13 mm) thick to a final bun height of up to about 24 in. (610 mm). In some cases, this yields a difference in properties between the bottom, equator, and top of the bun.

X1.3.2.6 Because the polymerization process is exothermic and because the PIR material is a good insulator, the interior of the bun will reach a higher temperature and will remain hotter for a longer period of time than will the edges of the bun. In some cases, this yields a difference in properties between the interior portions of the bun and the portions of the PIR bun nearer the edges.