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Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation¹

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

1. Scope

1.1 This specification² covers the types, physical properties, and dimensions of cellular polystyrene boards with or without facings or coatings made by molding (EPS) or extrusion (XPS) of expandable polystyrene. Products manufactured to this specification are intended for use as thermal insulation for temperatures from -65 to $+165^{\circ}\text{F}$ (-53.9 to $+73.9^{\circ}\text{C}$). This specification does not apply to laminated products manufactured with any type of rigid board facer including fiberboard, perlite board, gypsum board, or oriented strand board.

1.1.1 Additional requirements for Types IV and XIII for pipe, tank, and equipment thermal insulation for temperatures from -320 to $+165^{\circ}\text{F}$ (-196 to $+73.9^{\circ}\text{C}$) are contained in [Annex A1](#).

1.2 The use of thermal insulation materials covered by this specification is potentially regulated by codes that address fire performance. For some end uses, specifiers need to also address the effect of moisture and wind pressure resistance. Guidelines regarding these end use considerations are included in [Appendix X1](#).

1.3 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.

1.4 *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.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standard-*

ization 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:³

- 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
- C203 Test Methods for Breaking Load and Flexural Properties of Block-Type Thermal Insulation
- C272 Test Method for Water Absorption of Core Materials for Sandwich Constructions
- C303 Test Method for Dimensions and Density of Pre-formed Block and Board-Type Thermal Insulation
- C335 Test Method for Steady-State Heat Transfer Properties of Pipe Insulation
- C390 Practice for Sampling and Acceptance of Thermal Insulation Lots
- 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
- C870 Practice for Conditioning of Thermal Insulating Materials
- 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

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 This specification is similar to ISO 4898-1984, “Cellular Plastics—Specification for Rigid Cellular Materials Used in the Thermal Insulation of Buildings,” in title only. The scope and technical content are significantly different.

ISO standards are available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

³ 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.

- C1363 Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus
- C1512 Test Method for Characterizing the Effect of Exposure to Environmental Cycling on Thermal Performance of Insulation Products
- D1600 Terminology for Abbreviated Terms Relating to Plastics
- D1621 Test Method for Compressive Properties of Rigid Cellular Plastics
- D1622 Test Method for Apparent Density of Rigid Cellular Plastics
- D2126 Test Method for Response of Rigid Cellular Plastics to Thermal and Humid Aging
- D2863 Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)
- E84 Test Method for Surface Burning Characteristics of Building Materials
- E96/E96M Test Methods for Water Vapor Transmission of Materials
- E176 Terminology of Fire Standards

2.2 CAN/ULC Standard⁴

CAN/ULC S770 Standard Test Method for the Determination of Long-Term Thermal Resistance of Closed-Cell Thermal Insulating Foams

3. Terminology

3.1 Definitions:

3.1.1 Terms used in this specification are defined in Terminology C168.

3.1.2 Terms used in this specification that relate to fire standards are defined in Terminology E176.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *EPS*—letter designation for the molded expanded polystyrene thermal insulation classified by this specification. It is defined as cellular plastic product manufactured from pre-expanded polystyrene beads subsequently molded into desired shapes and sizes resulting in a product which is rigid with closed cellular structure.

3.2.2 *RCPS*—letter designations for the rigid cellular polystyrene thermal insulation classified by this specification that identifies the product as rigid cellular polystyrene.

3.2.3 *PS*—used in this specification to represent polystyrene in accordance with Terminology D1600.

3.2.4 *XPS*—letter designation for the extruded expanded polystyrene thermal insulation classified by this specification. It is defined as cellular plastic product manufactured in a one stage process by extrusion and expansion of the base polymer in the presence of blowing agent(s) resulting in a product which is rigid with closed cellular structure.

4. Classification

4.1 This specification covers types of RCPS thermal insulations currently commercially available as described by the physical property requirements in Table 1.

5. Ordering Information

5.1 Acquisition documents shall specify the following:

5.1.1 Title, number, and year of this specification,

5.1.2 Type (see Table 1),

5.1.3 *R*-value or thickness required (see Tables 1 and 2),

5.1.3.1 *Thermal Resistance/Thickness Relationship*—It is possible that the thermal resistance (*R*-value) and the thermal resistivity (*R*-value/inch) of RCPS thermal insulation will vary with thickness. Therefore, when ordering, specify the *R*-value or the thickness, or both. For additional information, see Practice C1045.

5.1.4 Density, if other than specified in Table 1,

5.1.5 Tolerance, if other than specified (see 8.2),

5.1.6 Length and width required (see Table 2 and 8.1),

5.1.7 If other than straight edges are required (see 8.3),

5.1.8 If either ship-lap or tongue-and-groove edges are required (see 8.6),

5.1.9 *Tapered Insulation*—Special ordering information. In addition to other applicable requirements in Section 5 (Note 1), acquisition documents for tapered RCPS thermal insulation shall specify the following:

5.1.9.1 Minimum starting thickness,

5.1.9.2 Slope, in./ft (mm/m),

5.1.9.3 Average *R*-value,

5.1.9.4 Minimum thickness,

5.1.9.5 *Shop Drawings*—The tapered insulation supplier shall provide shop drawings to illustrate installation patterns and dimensions for each tapered module,

5.1.10 Sampling, if different (see 10.1),

5.1.11 If a certificate of compliance is required (see 14.1), and

5.1.12 If marking is other than specified (see 15.1).

NOTE 1—Physical properties of tapered insulation should be determined on blocks of RCPS thermal insulation before the insulation is tapered.

5.1.13 *Type XIII*—Special ordering information. In addition to other applicable requirements in Section 5, acquisition documents for Type XIII thermal insulation shall specify if presence of surface skins is required.

6. Materials and Manufacture

6.1 RCPS thermal insulation shall be formed by the expansion of polystyrene resin beads or granules in a closed mold, or by the expansion of polystyrene base resin in an extrusion process. RCPS thermal insulation shall be of uniform density and have essentially closed cells. All RCPS thermal insulation shall contain sufficient flame retardants to meet the oxygen index requirements of Table 1.

7. Physical Requirements

7.1 Inspection Requirements:

7.1.1 The physical requirements listed in this section are defined as inspection requirements (refer to Practice C390).

⁴ Available from Underwriters Laboratories (UL), 2600 N.W. Lake Rd., Camas, WA 98607-8542, <http://www.ul.com>.

TABLE 1 Physical Property Requirements of RCPS Thermal Insulation

NOTE 1—It is possible that values for properties listed in this table will be affected by the presence of a surface skin which is a result of the manufacturing process. The values for Type XIII properties listed in this table must be generated on material with the surface skin removed. Where products are tested with skins-in-place, this condition shall be noted in the test report.

NOTE 2—Type III has been deleted because it is no longer available.

NOTE 3—In addition to the thermal resistance values in Table 1, values at mean temperatures of $25 \pm 2^\circ\text{F}$ ($-4 \pm 1^\circ\text{C}$), $40 \pm 2^\circ\text{F}$ ($4 \pm 1^\circ\text{C}$), and $110 \pm 2^\circ\text{F}$ ($43 \pm 1^\circ\text{C}$) are provided in X1.7 for information purposes.

NOTE 4—Values quoted are maximum values for 1.00 in. (25.4 mm) thick samples with natural skins intact. Lower values will result for thicker materials. Where water vapor permeance is a design issue, consult manufacturer.

NOTE 5—It is acceptable to determine the values for thermal resistance listed in this table on product at a thickness other than 1 in. (25.4 mm) in accordance with 7.2.2.1. When tested at a thickness other than 1 in. (25.4 mm), the thermal resistance per inch shall meet the minimum requirement.

NOTE 6—Types XI, I, VIII, II, IX, XIV and XV are typically EPS insulation. Types XII, X, XIII, IV, VI, VII and V are typically XPS insulation.

Classification	Type XI	Type I	Type VIII	Type II	Type IX	Type XIV	Type XV	Type XII	Type X	Type XIII	Type IV	Type VI	Type VII	Type V
Compressive resistance at yield or 10 % deformation, whichever occurs first (with skins intact), min, psi (kPa)	5.0 (35)	10.0 (69)	13.0 (90)	15.0 (104)	25.0 (173)	40.0 (276)	60.0 (414)	15.0 (104)	15.0 (104)	20.0 (138)	25.0 (173)	40.0 (276)	60.0 (414)	100.0 (690)
Thermal resistance of 1.00-in. (25.4-mm) thickness, min, $\text{F}\cdot\text{ft}^2\cdot\text{h}/\text{Btu}$ ($\text{K}\cdot\text{m}^2/\text{W}$)	3.1 (0.55)	3.6 (0.63)	3.8 (0.67)	4.0 (0.70)	4.2 (0.74)	4.2 (0.74)	4.3 (0.76)	4.6 (0.81)	5.0 (0.88)	3.9 (0.68)	5.0 (0.88)	5.0 (0.88)	5.0 (0.88)	5.0 (0.88)
Mean temperature: $75 \pm 2^\circ\text{F}$ ($24 \pm 1^\circ\text{C}$)														
Flexural strength, min, psi (kPa)	10 (70)	25 (173)	30 (208)	35 (240)	50 (345)	60 (414)	75 (517)	40 (276)	40 (276)	45 (310)	50 (345)	60 (414)	75 (517)	100 (690)
Water vapor permeance of 1.00-in. (25.4-mm) thickness (See Note 4.), max, perm ($\text{ng}/\text{Pa}\cdot\text{s}\cdot\text{m}^2$)	5.0 (287)	5.0 (287)	3.5 (201)	3.5 (201)	2.5 (143)	2.5 (143)	2.5 (143)	1.5 (86)	1.5 (86)	2.0 (114)	1.5 (86)	1.1 (63)	1.1 (63)	1.1 (63)
Water absorption by total immersion, max, volume %	4.0	4.0	3.0	3.0	2.0	2.0	2.0	0.3	0.3	1.0	0.3	0.3	0.3	0.3
Dimensional stability (change in dimensions), max, %	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Oxygen index, min, volume %	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
Density, min, lb/ft^3 (kg/m^3)	0.70 (12)	0.90 (15)	1.15 (18)	1.35 (22)	1.80 (29)	2.40 (38)	3.00 (48)	1.20 (19)	1.30 (21)	1.60 (26)	1.45 (23)	1.80 (29)	2.20 (35)	3.00 (48)

TABLE 2 Common Dimensions of RCPS Thermal Insulation

Type	XI, I, VIII, II, IX, XIV, XV	X, IV, XII	VI, VII	V	XIII
Width, in. (mm)	12 to 48 (305 to 1219)	16, 24, 48 (406, 610, 1219)	24 (610)	16 (406)	14 to 20 (356 to 508)
Length, in. (mm)	48 to 192 (1219 to 4877)	48, 96 108 (1219, 2438, 2743)	48, 96, (1219, 2438)	96 (2438)	36 to 112 (914 to 2845)
Thickness, in. (mm)	$\frac{3}{8}$ to 24 (9.5 to 610)	$\frac{1}{2}$ to 4 (13 to 102)	1 to 4 (25 to 102)	1 to 4 (25 to 102)	7 to 10 (178 to 254)

7.1.2 All dimensional requirements are described in Section 8.

7.1.3 All workmanship, finish, and appearance requirements are described in Section 9.

7.1.4 Density shall be in accordance with Table 1.

NOTE 2—For lots of 150 units or less, the tightened inspection sampling plan in Practice C390 will be followed.

7.2 Qualification Requirements:

7.2.1 The physical properties listed in this section of the specification are defined as qualification requirements (refer to Practice C390). Thermal resistance, compressive resistance, flexural strength, water vapor permeance, water absorption, dimensional stability, and oxygen index shall be in accordance

with Table 1. The average test value based upon testing the number of test specimens required by the specified test method for each physical property or Section 11 of this specification shall be used to determine compliance.

7.2.2 The mean thermal resistance of the material tested shall not be less than the minimum value identified in Table 1. The thermal resistances of individual specimens tested shall not be less than 90 % of the minimum value identified in Table 1.

7.2.2.1 Test 1 in. (25.4 mm) thick specimens for determination of compliance with thermal resistance, compressive resistance, water vapor permeance, water absorption, dimensional stability and density property requirements in Table 1. If

1 in. (25.4 mm) thickness product is not produced the next available commercially manufactured product thickness greater than 1 in. (25.4 mm) thickness shall be tested and reported.

7.2.3 Compliance with qualification requirements shall be in accordance with Practice C390.

7.3 *Long Term Thermal Resistance (LTTR)*—Determine and report values in accordance with Test Method C1303 or CAN/ULC S770. LTTR shall apply to types IV, V, VI, VII, and X only. The composition of the test stacks used for the test measurements⁵ shall be reported.

7.4 **Table 1** describes types of RCPS thermal insulation. However, it does not cover all available products on the market. The values stated in **Table 1** are not intended to be used as design values. It is the buyer's responsibility to specify design requirements and obtain supporting documentation from the material supplier.

7.5 *Combustibility Characteristics*—RCPS thermal insulation is an organic material and is, therefore, combustible. It shall not be exposed to flames or other ignition sources. The values obtained by the oxygen index test (see **Table 1** and **11.10**) do not necessarily indicate or describe the fire risk of the materials and are used in this specification primarily to distinguish between insulations formulated with flame retardants and those not so formulated.

8. Dimensions and Permissible Variations

8.1 The materials covered by this specification are commonly available in the sizes shown in **Table 2**. Other sizes shall be agreed upon between the supplier and the user.

8.2 *Dimensional Tolerances*—Unless otherwise specified, the length tolerance shall not exceed ± 0.03 in./ft (± 2.5 mm/m) of length; the width tolerance shall not exceed ± 0.06 in./ft (± 5.0 mm/m) of width; and the thickness tolerance shall not exceed ± 0.06 in./in. (± 59.5 mm/m) of thickness. For products less than 1.00 in. (25.4 mm) in thickness, the thickness tolerance shall not exceed ± 0.06 in. (1.5 mm).

8.2.1 *Dimensional Tolerances for RCPS Type XIII*—The length tolerance shall not exceed +1, -0 in (+25.4, -0 mm); the width tolerance shall not exceed +0.5, -0 in (+12.7, -0 mm); and the thickness tolerance shall not exceed +0.5, -0 in (+12.7, -0 mm).

8.3 *Edge Trueness*—Unless otherwise specified, RCPS thermal insulation shall be furnished with true edges. Edges shall not deviate more than 0.03 in./ft (2.5 mm/m) of length or width.

8.4 *Face Trueness*—RCPS thermal insulation shall not deviate from absolute trueness by more than 0.03 in./ft (2.5 mm/m) of length or width.

8.5 *Squareness*—RCPS thermal insulation shall not deviate from squareness by more than 0.06 in./ft (5.0 mm/m) of length or width.

⁵ Supporting data can be found in Oak Ridge National Lab Report number ORNL/TM-2012/214. Evaluation of Experimental Parameters in the Accelerated Aging of Closed-Cell Foam Insulation, December 2012.

8.6 *Ship-Lap and Tongue-and-Groove Edges*—When specified, RCPS thermal insulation shall be furnished with either ship-lap or tongue-and-groove edges.

8.6.1 For RCPS thermal insulation manufactured with ship-lap edges, the depth of the ship-lap cut shall be one half the board thickness $+0.06, -0$ in. ($+1.5, -0$ mm). The minimum width of the cut for RCPS thermal insulation of 1.00-in. (25.4-mm) thickness or greater shall be 0.50 ± 0.06 in. (12.7 ± 1.5 mm). For RCPS thermal insulation less than 1.00 in. (25.4 mm) in thickness, the minimum width of the cut shall be 0.25 ± 0.06 in. (6.4 ± 1.5 mm). The ship-lap cut shall be made on opposite faces of the board for both length and width. The resulting joint shall be smooth and uniform.

8.6.2 For RCPS thermal insulation manufactured with tongue-and-groove edges, the tongue of one shall fit snugly into the groove of a second. The resulting joint shall be smooth and uniform.

9. Workmanship, Finish, and Appearance

9.1 *Defects*—RCPS thermal insulation shall have no defects that will adversely affect its service qualities. RCPS thermal insulation shall be of uniform texture and free of foreign inclusions, broken edges and corners, slits, and objectionable odors.

9.2 *Crushing and Depressions*—RCPS thermal insulation shall have no crushed or depressed areas on any surface exceeding 0.13 in. (3.3 mm) in depth on more than 10 % of the total surface area.

9.3 The total number of voids on the board surface shall not exceed an average of 1 per square foot with dimensions larger than 0.13 by 0.13 by 0.13 in. (3.3 by 3.3 by 3.3 mm).

10. Sampling

10.1 Unless otherwise specified in the purchase order or contract, the material shall be sampled in accordance with Practice C390.

11. Test Methods

11.1 *Conditioning and Aging:*

11.1.1 Samples shall be conditioned as required by the test method to either preconditioned moisture equilibrium or conditioned moisture equilibrium, using procedures defined by Practice C870. Samples shall be held at equilibrium conditions until they are transferred into the testing equipment. Samples to be used for density test, dimensional stability test, and water vapor transmission test shall be conditioned at $73.4 \pm 4^\circ\text{F}$ ($23 \pm 2^\circ\text{C}$) and 50 ± 5 % relative humidity for a minimum of 40 h prior to the start of tests. Samples to be used for the compressive resistance test, oxygen index test, water absorption test, flexural strength test, and thermal resistance test shall be conditioned as specified in the applicable test procedure.

11.1.2 RCPS thermal insulations that incorporate a blowing agent other than air or pentane shall be aged for either 90 ± 2 days at $140 \pm 2^\circ\text{F}$ ($60 \pm 1^\circ\text{C}$) or 180 ± 5 days at $73.4 \pm 4^\circ\text{F}$ ($23 \pm 2^\circ\text{C}$) and 50 ± 5 % relative humidity prior to conditioning and thermal resistance testing. Air circulation shall be provided so that all surfaces of the insulation are exposed to the surrounding environmental conditions.