

Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation¹

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

1. Scope

1.1 This specification² covers the types, physical properties, and dimensions of cellular polystyrene 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 cover cryogenic applications. Consult the manufacturer for specific recommendations and properties in cryogenic conditions.

1.2 The use of thermal insulation materials covered by this specification may be regulated by building codes that address fire performance. For some end uses, specifiers should also address the effect of moisture. 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 the standard. The values given in parentheses are provided for information only.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

- C 165 Test Method for Measuring Compressive Properties of Thermal Insulations³
- C 168 Terminology Relating to Thermal Insulating Materials³
- C 177 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus³
- C 203 Test Methods for Breaking Load and Flexural Properties of Block-Type Thermal Insulation³
- C 236 Test Method for Steady-State Thermal Performance of Building Assemblies by means of a Guarded Hot Box³

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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 ANSI, 11 W. 42nd St., 13th Floor, New York, NY 10036.

³ *Annual Book of ASTM Standards*, Vol 04.06.

- C 272 Test Method for Water Absorption of Core Materials for Structural Sandwich Constructions⁴
- C 303 Test Method for Density of Preformed Block-Type Thermal Insulation³
- C 390 Criteria for Sampling and Acceptance of Preformed Thermal Insulation Lots³
- C 518 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus³
- C 550 Practice for Measuring Trueness and Squareness of Rigid Block and Board Thermal Insulation³
- C 870 Practice for Conditioning of Thermal Insulating Materials³
- C 976 Test Method for Thermal Performance of Building Assemblies by Means of a Calibrated Hot Box³
- C 1045 Practice for Calculating Thermal Transmission Properties from Steady-State Heat Flux Measurements³
- C 1058 Practice for Selecting Temperatures for Reporting and Evaluating Thermal Properties of Thermal Insulation³
- C 1114 Test Method for Steady-State Thermal Transmission Properties by Means of the Thin-Heater Apparatus³
- D 1600 Terminology Relating to Abbreviated Terms Relating to Plastics⁵
- D 1621 Test Method for Compressive Properties of Rigid Cellular Plastics⁵
- D 1622 Test Method for Apparent Density of Rigid Cellular Plastics⁵
- D 2126 Test Method for Response of Rigid Cellular Plastics to Thermal and Humid Aging⁵
- D 2863 Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-like Combustion of Plastics (Oxygen Index)⁶
- E 84 Test Method for Surface Burning Characteristics of Building Materials⁷
- E 96 Test Methods for Water Vapor Transmission of Materials³
- E 176 Terminology Related to Fire Standards⁷

3. Terminology

3.1 Definitions:

⁴ *Annual Book of ASTM Standards*, Vol 15.03.

⁵ *Annual Book of ASTM Standards*, Vol 08.01.

⁶ *Annual Book of ASTM Standards*, Vol 08.02.

⁷ *Annual Book of ASTM Standards*, Vol 04.07.

3.1.1 Terms used in this specification are defined in Terminology C 168.

3.1.2 Terms used in this specification that relate to fire standards are defined in Terminology E 176.

3.2 *Definitions of Terms Specific to This Standard:*

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

3.2.2 *PS*—used in this specification to represent polystyrene in accordance with Terminology D 1600.

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*—The thermal resistance (*R*-value) and the thermal resistivity (*R*-value/inch) of RCPS thermal insulation may vary with thickness. Therefore, when ordering, specify the *R*-value or the thickness, or both. For additional information, see Test Methods C 177, C 518, C 236, C 976, and C 1114 or Practice C 1045.

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),

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.

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 Criteria C 390).

7.1.2 All dimensional requirements are described in Section 8.

TABLE 1 Physical Property Requirements of RCPS Thermal Insulation

NOTE 1—The values for properties listed in this table may be affected by the presence of a surface skin which is a result of the manufacturing process. Where boards 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—Classifications are used to cross-reference Fed. Spec. HH-I-524C (see X1.6.1).

Property	0.70 (12)	0.90 (15)	1.15 (18)	1.20 (19)	1.30 (21)	1.35 (22)	1.60 (26)	1.80 (29)	1.80 (29)	2.20 (35)	3.00 (48)
Density, min, lb/ft ³ (kg/m ³)											
Thermal resistance of 1.00-in. (25.4-mm) thickness, min, F-ft ² -h/Btu (K-m ² /W)											
Mean temperature:											
25°F (-3.9°C)	3.45 (0.61)	4.20 (0.74)	4.40 (0.77)	5.20 (0.92)	5.60 (0.99)	4.60 (0.81)	5.60 (0.99)	4.80 (0.84)	5.60 (0.99)	5.60 (0.99)	5.60 (0.99)
40°F (4.4°C)	3.30 (0.58)	4.00 (0.70)	4.20 (0.74)	5.00 (0.88)	5.40 (0.95)	4.40 (0.77)	5.40 (0.95)	4.60 (0.81)	5.40 (0.95)	5.40 (0.95)	5.40 (0.95)
75°F (23.9°C)	3.10 (0.55)	3.60 (0.63)	3.80 (0.67)	4.60 (0.81)	5.00 (0.88)	4.00 (0.70)	5.00 (0.88)	4.20 (0.74)	5.00 (0.88)	5.00 (0.88)	5.00 (0.88)
110°F (43.3°C)	2.90 (0.51)	3.25 (0.57)	3.45 (0.61)	4.30 (0.76)	4.65 (0.82)	3.65 (0.64)	4.65 (0.82)	3.85 (0.69)	4.65 (0.82)	4.65 (0.82)	4.65 (0.82)
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)	15.0 (104)	15.0 (104)	25.0 (173)	25.0 (173)	40.0 (276)	60.0 (414)	100.0 (690)
Flexural strength, min, psi (kPa)	10.0 (70)	25.0 (173)	30.0 (208)	40.0 (276)	40.0 (276)	40.0 (276)	50.0 (345)	50.0 (345)	60.0 (414)	75.0 (517)	100.0 (690)
Water vapor permeance of 1.00-in. (25.4-mm) thickness, max, perm (ng/Pa-s-m ²)	5.0 (287)	5.0 (287)	3.5 (201)	1.1 (63)	1.1 (63)	3.5 (201)	1.1 (63)	2.0 (115)	1.1 (63)	1.1 (63)	1.1 (63)
Water absorption by total immersion, max, volume%	4.0	4.0	3.0	0.3	0.3	3.0	0.3	2.0	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
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
Classification	Type XI	Type I	Type VIII	Type XII	Type X	Type II	Type IV	Type IX	Type VI	Type VII	Type V

TABLE 2 Common Dimensions of RCPS Thermal Insulation

Type	XI, I, VIII, II, IX	X, IV	VI, VII	V
Width, in. (mm)	12 to 48 (305 to 1219)	16, 24, 48 (406, 610, 1219)	24 (610)	16 (406)
Length, in. (mm)	48 to 192 (1219 to 4877)	48, 96 108 (1219, 2438, 2743)	48, 96, (1219, 2438)	96 (2438)
Thickness, in. (mm)	¾ to 24 (9.5 to 610)	½ to 4 (13 to 102)	1 to 4 (25 to 102)	1 to 4 (25 to 102)

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 Criteria C 390 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 Criteria C 390). Thermal resistance, compressive resistance, flexural strength, water vapor permeance, water absorption, dimensional stability, and oxygen index shall be in accordance with Table 1.

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.

7.2.3 Compliance with qualification requirements shall be in accordance with Criteria C 390.

7.3 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 should not be used as design values. It is the buyer's responsibility to specify design requirements and obtain supporting documentation from the material supplier.

7.4 *Combustibility Characteristics*—RCPS thermal insulation is an organic material and is, therefore, combustible. It should 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 may 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).

8.3 *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.

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 Criteria C 390.

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 C 870. 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 days at $140 \pm 2^\circ\text{F}$ ($60 \pm 1^\circ\text{C}$) or six months at ambient conditions 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.

11.1.3 Where boards are tested with skins-in-place, this condition shall be noted in the test report.

11.2 *Dimensions and Density*—Test in accordance with Test Method C 303 or Test Method D 1622.

11.3 *Trueness and Squareness*—Test in accordance with Practice C 550.

11.4 *Thermal Resistance*—Test in accordance with Test Methods C 177, C 236, C 518, C 976, C 1114, or C 1045. Tests shall be conducted with a temperature differential of $50 \pm 2^\circ\text{F}$ ($28 \pm 1^\circ\text{C}$). In case of dispute, Test Method C 177 shall be the referee method.

11.4.1 See Practice C 1058.

11.5 *Compressive Resistance*—Test in accordance with Test Method C 165, Procedure A, at a crosshead speed of 0.1 in./min/in. of thickness (100 mm/min/m) at yield or 10 % deformation, whichever occurs first (with skins intact), or test in accordance with Test Method D 1621.

11.6 *Flexural Strength*—Test in accordance with Test Methods C 203, Method I, Procedure A. All test specimens shall be 1.00 ± 0.06 in. (25.4 ± 1.5 mm) or less in thickness. For samples less than or equal to 1.00 ± 0.06 in. in thickness (Note 2), cut test specimens from samples keeping both original major surfaces intact. If skins are present on only one major surface, test specimens with that surface in tension. For samples of greater thickness, trim test specimens to 1.00 ± 0.06 in. thickness retaining one original major surface. Specimens shall be tested with the original major surface in tension. For anisotropic products run the tests for both the length and cross directions of the sample. Report the average of these two series of tests as the value for flexural strength.

11.6.1 Specimens less than 1.00 ± 0.06 in. (25.4 ± 1.5 mm) in thickness may continue to flex without specimen failure (break). In such cases, flexural strength testing shall be performed using thicker specimens and the thickness shall be noted in the test report.

11.7 *Water Vapor Permeance*—Test in accordance with Test Methods E 96, using anhydrous calcium chloride as the desiccant at $73.4 \pm 4^\circ\text{F}$ ($23 \pm 2^\circ\text{C}$).

11.8 *Water Absorption*—Test in accordance with Test Method C 272. The immersion time shall be 24 h and the test specimens shall be 12 by 12 by 1 in. (305 by 305 by 25 mm).

11.9 *Dimensional Stability*—Test in accordance with Test Method D 2126 for 7 days (168 h) using the following conditions:

Temperature, °F (°C)	Relative Humidity, %
158 ± 4 (70 ± 2)	97 ± 3
-40 ± 6 (-40 ± 3)	ambient

11.10 *Oxygen Index*—Test in accordance with Test Method D 2863.

12. Inspection

12.1 Unless otherwise specified, Criteria C 390 shall govern the inspection of material for conformance to inspection requirements. Exceptions to these requirements shall be stated in the purchase contract.

13. Rejection and Rehearing

13.1 Material that fails to conform to the requirements of this specification may be rejected. Rejection should be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with the results of any test, the producer shall have the right to reinspect the rejected shipment and resubmit the lot after removal of that portion not conforming to requirements.

14. Certification

14.1 Unless otherwise specified in the purchase order or contract, Criteria C 390 shall be the basis for the certification. When specified in the purchase order or contract, a report of the test results shall be furnished.

15. Product Marking

15.1 The following shall be marked on each shipping container, bundle, or board:

- 15.1.1 Insulation specification number,
- 15.1.2 Type,
- 15.1.3 Manufacturer's name or trademark, and
- 15.1.4 *R*-value.

15.1.5 Instructions governing the *R*-value at 75°F (23.9°C) mean temperature for the thermal insulation thickness supplied, as follows: *R* means the resistance to heat flow; the higher the value, the greater the insulation power. This insulation must be installed properly to get the marked *R*-value. Follow the manufacturer's instructions carefully. If a manufacturer's fact sheet is not provided with the material shipment, request this and review it carefully.

16. Keywords

16.1 block/board; cellular polystyrene; foam plastic; polystyrene; RCPS; rigid cellular polystyrene; thermal insulation

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APPENDIX

(Nonmandatory Information)

X1. END-USE CONSIDERATIONS

X1.1 Combustibility Characteristics

X1.1.1 The fire performance of the material should be addressed through standard end-use fire test methods established by the appropriate governing documents.

X1.2 Test Method E 84/UBC Standard No. 8-1/UL 723

X1.2.1 These tests do not define the hazard that may be presented by RCPS thermal insulation under actual fire conditions. It is retained for reference in this specification as laboratory test data required by some building codes.

X1.3 Water Vapor Transmission

X1.3.1 Most thermal insulations function where there is both a temperature and moisture vapor pressure differential across the insulation. The water vapor permeability of RCPS thermal insulation may be a significant element to be considered when developing the specification for the vapor retarder component of the thermal package for a specific end use condition.

X1.4 Water Absorption

X1.4.1 This characteristic may have significance when this specification is used to purchase material for end uses requiring extended exposure to water. The water absorption of thermal insulations is an important property to the degree that significant content can degrade thermal performance.

X1.5 Freeze/Thaw Exposure

X1.5.1 RCPS insulating boardstock is sometimes used in

applications that may subject the insulation to various types of freeze/thaw exposure conditions. These conditions may vary significantly in service. Exposure conditions to be considered include actual temperatures, liquid water availability, and freeze/thaw cycle frequency and duration. Boardstock integrity, as well as thermal/physical property retention may be affected by actual end-use conditions. Consult the manufacturer for specific product, insulation system, and application recommendations.

X1.6 Specification C 578/HH-I-524C Cross Reference

X1.6.1 Federal Specification HH-I-524C was cancelled on Jan. 17, 1985. For the convenience of specifiers who may have contracts written in terms of HH-I-524C, the following is a cross-reference table. The letters NA indicate that the type designation has been deleted because products meeting the requirements are no longer available.

HH-I-524C Type Designation	Specification C 578 Type Designation
I	I
II	II
III	NA
IV	IV
V	V

X1.6.2 Additional type designations have been established since the cancellation of HH-I-524C to better define the variety of RCPS thermal insulations available.

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