



Designation: C1594 – 23

Standard Specification for Polyimide Rigid Cellular Thermal Insulation¹

This standard is issued under the fixed designation C1594; 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.

1. Scope

1.1 This specification covers the composition and physical properties of polyimide foam insulation with nominal densities from 1.0 lb/ft³ to 8.0 lb/ft³ (16 kg/m³ to 128 kg/m³) and intended for use as thermal and sound-isolating insulation for temperatures from –423°F to +600°F (–253°C to +316°C) in commercial and industrial environments.

1.1.1 The annex shall apply to this specification for marine applications.

1.1.2 This standard is designed as a material specification and not a design document.

1.1.3 The values stated in [Table 1](#) and [Table 2](#) are not to be used as design values. It is the buyer's responsibility to specify design requirements and obtain supporting documentation from the material supplier.

NOTE 1—The subject matter of this material specification is not covered by any other ASTM specification. There is no known ISO standard covering the subject of this standard.

1.2 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.

1.3 *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.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization 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.*

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. Referenced Documents

2.1 ASTM Standards:²

- 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
- C335 Test Method for Steady-State Heat Transfer Properties of Pipe Insulation
- C390 Practice for Sampling and Acceptance of Thermal Insulation Lots
- C411 Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation
- C421 Test Method for Tumbling Friability of Preformed Block-Type and Preformed Pipe-Covering-Type Thermal Insulation
- C447 Practice for Estimating the Maximum Use Temperature of Thermal Insulations
- C518 Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
- C634 Terminology Relating to Building and Environmental Acoustics
- C665 Specification for Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing
- 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
- C1304 Test Method for Assessing the Odor Emission of Thermal Insulation Materials
- C1338 Test Method for Determining Fungi Resistance of Insulation Materials and Facings
- C1482 Specification for Polyimide Flexible Cellular Thermal and Sound Absorbing Insulation

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.

TABLE 1 Polyimide Foam Classification (inch pound)

Property	Type I Grade 1	Type I Grade 2	Type I Grade 3	Type II Grade 1 Class 1	Type II Grade 2 Class 1	Type II Grade 3 Class 1	Type II Grade 1 Class 2	Type II Grade 2 Class 2	Type II Grade 3 Class 2	Type III Grade 4
Density, lb/ft ³ (max)	8.0	6.0	3.0	8.0	6.0	3.0	8.0	6.0	3.0	1.5
Thermal Conductivity, Btu-in./h-ft ² -°F (max)										
-238°F	*	*	*	*	*	0.048	*	*	*	*
-150°F	*	*	*	*	*	0.036	*	*	*	*
-50°F	*	*	*	*	*	0.096	*	*	*	*
24°F	0.230	0.220	0.210	*	*	0.180	*	*	*	*
65°F	0.248	0.238	0.220	*	*	0.228	*	*	*	*
75°F	0.250	0.240	0.240	0.260	0.250	0.246	0.234	0.250	0.225	0.240
100°F	0.260	0.250	0.250	*	*	0.264	*	*	*	*
150°F	0.280	0.270	0.270	*	*	0.324	*	*	*	*
200°F	0.305	0.295	0.300	*	*	0.396	*	*	*	*
300°F	*	*	*	*	*	0.516	*	*	*	*
572°F	*	*	*	*	*	0.876	NA	NA	NA	*
Upper Temperature Limit – test temperature for C411, °F	600	600	600	600	600	600	400	400	400	600
High Temperature Stability – % of initial tensile strength retained after 1000 hours in air oven at 572°F, (min.)	*	*	*	*	*	95	*	*	*	*
Tensile Strength PSI (min.)	244	134	41	180	80	14	180	80	14	41
Compressive Strength PSI @ 10% def. (min.)	95	65	28	*	*	*	*	*	*	*
Compressive Force Deflection PSI @ 20% def. (min.)	*	*	*	18	6	2	18	6	2	26
Steam Aging	25	25	25	25	25	25	25	25	25	25
Change in tensile Strength % (max.)	10	10	10	10	10	10	10	10	10	10
Dimensional and weight changes % (max.)										
Water Vapor Permeability Perm in. (max.)	0.5	0.5	3.5	2.5	5.0	8.0	2.0	2.5	5.0	2.9
Oxygen Index % (min.)	46	45	43	52	50	48	30	30	30	47
Surface Burning Characteristics, 2 in. thickness	10	10	10	10	10	10	10	10	10	10
Flame Spread Index, (max.)	15	15	15	15	15	15	15	15	15	15
Smoke Developed Index, (max.)										
Vertical Burn										
Flame Application sec	60	60	60	60	60	60	60	60	60	60
Flame Time sec (max.)	0	0	0	0	0	0	0	0	0	0
Burn Length in. (max.)	0.6	0.6	1.6	0.5	0.6	0.6	0.6	0.6	0.8	0.6
Dripping	None	None	None	None	None	None	None	None	None	None
Specific Optical Density	3	2	1	2	2	2	5	5	5	1
Avg. Dm. Flaming Exposure (max.)	3	2	1	1	1	1	3	3	3	1
Avg. Dm. Non-Flaming Exposure (max.)										
Corrosiveness	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Chemical resistance	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
By-Products of Combustion, ppm (max.)										
Carbon Monoxide	275	200	100	300	300	300	300	300	300	125
Flaming	3	2	1	10	10	10	10	10	10	3
Non-Flaming										
Hydrogen Fluoride	5	4	4	5	5	5	5	5	5	2
Flaming	5	4	4	5	5	5	5	5	5	2
Non-Flaming										
Hydrogen Chloride	9	7	5	10	10	10	10	10	10	3
Flaming	9	7	5	10	10	10	10	10	10	3
Non-Flaming										
Nitrogen Oxides	10	10	10	10	10	10	10	10	10	6
Flaming	10	10	10	10	10	10	10	10	10	3
Non-Flaming										
Sulfur Dioxide	5	5	5	5	5	5	5	5	5	2
Flaming	5	5	5	5	5	5	5	5	5	2
Non Flaming										
Hydrogen Cyanide	5	5	5	5	5	5	10	10	10	4
Flaming	5	5	5	5	5	5	5	5	5	3
Non Flaming										
¼ Scale Room Burn – No Flash Over	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Percent closed cell (range)	100–76	100–76	100–76	30–0	30–0	30–0	30–0	30–0	30–0	75–20
Tumbling Friability										
600 Revolutions, mass loss, max, %	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
1200 Revolutions, mass loss, max, %	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Odor Emission	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Fungi Resistance	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Wicking, 48 hrs, distance above water line, max. @ 72°F, in.	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

* = Not available consult manufacturer for additional information.

NA = Not Applicable

NB = A manufacturer can only claim conformance to this standard to the values reported in this table. The * notes are confidential data to the manufacturers and as such are not considered part of any qualifying requirements for the standard and only tell the user to inquire about that data.

TABLE 2 Polyimide Foam Classification (SI)

Property	Type I Grade 1	Type I Grade 2	Type I Grade 3	Type II Grade 1 Class 1	Type II Grade 2 Class 1	Type II Grade 3 Class 1	Type II Grade 1 Class 2	Type II Grade 2 Class 2	Type II Grade 3 Class 2	Type III Grade 4
Density, kg/m ³ (max)	128	96	48	128	96	48	128	96	48	
Thermal Conductivity, W/m-K (max)										
-150°C	*	*	*	*	*	0.007	*	*	*	*
-101°C	*	*	*	*	*	0.005	*	*	*	*
-46°C	*	*	*	*	*	0.014	*	*	*	*
-4°C	0.033	0.032	0.030	*	*	0.026	*	*	*	*
18°C	0.036	0.034	0.032	*	*	0.033	*	*	*	*
24°C	0.036	0.035	0.035	0.038	0.036	0.036	0.034	0.036	0.032	0.035
38°C	0.038	0.036	0.036	*	*	0.038	*	*	*	*
66°C	0.040	0.039	0.039	*	*	0.047	*	*	*	*
93°C	0.044	0.042	0.043	*	*	0.057	*	*	*	*
149°C	*	*	*	*	*	0.074	*	*	*	*
300°C	*	*	*	*	*	0.126	NA	NA	NA	*
Upper Temperature Limit – test temperature for C411 °C	315	315	315	315	315	315	204	204	204	315
High Temperature Stability – % of initial tensile strength retained	*	*	*	*	*	95	*	*	*	*
after 1000 hours in air oven at 300°C, (min.)										
Tensile Strength MPa (min.)	1.68	0.92	0.28	1.24	0.55	0.096	1.24	0.55	0.096	0.28
Compressive Strength MPa @ 10% def. (min.)	0.65	0.45	0.19	*	*	*	*	*	*	*
Compressive Force Deflection MPa @ 20% def. (min.)	*	*	*	0.12	0.04	0.01	0.12	0.04	0.01	0.18
Steam Aging	25	25	25	25	25	25	25	25	25	25
Change in tensile Strength % (max)	10	10	10	10	10	10	10	10	10	10
Dimensional and weight changes % (max)										
Water Vapor Permeability g/Pa s m (max.)	0.7×10 ⁻⁹	0.7×10 ⁻⁹	5.1×10 ⁻⁹	3.6×10 ⁻⁹	7.3×10 ⁻⁹	11.6×10 ⁻⁹	2.9×10 ⁻⁹	3.6×10 ⁻⁹	7.3×10 ⁻⁹	4.2×10 ⁻⁹
Oxygen Index % (min.)	46	45	43	52	50	48	30	30	30	47
Surface Burning Characteristics, 50mm thick- ness	10	10	10	10	10	10	10	10	10	10
Flame Spread Index, (max.)	15	15	15	15	15	15	15	15	15	15
Smoke Developed Index, (max.)										
Vertical Burn										
Flame Application sec	60	60	60	60	60	60	60	60	60	60
Flame Time sec (max.)	0	0	0	0	0	0	0	0	0	0
Burn Length cm (max.)	1.5	1.5	4.0	1.3	1.4	1.4	1.4	1.4	2.0	1.4
Dripping	None	None	None	None	None	None	None	None	None	None
Specific Optical Density	3	2	1	2	2	2	5	5	5	1
Avg. Dm. Flaming Exposure (max)	3	2	1	1	1	1	3	3	3	1
Avg. Dm. Non-Flaming Exposure (max.)										
Corrosiveness	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Chemical resistance	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
By-Products of Combustion, ppm (max.)										
Carbon Monoxide	275	200	100	300	300	300	300	300	300	125
Flaming	3	2	1	10	10	10	10	10	10	3
Non-Flaming										
Hydrogen Fluoride	5	4	3	5	5	5	5	5	5	2
Flaming	5	4	3	5	5	5	5	5	5	2
Non-Flaming										
Hydrogen Chloride	9	7	5	10	10	10	10	10	10	3
Flaming	9	7	5	10	10	10	10	10	10	3
Non-Flaming										
Nitrogen Oxides	10	10	10	10	10	10	10	10	10	6
Flaming	10	10	10	10	10	10	10	10	10	3
Non-Flaming										
Sulfur Dioxide	5	5	5	5	5	5	5	5	5	2
Flaming	5	5	5	5	5	5	5	5	5	2
Non-Flaming										
Hydrogen Cyanide	5	5	5	5	5	5	10	10	10	4
Flaming	5	5	5	5	5	5	5	5	5	3
Non-Flaming										
¼ Scale Room Burn – No Flash Over	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Percent closed cell (range)	100–76	100–76	100–76	30–0	30–0	30–0	30–0	30–0	30–0	75–20
Tumbling Friability										
600 Revolutions, mass loss, max, %	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
1200 Revolutions, mass loss, max, %	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Odor Emission	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Fungi Resistance	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Wicking, 48 hrs, distance above water line, max. @ 22°C, mm	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0

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- C1559** Test Method for Determining Wicking of Fibrous Glass Blanket Insulation (Aircraft Type)
- D543** Practices for Evaluating the Resistance of Plastics to Chemical Reagents
- D638** Test Method for Tensile Properties of Plastics
- D1621** Test Method for Compressive Properties 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)
- D3574** Test Methods for Flexible Cellular Materials—Slab, Bonded, and Molded Urethane Foams
- 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 Gravimetric Determination of Water Vapor Transmission Rate of Materials
- E176** Terminology of Fire Standards
- E662** Test Method for Specific Optical Density of Smoke Generated by Solid Materials
- E2231** Practice for Specimen Preparation and Mounting of Pipe and Duct Insulation Materials to Assess Surface Burning Characteristics
- 2.2 *U.S. Federal Standards:*
- FAR 25.853(a), Appendix F, Part 1, (a) (1) (i) Test Criteria and Procedures for Showing Compliance with Sec. 25.853, or 25.855³**
- 2.3 *Private Sector Standards:*
- Boeing BSS 7239 Test Method for Toxic Gas Generation by Materials on Combustion⁴**

3. Terminology

3.1 *Definitions*—Terms used in this specification are defined in Terminology **C168**, Terminology **C634**, and Terminology **E176**. In the case of a conflict, Terminology **C168** shall be the dominant authority.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *slab*—a rectangular section, piece, or sheet of foam that is cut from a bun, or block of foam.

4. Classification

4.1 The polyimide cellular insulations of the specification are classified into Types I, II and III. Type I is polyimide foam with a closed cell content of greater than 75 % and Type II is open celled polyimide foam with a closed cell content of less than 30 %. Type III is polyimide foam with a closed cell content of between 20 and 75 %. The polyimide cellular insulation is further classified into grades according to density.

4.1.1 *Grade 1*—Densities to 8.0 lb/ft³ (128 kg/m³).

4.1.2 *Grade 2*—Densities to 6.0 lb/ft³ (96 kg/m³).

4.1.3 *Grade 3*—Densities to 3.0 lb/ft³ (48 kg/m³).

4.1.4 *Grade 4*—Densities to 1.5 lb/ft³ (24 kg/m³).

4.2 Type II polyimide cellular insulation is further divided into Classes 1 and 2 based on Upper Temperature Limits of 600°F and 400°F (316°C and 204°C) respectively.

4.3 Use Upper Temperature Limit for classification only. Actual temperature use limits are application dependant and shall be as agreed upon between the manufacturer and purchaser.

5. Materials and Manufacture

5.1 Polyimide foam shall be manufactured from the appropriate monomers, and necessary compounding ingredients to conform to the definition in Terminology **C168**.

NOTE 2—Type I and III materials are typically prepared by foaming in a closed mold while Type II material are typically prepared by compressing polyimide foams of the type specified in Specification **C1482**.

NOTE 3—Polyimide foam products made using different monomers are not equivalent, which can affect physical properties.

6. Physical Properties

6.1 The insulation shall conform to the requirements in **Table 1** and **Table 2** for each type, unless specifically stated otherwise by agreement between the supplier and the purchaser. Tests shall be made in accordance with the methods specified in **11.1 – 11.22**.

6.1.1 *Upper Temperature Limit*—Upper temperature limit shall be determined according to **11.4**.

6.1.2 *Burning Characteristics*—The uncoated and unfaced foam shall conform to the requirements in **Table 1** and **Table 2** for each type, when tested in accordance with **11.13 – 11.18**, without the use of flame/smoke or heat suppressant barriers or coatings.

7. Workmanship and Appearance

7.1 The slab offered as saleable material shall be free of foreign materials and defects that will adversely affect its performance in service as agreed upon by the supplier and customer.

8. Sampling

8.1 *Sampling*—The insulation shall be sampled in accordance with requirements of Practice **C390**. Otherwise, specific provisions for sampling shall be as agreed upon between the user and the supplier.

8.2 *Specimen*—For polyimide foam insulation, specimens of dimensions 12 by 12 by 1 in. (300 by 300 by 25 mm) are sufficient for purposes of acceptance inspection of samples.

9. Qualification Requirements

9.1 Due to the highly varied applications in which the products are used, qualification requirements shall be as agreed upon between the user and the supplier. The following properties are generally employed for initial material or product qualification:

9.1.1 Upper Temperature Limit,

9.1.2 Apparent Thermal Conductivity at 75°F (24°C),

³ Federal Aviation Regulations Part 25 (Airworthiness Standards, Transport Category Aircraft, and Section 25.853. Procedure in appendix F, Part I (a) (1) (i) and (ii). Available from Superintendent of Documents, U.S. Government Printing Office P.O. Box 371954, Pittsburgh, PA 15250-7954.

⁴ Available from Boeing Commercial Airplane Group, Material Division, P.O. Box 3707, Seattle, WA 98124-2207.