



Designation: C 1594 – 04

## Standard Specification for Polyimide Rigid Cellular Thermal Insulation<sup>1</sup>

This standard is issued under the fixed designation C 1594; 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 ( $\epsilon$ ) 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 2.0 lb/ft<sup>3</sup> to 8.0 lb/ft<sup>3</sup> (32 kg/m<sup>3</sup> to 128 kg/m<sup>3</sup>) 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 Tables 1 and 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.

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

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

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.

### 2. Referenced Documents

#### 2.1 ASTM Standards:<sup>2</sup>

- C 168 Terminology Relating to Thermal Insulation
- C 177 Test Method for Steady-State Heat-Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus
- C 335 Test Method for Steady-State Heat Transfer Properties of Horizontal Pipe Insulation

- C 390 Practice for Sampling and Acceptance of Thermal Insulation Lots
- C 411 Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation
- C 447 Practice for Estimating the Maximum Use Temperature of Thermal Insulations
- C 518 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
- C 634 Terminology Relating to Environmental Acoustics
- C 665 Specification for Mineral-Fiber Blanket Insulation for Light Frame Construction and Manufactured Housing
- C 1045 Practice for Calculating Thermal Transmission Properties from Steady-State Heat Flux Measurements
- C 1058 Practice for Selecting Temperatures for Evaluating and Reporting Thermal Properties of Thermal Insulation
- C 1114 Test Method for Steady-State Thermal Transmission Properties by Means of the Thin-Heater Apparatus
- C 1482 Specifications for Polyimide Flexible Cellular Thermal and Sound Absorbing Insulation
- D 543 Test Method for Resistance of Plastics to Chemical Reagents
- D 638 Test Method for Tensile Properties of Plastics
- D 1621 Test Method for Compressive Properties Of Rigid Cellular Plastics
- D 2126 Test Method for Response of Rigid Cellular Plastics to Thermal and Humid Aging
- D 2856 Test Method for Open-Cell Content of Rigid Cellular Plastics by the Air Pycnometer
- D 2863 Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)
- D 3574 Test Methods for Flexible Cellular Materials—Slab, Bonded, and Molded Urethane Foams
- E 84 Test Method for Surface Burning Characteristics of Building Materials
- E 96 Test Method for Water Vapor Transmission of Materials
- E 176 Terminology of Fire Standards
- E 662 Test Method for Specific Optical Density of Smoke Generated by Solid Materials

<sup>1</sup> 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 Non-homogenous Inorganic Thermal Insulations.

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<sup>2</sup> 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.

E 2231 Practice for Specimen Preparation and Mounting of Pipe and Duct Insulation to Access 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 25.855<sup>3</sup>

### 2.3 Private Sector Standards:

Boeing BSS 7239 Test Method for Toxic Gas Generation by Materials on Combustion<sup>4</sup>

## 3. Terminology

3.1 *Definitions*—Terms used in this specification are defined in Terminology C 168, Terminology C 634, and Terminology E 176. In the case of a conflict, Terminology C 168 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.

3.2.2 *polyimide foam*—a cellular product in which the bonds formed between monomers during polymerization are imide or amide bonds. The theoretical mole fraction of imide bonds must be greater than the theoretical mole fraction of amide bonds.

## 4. Classification

4.1 The polyimide cellular insulations of the specification are classified into Types I and II. Type I is manufactured 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 20 %. The polyimide cellular insulation is further classified into grades according to density.

4.1.1 *Grade 1*—Densities to 8.0 lb/ft<sup>3</sup> (128 kg/m<sup>3</sup>).

4.1.2 *Grade 2*—Densities to 6.0 lb/ft<sup>3</sup> (96 kg/m<sup>3</sup>).

4.1.3 *Grade 3*—Densities to 3.0 lb/ft<sup>3</sup> (48 kg/m<sup>3</sup>).

4.2 Type II polyimide cellular insulation is further divided into Classes 1 and 2 based on upper use temperature.

NOTE 2—Type II Class 1 and 2 recommended upper use temperatures are 600°F and 400°F (316°C and 204°C) respectfully.

## 5. Materials and Manufacture

5.1 Polyimide foam shall be manufactured from the appropriate monomers, and necessary compounding ingredients to conform to 3.2.2.

5.2 Type I materials can prepared by foaming in a closed mold while Type II materials can be prepared by compressing polyimide foams of the type specified in Specification C 1482.

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

<sup>3</sup> 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.

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

## 6. Physical Properties

6.1 The insulation shall conform to the requirements in Tables 1 and 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 11.1-11.18.

6.1.1 *Upper Temperature Limit*—Upper temperature limit shall be determined according to 11.4 at the intended maximum use temperature for the application or at a temperature determined by agreement between the purchaser and manufacturer.

6.1.2 *Burning Characteristics*—The uncoated and unfaced foam shall conform to the requirements in Tables 1 and 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 C 390. 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),

9.1.3 Tensile Strength,

9.1.4 Water and Gas Permeability (Type I), and

9.1.5 Percent Closed Cell (Type I).

## 10. Inspection

10.1 The requirements shall be as agreed upon between the user and the supplier. The following requirements are generally employed for acceptance sampling of lots or shipments of qualified polyimide foam insulation:

10.1.1 Density,

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

10.1.3 Percent Closed Cell (Type I).

10.2 As agreed to by the purchaser and the manufacturer, the inspection of the material shall be made at either the point of shipment or point of delivery.

## 11. Test Methods

### 11.1 Sample Preparation:

11.1.1 In cases where the material is cut into pipe insulation and other shapes without further treatment, slab foam test

results are generally representative. If other processes are used for specific applications, it is recommended that qualification testing be conducted using slab specimens, and that physical inspection testing be conducted on the processed material.

11.1.2 Tests for physical and mechanical properties shall be carried out at a temperature of  $73.4 \pm 3.6^{\circ}\text{F}$  ( $23 \pm 2^{\circ}\text{C}$ ) and at a relative humidity of  $50 \pm 5\%$ . Thermal and flammability tests shall be carried out at conditions specified in the applicable test methods.

11.2 *Density*—Test Method **D 3574**, Test A.

11.3 *Apparent Thermal Conductivity*—Test Methods **C 177**, **C 1114**, or **C 518** in conjunction with Practice **C 1045**. Test Method **C 518** shall not be used at temperatures or resistances other than those in the range of the calibration. Test temperatures shall be chosen in accordance with Table 3 of Practice **C 1058**. Use the large temperature difference recommended in Table 3 of Practice **C 1058** for temperatures between 25 and 110°F (−4 and 43°C); for mean temperatures under 25°F (−4°C) and over 110°F (43°C) use the smaller temperature difference. For pipe insulations use Test Method **C 335**.

11.4 *Upper Temperature Limit*—Test Method **C 411** and Practice **C 447** shall be used at the maximum use temperature of the insulation and at maximum design thickness. No special requirements for heat-up shall be specified by the manufacturer. The foam shall not flame, glow, smolder, smoke, soften, collapse, melt or drip during hot surface exposure.

11.5 *High Temperature Stability*—Test Method **D 2126** incorporating Test Method **D 638**. Use Test Method **D 2126**, with a modified test temperature of 572°F (300°C) as shown in **Tables 1** and **2**. Test before and after aging using Test Method **D 638**, Type III specimens.

11.6 *Compressive Strength*—Test Method **D 1621**.

11.7 *Compressive Force Deflection*—Test Methods **D 3574**, Test C.

11.8 *Percent Closed Cells*—Test Method **D 2856** incorporating Test Method B—Determination of Open Cell Content, Correcting for Cells Opened in Specimen Preparation. The test specimen shall be a cube having a nominal dimension of 0.984 by 0.984 by 0.984 in. (25 by 25 by 25 mm). Unless otherwise agreed upon, at least five specimens, selected at random, shall be tested. Each cube will be dissected along planes parallel to the sides of each cube.

11.9 *Water Vapor Transmission*—Test Method **E 96**.

11.10 *Steam Aging*—Test Method **D 3574**, Procedure J1 and Test E.

11.11 *Corrosiveness*—Test Method in Specification **C 665**.

11.12 *Chemical Resistance*—Test Method **D 543**, Practice A, Procedure I at room temperature with reagents 6.3.8, 6.3.40, 6.3.46, 6.3.50, aviation turbine fuel grade JP-5 and ethylene glycol antifreeze from **Table 1**, and SKYDROL hydraulic fluid. Final weight and dimensions are to be determined 24 h after removal from immersion.

11.13 *Vertical Burn*—Test Method **FAR 25.853**, **Appendix F**, Part 1, (a) (1) (i).

11.14 *Specific Optical Smoke Density*—Test Method **E 662**.

11.15 *Toxic Gas Generation*—**Boeing BSS 7239**.

11.16 *Surface Burning Characteristics*—Test Method **E 84** and for material used in pipe and duct applications use Practice **E 2231**.

11.17 *¼ Scale Room Burn Test*—See **Annex A1**.

11.18 *Oxygen Index*—Test Method **D 2863**.

## 12. Certification

12.1 When specified in the purchase order or contract, the purchaser shall be furnished certification that samples representing each lot have been either tested or inspected as directed in this specification and the requirements have been met. When specified in the purchase order or contract, a report of the test results shall be furnished. For the purpose of this specification, a lot consists of all material of the same type manufactured in one unchanged production run and offered for delivery at the same time.

## 13. Packaging and Package Marking

13.1 *Packaging*—Unless otherwise specified, the insulation shall be supplied in the manufacturer's standard commercial packaging.

13.2 *Marking*—Unless otherwise specified, each container shall be plainly marked with the manufacturer's name, the product name, trademark, and the manufacturer's address, with dimensions and/or volumes expressed in units agreed upon by the supplier and customer.

## 14. Keywords

14.1 cellular insulation; closed cell; pipe insulation; polyimide; ship insulation; thermal insulation; thermal protection systems