Designation: C1594 – 11 (Reapproved 2017)

Standard Specification for Polyimide Rigid Cellular Thermal Insulation[1]

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/ft^3 to 8.0 lb/ft^3 (16 kg⁄m^3 to 128 kg/m^3) 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.

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 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:*[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

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)

[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.

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 after 1000 hours in air oven at 300°C, (min.)	*	*	*	*	*	95	*	*	*	*
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 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 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

* = 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.

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 Water Vapor Transmission 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 25.855[3]

2.3 *Private Sector Standards:*
Boeing BSS 7239 Test Method for Toxic Gas Generation by Materials on Combustion[4]

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/ft^3 (128 kg/m^3).
4.1.2 *Grade 2*—Densities to 6.0 lb/ft^3 (96 kg/m^3).
4.1.3 *Grade 3*—Densities to 3.0 lb/ft^3 (48 kg/m^3)
4.1.4 *Grade 4*—Densities to 1.5 lb/ft^3 (24 kg/m^3)

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.

[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.

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 polymide 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),
9.1.3 Tensile Strength,
9.1.4 Water and Gas Permeability (Type I), and
9.1.5 Percent Closed Cell.

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.

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 ± 3.6°F (23 ± 2°C) and at a relative humidity of 50 ± 5 %. Thermal and flammability tests shall be carried out at conditions specified in the applicable test methods.

11.2 *Density*—Test Method D3574, Test A.

11.3 *Apparent Thermal Conductivity*—Test Methods C177, C1114, or C518 in conjunction with Practice C1045. Test Method C518 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 C1058. Use the large temperature difference recommended in Table 3 of Practice C1058 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 C335.

11.4 *Upper Temperature Limit*—Test Method C411 and Practice C447 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 D2126 incorporating Test Method D638. Use Test Method D2126, with a modified test temperature of 572°F (300°C) as shown in Table 1 and Table 2. Test before and after aging using Test Method D638, Type III specimens.

11.6 *Compressive Strength*—Test Method D1621.

11.7 *Compressive Force Deflection*—Test Methods D3574, Test C.

11.8 *Percent Closed Cells*—Test Method D6226 incorporating Appendix X1, Correcting for Cells Opened During Specimen Preparation. The test specimen shall be a cube having a nominal dimension of 0.984 by 0.984 by 0.984 in. (2.50 by 2.50 by 2.50 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 E96/E96M, Procedure B, Water Method.

11.10 *Steam Aging*—Test Method D3574, Procedure J1 and Test E.

11.11 *Corrosiveness*—Test Method in Specification C665.

11.12 *Chemical Resistance*—Test Method D543, 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 E662.

11.15 *Toxic Gas Generation*—Boeing BSS 7239.

11.16 *Surface Burning Characteristics*—Test Method E84 and for material used in pipe and duct applications use Practice E2231.

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

11.18 *Oxygen Index*—Test Method D2863.

11.19 *Tumbling Friability*—Test Method C421. The test shall be run for a total of 1200 revolutions (20 min.). The mass loss shall not be greater than 3% after the first 600 ± 3 revolutions(10 min.) and not greater than 5% after the next 600±3 revolutions(10 min.; 20 min. total).

11.20 *Odor Emission*—Test Method C1304. A strong and objectionable odor shall not be detected by more than two judges.

11.21 *Fungi Resistance*—Test Method C1338. The foam shall not exhibit greater growth than the comparative item.

11.22 *Wicking*—Test Method C1559, Procedure A. Only the room temperature water test shall be used and for only 48 h, ± 2 h. Wicking shall not exceed 0.5 in. above the water line. In addition, precipitates shall not form in the water bearing the wicking specimens

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 standard commercial packaging of the manufacturer.

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 or volumes, or both, 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

ANNEX

(Mandatory Information)

A1. SUPPLEMENTAL REQUIREMENTS TO POLYIMIDE CELLULAR THERMAL INSULATION FOR MARINE APPLICATIONS

A1.1 Scope

A1.1.1 This annex gives the requirements for fire resistant thermal polyimide foam insulation panels and for preformed thermal insulation for use on pipes at surface temperatures from 100 to 600°F (38 to 315°C) for use in U.S. Navy shipboard applications.

A1.2 Workmanship

A1.2.1 Material shall be uniform in quality and condition. Material shall be clean and free from foreign materials, contaminates, and defects that will impair material use and serviceability as agreed upon by the supplier and customer.

A1.3 Qualification Requirements

A1.3.1 The following requirements are generally employed for initial material or product qualification with the U.S. government. When specified in the contract or order, a certificate of compliance shall be prepared. Fire, acoustic and thermal test results in the certificate of compliance shall be less than three years old. Any changes in basic ingredients or process in an U.S. Navy contract shall be promptly reported to both the contracting activity and Commander, Naval Sea Systems Command (NAVSEA).

A1.4 Test Methods

A1.4.1 Determination of the flashover potential of a lining material using a quarter-scale room fire test.

A1.4.2 *Scope:*

A1.4.2.1 This method describes a procedure to determine the flashover potential of materials in a room when subjected to a fire exposure. The method described will yield a time from the introduction of the fire exposure until the moment of flashover. The information contained herein is intended for compliance.

A1.4.2.2 This method is used to measure and describe the response of materials, products or assemblies to heat and flame under controlled laboratory conditions, but does not incorporate all factors required for fire hazard or fire risk assessment of materials, products, or assemblies under actual fire conditions.

A1.4.3 *Significance and Use*—In the interest of reducing both set-up time and cost associated with fire testing in a full size room (defined as a 10 ft (3.05 m) long by 10 ft (3.05 m) wide by 8 ft (2.44 m) high room having a 30 in. (76.2 cm) wide by 80 in. (203 cm) high doorway), a one-quarter scale room fire test was devised to predict flashover potential of lining materials.

A1.4.4 *Equipment:*

A1.4.4.1 The quarter-scale room shall be constructed from a suitable insulation board and shall form an airtight box having a ceiling and four sides. The box shall sit on a floor fabricated from the same material. The interior dimensions of the fully lined quarterscale room shall be 30 in. (76.2 cm) long by 30 in. (76.2 cm) wide by 24 in. (61 cm) high. The doorway is located at the center of one wall and shall be 19.5 in. (49.5 cm) wide and 17 in. (43.2 cm) high to secure proper ventilation and fire development. The height between the finished ceiling and top of the doorway shall be 7 in. (17.8 cm). The floor of the model room shall extend at least 12 in. (30.5 cm) outside the doorway. The box shall be removable to allow for application of ceiling and wall covering. The entire base of the box in contact with the floor shall be airtight.

A1.4.4.2 A porous plate diffusion flame burner shall be used as the fire source. The burner shall be 3.5 in. (8.9 cm) long by 3.5 in. (8.9 cm) wide by 3 in. (7.6 cm) high, consisting of horizontal porous plate area of 3 by 3 in. (7.6 by 7.6 cm) with 0.25 in. (0.64 cm) wide steel plate perimeter and steel plate sides and bottom.

A1.4.4.3 Four 10 mil chromel-alumel thermocouples shall be used, 1 in. (2.5 cm) and 3 in. (7.6 cm) below the center of the overhead and 1 in. (2.5 cm) and 2 in. (5.1 cm) below the top of the doorway.

A1.4.5 *Procedure:*

A1.4.5.1 The test material shall fully line the walls and ceiling.

A1.4.5.2 Prior to testing, the fully lined test room shall be conditioned for at least 24 h at a relative humidity between 20 and 60 %, and a temperature of 73 ± 9°F (23 ± 5°C).

A1.4.5.3 The fire source shall be positioned on the floor snugly against one rear corner of the test room. A flow rate of 0.32 ft^3/min (0.15 1/s) methane shall be used to produce a constant heat input of approximately 320 Btu (338 kJ) for the duration of the test.

A1.4.5.4 The test data from the four thermocouples shall be recorded as a continuous function of time.

A1.4.5.5 The primary data generated by this test will be the time to flashover, if it occurs, and the maximum temperature if flashover is not reached. Flashover is characterized by thermal flux levels equal to or greater than 12.9 W/$in.^2$ (2 W/cm^2) at the floor level. This corresponds to interior temperatures of 1,112°F (600°C) and higher, and doorway temperatures of 932°F (500°C) and higher. For this test purpose, flashover is defined as the fire condition when one of the interior thermocouple measurements reaches 1,112°F (600°C) or one of the doorway measurements reaches 932°F (500°C), whichever occurs first.

A1.4.5.6 A color photographic record shall be made of the material before the test, at the point of maximum involvement and after the fire has been extinguished.

A1.4.6 *Precision and Bias*—No information is presented about either the precision or bias of Test Method for flashover potential of a lining material using a quarter-scale room fire since the test result is nonquantitative.

APPENDIX

(Nonmandatory Information)

X1. RATIONALE

X1.1 This specification covers the composition and physical properties of lightweight, closed cell polyimide. The Annex is intended to incorporate Navy requirements into an ASTM commercial specification. The foam is used as thermal insulation for a wide variety of industrial and commercial applications. U.S. Navy and marine applications are one of the major markets. Several different polyimide foam products with different requirements are sold into numerous specialty markets where polyimide foam has proven performance.