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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 ~~Tables 1 and 2~~ 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 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:*[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

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[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										
Change in tensile Strength % (max.)	25	25	25	25	25	25	25	25	25	25
Dimensional and weight changes % (max.)	10	10	10	10	10	10	10	10	10	10
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										
Flame Spread Index, (max.)	10	10	10	10	10	10	10	10	10	10
Smoke Developed Index, (max.)	15	15	15	15	15	15	15	15	15	15
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~~										
~~Avg. Dm. Flaming Exposure (max.)~~	~~0~~	~~1~~	~~1~~	~~2~~	~~2~~	~~2~~	~~5~~	~~5~~	~~5~~	~~1~~
~~Avg. Dm. Non-Flaming Exposure (max.)~~	~~0~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~3~~	~~3~~	~~3~~	~~1~~
Specific Optical Density										
Avg. Dm. Flaming Exposure (max.)	3	2	1	2	2	2	5	5	5	1
Avg. Dm. Non-Flaming Exposure (max.)	3	2	1	1	1	1	3	3	3	1
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~~										
~~Flaming~~	~~62.5~~	~~62.5~~	~~62.5~~	~~300~~	~~300~~	~~300~~	~~300~~	~~300~~	~~300~~	~~125~~
~~Non-Flaming~~	~~1~~	~~1~~	~~1~~	~~10~~	~~10~~	~~10~~	~~10~~	~~10~~	~~10~~	~~3~~
Carbon Monoxide										
Flaming	275	200	100	300	300	300	300	300	300	125
Non-Flaming	3	2	1	10	10	10	10	10	10	3
~~Hydrogen Fluoride~~										
~~Flaming~~	~~0~~	~~0~~	~~0~~	~~5~~	~~5~~	~~5~~	~~5~~	~~5~~	~~5~~	~~2~~
~~Non-Flaming~~	~~0~~	~~0~~	~~0~~	~~5~~	~~5~~	~~5~~	~~5~~	~~5~~	~~5~~	~~2~~
Hydrogen Fluoride										
Flaming	5	4	4	5	5	5	5	5	5	2
Non-Flaming	5	4	4	5	5	5	5	5	5	2
~~Hydrogen Chloride~~										
~~Flaming~~	~~1~~	~~1~~	~~1~~	~~10~~	~~10~~	~~10~~	~~10~~	~~10~~	~~10~~	~~3~~
~~Non-Flaming~~	~~1~~	~~1~~	~~1~~	~~10~~	~~10~~	~~10~~	~~10~~	~~10~~	~~10~~	~~3~~
Hydrogen Chloride										
Flaming	9	7	5	10	10	10	10	10	10	3
Non-Flaming	9	7	5	10	10	10	10	10	10	3
~~Nitrogen Oxides~~										
~~Flaming~~	~~4.5~~	~~4.5~~	~~4.5~~	~~10~~	~~10~~	~~10~~	~~10~~	~~10~~	~~10~~	~~6~~
~~Non-Flaming~~	~~1~~	~~1~~	~~1~~	~~10~~	~~10~~	~~10~~	~~10~~	~~10~~	~~10~~	~~3~~
Nitrogen Oxides										
Flaming	10	10	10	10	10	10	10	10	10	6
Non-Flaming	10	10	10	10	10	10	10	10	10	3
~~Sulfur Dioxide~~										
~~Flaming~~	~~0~~	~~0~~	~~0~~	~~5~~	~~5~~	~~5~~	~~5~~	~~5~~	~~5~~	~~2~~
~~Non Flaming~~	~~0~~	~~0~~	~~0~~	~~5~~	~~5~~	~~5~~	~~5~~	~~5~~	~~5~~	~~2~~
Sulfur Dioxide										
Flaming	5	5	5	5	5	5	5	5	5	2
Non Flaming	5	5	5	5	5	5	5	5	5	2
~~Hydrogen Cyanide~~										
~~Flaming~~	~~2~~	~~2~~	~~2~~	~~5~~	~~5~~	~~5~~	~~10~~	~~10~~	~~10~~	~~4~~
~~Non Flaming~~	~~1~~	~~1~~	~~1~~	~~5~~	~~5~~	~~5~~	~~5~~	~~5~~	~~5~~	~~3~~
Hydrogen Cyanide										
Flaming	5	5 2	5	5	5	5	10	10	10	4
Non Flaming	5	5	5	5	5	5	5	5	5	3
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

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										
Change in tensile Strength % (max)	25	25	25	25	25	25	25	25	25	25
Dimensional and weight changes % (max)	10	10	10	10	10	10	10	10	10	10
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										
Flame Spread Index, (max.)	10	10	10	10	10	10	10	10	10	10
Smoke Developed Index, (max.)	15	15	15	15	15	15	15	15	15	15
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~~										
~~Avg. Dm. Flaming Exposure (max)~~	~~0~~	~~1~~	~~1~~	~~2~~	~~2~~	~~2~~	~~5~~	~~5~~	~~5~~	~~1~~
~~Avg. Dm. Non-Flaming Exposure (max.)~~	~~0~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~3~~	~~3~~	~~3~~	~~1~~
Specific Optical Density										
Avg. Dm. Flaming Exposure (max)	3	2	1	2	2	2	5	5	5	1
Avg. Dm. Non-Flaming Exposure (max.)	3	2	1	1	1	1	3	3	3	1
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~~										
~~Flaming~~	~~62.5~~	~~62.5~~	~~62.5~~	~~300~~	~~300~~	~~300~~	~~300~~	~~300~~	~~300~~	~~125~~
~~Non-Flaming~~	~~1~~	~~1~~	~~1~~	~~10~~	~~10~~	~~10~~	~~10~~	~~10~~	~~10~~	~~3~~
Carbon Monoxide										
Flaming	275	200	100	300	300	300	300	300	300	125
Non-Flaming	3	2	1	10	10	10	10	10	10	3
~~Hydrogen Fluoride~~										
~~Flaming~~	~~0~~	~~0~~	~~0~~	~~5~~	~~5~~	~~5~~	~~5~~	~~5~~	~~5~~	~~2~~
~~Non-Flaming~~	~~0~~	~~0~~	~~0~~	~~5~~	~~5~~	~~5~~	~~5~~	~~5~~	~~5~~	~~2~~
Hydrogen Fluoride										
Flaming	5	4	3	5	5	5	5	5	5	2
Non-Flaming	5	4	3	5	5	5	5	5	5	2
~~Hydrogen Chloride~~										
~~Flaming~~	~~1~~	~~1~~	~~1~~	~~10~~	~~10~~	~~10~~	~~10~~	~~10~~	~~10~~	~~3~~
~~Non-Flaming~~	~~1~~	~~1~~	~~1~~	~~10~~	~~10~~	~~10~~	~~10~~	~~10~~	~~10~~	~~3~~
Hydrogen Chloride										
Flaming	9	7	5	10	10	10	10	10	10	3
Non-Flaming	9	7	5	10	10	10	10	10	10	3
~~Nitrogen Oxides~~										
~~Flaming~~	~~4.5~~	~~4.5~~	~~4.5~~	~~10~~	~~10~~	~~10~~	~~10~~	~~10~~	~~10~~	~~6~~
~~Non-Flaming~~	~~1~~	~~1~~	~~1~~	~~10~~	~~10~~	~~10~~	~~10~~	~~10~~	~~10~~	~~3~~
Nitrogen Oxides										
Flaming	10	10	10	10	10	10	10	10	10	6
Non-Flaming	10	10	10	10	10	10	10	10	10	3
~~Sulfur Dioxide~~										
~~Flaming~~	~~0~~	~~0~~	~~0~~	~~5~~	~~5~~	~~5~~	~~5~~	~~5~~	~~5~~	~~2~~
~~Non-Flaming~~	~~0~~	~~0~~	~~0~~	~~5~~	~~5~~	~~5~~	~~5~~	~~5~~	~~5~~	~~2~~
Sulfur Dioxide										
Flaming	5	5	5	5	5	5	5	5	5	2
Non-Flaming	5	5	5	5	5	5	5	5	5	2
~~Hydrogen Cyanide~~										
~~Flaming~~	~~2~~	~~2~~	~~2~~	~~5~~	~~5~~	~~5~~	~~10~~	~~10~~	~~10~~	~~4~~
~~Non-Flaming~~	~~1~~	~~1~~	~~1~~	~~5~~	~~5~~	~~5~~	~~5~~	~~5~~	~~5~~	~~3~~
Hydrogen Cyanide										
Flaming	5	5	5	5	5	5	10	10	10	4
Non-Flaming	5	5	5	5	5	5	5	5	5	3
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