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Standard Specification for Flexible Aerogel Insulation¹

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1. Scope

1.1 This specification covers the classification and performance of flexible aerogel thermal insulation. This will cover the range of continuous exposure operating temperatures from -321°F (-196°C) up to 1200°F (649°C).

1.2 For satisfactory performance, properly installed protective vapor retarders or barriers shall be used on below ambient temperature applications to reduce movement of moisture through or around the insulation to the colder surface. Failure to use a vapor retarder or barrier could lead to insulation and system non-performance.

1.3 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.

1.4 The following safety hazards caveat pertains only to the test methods described in this specification. *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.*

1.5 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*²

C165 Test Method for Measuring Compressive Properties of Thermal Insulations

¹ This specification is under the jurisdiction of ASTM Committee C16 on Thermal Insulation and is the direct responsibility of Subcommittee C16.23 on Blanket and Loose Fill Insulation.

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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.

- C167** Test Methods for Thickness and Density of Blanket or Batt Thermal Insulations
- 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
- C303** Test Method for Dimensions and Density of Preformed Block and Board-Type Thermal Insulation
- C335** Test Method for Steady-State Heat Transfer Properties of Pipe Insulation
- C356** Test Method for Linear Shrinkage of Preformed High-Temperature Thermal Insulation Subjected to Soaking Heat
- C390** Practice for Sampling and Acceptance of Thermal Insulation Lots
- C411** Test Method for Hot-Surface Performance of High-Temperature 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
- C795** Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel
- 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
- C1101/C1101M** Test Methods for Classifying the Flexibility or Rigidity of Mineral Fiber Blanket and Board Insulation
- C1104/C1104M** Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation
- C1114** Test Method for Steady-State Thermal Transmission Properties by Means of the Thin-Heater Apparatus
- C1338** Test Method for Determining Fungi Resistance of Insulation Materials and Facings
- C1617** Practice for Quantitative Accelerated Laboratory Evaluation of Extraction Solutions Containing Ions Leached from Thermal Insulation on Aqueous Corrosion of Metals
- C1763** Test Method for Water Absorption by Immersion of Thermal Insulation Materials
- E84** Test Method for Surface Burning Characteristics of Building Materials

E2231 Practice for Specimen Preparation and Mounting of Pipe and Duct Insulation Materials to Assess Surface Burning Characteristics

2.2 *Other Standards*.³

CAN/ULC-S102 Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies

3. Terminology

3.1 *Definitions*: For definitions used in this specification, see Terminology A3.

3.1.1 *flexible aerogel insulation, n*—a flexible insulation containing a composite of aerogel, fibrous carrying media, or reinforcements, or a combination thereof.

3.1.1.1 *Discussion*—Opacifiers are sometimes added as either fibers or powders.

3.2 *Abbreviations*:

3.2.1 *N/A*—Not applicable.

4. Classification

4.1 Flexible aerogel insulation shall be classified into five Types based on the maximum use temperature:

4.1.1 *Type I*—257°F (125°C)

4.1.2 *Type II*—390°F (200°C)

4.1.3 *Type III*—1200°F (649°C)

4.1.4 *Type IV*—482°F (250°C)

4.1.5 *Type V*—1200°F (649°C)

4.2 Type I is subdivided as Grade 1 (tested in flat configuration) and Categories A or B by thermal conductivity.

4.3 Type II comprises Grade 1 (tested in flat configuration) and Category A.

4.4 Type III is subdivided into two Grades 1 and 2 whereby Grade 1 is tested in a flat configuration using Test Method C177 and Grade 2 is tested only in a pipe configuration using Test Method C335. Grade 1 is subdivided into Categories A and B. Category A evaluates maximum use temperature and exothermic temperature rise with test apparatus at the materials maximum use temperature. Category B allows those evaluations to be conducted with the test apparatus ramping up to the maximum use temperature.

4.5 Type IV comprises Grade 1 (tested in flat configuration) and Category A.

4.6 Type V comprises Grade 1 (tested in flat configuration) and Category A.

5. Ordering Information

5.1 The Type, Grade, Category, dimensions, and thickness shall be specified by the purchaser. A product certification (if required) shall be specified in the purchase order.

6. Materials and Manufacture

6.1 *Composition*—Flexible aerogel insulation is a composite of an amorphous silica-based aerogel, a fibrous carrying media,

or reinforcements, or a combination thereof, that allow the construct to be flexible.

6.1.1 A fibrous carrying media or reinforcement, or both, consists of the following: fibers, batts, strips, sheets, or some combination thereof.

6.1.1.1 This fibrous carrying media or reinforcement material, or both, is either organic, such as polyester, or inorganic, such as glass fibers. Additionally, some flexible aerogel insulation contains additives such as a water resistant treatment or opacifiers, or both.

7. Physical, Mechanical and Chemical Property Requirements

NOTE 1—Performance requirements for flexible aerogel insulation (Type I Grade 1 Category A, Type I Grade 1 Category B, Type II Grade 1 Category A, Type III Grade 1 Category A, Type III Grade 1 Category B, Type III Grade 2 Category A, Type IV Grade 1 Category A, and Type V Grade 1 Category A) are given in Table 1.

7.1 *Maximum Use Temperature*—Test in accordance with Test Method C411 and the hot surface performance of Practice C447 at the maximum use temperature of the insulation in flat configuration. The test thickness shall be 3.2 in. (80 mm) or the manufacturer's maximum recommended thickness and tested without metal jacketing or other protective layers. The flexible aerogel insulation shall not flame or glow during hot surface exposure. No evidence of melting or fiber degradation shall be evident upon post test inspection. The test surface shall be at the maximum use temperature specified in Table 1 for all Types except Type III, Grade 1 Category B, when the insulation is applied. For Type III Grade 1 Category B materials a temperature ramp of the test surface is permissible and shall be a minimum of 300°F (167°C)/h and detailed in the test report.

7.2 *Thickness and Density*—The thickness and density shall be determined and reported in accordance with Test Methods C167 or C303.

7.3 *Apparent Thermal Conductivity*:

7.3.1 Determine the thermal conductivity as a function of temperature for the representative specimens with data obtained from a series of thermal tests utilizing Test Methods C177, C518, C1114, or C335 as appropriate for the material under study. Specimen shall be tested unfaced and, for Type III, Grade 2 (pipe configuration per Test Method C335), test at a minimum of 4 layers. Each layer shall have a minimum thickness of 0.2 in. (5 mm). The test report shall state the barometric pressure at the time of the tests. See Note 2 below.

7.3.2 As specified in Practice C1045, the range of test conditions must include at least one test where the hot surface temperature is greater than, or equal to, the hot limit of the temperature range of desired data and at least one test where the cold temperature is less than, or equal to, the cold limit of the temperature range desired. At least two additional tests shall be performed and distributed evenly over the rest of the temperature range.

7.3.3 Final analysis of the thermal data shall be conducted in accordance with Practice C1045 to generate a thermal conductivity versus temperature relationship for the specimen.

7.3.4 The final step of Practice C1045 analysis is to calculate the thermal conductivity using the equations generated at a set of mean temperatures for comparison to the specification.

³ Available from Underwriters Laboratories (UL), 2600 N.W. Lake Rd., Camas, WA 98607-8542, <http://www.ul.com>.

TABLE 1 Performance Requirements for Types I, II, III, and IV Flexible Aerogel Insulation

Type	I	I	II	III	III	III	IV	V
Grade	1	1	1	1	1	2	1	1
Category	A	B	A	A	B	A	A	A
Maximum use temperature, °F (°C)	257 (125)	257 (125)	390 (199)	1200 (649)	1200 (649)	1200 (649)	482 (250)	1200 (649)
Minimum use temperature, °F (°C)	-321 (-196)	-321 (-196)	-321 (-196)	75 (24)	75 (24)	75 (24)	-321 (-196)	75 (24)
Minimum / Maximum Composite Density, lbs/ft ³ (kg/m ³)	1.9 to 6.3 (30 to 100)	5.0 to 11.2 (80 to 180)	4.7 to 9.4 (75 to 150)	10.0 to 15.0 (160 to 240)	10.0 to 15.0 (160 to 240)	10.0 to 15.0 (160 to 240)	10.0 to 15.0 (160 to 240)	7.5 to 11.2 (120 to 180)
Apparent thermal conductivity, max, Btu•in/h•ft ² •°F (W/m•K)								
Mean Temperature, °F (°C)								
-200 (-129)	0.098 (0.014)	0.096 (0.014)	0.073 (0.011)	NA	NA	NA	0.10 (0.015)	NA
-100 (-73.3)	0.12 (0.017)	0.10 (0.015)	0.091 (0.013)	NA	NA	NA	0.12 (0.017)	NA
0 (-17.8)	0.14 (0.021)	0.11 (0.016)	0.11 (0.016)	NA	NA	NA	0.14 (0.020)	NA
75 (23.9)	0.17 (0.024)	0.12 (0.017)	0.13 (0.019)	0.14 (0.021)	0.14 (0.021)	0.16 (0.023)	0.15 (0.022)	0.20 (0.029)
100 (37.8)	0.17 (0.025)	0.12 (0.017)	0.14 (0.020)	0.15 (0.022)	0.15 (0.022)	0.17 (0.024)	0.15 (0.022)	0.22 (0.032)
200 (93.3)	0.21 (0.030)	0.13 (0.019)	0.18 (0.025)	0.16 (0.023)	0.16 (0.023)	0.18 (0.024)	0.16 (0.023)	0.26 (0.038)
300 (149)	NA	NA	0.22 (0.032)	0.18 (0.025)	0.18 (0.025)	0.21 (0.028)	0.17 (0.025)	0.30 (0.043)
400 (204)	NA	NA	NA	0.20 (0.029)	0.20 (0.029)	0.24 (0.033)	0.20 (0.029)	0.34 (0.049)
500 (260)	NA	NA	NA	0.22 (0.032)	0.22 (0.032)	0.28 (0.035)	NA	0.39 (0.056)
600 (316)	NA	NA	NA	0.25 (0.036)	0.25 (0.036)	0.33 (0.040)	NA	0.44 (0.064)
700 (371)	NA	NA	NA	0.30 (0.043)	0.30 (0.043)	0.39 (0.048)	NA	0.51 (0.073)
Compressive resistance, min, @ 10% deformation, psi (kPa)	0.75 (5.2)	5 (34.5)	5 (34.5)	3 (20.7)	3 (20.7)	3 (20.7)	5 (34.5)	3 (20.7)
Surface burning characteristics: Flame spread index, max Smoke developed, max	Not Rated	25 50	Not Rated	5 10	5 10	5 10	25 50	5 10
Exothermic temperature rise, maximum, with no facings or jacketing of any type, run at maximum recommended thickness	NA	NA	NA	200°F (111°C)	200°F (111°C)	200°F (111°C)	200°F (111°C)	200°F (111°C)
Water absorption, maximum % by weight After conditioning at 600°F (316°C) for 24 h	150 % NA	8 % NA	8 % NA	8 % 16 %	8 % 16 %	8 % 16 %	8 % NA	8 % 16 %

7.3.5 Practice **C1058** shall be used to obtain recommended test temperature combinations for testing purposes.

7.4 *Flexibility*—When tested at the installed thickness in accordance with the Test Methods **C1101/C1101M**, the sheet must qualify as flexible.

7.5 *Corrosiveness to Steel*—When tested in accordance with Practice **C1617**, the mass loss corrosion rate of the unfaced insulation extract shall not exceed that of the 5-ppm chloride solution. Test the composite insulation material (with facing

and adhesive) when a facing is factory adhered by the manufacturer or the fabricator.

7.6 *Water Vapor Sorption*—When tested in accordance the Test Method **C1104/C1104M**, the water vapor sorption of the flexible insulation shall be not more than 5 % by weight.

7.7 *Fungi Resistance*—When tested in accordance with the fungi resistance Test Method **C1338**, the test specimens shall have no growth greater than that on a comparative item (white birch wood).