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Standard Specification for Beryllia Ceramics for Electronic and Electrical Applications¹

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1. Scope

1.1 This specification covers fabricated beryllia parts suitable for electronic and electrical applications. This standard specifies limits and methods of test for electrical, mechanical, thermal, and general properties of the bodies used for these fabricated parts, regardless of geometry.

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

2. Referenced Documents

2.1 ASTM Standards:

- C 20 Test Methods for Apparent Porosity, Water Absorption, Apparent Specific Gravity, and Bulk Density of Burned Refractory Brick and Shapes by Boiling Water²
- C 108 Symbols for Heat Transmission²
- C 242 Terminology of Ceramic Whitewares and Related Products.³
- C 351 Test Method for Mean Specific Heat of Thermal Insulation⁴
- C 408 Test Method for Thermal Conductivity of Whiteware Ceramics³
- C 573 Methods for Chemical Analysis of Fireclay and High-Alumina Refractories⁵
- C 623 Test Method for Young's Modulus, Shear Modulus, and Poisson's Ratio for Glass and Glass-Ceramics by Resonance³
- C 773 Test Method for Compressive (Crushing) Strength of Fired Whiteware Materials³
- D 116 Methods of Testing Vitrified Ceramic Materials for Electrical Applications⁶
- D 149 Test Methods for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials

- at Commercial Power Frequencies⁶
- D 150 Test Methods for A-C Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulating Materials^{6,7}
- D 257 Test Methods for D-C Resistance or Conductance of Insulating Materials⁶
- D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing⁸
- D 1711 Terminology Relating to Electrical Insulation⁶
- D 1829 Test Method for Electrical Resistance of Ceramic Materials at Elevated Temperatures⁶
- D 2149 Test Method for Permittivity (Dielectric Constant) and Dissipation Factor of Solid Ceramic Dielectrics at Frequencies to 10 MHz and Temperatures to 500°C⁶
- D 2520 Test Methods for Complex Permittivity (Dielectric Constant) of Solid Electrical Insulating Materials at Microwave Frequencies and Temperatures to 1650°C⁷
- E 6 Terminology Relating to Methods of Mechanical Testing⁹
- E 12 Terminology Relating to Density and Specific Gravity of Solids, Liquids, and Gases¹⁰
- E 122 Practice for Choice of Sample Size to Estimate a Measure of Quality for a Lot or Process¹¹
- E 165 Practice for Liquid Penetrant Inspection Method¹²
- E 228 Test Method for Linear Thermal Expansion of Solid Materials with a Vitreous Silica Dilatometer¹¹
- F 19 Test Method for Tension and Vacuum Testing Metalized Ceramic Seals¹³
- F 77 Test Method for Apparent Density of Ceramics for Electron Device and Semiconductor Application³
- F 109 Terminology Relating to Surface Imperfections on Ceramics³
- F 134 Test Methods for Determining Hermeticity of Electron Devices with a Helium Mass Spectrometer Leak Detector¹³

¹ This specification is under the jurisdiction of Committee C-21 on Ceramic Whitewares and Related Products and is the direct responsibility of Subcommittee C21.03 on Fundamental Properties.

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² *Annual Book of ASTM Standards*, Vol 15.01.

³ *Annual Book of ASTM Standards*, Vol 15.02.

⁴ *Annual Book of ASTM Standards*, Vol 04.06

⁵ *Annual Book of ASTM Standards*, Vol 03.05.

⁶ *Annual Book of ASTM Standards*, Vol 10.01.

⁷ *Annual Book of ASTM Standards*, Vol 10.02.

⁸ *Annual Book of ASTM Standards*, Vols 08.01 and 10.01.

⁹ *Annual Book of ASTM Standards*, Vol 03.01.

¹⁰ *Annual Book of ASTM Standards*, Vol 15.05.

¹¹ *Annual Book of ASTM Standards*, Vol 14.02.

¹² *Annual Book of ASTM Standards*, Vol 03.03.

¹³ *Annual Book of ASTM Standards*, Vol 10.04.

F 417 Test Method for Flexural Strength (Modulus of Rupture) of Electronic-Grade Ceramics³

2.2 Military Standards:

MIL-STD-105 Sampling Procedures and Tables for Inspection of Attributes¹⁴

MIL-STD-883 Test Methods and Procedures for Microelectronics¹⁴

2.3 American National Standard:

ANSI B46.1 Surface Texture¹⁵

3. Terminology

3.1 Definitions:

3.1.1 The definitions of terms found in the following ASTM standards apply to this specification: Symbols C 108 and Definitions C 242, D 1711, E 6, E 12, and F 109.

4. Classification

4.1 Ceramics covered by this specification shall be classified by beryllia content as follows:

Type	Beryllia Content, Weight Percent Minimum
I	95
II	98
III	99

NOTE 1—Beryllia content alone does not control physical and electrical properties. Both purchaser and manufacturer must be in accord where stricter control of additives is required as additives affect the chemical resistance, thermal, mechanical, and electrical properties as well as microstructure.

5. Ordering Information

5.1 Purchase orders for ceramic parts furnished to this specification shall include the following information:

5.1.1 Type designation (see 3.1),

5.1.2 Surface finish and allowable defect limits, if required (Definitions F 109, ANSI B46.1, and Appendix X1),

5.1.3 Part drawing with dimensional tolerances (Appendix X1),

5.1.4 Specific tests (if required),

5.1.5 Certification (if required), and

5.1.6 Packaging and marking.

NOTE 2—*Toxicity of Beryllia*—In working with beryllia ceramics, personnel should avoid exposure to dust or fume producing operations such as sawing, grinding, drilling, or processing moist atmospheres at temperatures in excess of 1200°C. Specialized equipment is necessary to prevent the dispersal of dust and fumes into the air.

6. Requirements

6.1 This material shall conform to the electrical, mechanical, thermal, and general property requirements specified in Table 1, Table 2, Table 3, and Table 4.

6.2 Dimensional and surface finish requirements of the parts shall be as agreed between manufacturer and purchaser; however, guidance for establishing such agreement is provided in Appendix X1.

6.3 Visual Requirements:

6.3.1 Parts shall be uniform in color and texture. Cracks, blisters, holes, porous areas, inclusions, adherent foreign particles and surface imperfections, such as pits, pocks, chips (open and closed), surface marks, fins, ridges, and flow lines shall be limited by mutual agreement between the manufacturer and purchaser. Limiting dimensions for these defects, when required for clarification, will be listed in the parts drawing or purchase description. For definitions of the surface imperfections enumerated above, see Definitions F 109.

6.3.2 For hermetic seal applications at least ¾ of the width of the seal surface shall remain intact at the location of any defect.

6.3.3 On other surfaces the limits for defects are such that the dimensional tolerances of the part are not affected at the location of the defect.

7. Test Specimens

7.1 The preferred specimens for test are, where possible, the actual part. When necessary, however, specific test specimens shall be prepared from the same batch of material and by the same processes as those employed in fabricating the ceramic part insofar as possible.

8. Specimen Preparation

8.1 The specimens for tests described in 9.1-9.3 shall be preconditioned in accordance with Procedure A of Methods D 618, unless otherwise specified.

TABLE 1 Electrical Requirements

Property	Type I	Type II	Type III
Dielectric constant, max 25°C:			
at 1 MHz	7.0	7.0	7.0
at 10 GHz	6.8	6.8	6.9
Dissipation factor, max 25°C:			
at 1 MHz	0.0005	0.0005	0.0004
at 10 GHz	0.001	0.001	0.001
Volume resistivity, min, Ω·cm:			
at 25°C	10 ¹⁴	10 ¹⁵	10 ¹⁵
at 300°C	10 ¹¹	10 ¹²	10 ¹²
at 500°C	10 ¹⁰	10 ¹¹	10 ¹¹
at 700°C	10 ⁹	10 ⁹	10 ⁹
at 900°C	10 ⁶	10 ⁸	10 ⁸
T _e Value, °C (°F)	1100 (2012)	1200 (2192)	1250 (2282)
Dielectric strength, min, 3.18 mm (0.125 in.) kV/mm (V/mil)	11.9 (300)	11.9 (300)	11.9 (300)

¹⁴ Available from Standardization Documents, Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

¹⁵ Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.