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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Specification for Alumina Ceramics for Electrical and Electronic Applications¹

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1. Scope

1.1 This specification covers the requirements for fabricated alumina parts suitable for electronic and electrical applications and ceramic-to-metal seals as used in electron devices. 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 part geometry.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are 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 Products³

C 408 Test Method for Thermal Conductivity of Whiteware Ceramics³

C 573 Methods for Chemical Analysis of Fireclay and High-Alumina Refractories⁴

C 623 Test Method for Young's Modulus, Shear Modulus, and Poisson's Ratio for Glass and Glass-Ceramics by Resonance³

D 116 Methods of Testing Vitrified Ceramic Materials for Electrical Applications⁵

D 149 Test Methods for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies⁵

D 150 Test Methods for A-C Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulating Materials⁵

D 257 Test Methods for D-C Resistance or Conductance of Insulating Materials⁵

D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing⁶

D 1711 Terminology Relating to Electrical Insulation⁵

D 1829 Test Method for Electrical Resistance of Ceramic Materials at Elevated Temperatures⁵

D 2149 Test Method for Permittivity (Dielectric Constant) and Dissipation Factor of Solid Ceramic Dielectrics at Frequencies to 10 MHz and Temperatures to 500°C⁵

D 2520 Test Method 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 Testing⁸

E 12 Terminology Relating to Density and Specific Gravity of Solids, Liquids, and Gases⁹

E 122 Practice for Choice of Sample Size to Estimate a Measure of Quality for a Lot or Process¹⁰

E 165 Practice for Liquid Penetrant Inspection Method¹¹

E 228 Test Method for Linear Thermal Expansion of Solid Materials with a Vitreous Silica Dilatometer¹⁰

F 19 Test Method for Tension and Vacuum Testing Metalized Ceramic Seals¹²

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 Detector¹²

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

2.2 Other Standards:

MIL-STD-105 Sampling Procedures and Tables for Inspection by Attributes¹³

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.

This specification also includes material and suggestions provided by ASTM Committee D-9 on Electrical and Electronic Insulating Materials.

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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 03.05.

⁵ *Annual Book of ASTM Standards*, Vol 10.01.

⁶ *Annual Book of ASTM Standards*, Vol 08.01.

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

⁸ *Annual Book of ASTM Standards*, Vol 03.01.

⁹ *Annual Book of ASTM Standards*, Vol 15.05.

¹⁰ *Annual Book of ASTM Standards*, Vol 14.02.

¹¹ *Annual Book of ASTM Standards*, Vol 03.03.

¹² *Annual Book of ASTM Standards*, Vol 10.04.

¹³ Available from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.

MIL-STD-883 Test Methods and Procedures for Microelectronics¹⁴
ANSI B46.1 Surface Texture¹⁵

3. Terminology

3.1 Definitions:

3.1.1 The applicable definitions of terms in the following documents shall apply to this specification: Symbols C108, 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 alumina content as follows:

Type	Alumina Content Weight percent, min
I	82
II	93
III	97
IV	99

5. Basis of Purchase

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 Packing and marking.

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.

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 West 42nd Street, 13th Floor, New York, NY 10036.

TABLE 1 Electrical Requirements

Property	Type I	Type II	Type III	Type IV
Dielectric constant, max 25°C:				
at 1 MHz	8.8	9.6	9.8	10.1
at 10 GHz	8.7	9.6	9.8	10.1
Dissipation factor, max 25°C:				
at 1 MHz	0.002	0.001	0.0005	0.0002
at 10 GHz	0.002	0.001	0.0005	0.0002
Volume resistivity, min Ω-cm:				
at 25°C	10 ¹⁴	10 ¹⁴	10 ¹⁴	10 ¹⁴
at 300°C	1 × 10 ¹⁰	1 × 10 ¹⁰	1 × 10 ¹⁰	7 × 10 ¹⁰
at 500°C	4 × 10 ⁷	2 × 10 ⁷	8 × 10 ⁷	1 × 10 ⁸
at 700°C	4 × 10 ⁶	2 × 10 ⁶	6 × 10 ⁶	1 × 10 ⁷
at 900°C	4 × 10 ⁵	2 × 10 ⁵	8 × 10 ⁵	1 × 10 ⁶
Dielectric strength:				
3.175 mm (0.125 in.) min kV/mm	9.85 (250 V/mil)	9.85 (250 V/mil)	9.85 (250 V/mil)	9.85 (250 V/mil)

TABLE 2 Mechanical Requirements

Property	Type I	Type II	Type III	Type IV
Flexural strength, min avg, ^A MPa (psi)	240 (35 000)	275 (40 000)	275 (40 000)	275 (40 000)
Modulus of elasticity, min, GPa (psi)	215 (31 × 10 ⁶)	275 (40 × 10 ⁶)	310 (45 × 10 ⁶)	345 (50 × 10 ⁶)
Poisson's ratio, average	0.20 to 0.25	0.20 to 0.25	0.20 to 0.25	0.20 to 0.25

^AMaximum permissible coefficient of variation is 10 percent.

6.2 Dimensional and surface finish requirements of the parts shall be as agreed between the supplier and the purchaser; however, guidance for establishing such an 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, and adherent foreign particles shall not be permitted. The limits of surface imperfections such as pits, pocks, chips (open or closed), surface marks, fins, ridges, and flow lines shall be set by mutual agreement between the supplier and the 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 Test Methods D 618.

9. Test Methods

9.1 *Dielectric Constant and Dissipation Factor*—Determine in accordance with Test Methods D 150. Determine values at higher frequencies in accordance with Test Methods D 2520.¹⁶ Determine values at higher temperatures in accordance with Test Method D 2149.

9.2 *Volume Resistivity*—Determine in accordance with Test Methods D 257. For elevated temperature measurements use Procedure A of Test Method D 1829.

9.3 *Dielectric Strength*—Run this test under oil in accordance with 6.1.1 of Test Methods D 149, with a rise rate of

¹⁶ For another suitable method see *Dielectric Materials and Applications*, edited by Von Hippel, A., John Wiley and Sons, Inc., New York, N.Y., 1954.