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Standard Specification for Alumina Ceramics for Electrical and Electronic Applications[1]

This standard is issued under the fixed designation D2442; 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 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*:[2]

C20 Test Methods for Apparent Porosity, Water Absorption, Apparent Specific Gravity, and Bulk Density of Burned Refractory Brick and Shapes by Boiling Water
C108 Symbols for Heat Transmission
C242 Terminology of Ceramic Whitewares and Related Products
C408 Test Method for Thermal Conductivity of Whiteware Ceramics
C573 Methods for Chemical Analysis of Fireclay and High-Alumina Refractories (Withdrawn 1995)[3]
C623 Test Method for Young's Modulus, Shear Modulus, and Poisson's Ratio for Glass and Glass-Ceramics by Resonance
D116 Test Methods for Vitrified Ceramic Materials for Electrical Applications
D149 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
D150 Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulation
D257 Test Methods for DC Resistance or Conductance of Insulating Materials
D618 Practice for Conditioning Plastics for Testing
D1711 Terminology Relating to Electrical Insulation
D1829 Test Method for Electrical Resistance of Ceramic Materials at Elevated Temperatures (Withdrawn 2001)[3]
D2149 Test Method for Permittivity (Dielectric Constant) And Dissipation Factor Of Solid Dielectrics At Frequencies To 10 MHz And Temperatures To 500°C
D2520 Test Methods for Complex Permittivity (Dielectric Constant) of Solid Electrical Insulating Materials at Microwave Frequencies and Temperatures to 1650°C
E6 Terminology Relating to Methods of Mechanical Testing
E12 Terminology Relating to Density and Specific Gravity of Solids, Liquids, and Gases (Withdrawn 1996)[3]
E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process
E165 Practice for Liquid Penetrant Examination for General Industry
E228 Test Method for Linear Thermal Expansion of Solid Materials With a Push-Rod Dilatometer
F19 Test Method for Tension and Vacuum Testing Metallized Ceramic Seals
F77 Test Method for Apparent Density of Ceramics for Electron Device and Semiconductor Application (Withdrawn 2001)[3]

[1] This specification is under the jurisdiction of Committee C21 on ~~Ceramic Whitewares and Related Products and is the direct responsibility of Subcommittee~~ Electrical and Electronic Insulating Materials.~~C21.03 on Methods for Whitewares and Environmental Concerns.~~

~~This specification also includes material and suggestions provided by ASTM Committee D09 on Electrical and Electronic Insulating Materials.~~

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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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

F109 Terminology Relating to Surface Imperfections on Ceramics
F134 Test Methods for Determining Hermeticity of Electron Devices with a Helium Mass Spectrometer Leak Detector (Withdrawn 1996)[3]
F417 Test Method for Flexural Strength (Modulus of Rupture) of Electronic-Grade Ceramics (Withdrawn 2001)[3]

2.2 *Other Standards:*
MIL-STD-105 Sampling Procedures and Tables for Inspection by Attributes[4]
MIL-STD-883 Test Methods and Procedures for Microelectronics[5]
ANSI B46.1 Surface Texture[6]

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 C242, D1711, E6, E12, and F109.

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 F109, 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.

[4] Available from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.
[5] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.
[6] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org..

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

[A]Maximum 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 F109.

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 D618.

9. Test Methods

9.1 *Dielectric Constant and Dissipation Factor*—Determine in accordance with Test Methods D150. Determine values at higher frequencies in accordance with Test Methods D2520.[7] Determine values at higher temperatures in accordance with Test Method D2149.

9.2 *Volume Resistivity*—Determine in accordance with Test Methods D257. For elevated temperature measurements use Procedure A of Test Method D1829.

9.3 *Dielectric Strength*—Run this test under oil in accordance with 6.1.1 of Test Methods D149, with a rise rate of 1000 V/s on a 3.175-mm (0.125-in.) thick test specimen.

9.4 *Flexural Strength*—Determine in accordance with Test Method F417 or Methods D116. Somewhat lower values will result if Methods D116 are used. The method to be used shall be agreed upon between the supplier and the purchaser.

9.5 *Modulus of Elasticity and Poisson's Ratio*—Determine in accordance with Test Method C623.

9.6 *Thermal Expansion*—Determine in accordance with Test Method E228.

9.7 *Thermal Conductivity*—Determine in accordance with Test Method C408. For temperatures in excess of 149 C (300 F), use a suitable method.[8]

9.8 *Thermal Shock Resistance*—This test is to be agreed upon between supplier and purchaser. It is suggested that the cold end of the cycle be ice water at 0°C. Methods of heating and conditions at elevated temperatures shall be negotiated. The transfer from one temperature extreme to another shall be immediate.

9.9 *Temperature Deformation*—Determine deformation at 1500°C in accordance with Appendix X2.

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

[8] For a suitable method see Francl, J., and Kingery, W. D., "An Apparatus for Determining Conductivity by a Comparative Method," *Journal of the American Ceramic Society*, JACTA Vol 37, 1954, p. 80.