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RDT Standard

CERAMIC ELECTRICAL INSULATORS

AUGUST 1974

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FOREWORD

This standard supersedes the July 1970 issue of RDT C 18-1T and incorporates those changes to that issue that were approved and published as Amendments 1 and 2 and those changes approved for publication in this revision. These changes are identified by the following marginal notations:

- A1 Amendment 1, April 1973
- A2 Amendment 2, June 1973
- C Change approved August 1974
- A Addition approved August 1974

Editorial changes that were made during preparation of this revision are not identified.

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UNITED STATES ATOMIC ENERGY COMMISSION
DIVISION OF REACTOR RESEARCH AND DEVELOPMENT

RDT C 18-1T

DATE August 1974

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CERAMIC ELECTRICAL INSULATORS

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CERAMIC ELECTRICAL INSULATORS

1. SCOPE

This standard covers the requirements for ceramic electrical insulators to be used for high-temperature instrument application. Ceramic compositions are presented. Methods are presented for conditioning the insulators and determining bulk density.

1.1 Applicability. Ceramic electrical insulating material covered by this standard includes glazed and unglazed, crushable and high-fired (noncrushable) single- and multiple-hole beads; single- and multiple-hole tubing; and granular and powder forms. The intended use in a specific application requires evaluation of the compatibility of the material with its service environment (i.e., temperature, atmosphere, nuclear radiation, vibration, and with the materials in the proposed application).

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1.2 Definitions. For the purpose of this document, the following definitions shall apply.

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1.2.1 Batch. A quantity of insulating material produced at one operation from the same source materials.

1.2.2 Lot. A group of insulators, beads, or tubing made from the same batch of starting materials pressed and fired at the same processing conditions.

1.2.3 High-Fired. The processed state where material is sintered to a high modulus of rupture; noncrushable.

1.2.4 Crushable. The processed state where material is sintered to a low modulus of rupture that is readily reduced to fine particles.

1.2.5 Processed State. Either high-fired (noncrushable) or crushable, depending on manufacturing processes performed.

1.2.6 Camber. Bowing or bending of the longitudinal axis of the tubular insulator; warpage; ratio of arc height to maximum length of the part.

1.2.7 Twist. The rotation of the multihole insulator pattern about the longitudinal axis, along the longitudinal axis.

1.2.8 Powder. The condition where the material is in the sub-micron particle size.

2. APPLICABLE DOCUMENTS

The following documents are a part of this standard to the extent specified in Sections 3 through 5. The issue of the document in effect on the date of invitation to bid, including any amendments or other published changes also in effect, shall be as specified in the Ordering Data. Where this standard appears to conflict with the requirements of a referenced document, such conflict shall be brought to the attention of the purchaser for resolution.

2.1 RDT Standards.

RDT F 2-4T Quality Verification Requirements

RDT F 3-2T Calibration Program Requirements

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2.2 American Society for Testing and Materials (ASTM) Standards.

ASTM E 135 Terms and Symbols Relating to Emission Spectroscopy,
Standard Definitions of

ASTM E 158 Spectrochemical Computations, Recommended Practices
for

2.3 American National Standards (ANSI).

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ANSI Z1.4 Sampling Procedures and Tables for Inspection by
Attributes

ANSI Z1.9 Sampling Procedures and Tables for Inspection by
Variables for Percent Defective

3. TECHNICAL REQUIREMENTS

3.1 Dimensions and Tolerances. Unless otherwise specified in the Ordering Data, the following dimensions and tolerances shall apply:

1. The outside diameter specified in decimal inches shall be met within a tolerance of $\pm 1\%$.
2. The hole diameter(s) specified in decimal inches shall be met within a tolerance of $\pm 1\%$.
3. The length specified in inches shall be met within a tolerance of $\pm 2\%$.

3.2 Hole Spacing. The holes shall be spaced such that the bead or tubing shall have equal wall and web dimensions when two or more holes are required, unless otherwise specified in the Ordering Data.

3.3 Wall Thickness. The wall thickness shall be at least 10% of the outside diameter of single holes unless otherwise specified in the Ordering Data.

3.4 Straightness. The tube shall be straight within 0.005 in./in. of length, maximum, unless otherwise specified in the Ordering Data.

3.5 Chemical and Physical Requirements. The chemical and physical requirements of ceramic electrical insulators shall satisfy the following:

3.5.1 Alpha Alumina.

3.5.1.1 High Purity Alumina.

Chemical Composition

SiO ₂	1000 ppm maximum	B+Cd	30 ppm maximum
Fe ₂ O ₃	1000 ppm maximum	S	50 ppm maximum
CaO	1000 ppm maximum	C	300 ppm maximum
Na ₂ O	1000 ppm maximum	Al ₂ O ₃	99.5% minimum

Total of all impurities in the alumina shall be no more than 5000 ppm.

3.5.1.2 High Purity Alumina for Rods, Beads, and Mandrels.

Chemical Composition

SiO ₂	7000 ppm maximum	CaO	1000 ppm maximum
MgO	1000 ppm maximum	FeO	1000 ppm maximum
Na ₂ O	1000 ppm maximum	Al ₂ O ₃	99.0% minimum

Physical Properties

Flexural strength	55,000 psi
Compressive strength	300,000 psi
Tensile strength	30,000 psi
Young's Modulus	50 x 10 ⁴ psi

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3.5.2 Beryllia.

Al	100 ppm maximum	Mn	5 ppm maximum
SiO ₂	100 ppm maximum	Ni	10 ppm maximum
Ca	50 ppm maximum	B	3 ppm maximum
Mg	50 ppm maximum	Cd	2 ppm maximum
Fe	50 ppm maximum	Br	10 ppm maximum
Na	50 ppm maximum	Co	3 ppm maximum
Cu	5 ppm maximum	Pb	5 ppm maximum
S	1500 ppm maximum	Li	3 ppm maximum
Mo	5 ppm maximum	Ag	3 ppm maximum
K	50 ppm maximum	BeO	99.8% minimum

3.5.3 Boron Nitride.

Methanol soluble borate	24,000 ppm maximum
Alkaline earth oxides	1,000 ppm maximum
Alumina and silica	2,000 ppm maximum
Carbon	80 ppm maximum
BN	97% minimum

3.5.4 Hafnia.

Zr	4000 ppm maximum	Si	10 ppm maximum
Ca	80 ppm maximum	Al	10 ppm maximum
Mg	40 ppm maximum	HfO ₂	95.5% minimum

3.5.5 Magnesia.3.5.5.1 Thermocouple and Signal Cables.

A2

Chemical Composition

SiO ₂	3000 ppm maximum	B	25 ppm maximum
Fe ₂ O ₃	1500 ppm maximum	Cd	10 ppm maximum
Al ₂ O ₃	1500 ppm maximum	S	50 ppm maximum
CaO	3500 ppm maximum	C	200 ppm maximum
MgO	99.4% minimum		

Physical Properties

Crushable

<u>Outside Diameter</u>	<u>Modulus of Rupture</u>
up to 0.059 in.	8,000 to 12,000 psi
0.060 to 0.120 in.	7,000 to 10,000 psi
0.121 to 0.240 in.	5,000 to 8,000 psi
0.241 to 0.500 in.	3,000 to 6,000 psi

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High-Fired

<u>Outside Diameter</u>	<u>Modulus of Rupture</u>
up to 0.500 in.	Greater than 50,000 psi

3.5.5.2 Sheathed Electrical Heaters (Granular).

A1

Chemical Composition

SiO ₂	40,000 ppm maximum	Fe ₂ O ₃	10,000 ppm maximum
CaO	30,000 ppm maximum	R ₂ O ₃	2,000 ppm maximum
MgO	94.0% minimum		

Physical Properties

<u>Screen Analysis</u>	<u>Percent</u>
Retained on 40 mesh	Zero
Retained on 60 mesh	25 to 31
Retained on 80 mesh	23 minimum
Retained on 200 mesh	36 minimum
Retained on 325 mesh	5 to 11
Passes through 425 mesh	1.5 maximum

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3.5.6 Thoria.

Al	500 ppm maximum	K	20 ppm maximum
Si	500 ppm maximum	Zr	20 ppm maximum
Mg	300 ppm maximum	B	10 ppm maximum
N	50 ppm maximum	Na	10 ppm maximum
C	50 ppm maximum	La	5 ppm maximum
Ti	50 ppm maximum	Ce	5 ppm maximum
Ca	50 ppm maximum	Li	5 ppm maximum
Fe	50 ppm maximum	ThO ₂	99.8% minimum

3.5.7 Stabilized Zirconia.

CaO	40,000 ppm maximum	TiO ₂	2,500 ppm maximum
HfO ₂	20,000 ppm maximum	Fe ₂ O ₃	1,500 ppm maximum
Al ₂ O ₃	10,000 ppm maximum	B	10 ppm maximum
SiO ₂	5,000 ppm maximum	ZrO ₂	92.0% minimum

3.5.8 Powdered Silicon Dioxide.

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Chemical Composition

Al	100 ppm maximum	Fe	15 ppm maximum
B	5 ppm maximum	Mn	3 ppm maximum
C	5 ppm maximum	Na	50 ppm maximum
Ca	15 ppm maximum	Pb	10 ppm maximum
Cd	15 ppm maximum	S	5 ppm maximum
Co	15 ppm maximum	SiO ₂	99.8% minimum

Physical Properties

X-ray structure	amorphous
Particle size	0.007 to 0.050 microns
Retained on 325 mesh	0.05% maximum

3.6 Bulk Density. The density shall be as specified in the Ordering Data for high-fired or crushable condition. For high-fired ceramic electrical insulators, the following bulk densities shall be used as a guide, unless otherwise specified in the Ordering Data.

<u>Material</u>	<u>Bulk Density (minimum) (g/cm³)</u>
Alpha alumina	3.70
Beryllia	2.86
Boron nitride	2.10
Hafnia	8.72
Magnesia	3.48
Thoria	8.72
Stabilized zirconia	5.64
Powdered silicon dioxide	2.20

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For reference purposes, Appendix A of this standard, "Method of Determining Bulk Density of Ceramic Electrical Insulators," shall apply.

3.7 Conditioning. When specified in the Ordering Data, the insulators shall be conditioned by the method presented in Appendix B of this standard, or by the method specified by the manufacturer and acceptable to the purchaser. The conditioned insulators shall be considered acceptable for final assembly of high-temperature instrumentation.

3.8 Certifications. A certification that the ceramic insulators are in compliance with the requirements of this standard shall be

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provided. Physical dimensions of beads or tubing, chemical composition, and density test results shall be included in the certification. Methods used in determining chemical composition shall be identified.

C

3.8.1 Chemical Composition. The chemical composition of at least one piece of each sample shall be determined and reported in accordance with Appendix C. Terms and methods presented in ASTM E 135 and ASTM E 158 shall apply. The quantity of at least each element or compound specified in 3.5 shall be listed in parts per million (ppm) and percentage (%) as applicable. An estimate of the accuracy shall be stated.

C

Alternate methods of chemical analysis that meet the requirements of Appendix C may also be used. A supplier who proposes to use an alternate method shall submit the proposed method for approval.

3.8.2 Density. The bulk density of at least five random samples from each batch of insulating material shall be measured and reported. The method of measurement and an estimate of measurement accuracy shall be provided.

3.9 Sampling Procedures for Inspection. Sampling procedures for inspection shall be in accordance with ANSI Z1.2 or ANSI Z1.9 or both. All sampling and tests shall be performed on the finished product.

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3.10 Packaging and Identification. Each type of insulation (granular, beads, or tubing) shall be packaged immediately after conditioning, sealed in containers, and marked. Identification and marking shall be subject to approval prior to manufacture and shall include:

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1. Material.
2. Insulation type (granular, beads).
3. Batch or lot number.
4. Processed state (crushable or noncrushable).
5. Quantity.
6. Size (diameter, number of holes, size of holes, etc.).
7. RDT standard number.
8. Purchase order number.
9. Supplier's name or trademark.

pores of the insulator. Excessive blotting will introduce errors by withdrawing water from the pores, if any, of the specimen.

A.4.4 The volume, V , in cubic centimeters of each test specimen may be obtained by subtracting the suspended weight from the saturated weight, both in grams, as follows:

$$V = W - S \text{ cm}^3$$

A.5 BULK DENSITY, B

The bulk density, B , in grams per cubic centimeter of each specimen is the quotient of dry weight, D , divided by the exterior volume, V , and shall be calculated as follows:

$$B = D/V \text{ g/cm}^3$$

APPENDIX B

CONDITIONING CERAMIC ELECTRICAL INSULATORS

B.1 SCOPE

This method applies to the conditioning of ceramic electrical insulators prior to use in final assembly of high-temperature instrumentation.

B.2 EQUIPMENT REQUIRED

The following items are required to complete this procedure:

1. Platinum crucible.
2. Furnace, capable of being controlled up to a temperature of 1600°F.
3. Long-handled tongs.

B.3 CRUCIBLE CLEANING

The platinum crucible shall be cleaned to remove oils, carbon, dirt, drawing compounds, dust, and other contaminants. After the crucible is washed, an initial rinse with tap water is to be made. At this time and hereafter, the crucible shall be handled using rubber surgical gloves or other means to prevent oil or acids from the hands from contaminating the rinsed surfaces. Sufficient water shall be used to remove all soap. A final rinse shall be made with distilled or demineralized water. The crucible shall then be air-dried on a clean plastic surface in an essentially dust-free area.

B.4 PREPARATION

Place in the platinum crucible the estimated number of insulators required, plus an allowance for 25% overage (the latter to cover loss due to droppage, contamination, and breakage during assembly). Bring the furnace temperature up to a controlled temperature of 1500°F. The furnace atmosphere shall be clean, normal air, unless otherwise specified in the Ordering Data.

B.5 CONDITIONING

Using long-handled tongs, place the platinum crucible containing the ceramic insulators in the furnace. Allow the crucible and insulators to bake at 1550°F for 30 min. Using long-handled tongs, remove the crucible and insulators from the furnace and allow them to air-cool to room temperature.

APPENDIX C

CHEMICAL ANALYSIS OF CERAMIC ELECTRICAL INSULATOR MATERIAL

C.1 SCOPE

Defined herein is a method for performing a chemical analysis of ceramic electrical insulator material and reporting the results.

C.2 SAMPLE MATERIAL

Upon receipt of the sample material, the packaging shall be visually inspected for damage that could cause or lead to sample contamination which in turn would contribute to an erroneous analysis of the intended material.

If such damage has occurred, the information shall be reported to the purchaser within 1 day after receipt of the package. In any case, a receiving report indicating the condition of the package and sample shall be supplied to the purchaser along with the analytical report. The receiving report shall be dated and signed by an authorized representative and identified with the purchase order number and the purchaser.

At all times until the analysis of the sample is completed, the sample shall not be touched by bare hands and shall be handled with care in a manner that prevents any contamination which would contribute to an erroneous analysis of the intended material.

C.3 ANALYTICAL EQUIPMENT CALIBRATION AND CONTROL

Procedures for the selection, use, calibration, adjustment, maintenance, and control of all analytical equipment used in the performance of the chemical analysis shall be established and maintained in accordance with RDT F 3-2.

C.4 CHEMICAL ANALYSIS

A quantitative analysis shall be performed for each of the elements and oxides for the applicable ceramic material listed in 3.5 of this standard. Terms and methods presented in ASTM E 135 and ASTM E 158 shall apply.

C.4.1 Methods of Analysis. Optical emission spectrochemical analysis with d-c carbon arc or atomic absorption spectrophotometry shall be used in analysis for all the elements and oxides listed in 3.5 except carbon and sulfur. The electrodes shall be high-purity graphite to prevent contamination detrimental to the required analysis. A 1.5-m or better spectrograph, densitometer, or direct reader shall be used. The accuracy of analysis shall be $\pm 20\%$ or better relative.

The carbon content shall be determined by standard combustion technique with an accuracy of 20% or better relative.

The sulfur content shall be determined by standard combustion technique with an accuracy of 30% or better relative.

An estimate of the accuracy of each type of analysis shall be determined, recorded, and included in the analytical report.

C.4.2 Analytical Quantity. The quantity of each element or oxide listed in 3.5 for the applicable material shall be listed in parts per million (ppm) or percentage (%), as applicable, and shall be referenced by weight. The quantity designation shall apply to the element where an element is specified and to the oxide where an oxide is specified. In other words, where an oxide is specified, the determined elemental quantity shall be converted to include the oxygen. Any element or oxide sought and not detected shall be reported as being less than a number equal to the limit of sensitivity for the analytical equipment being used and the element. The percent of ceramic shall be determined by difference and reported as such.

C.4.3 Analytical Sensitivity. The analytical sensitivity for the applicable elements of 3.5 shall be as good or better than that specified in Table 1. The analytical sensitivity for those elements not specified in Table 1, but listed in the applicable subparagraph of 3.5, shall be the best practical. The equipment capable limit of analytical sensitivity for each element sought shall be indicated in the analytical report with the results of the quantitative analysis.

Table 1. Minimum Analytical Sensitivities

Element	ppm	Element	ppm
Si	20	Cr	5
Mg	50	Pb	8
Ca	1	Mn	5
Fe	10	Ga	10
Na	5	Cd	8
Ti	5	B	10
K	20	C	10
Zr	10	S	10

C.4.4 Analytical Report. A report of the analytical results shall be prepared for submittal to the purchaser. The report shall include a description of the equipment used (type, model, and manufacturer), a description of basic methods and techniques used, the results of the quantitative analysis (C.3 and C.3.2), a statement of the estimated accuracy of each type of analysis performed (C.3.1), and a listing of the capable limit of analytical sensitivity for each element sought (C.3.3). The report shall identify the analytical laboratory and the purchaser and shall include the job number of the laboratory, the purchase order number, the sample number, if different than the purchase order number, the date of analysis, and the signature of the analyst.

C.4.5 Certificate of Conformance. A Certificate of Conformance, stating that the analysis has been performed in accordance with the requirements of this Appendix C, shall be submitted with the analytical report. It shall be identified with the purchase order number and purchaser.

C.5 DOCUMENTATION REQUIREMENTS

Documentation, such as analytical procedures and equipment calibration and maintenance procedures, shall be maintained and available as objective evidence of conformance to the requirements herein. All documents or copies thereof shall be legible. The following documents shall be submitted with the ceramic material:

1. Receiving Report (C.2)
2. Analytical Report (C.3.4)
3. Certificate of Conformance (C.3.5)

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