



Standard Specification for Nuclear-Grade Beryllium Oxide Powder¹

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1. Scope

1.1 This specification defines the physical and chemical requirements of nuclear-grade beryllium oxide (BeO) powder to be used in fabricating nuclear components.

1.2 This specification does not include requirements for health and safety (1-5).² It recognizes the material as a Class B poison and suggests that producers and users become thoroughly familiar with and comply to applicable federal, state, and local regulations and handling guidelines (1).

1.3 Special tests and procedures are given in Annex A1 and Annex A2.

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

2. Referenced Documents

2.1 ASTM Standards:³

C373 Test Method for Water Absorption, Bulk Density, Apparent Porosity, and Apparent Specific Gravity of Fired Whiteware Products, Ceramic Tiles, and Glass Tiles

C859 Terminology Relating to Nuclear Materials

C1233 Practice for Determining Equivalent Boron Contents of Nuclear Materials

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

E105 Practice for Probability Sampling of Materials

2.2 ASME Standard:

ASME NQA-1 Quality Assurance Program Requirements for Nuclear Facilities⁴

2.3 U.S. Government Standard:

Title 10, Code of Federal Regulations, Energy Part 50 (10CFR50) Domestic Licensing of Production and Utilization Facilities⁵

3. Terminology

3.1 Definitions:

3.1.1 Terms shall be defined in accordance with Terminology C859 except as defined in 3.2.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *beryllium oxide powder*—BeO that contains no hard aggregates larger than No. 20 sieve designation (850 μ m).

3.2.2 *buyer*—organization issuing the purchase order.

3.2.3 *calcination*—process of heating a material to a high temperature but without fusing in order to drive off volatile matter or to effect physical, chemical, or crystallographic changes.

3.2.4 *powder lot*—that quantity of beryllium-oxide powder processed such that samples taken in accordance with the procedures of Section 8 can be considered as representative of the entire powder lot.

3.2.5 *seller*—beryllium oxide powder supplier.

4. Ordering Information

4.1 The beryllium oxide powder must meet the chemical (Section 5) and physical (Section 6) requirements of this specification, based upon samples taken in accordance with Section 8. Deviation from these procedures and requirements or additions to them must be agreed upon between the buyer and the seller.

4.2 To be consistent with the requirements in 4.1, the buyer may specify the following information on the order:

4.2.1 Quantity (weight of delivered product),

4.2.2 Lot size,

4.2.3 Degree of calcination (optional),

4.2.4 Nominal particle size range and applicable tolerances in accordance with Specification E11 (U.S. Standard Sieve

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² The boldface numbers in parentheses refer to a list of references at the end of this standard.

³ 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.

⁴ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

⁵ Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, <http://www.access.gpo.gov>.

Series). For particle sizes smaller than No. 270 sieve designation (53 μm), the particle size distribution shall be agreed upon between the buyer and the seller, and

4.2.5 Sampling requirements.

5. Chemical Composition

5.1 Beryllium-oxide powder is used for a variety of nuclear applications. Depending upon end use, the purity requirements may be quite variable.

5.2 Use analytical methods as agreed upon between the buyer and the seller.

5.3 Mass loss on drying a 5 to 10-g sample of the powder at $110 \pm 5^\circ\text{C}$ for 1 h shall be 0.50 % maximum. After drying, the mass loss on ignition of the sample at $1000 \pm 50^\circ\text{C}$ for 3 h shall be 1.0 % maximum.

5.4 Impurity concentrations before drying (see 5.3) shall not exceed the limits given in Table 1.

5.5 Sample material (see 5.3) shall not exceed the impurity limits given in Table 2.

5.6 Other elements, in addition to those listed in Table 2, may be included in the buyer's impurity content requirements by mutual agreement between the buyer and the seller.

5.7 The total equivalent boron content (EBC) of the impurities shall not exceed 9 $\mu\text{g/g}$ on a mass basis relative to BeO. The method of performing the calculation shall be as indicated in Practice C1233. The individual EBC values are calculated as follows:

$$\text{EBC of impurity} = (\text{EBC factor}) \times (\mu\text{g of impurity/g BeO})$$

where:

$$\begin{aligned} \text{EBC factor} &= (\text{atomic mass of boron}) \times (\sigma_a \text{ impurity}) / \\ &\quad (\text{atomic mass of impurity}) \times (\sigma_a \text{ boron}), \text{ and} \\ \sigma_a &= \text{atomic absorption cross section in barns.} \end{aligned}$$

5.7.1 Should the EBC of additional elements not listed in Practice C1233 be of concern, their inclusion in the summation and their respective EBC factors must be mutually agreed upon between the buyer and the seller.

6. Physical Requirements

6.1 All of the beryllium-oxide shall be passed through a No. 20 sieve designation (850 μm) or equivalent.

6.2 The powder shall be at least 99.5 mass % less than a No. 100 sieve designation (150 μm) determined by the wet sieve test in Annex A1 or other test mutually agreed upon between the buyer and the seller.

TABLE 1 Impurity Limits for Beryllium-Oxide Powder Before Drying^A

Element	Maximum Concentration ($\mu\text{g/g BeO}$)
S	1500
F	500
Cl	100
C	500
P	300
S+F+Cl+C+P	2000

^A After drying sample in accordance with 5.3.

TABLE 2 Impurity Limits for Beryllium-Oxide Powder After Ignition

Element	Maximum Concentration ($\mu\text{g/g BeO}$)
Al	100
B	3
Cd	2
Ca	50
Cr	20
Co	5
Cu	10
Fe	50
Li	3
Mg	100
Mn	10
Ni	15
Si	150

6.3 Beryllium-oxide powders may exhibit different bulk or tap densities, or both, due to different production methods. The acceptable density values for nuclear grade BeO powder are as follows:

6.3.1 *Bulk Density*—0.15 to 0.50 g/cm^3 , and

6.3.2 *Tap Density*—0.30 to 1.00 g/cm^3 .

6.4 *Sinterability*—Test pellets shall be produced and measured in accordance with a sintering performance test agreed upon between the buyer and the seller. A sinterability performance test described in Annex A2 is presented as a guide.

7. Cleanliness

7.1 The powder lot shall be handled in a manner to avoid contamination by foreign matter such as dust, cleaning agents and organics, and materials such as plastics and paper used in packaging. Cleaning solutions, if used, shall be free of halides and nonvolatile additives and shall be removed from the powder prior to sampling and packaging.

8. Sampling

8.1 Sampling plans to meet acceptance criteria and inspection and measurement procedures that describe the method of compliance with this specification shall be established by the seller and submitted to the buyer for approval. The degree of sampling where not specified in this specification, varies with the application and for this reason should be specified on the purchase order. Practice E105 is referenced as a guide.

8.2 Each sample taken shall be sufficient for quality verification tests, acceptance tests, referee tests, and achieve tests as needed.

8.3 Archive samples shall be retained for a period of time specified by the buyer and be delivered to the buyer upon request.

8.4 Each sample shall be plainly marked with the following:

- 8.4.1 Beryllium-oxide powder,
- 8.4.2 Purchase order number,
- 8.4.3 Purchase order specification,
- 8.4.4 Gross, net, and tare weights,
- 8.4.5 Lot number, and
- 8.4.6 Name of seller.

8.5 Lot samples shall be prepared by blending and splitting the container samples.