Designation: C 784 – 05

Standard Specification for Nuclear-Grade Aluminum Oxide-Boron Carbide Composite Pellets[1]

This standard is issued under the fixed designation C 784; 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 applies to pellets composed of mixtures of aluminum oxide and boron carbide that may be ultimately used in a reactor core, for example, in neutron absorber rods.

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]

C 559 Test Method for Bulk Density by Physical Measurements of Manufactured Carbon and Graphite Articles

C 750 Specification for Nuclear-Grade Boron Carbide Powder

C 809 Methods for Chemical, Mass Spectrometric, and Spectrochemical Analysis of Nuclear-Grade Aluminum Oxide and Aluminum Oxide-Boron Carbide Composite Pellets

C 859 Terminology Relating to Nuclear Materials

C 1031 Specification for Nuclear Grade Aluminum Oxide Powder

E 11 Specification for Wire-Cloth Sieves for Testing Purposes

E 105 Practice for Probability Sampling of Materials

2.2 *ANSI Standard:*

ANSI/ASME NQA-1 Quality Assurance Program Requirements for Nuclear Facilities[3]

2.3 *Government Standard:*

Title 10, Code of Federal Regulations, Energy Part 50 (10CFR50), Domestic Licensing of Production and Utilization Facilities[4]

3. Terminology

3.1 *Definitions:*

3.1.1 Terms shall be defined in accordance with Terminology C 859 except for the following:

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *buyer*—organization issuing the purchase order.

3.2.2 *pellet*—a fabricated geometric shape of aluminum oxide-boron carbide having a chemical composition as described in Section 4.

3.2.3 *pellet lot*—that quantity of pellets produced from one powder mixture lot using one set of mixing and process parameters. Pellet lot size shall be agreed upon between the seller and the buyer.

3.2.4 *powder mixture lot*—a specified quantity of aluminum oxide and boron carbide made up of powders from one or more sources blended together such that samples taken in accordance with Section 7 can be considered as representative of the entire specified quantity.

3.2.5 *seller*—pellet supplier.

4. Technical Requirements

4.1 *Major Constituents*—Aluminum oxide-boron carbide pellets shall be fabricated using major constituents that meet the requirements of Specifications C 750 and C 1031.

4.2 *Chemical Composition*:

4.2.1 Use analytical chemistry methods in accordance with Methods C 809 or demonstrated alternate methods agreed upon between the buyer and the seller.

4.2.2 The finished pellets shall conform to the following chemical analysis:

Si	2.0 weight % max
Fe + Cr + Ni	0.6 weight % max
Mg	1.0 weight % max
Na	0.2 weight % max
Ca	0.3 weight % max
Hf	200 µg/g pellet max

[1] This specification is under the jurisdiction of ASTM Committee C26 on Nuclear Fuel Cycle and is the direct responsibility of Subcommittee C26.03 on Neutron Absorber Materials Specifications.

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

[4] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

F	50 µg/g pellet max
F + Cl + I + Br	100 µg/g pellet max
Gd	25 µg/g pellet max
Sm	50 µg/g pellet max
Eu	50 µg/g pellet max
Dy	50 µg/g pellet max

Any elemental impurity not listed in 4.2.2 shall not exceed 1 weight % as determined by emission spectroscopy. The sum of all impurities shall not exceed 4.0 weight %. A water-soluble boron limit may be required in certain designs in which case it shall be determined on a sample crushed to pass through a No. 100 mesh (150-µm) U.S. standard sieve (see Specification E 11.)

4.2.3 Should elements not listed in 4.2.2 be of concern, their inclusion in the listing shall be mutually agreed upon between the buyer and the seller.

4.2.4 In specifying the allowable range in ^{10}B concentration the buyer shall consider the following:

4.2.4.1 Variations in chemical composition,

4.2.4.2 Bulk pellet density,

4.2.4.3 Boron isotopic composition,

4.2.4.4 Pellet dimensions, and

4.2.4.5 Typical units are grams of ^{10}B per unit volume or grams of ^{10}B per centimeter length.

4.2.5 The hydrogen impurity (including moisture content), the detailed procedure for measuring hydrogen, and packaging requirements associated with hydrogen contamination, shall be agreed upon between the buyer and the seller.

5. Physical Requirements

5.1 *Physical Dimensions*:

5.1.1 Dimensional requirements shall be in accordance with applicable drawings and purchase order documents.

5.1.2 Pellet dimensions shall be measured to ensure compliance with the buyer's requirements. Sampling plans to meet acceptance criteria shall be agreed upon between the seller and the buyer to ensure that the pellets represented by the sample are within the required tolerances.

5.2 *Density*:

5.2.1 Pellet density limits shall be specified by the buyer.

5.2.2 The method of density measurement shall be Test Method C 559 or an alternative method approved by the buyer prior to use. Sampling plans to meet acceptance criteria shall be agreed upon between the seller and the buyer.

5.3 *Boron Carbide Homogeneity*:

5.3.1 The boron carbide shall be uniformly dispersed in the aluminum oxide matrix as determined by ceramographic examination.

5.3.2 The methods of ceramographic preparation and examination shall be approved by the buyer prior to use.

5.3.3 Pellets selected by mutual agreement between the buyer and the seller shall be used as standards of acceptability to satisfy the requirements of 5.3.1. The seller shall submit as homogeneity standards, pellets representative of each specified boron concentration (4.2.1).

5.3.4 Particle size limits of boron carbide particles shall be specified by the buyer in accordance with his particular application.

5.4 *Mechanical Properties*—Required mechanical properties and test methods shall be mutually agreed upon between the buyer and the seller.

5.5 *Visual Appearance*—Visual examination shall be conducted on finished pellets in accordance with Section 7. The seller and the buyer shall agree on visual standards as representing the requirements of 5.5.1, 5.5.2, and 5.5.3. These standards shall be used as acceptance standards for the visual examination of the pellets. The method of defect measurement shall be approved by the buyer prior to use. Maximum permissible defects are defined as follows:

5.5.1 *End Chips*—Pellet end surface shall not be chipped beyond 10 % of the end-face surface area and no chip shall exceed 1.0 mm (0.040 in.) in depth.

5.5.2 *Circumferential Chips*—Pellet circumferential surfaces shall not be chipped beyond 5 % of the circumferential surface area. No single chip shall exceed a depth of 1.0 mm (0.040 in.).

5.5.3 *Cracks*—No single crack shall exceed 90° of circumference in length.

5.5.4 Fissures and other defects shall be evaluated with respect to the criteria of 5.5.1, 5.5.2, and 5.5.3.

6. Cleanliness

6.1 The finished pellets shall be handled in a manner to avoid contamination by grinding fluids and dust, cleaning agents, and organic 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 pellets prior to sampling and packaging.

7. Sampling

7.1 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 prior to manufacture of the required product. The degree of sampling shall be specified on the purchase order. Practice E 105 is referenced as a guide.

7.2 Each sample taken shall be sufficient for quality verification tests, referee tests and archive samples as needed.

7.3 Archive samples shall be retained and disposed by the seller in accordance with the buyer's instructions.

8. Inspection and Certification

8.1 The seller shall inspect the material covered by this specification and shall furnish the buyer with certificates of tests showing the results of testing and inspection performed on each pellet lot prior to shipment. The seller shall certify that each pellet lot is in compliance with the provisions of this specification.

9. Rejection

9.1 Unless the buyer and the seller agree otherwise, rejection and acceptance shall be on a pellet lot basis.

9.2 Pellet lots that fail to conform to the requirements of this specification may be rejected by the buyer. The seller may petition the buyer to waive selected requirements for identified out-of-specification lots. Decision to grant such waiver belongs

to the buyer. The seller may also apply any remedy to bring rejected lots into specification providing he can demonstrate to the buyer that such remedy does not impair the function or preclude the certification of the rejected material.

9.3 In the event of disagreement over the results of analysis, samples shall be submitted to a mutually selected referee for resolution.

10. Packaging and Shipping

10.1 The pellets shall be packaged in sealed containers for shipment from the seller to the buyer. The seller shall be responsible for using the shipping container to assure the pellets arrive still in conformance with the specification, and to assure reasonable ease of unpacking.

10.2 Each container shall be clearly marked with the following:

10.2.1 Aluminum oxide-boron carbide composite pellets,
10.2.2 Purchase order number,
10.2.3 Gross, net, and tare weights,
10.2.4 Lot number, and
10.2.5 Name of manufacturer.

11. Quality Assurance

11.1 Quality assurance requirements shall be specified in the purchase order. Code of Federal Regulations, Title 10, Part 50, Appendix B, and ANSI/ASME NQA-1 are referenced as guides.

12. Keywords

12.1 absorber pellets; aluminum oxide; boron carbide; poison pellets