



Standard Specification for Nuclear-Grade Boron Carbide Powder¹

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1. Scope

1.1 This specification defines the chemical and physical requirements for boron carbide powder intended for a variety of nuclear applications. Because each application has a different need for impurity and boron requirements, three different chemical compositions of powder are specified. In using this specification, it is necessary to dictate which type of powder is intended to be used. In general, the intended applications for the various powder types are as follows:

1.1.1 *Type 1*—For use as particulate material in nuclear reactor core applications.

1.1.2 *Type 2*—Powder that will be further processed into a fabricated shape for use in a nuclear reactor core or used in non-core applications when the powder directly or indirectly may cause adverse effects on structural components, such as halide stress corrosion of stainless steel.

1.1.3 *Type 3*—Powder that will be used for non-core applications or special in-core applications.

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

1.3 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*²

B527 Test Method for Tap Density of Metal Powders and Compounds

B822 Test Method for Particle Size Distribution of Metal

Powders and Related Compounds by Light Scattering
B923 Test Method for Metal Powder Skeletal Density by Helium or Nitrogen Pycnometry

C371 Test Method for Wire-Cloth Sieve Analysis of Non-plastic Ceramic Powders

C791 Test Methods for Chemical, Mass Spectrometric, and Spectrochemical Analysis of Nuclear-Grade Boron Carbide

C859 Terminology Relating to Nuclear Materials

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

E105 Practice for Probability Sampling of Materials

2.2 *ANSI Standard:*³

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

2.3 *U.S. Government Document:*⁴

Title 10, Part 50 (Appendix B) NRC Regulations, Code of Federal Regulations, Domestic Licensing of Production and Utilization Facilities

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *buyer*—organization issuing the purchase order.

3.1.2 *powder lot*—that quantity of boron carbide powder blended together such that samples taken in accordance with the procedures of 8.1 can be considered as representative of the entire powder lot.

3.1.3 *seller*—boron carbide powder supplier.

4. Ordering Information

4.1 The buyer may specify the following information on the order:

4.1.1 Quantity (weight of delivered product).

4.1.2 Nominal particle size, particle size range, and applicable tolerance.

4.1.3 Density and method of measurement.

4.1.4 Angular or spherical shape.

4.1.5 Shape factor.

4.1.6 Lot size.

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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 (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

⁴ Available from U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, <https://www.nrc.gov/reading-rm/doc-collections/cfr/>.

- 4.1.7 Sampling requirements.
- 4.1.8 Powder type (1, 2, or 3).
- 4.1.9 Isotopic content (¹⁰B).

5. Chemical Composition

NOTE 1—B₄C powder is hygroscopic and certain applications require low-moisture content.

5.1 The material shall conform to the chemical composition requirements prescribed in **Table 1** (see Methods **C791**).

5.2 When agreed upon between the buyer and the seller, the weight loss of the powder shall not exceed 1 % when heated at 110°C for 1 h in air.

6. Physical Requirements

6.1 The nominal particle size, particle size range, and applicable tolerances shall be agreed upon between the buyer and the seller. Method **C371** and **E11** shall be applied for particles larger than or equal to 75 μm. For particles smaller than 75 μm, the particle size distribution shall be determined by method **B822**.

6.2 The density shall be determined when specified. The Tap-density (Test Method **B527**) or Skeletal Density (Test Method **B923**) are approved methods. The recommended value to be used for the theoretical density of stoichiometric B₄C of natural isotopic content is 2.52 g/cm².

6.3 When specified, the angular or spherical shape shall be determined utilizing a method agreed upon between the buyer and the seller.

6.4 When specified, the shape factor shall be determined utilizing a method agreed upon between the buyer and the seller.

7. Cleanliness

7.1 The lot shall be handled in a manner that precludes contamination by dust, organics, plastics, or other foreign materials.

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 in the purchase order. Recommended Practice **E105** is referenced as a guide.

8.2 Each sample taken shall be sufficient to perform the following in the event they are necessary or desired by the buyer:

- 8.2.1 Quality control tests,
- 8.2.2 Acceptance tests,
- 8.2.3 Referee tests, and
- 8.2.4 Retention of archive samples by the seller.

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

9. Inspection and Certification

9.1 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 for each powder lot prior to shipment. The seller shall certify that each powder lot is in compliance with the provisions of this specification.

10. Rejection

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

10.2 Powder 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 buyer shall approve, prior to use, any remedy proposed to bring rejected lots into specification.

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

11. Packaging and Package Marking

11.1 The powder shall be packaged in sealed containers for shipment from the seller to the buyer. The seller will be responsible for designing the shipping container to ensure cleanliness, minimize moisture pickup, provide adequate protection against damage during transportation, and ensure reasonable ease of unpackaging.

11.2 Each container shall be clearly marked with the following: boron carbide powder, powder type (1, 2, or 3), purchase order number, purchase order specification, gross, net, and tare weights, lot number, and name of seller.

12. Quality Assurance

12.1 Quality assurance requirements shall be agreed upon between the buyer and the seller when specified in the purchase order. NRC Regulations, Code of Federal Regulations, Title 10, Part 50 (Appendix B) and ANSI/ASME NQA-1 are referenced as guides.

TABLE 1 Chemical Requirements

Constituent	Composition, Weight % ^A		
	Type 1	Type 2	Type 3
Total boron (B) ^B	81.0 max 76.5 min	81.0 max 73.0 min	81.0 max 70.0 min
HNO ₃ -soluble boron	0.5 max	0.6 max	not determined
Water soluble boron	0.2 max	0.2 max	1.0 max
Fluoride (F)	25 μg/g max	25 μg/g max	not determined
Chloride (Cl)	75 μg/g max	75 μg/g max	not determined
Calcium (Ca)	0.3 max	0.3 max	not determined
Iron (Fe)	1.0 max	1.0 max	2.0 max
Total boron (B) plus total carbon (C)	98.0 min	97.0 min	94.0 min

^A Unless otherwise indicated (percentages based on a dry weight of boron carbide).

^B Unless otherwise specified, the ¹⁰B isotopic content in the boron shall be 19.90 ± 0.3 atom % for Types 1 and 2 and 19.90 ± 0.5 atom % for Type 3.

13. Keywords

13.1 boron carbide; powder

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