



Designation: C753 – 16

Standard Specification for Nuclear-Grade, Sinterable Uranium Dioxide Powder¹

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INTRODUCTION

This specification is intended to provide the nuclear industry with a general standard for sinterable uranium dioxide (UO_2) powder. It recognizes the diversity of manufacturing methods by which UO_2 powders are produced and the many special requirements for chemical and physical characterization that may be applicable for a particular fuel pellet manufacturing process or imposed by the end user of the powder in a specific reactor system. It is, therefore, anticipated that the buyer may supplement this specification with more stringent or additional requirements for specific applications.

1. Scope

1.1 This specification covers nuclear-grade, sinterable UO_2 powder. It applies to UO_2 powder containing uranium (U) of any ^{235}U concentration in the production of nuclear fuel pellets for use in nuclear reactors.

1.2 This specification recognizes the presence of reprocessed U in the fuel cycle and consequently defines isotopic limits for commercial grade UO_2 . Such commercial grade UO_2 is defined so that, regarding fuel design and manufacture, the product is essentially equivalent to that made from unreprocessed U. UO_2 falling outside these limits cannot necessarily be regarded as equivalent and may thus need special provisions at the fuel fabrication plant or in the fuel design.

1.3 This specification does not include provisions for preventing criticality accidents or requirements for health and safety. Observance of this specification does not relieve the user of the obligation to be aware of and conform to all international, national, or federal, state, and local regulations pertaining to possessing, shipping, processing, or using source or special nuclear material.

1.4 This specification refers expressly to UO_2 powder before the addition of any die lubricant, binder, or pore former. If powder is sold with such additions or prepared as press feed, sampling procedures, allowable impurity contents, or powder physical requirements may need to be modified by agreement between the buyer and the seller.

1.5 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory requirements prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

- B243 Terminology of Powder Metallurgy
 - B329 Test Method for Apparent Density of Metal Powders and Compounds Using the Scott Volumeter
 - C696 Test Methods for Chemical, Mass Spectrometric, and Spectrochemical Analysis of Nuclear-Grade Uranium Dioxide Powders and Pellets
 - C859 Terminology Relating to Nuclear Materials
 - C996 Specification for Uranium Hexafluoride Enriched to Less Than 5 % ^{235}U
 - 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:³
- ASME NQA-1 Quality Assurance Requirements for Nuclear Facility Applications

¹ This specification is under the jurisdiction of ASTM Committee C26 on Nuclear Fuel Cycle and is the direct responsibility of Subcommittee C26.02 on Fuel and Fertile Material 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 Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

2.3 Federal Regulation:⁴

Code of Federal Regulations, Title 10, Chapter 1, Nuclear Regulatory Commission, Applicable Parts

3. Terminology

3.1 *Definitions*—Definitions of terms are as given in Terminologies **B243** and **C859**.

4. Chemical Composition

4.1 *Uranium Content*—The U content shall be determined on a basis to be agreed upon between the buyer and seller.

4.2 *Oxygen-to-Uranium Ratio (O/U)*—The O/U ratio may be specified as agreed upon between the buyer and seller. The determination of the O/U ratio shall be in accordance with Test Methods **C696** or a demonstrated equivalent.

4.3 *Impurity Content*—The impurity content shall not exceed the individual element limit specified in **Table 1** on a U basis. Total non-volatile oxide impurity content (see **Table 1** and other impurity elements not having associated limits in **Table 2**) shall not exceed 1500 µg/gU. If an element analysis is reported as “less than” a given concentration, this “less than” value shall be used in the determination of total impurities. Impurity elements measured and their associated limits may differ from what is listed in this specification agreed upon between the buyer and seller.

4.4 *Moisture Content*—The moisture content shall not exceed 0.50 weight percent of the powder.

⁴ Available from U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Washington, DC 20401-0001, <http://www.access.gpo.gov>.

TABLE 1 Impurity Elements and Maximum Concentration Limits

Element ^B	Maximum Concentration Limit of Uranium, µg/gU
Aluminum (Al)	300
Carbon (C)	100
Calcium (Ca) + magnesium (Mg)	200
Chlorine (Cl)	100
Chromium (Cr)	200
Cobalt (Co)	100
Copper (Cu)	250
Fluorine (F)	100
Iron (Fe)	250
Lead (Pb)	250
Manganese (Mn)	250
Molybdenum (Mo)	250
Nickel (Ni)	200
Nitrogen (N)	200
Phosphorus (P)	250
Silicon (Si)	300
Tantalum (Ta)	250
Thorium ^A (Th)	10
Tin (Sn)	250
Titanium (Ti)	250
Tungsten (W)	250
Vanadium (V)	250
Zinc (Zn)	250

^A Thorium is primarily of concern because of the reactor production of ²³³U.

^B Any additional potential impurities, added by the fabrication process for example, beyond those listed here shall be evaluated (for example, in terms of equivalent boron) and associated limits established and agreed upon between the buyer and seller.

TABLE 2 Additional Impurity Elements

Element	
Beryllium (Be)	Manganese (Mn)
Bismuth (Bi)	Niobium (Nb)
Boron (B)	Potassium (K)
Cadmium (Cd)	Silver (Ag)
Dysprosium (Dy)	Samarium (Sm)
Europium (Eu)	Sodium (Na)
Gadolinium (Gd)	Sulfur (S)
Indium (In)	Zirconium (Zr)
Lithium (Li)	

4.5 Isotopic Content:

4.5.1 For UO₂ powder with an isotopic content of ²³⁵U below 5 %, the isotopic limits of Specification **C996** shall apply, unless otherwise agreed upon between the buyer and the seller. If the ²³⁶U content is greater than Enriched Commercial Grade UF₆ requirements, the isotopic analysis requirements of Specification **C996** shall apply. The specific isotopic measurements required by Specification **C996** may be waived, provided that the seller can demonstrate compliance with Specification **C996**, for instance, through the seller’s quality assurance records.

4.5.2 For UO₂ powder that does not have an assay in the range set forth in **4.5.1**, the isotopic requirements shall be as agreed upon between the buyer and the seller.

4.6 *Equivalent Boron Content*—For thermal reactor use, the total equivalent boron content (EBC) shall not exceed 4.0 µg/g on a U basis. For purpose of EBC calculation B, Gd, Eu, Dy, Sm, and Cd shall be included in addition to elements listed in **Table 1**. The method of performing the calculation shall be as indicated in Practice **C1233**. For fast reactor use, the above limitation on EBC does not apply.

5. Physical Properties

5.1 *Cleanliness and Workmanship*—The UO₂ powder shall be free of visible fragments of foreign matter.

5.2 *Particle Size*—UO₂ powder particle size limits and method of determination shall be as agreed upon between the buyer and seller. As an example, the fraction of a representative sample not passing through a 425-µm (No. 40) standard sieve conforming to Specification **E11** shall be reported to the buyer.

5.3 *Bulk Density*—The bulk density of UO₂ powder will depend on the processing method. Unless otherwise agreed upon between the buyer and seller, the bulk density shall be a minimum of 0.625 g/cm³ as determined by Test Method **B329**, or an agreed upon alternative.

5.4 *Sinterability*—Test pellets shall be produced and measured in accordance with a sintering performance test agreed upon between the buyer and seller. A sinterability performance test described in **Appendix X1** is presented as a guide.

6. Sampling

6.1 A lot is defined as a quantity of UO₂ powder that is uniform in isotopic, chemical, physical, and sinterability characteristics.

6.2 The identity of a lot shall be retained throughout its processing history.