Designation: ~~C753 – 04 (Reapproved 2009)~~ C753 – 16

Standard Specification for Nuclear-Grade, Sinterable Uranium Dioxide Powder[1]

This standard is issued under the fixed designation C753; 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.

INTRODUCTION

This specification is intended to provide the nuclear industry with a general ~~specification~~standard for sinterable uranium dioxide (UO_2) powder. It recognizes the diversity of manufacturing methods by which ~~uranium~~UO_2 ~~dioxide~~ powders are produced and the many special requirements for chemical and physical characterization ~~which may be~~ that may be applicable for a particular fuel pellet manufacturing process or imposed by the end ~~use~~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 ~~uranium dioxide (UO~~UO_2~~)~~ powder. It applies to ~~uranium~~UO_2 ~~dioxide~~ 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 ~~uranium~~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 ~~uranium.~~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 ~~calcined~~ 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

[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.

Current edition approved ~~June 1, 2009~~Feb. 1, 2016. Published ~~July 2009~~March 2016. Originally approved in 1973. Last previous edition approved in ~~2004~~2009 as ~~C753 – 04.~~C753 – 04 (2009). DOI: ~~10.1520/C0753-04R09.~~10.1520/C0753-16.

[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.

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves
E105 Practice for Probability Sampling of Materials
2.2 *ANSI/ASME Standard:*[3]
ANSI/ASME NQA-1 Quality Assurance Requirements for Nuclear Facility Applications
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 Terminology Terminologies B243 and C859.

4. Chemical Requirements Composition

4.1 *Uranium Content*—The uranium 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 uranium weight basis. The summation of the contribution of each U basis. Total non-volatile oxide impurity content (see Table 1 of the and other impurity elements listed in not having Table 1 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. 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 0.40 0.50 weight percent of the powder.

4.5 *Isotopic Content:*

4.5.1 For UO_2 powder with an isotopic content of ^{235}U between that of natural uranium and below 5 %, the isotopic limits of Specification C996 shall apply, unless otherwise agreed upon between the buyer and the seller. If the ^{236}U content is greater than Enriched Commercial Grade UF_6 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. A ^{236}U content greater than that specified in C996 for Enriched Commercial Grade UF_6 may be agreed between the buyer and the seller since it is not a safety concern.

4.5.2 For UO_2 powder, not having 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 uranium weight 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.

4.7 *Cleanliness and Workmanship*—The powder shall be visually free of foreign material such as metallic particles and oil.

5. Physical Requirements Properties

5.1 *Cleanliness and Workmanship*—The UO_2 powder shall be free of visible fragments of foreign matter.

5.2 *Particle Size*—Based on visual observation, all of a representative sample of the UO_2 shall pass through a 425-µm (No. 40) standard sieve conforming to Specification powder particle E11. Particle size distribution limits and method of determination shall be as agreed upon between the buyer and seller. Alternatively, as agreed upon between the buyer and the seller, the fraction 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 UO_2 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 kg/mg/cm^3 as determined by Test Method B329, or an agreed upon alternative.

NOTE 1—For powder prepared as a press feed, a minimum bulk density of 1.8 g/cm^3 is recommended.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10036, http://www.ansi.org. 10016-5990, http://www.asme.org.
[4] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://www.dodssp.daps.mil. U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Washington, DC 20401-0001, http://www.access.gpo.gov.
[5] The intent of the C996 isotope limits is to indicate possible presence of reprocessed UF_6. Acceptance of UO_2 pellets with ^{236}U content above that specified for Enriched Commercial Grade UF_6, shall be based on fuel performance evaluation.

TABLE 1 Impurity Elements and Maximum Concentration Limits

Element	Maximum Concentration Limit of Uranium, µg/gU
~~Aluminum~~	~~250~~
Carbon	100
~~Calcium + magnesium~~	~~200~~
Chlorine	100
Chromium	200
Cobalt	100
Copper	250
Fluorine	100
Iron	250
Lead	250
Manganese	250
Molybdenum	250
Nickel	200
Nitrogen	200
Phosphorus	250
Silicon	300
Tantalum	250
Thorium[A]	10
Tin	250
Titanium	250
Tungsten	250
Vanadium	250
Zinc	250

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 ^{233}U.

[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)	