



Designation: C833 – 01 (Reapproved 2008)

Standard Specification for Sintered (Uranium-Plutonium) Dioxide Pellets¹

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INTRODUCTION

This specification is intended to provide the nuclear industry with a general standard for uranium-plutonium dioxide pellets for thermal reactor use. It recognizes the diversity of manufacturing methods by which uranium-plutonium dioxide pellets are produced and the many special requirements for chemical and physical characterization that may be imposed by the operating conditions to which the pellets will be subjected in specific reactor systems. It does not recognize the possible problems associated with the reprocessing of such pellets. It is, therefore, anticipated that the purchaser may supplement this specification with additional requirements for specific applications.

1. Scope

1.1 This specification covers finished sintered and ground (uranium-plutonium) dioxide pellets for use in thermal reactors. It applies to uranium-plutonium dioxide pellets containing plutonium additions up to 15 % weight. This specification may not completely cover the requirements for pellets fabricated from weapons-derived plutonium.

1.2 This specification does not include (1) provisions for preventing criticality accidents or (2) 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 applicable international, federal, state, and local regulations pertaining to possessing, processing, shipping, or using source or special nuclear material. Examples of U.S. government documents are Code of Federal Regulations Title 10, Part 50—Domestic Licensing of Production and Utilization Facilities; Code of Federal Regulations Title 10, Part 71—Packaging and Transportation of Radioactive Material; and Code of Federal Regulations Title 49, Part 173—General Requirements for Shipments and Packaging.

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

1.4 The following safety hazards caveat pertains only to the technical requirements portion, Section 4, of this specification:

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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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 limitations prior to use.

2. Referenced Documents

2.1 ASTM Standards:²

- C698 Test Methods for Chemical, Mass Spectrometric, and Spectrochemical Analysis of Nuclear-Grade Mixed Oxides ((U, Pu)O₂)
- C753 Specification for Nuclear-Grade, Sinterable Uranium Dioxide Powder
- C757 Specification for Nuclear-Grade Plutonium Dioxide Powder, Sinterable
- C859 Terminology Relating to Nuclear Materials
- C1165 Test Method for Determining Plutonium by Controlled-Potential Coulometry in H₂SO₄ at a Platinum Working Electrode
- C1204 Test Method for Uranium in Presence of Plutonium by Iron(II) Reduction in Phosphoric Acid Followed by Chromium(VI) Titration
- C1206 Test Method for Plutonium by Iron (II)/Chromium (VI) Amperometric Titration
- C1233 Practice for Determining Equivalent Boron Contents of Nuclear Materials
- E105 Practice for Probability Sampling of Materials

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.

2.2 ANSI Standard:³

ANSI/ASME NQA-1 Quality Assurance Requirements for Nuclear Facility Applications

2.3 U.S. Government Documents:⁴

USNRC Regulatory Guide 1.126 An Acceptable Model and Related Statistical Methods for the Analysis of Fuel Densification

Code of Federal Regulations Title 10, Part 50 Domestic Licensing of Production and Utilization Facilities

Code of Federal Regulations Title 10, Part 71 Packaging and Transportation of Radioactive Material

Code of Federal Regulations Title 49, Part 173 General Requirements for Shipments and Packaging

3. Terminology

3.1 *Definitions*—Definitions shall be in accordance with Terminology C859.

4. Technical Requirements

4.1 *Chemical Requirements*—All chemical analyses shall be performed on portions of the representative sample prepared in accordance with Section 6. Analytical chemistry methods shall be as stated in Test Methods C698 (latest edition) or demonstrated equivalent as mutually agreed to between the buyer and the seller.

4.1.1 *Uranium and Plutonium Content*—Unless agreed upon by the buyer and seller, individual powders shall meet the requirements of Specifications C753 and C757, which also reference Test Methods C1165, C1204, and C1206. The uranium and plutonium contents combined shall be a minimum of 87.7 % weight on a dry weight basis compensated for the Am-241 content. (Dry weight is defined as the sample weight minus the moisture content). The plutonium content shall be that specified by the buyer, up to the limits covered in this specification (15 %).

4.1.2 *Impurity Content*—The impurity content shall not exceed the individual element limit specified in Table 1 based on the heavy metal content (uranium plus plutonium). The summation of the contribution of each of the impurity elements listed in Table 1 shall not exceed 1500 µg/g (U + P). 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.

NOTE 1—Higher impurity limits should be acceptable for restricted burnups and linear power ratings if there is evidence to substantiate the relaxation. Higher impurity levels of 450 ppm aluminum, 250 ppm carbon, 250 ppm nitrogen, and 450 ppm silicon have been supported for burnups of less than 35 000 MWd/t. The extension of the burnup limit may be determined by agreement between the buyer and seller as supporting data are accumulated.

4.1.3 *Stoichiometry*—The oxygen-to-heavy metal ratio of sintered fuel pellets shall be within the range from 1.98 to 2.02.

The nominal value and allowable tolerance shall be agreed upon between the buyer and seller.

4.1.4 *Moisture Content*—The moisture content limit is included in the total hydrogen limit (see Table 1).

4.1.5 *Gas Content*—The gas content, exclusive of moisture, shall not exceed, at Standard Temperature and Pressure (0°C and one atmosphere), 0.05 L/kg of the heavy metal content.

4.1.6 *Americium-241 Content*—The americium-241 content shall be measured by the seller and reported to the buyer. The americium-241 content or activity is important in the handling of UO₂-PuO₂ pellets and will vary with time. The maximum acceptable americium-241 content on a given date along with the date of analysis shall be agreed upon between the buyer and seller. The dates of separation of plutonium from this isotope and the analysis dates shall be considered; methods of reporting shall be agreed upon between the buyer and seller.

4.2 Nuclear Requirements:

4.2.1 *Isotopic Content*—The isotopic content of the americium, uranium, and plutonium in the (uranium-plutonium) dioxide pellets shall be determined and the date of the determination recorded. The ²³⁴U, ²³⁵U, ²³⁶U, and ²³⁸U content of the uranium shall be reported as a mass percentage with respect to total uranium, and the ²³⁸Pu, ²³⁹Pu, ²⁴⁰Pu, ²⁴¹Pu, and ²⁴²Pu content of the plutonium shall be reported on a Pu mass % or on (Pu + Am) mass % basis. The equivalent plutonium content based on uranium and plutonium isotopic concentrations shall be as agreed upon between the buyer and seller.

4.2.2 *Plutonium Equivalent at a Given Date*—(uranium-plutonium) dioxide fuel shall be considered as defined by the plutonium content with adjustment (credit or debit) for the actual isotopic composition of plutonium, americium, and uranium. The dates of isotopic analyses in support of these determinations shall be recorded by the seller and reported to the buyer. The allowable tolerances of the plutonium equivalent content (either as uranium plus plutonium or as the individual elements) shall be as agreed upon between the buyer and seller.

4.2.3 *Equivalent Boron Content*—For thermal reactor use, the total equivalent boron content (EBC) shall not exceed 4.0 µg/g on a heavy metal basis. The method of performing the calculation shall be as indicated in Practice C1233. For the purposes of EBC calculation, B, Gd, Eu, Dy, Sm, and Cd shall be included.

TABLE 1 Impurity Elements and Maximum Concentration Limits

Element	Maximum Concentration Limit (µg/g of U + Pu)
Aluminum	250
Carbon	100
Calcium + magnesium	200
Chlorine	25
Chromium	250
Cobalt	100
Fluorine	25
Hydrogen (total from all sources)	1.3
Iron	500
Nickel	250
Nitride/nitrogen	75
Silicon	250

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