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.

Designation: C833 – 23

Standard Specification for Sintered (Uranium-Plutonium) Dioxide Pellets for Light Water Reactors[1]

This standard is issued under the fixed designation C833; 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 standard for uranium-plutonium dioxide ((U, Pu)O_2) pellets for light water reactor use. It recognizes the diversity of manufacturing methods by which (U, Pu)O_2 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 different light water reactors. 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 (U, Pu)O_2 pellets for use in light water reactors. It applies to (U, Pu)O_2 pellets containing a plutonium mass fraction up to 15 % (that is, mass of Pu divided by the sum of masses U, Pu, and Am yielding 0.15 or less).

1.2 Pellets produced under this specification are available in four grades.

1.2.1 *Grade R*—^{240}Pu / (Pu + Am) isotope mass fraction is at least 19 %.

1.2.2 *Grade F*—^{240}Pu / (Pu + Am) isotope mass fraction is at least 7 % and less than 19 %.

1.2.3 *Grade N1*—^{240}Pu / (Pu + Am) isotope mass fraction is less than 7 %.

1.2.4 *Grade N2*—^{240}Pu /^{239}Pu isotope mass fraction does not exceed 0.10 (10 %).

1.3 There is no discussion of or provision for preventing criticality incidents, nor are health and safety requirements, the avoidance of hazards, or shipping precautions and controls discussed. 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.

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

1.5 The following safety hazards caveat pertains only to the technical requirements portion, Section 4, of this specification: *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *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]

B243 Terminology of Powder Metallurgy

C698 Test Methods for Chemical, Mass Spectrometric, and Spectrochemical Analysis of Nuclear-Grade Mixed Oxides ((U, Pu)O_2)

[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.

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C753 Specification for Nuclear-Grade, Sinterable Uranium Dioxide Powder
C757 Specification for Nuclear-Grade Plutonium Dioxide Powder for Light Water Reactors
C859 Terminology Relating to Nuclear Materials
C1233 Practice for Determining Equivalent Boron Contents of Nuclear Materials
E105 Guide for Probability Sampling of Materials
E112 Test Methods for Determining Average Grain Size

2.2 *ASME Standard:*[3]

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 of terms are as given in Terminologies B243 and 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. The combined U and Pu mass fractions shall be a minimum of 87.7 % on a dry weight basis compensated for the Americium 241 (^{241}Am) content. (Dry weight is defined as the sample weight minus the moisture content). The content shall be that specified by the buyer, up to the limits covered in this specification (that is, 15 wt%).

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 (U + Pu + Am). The summation of the contribution of each of the impurity elements listed in Table 1 shall not exceed 1500 µg/g (U + Pu + Am). Some other elements such as those listed in Table 2 may also be of concern for the buyer and should be measured and reported if requested. 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 as agreed upon between the buyer and seller.

TABLE 1 Impurity Elements and Maximum Concentration Limits[A]

Element[B]	Maximum Concentration Limit (µg/g of U + Pu + Am)
Aluminum (Al)	250
Carbon (C)	100
Calcium (Ca) + magnesium (Mg)	200
Chlorine (Cl)	25
Chromium (Cr)	250
Cobalt (Co)	100
Fluorine (F)	25
Hydrogen (H, total from all sources)	1.3
Iron (Fe)	500
Nickel (Ni)	250
Nitrogen (N)	75
Silicon (Si)	250

[A]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.
[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)	Silver (Ag)
Bismuth (Bi)	Sodium (Na)
Copper (Cu)	Sulfur (S)
Indium (In)	Tantalum (Ta)
Lead (Pb)	Thorium (Th)
Lithium (Li)	Tin (Sn)
Manganese (Mn)	Titanium (Ti)
Molybdenum (Mo)	Tungsten (W)
Neptunium (Np)	Vanadium (V)
Niobium (Nb)	Zinc (Zn)
Phosphorous (P)	Zirconium (Zr)
Potassium (K)	

4.1.3 *Stoichiometry*—The oxygen-to-heavy metal ratio (O/(U + Pu + Am)) 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 be determined as agreed upon between the buyer and the seller. Typical methods include calculation based on C, N_2, and H_2 contents or determination by high temperature vacuum extraction, or combinations thereof.

4.1.6 *Americium-241 Content*—The ^{241}Am content shall be measured by the seller and reported to the buyer. The ^{241}Am content or activity is important in the handling of (U, Pu)O_2 pellets and subsequent helium generation from alpha decay during irradiation and will vary with time. The maximum acceptable ^{241}Am content on a given date along with the date of analysis shall be agreed upon between the buyer and seller.

[3] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, http://www.asme.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.gpo.gov.