



Designation: C 1008 – 99

Standard Specification for Sintered (Uranium-Plutonium) Dioxide Pellets—Fast Reactor Fuel¹

This standard is issued under the fixed designation C 1008; 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 pellets for fast 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 which 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 buyer may supplement this specification with additional requirements for specific applications.

1. Scope

1.1 This specification is for finished sintered (uranium-plutonium) dioxide pellets. It applies to (uranium-plutonium) dioxide pellets containing plutonium additions in the range from 10 to 40 weight % and uranium of any ²³⁵U content. The isotopic composition of the plutonium component will be as normally produced by in-reactor neutron irradiation of uranium having less than 5 % ²³⁵U or by in-reactor neutron irradiation of recycled plutonium mixed with uranium.

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; Title 10, Part 71 — Packaging and Transportation of Radioactive Material; and Title 49, Part 173 — General Requirements for Shipments and Packaging.

1.3 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 and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 ASTM Standards:

- C 698 Test Methods for Chemical, Mass Spectrometric, and Spectrochemical Analysis of Nuclear-Grade Mixed Oxides ((U, Pu)O₂)²
- C 753 Specification for Nuclear-Grade, Sinterable Uranium Dioxide Powder²
- C 757 Specification for Nuclear-Grade Plutonium Dioxide Powder, Sinterable²
- C 859 Terminology Relating to Nuclear Materials²
- C 1165 Test Method for Determining Plutonium by Controlled-Potential Coulometry in H₂SO₄ at a Platinum Working Electrode²
- C 1204 Test Method for Uranium in the Presence of Plutonium by Iron (II) Reduction in Phosphoric Acid Followed by Chromium (VI) Titration²
- C 1206 Test Method for Plutonium by Iron (II)/Chromium (VI) Amperometric Titration²
- E 105 Practice for Probability Sampling of Materials³

2.2 ANSI Standard:

- ANSI/ASME NQA-1 Quality Assurance Program Requirements for Nuclear Facility Applications⁴

¹ This specification is under the jurisdiction of ASTM Committee C-26 on Nuclear Fuel Cycle and is the direct responsibility of Subcommittee C26.02 on Fuel and Fertile Material Specifications.

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² Annual Book of ASTM Standards, Vol 12.01.

³ Annual Book of ASTM Standards, Vol 14.02.

⁴ Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

2.3 U.S. Government Documents:

Code of Federal Regulations, Title 10, (Energy) Part 50, Domestic Licensing of Production and Utilization Facilities (10 CFR 50)⁵

U.S. Department of Transportation, Title 49, Transportation, Chapter 1, Materials Transportation Bureau, applicable parts⁵

U.S. Nuclear Regulatory Commission, Title 10, Part 71, Packaging and Transportation of Radioactive Material⁵

3. Terminology

3.1 *Definitions*—Definitions shall be in accordance with Terminology C 859.

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 C 698 (latest edition) or demonstrated equivalent as mutually agreed upon between the buyer and the seller.

4.1.1 *Uranium and Plutonium Content*—Individual powders shall meet the requirements of Specifications C 753 and C 757. The uranium and plutonium contents combined shall be a minimum of 87.7 weight % on a dry weight basis compensated for the americium-241 content. (Dry weight is defined as the sample weight minus the moisture content.) The plutonium content shall be that specified by the buyer.

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 5000 µg/g (U + Pu). If an element analysis is reported as “less than” a given concentration, this “less than” value shall be used in the determination of the total impurities.

⁵ Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

TABLE 1 Impurity Elements and Maximum Concentration Limits

Elements	Maximum Concentration Limit (µg/g of U + Pu)
Aluminum	900
Calcium	250
Carbon	300
Chlorine	25
Chromium	500
Fluorine	25
Iron	1600
Magnesium	150
Nickel	500
Nitride nitrogen	200
The sum of copper, zinc, and silicon	1400
The sum of silver, manganese, molybdenum, lead, and tin	400

4.1.3 *Stoichiometry*—The oxygen-to-heavy-metal ratio of sintered fuel pellets shall be within the range from 1.94 to 2.01. The nominal value and allowable tolerances shall be agreed upon between the buyer and the seller.

4.1.4 *Moisture Content*—The moisture content shall not exceed 30 µg/g total weight.

4.1.5 *Gas Content*—The gas content, exclusive of moisture, shall not exceed, at standard temperature and pressure, 0.18 L/kg of the heavy metal content.

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

4.1.7 The uranium, thorium, and americium contents or activity, or both, are important in the handling of plutonium dioxide (PuO₂) containing materials and will vary with time. The dates of separation of the plutonium used from these elements and the analysis dates shall be considered. Methods of reporting shall be agreed upon between the seller and the buyer.

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. 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 a (Pu + Am) mass % basis. The equivalent plutonium content based on uranium and plutonium isotopic concentrations shall be as specified by the buyer.

4.2.2 *Equivalent Plutonium at a Given Date*—The equivalent plutonium of the (uranium-plutonium) dioxide pellets shall be considered as the sum of the fissile isotopes of uranium, plutonium, and americium. Debits in fissile inventory will be considered, as necessary, for poisons, for example, U236 or Am241. The dates of isotopic analyses in support of these determinations will be recorded by the seller and reported to the buyer. The permissible tolerances of the plutonium content (either as americium, uranium plus plutonium, or as the individual elements) and their evaluation criteria shall be as agreed upon between the buyer and the seller.

4.3 Physical Characteristics:

4.3.1 *Dimensions*—The dimensions of the pellet shall be as specified by the buyer. These shall include diameter, length, perpendicularity, and, as required, other geometric parameters including surface finish.

4.3.2 *Pellet Density*—The density of sintered pellets shall be as specified by the buyer. The theoretical density for uranium dioxide (UO₂) of natural isotopic content shall be considered as 10.96 g/cm³. The theoretical density for PuO₂ shall be considered as 11.46 g/cm³. The theoretical density for the uranium-plutonium dioxide ((U, Pu)O₂) pellets shall be calculated by linear interpolation between these values. Density measurements shall be made by the method stated in