



Designation: ~~C922-00~~ Designation: **C 922 – 08**

Standard Specification for Sintered Gadolinium Oxide-Uranium Dioxide Pellets¹

This standard is issued under the fixed designation C 922; 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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

INTRODUCTION

This specification is intended to provide the nuclear industry with a general specification for gadolinium oxide-uranium dioxide pellets. It recognizes the diversity of manufacturing methods by which gadolinium oxide-uranium 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. Therefore, it is anticipated that the purchaser may supplement this specification with additional requirements for specific applications.

1. Scope

1.1 This specification is for finished sintered gadolinium oxide-uranium dioxide pellets for use in light-water reactors. It applies to gadolinium oxide-uranium dioxide pellets containing uranium of any ^{235}U concentration and any concentration of gadolinium oxide.

1.2 This specification recognizes the presence of reprocessed uranium in the fuel cycle and consequently defines isotopic limits for gadolinium oxide-uranium dioxide pellets made from 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~~ unirradiated uranium. 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 (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 international, federal, state, and local regulations pertaining to possessing, shipping, processing, or using source or special nuclear material. Examples of U.S. Governmental documents are Code of Federal Regulations (Latest Edition), Title 10, Part 50, Title 10, Part 71, and Title 49, Part 173.

1.4 The following precautionary 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:

~~E 696 Test Methods for Chemical, Mass Spectrometric, and Spectrochemical Analysis of Nuclear-Grade Uranium Dioxide Powders and Pellets²~~

~~C 753 Specification for Nuclear-Grade, Sinterable Uranium Dioxide Powder²~~ Terminology Relating to Sewn Products Automation

~~C 859 Terminology Relating to Nuclear Materials²~~ Terminology Relating to Sewn Products Automation

C 888 Specification for Nuclear-Grade Gadolinium Oxide (Gd_2O_3) Powder

~~C 968 Test Methods for Analysis of Sintered Gadolinium Oxide-Uranium Dioxide Pellets²~~ Terminology Relating to Sewn Products Automation

~~C 996 Specification for Uranium Hexafluoride Enriched to Less than 5% ^{235}U~~

¹ This specification is under the jurisdiction of ASTM Committee ~~E-26~~ 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*, Vol 12.01, volume information, refer to the standard's Document Summary page on the ASTM website.

~~C1233 Practice for Determining the Equivalent Boron Content of Nuclear Materials²~~ 996 Terminology Relating to Sewn Products Automation

~~E 105 Practice for Probability Sampling of Materials~~ Terminology Relating to Sewn Products Automation

2.2 *ANSI Standard:*³

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

2.3 *U.S. Government Documents:*⁴

Code of Federal Regulations (Latest Edition), Title 10, Part 50, Energy (10 CFR 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

Regulatory Guide NUREG 1.126, An Acceptable Model and Related Statistical Methods for the Analysis of Fuel Densification, Rev. 1 March 1978⁵

3. Terminology

3.1 *Definitions*—For definitions of terms, refer to Terminology C 859.

4. Technical Requirements

4.1 *Major Constituents*—Gadolinium oxide-uranium dioxide pellets shall be fabricated using major constituents that meet the requirements of Specifications C 753 ~~and C 888~~ and C 888.

4.2 *Chemical Requirements*—All chemical analyses shall be performed on portions of the representative sample prepared in accordance with Section 6. Analytical chemistry methods used shall be as stated in Test Methods C 968 (latest edition) or demonstrated equivalent as mutually agreed to between the seller and the buyer.

4.2.1 *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 of the impurity elements listed in Table 1 shall not exceed 1500 µg/g U. 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. The thorium measurements required by Table 1 may be waived, provided that the seller can otherwise demonstrate compliance with this specification, for instance, through the seller’s quality assurance records.

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

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

4.2.4 *Gd₂O₃ Concentration*—The gadolinium oxide (Gd₂O₃) concentration shall be as specified in the purchase order.

4.3 *Nuclear Requirements:*

4.3.1 *Isotopic Content:*

For (U,Gd)O₂ pellets with an isotopic content of ²³⁵U between that of natural uranium and 5 %, the isotopic limits of Specification C 996 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 C 996 shall apply. The specific isotopic measurements required by Specification C 996 may be waived, provided that the seller can otherwise demonstrate compliance with Specification C 996, for instance, through the seller’s quality assurance records. A ²³⁶U content greater than the

² Annual Book of ASTM Standards, Vol 14.02.

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

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>.

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

⁵ Available from U.S. Nuclear Regulatory Commission, Washington, DC 20555. Attention: Director, Division of Document Control.

TABLE 1 Impurity Elements and Maximum Concentration Limits

Element	Maximum Concentration Limit (µg/g U)
Aluminum	250
Carbon	100
Calcium + magnesium	200
Chlorine	25
Chromium	250
Fluorine	15
Hydrogen (total from all sources)	1.3
Iron	500
Nickel	250
Nitrogen	75
Silicon	500
Thorium	10