



Standard Specification for Blended Uranium Oxides with a ^{235}U Content of Less Than 5 % for Direct Hydrogen Reduction to Nuclear Grade Uranium Dioxide¹

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INTRODUCTION

This specification is intended to provide the nuclear industry with a general standard for such uranium oxide powders. It recognizes the diversity of conversion processes and the many special requirements for chemical and physical characterization that may be imposed by the end use of the powder. It is anticipated, therefore, that this specification may be supplemented with additional requirements by agreement between the buyer and the seller.

1. Scope

1.1 This specification covers blended uranium trioxide (UO_3), U_3O_8 , or mixtures of the two, powders that are intended for conversion into a sinterable uranium dioxide (UO_2) powder by means of a direct reduction process. The UO_2 powder product of the reduction process must meet the requirements of Specification C 753 and be suitable for subsequent UO_2 pellet fabrication by pressing and sintering methods. This specification applies to uranium oxides with a ^{235}U enrichment less than 5 %.

1.2 This specification includes chemical, physical, and test method requirements for uranium oxide powders as they relate to the suitability of the powder for storage, transportation, and direct reduction to UO_2 powder. This specification is applicable to uranium oxide powders for such use from any source.

1.3 The scope of this specification does not comprehensively cover all provisions for preventing criticality accidents, for health and safety, or for shipping. Observance of this specification does not relieve the user of the obligation to conform to all international, national, state, and local regulations for processing, shipping, or any other way of using uranium oxide powders (see 2.2 and 2.3).

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.5 The following safety hazards caveat pertains only to the test methods portion of the annexes in 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:

- B 329 Test Method for Apparent Density of Metal Powders and Related Compounds Using the Scott Volumeter²
 - C 696 Test Methods for Chemical, Mass Spectrometric, and Spectrochemical Analysis of Nuclear-Grade Uranium Dioxide Powders and Pellets³
 - C 753 Specification for Nuclear-Grade, Sinterable Uranium Dioxide Powder³
 - C 799 Test Methods for Chemical, Mass Spectrometric, Spectrochemical, Nuclear, and Radiochemical Analysis of Nuclear-Grade Uranyl Nitrate Solutions³
 - C 859 Terminology Relating to Nuclear Materials³
 - C 996 Specification for Uranium Hexafluoride Enriched to Less Than 5 % ^{235}U ³
 - C 1233 Practice for Determining Equivalent Boron Contents of Nuclear Materials³
 - C 1287 Test Method for Determination of Impurities in Uranium Dioxide by Inductively Coupled Plasma Mass Spectrometry³
 - E 11 Specification for Wire-Cloth Sieves for Testing Purposes⁴
 - E 105 Practice for Probability Sampling of Materials⁴
- #### 2.2 ANSI Standard:
- NQA-1 Quality Assurance Program, Requirements for Nuclear Facilities⁵

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 02.05.

³ Annual Book of ASTM Standards, Vol 12.01.

⁴ Annual Book of ASTM Standards, Vol 14.02.

⁵ Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

2.3 U.S. Government Document:

CFR Title 10 (Energy), Part 50, Domestic Licensing of Production and Utilization Facilities⁶

TABLE 1 Impurity Elements and Maximum Concentration Limits

Element	Maximum Concentration Limit of Uranium, $\mu\text{g/gU}$
Aluminum	50
Barium	5
Beryllium	100
Bismuth	3
Calcium + magnesium	100
Carbon	100
Chlorine	100
Chromium	100
Cobalt	80
Copper	100
Fluorine	100
Iron	150
Lead	40
Manganese	50
Molybdenum	200
Nickel	80
Phosphorus	100
Silicon	200
Sodium	20
Tantalum	200
Thorium	10
Tin	50
Titanium	50
Tungsten	100
Vanadium	10
Zinc	20

3. Terminology

3.1 *Definitions*—Terms shall be defined in accordance with Terminology C 859, except the following.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *Commercial-Grade Uranium Oxide*—uranium trioxide (UO_3), U_3O_8 , or a mixture of the two, made from unirradiated uranium. It is recognized that some contamination with reprocessed uranium may occur during routine processing; this is acceptable, provided that the specification for Commercial-Grade Uranium Oxide, as set forth in 4.1, is met.

4. Isotopic Content

4.1 For Commercial-Grade Uranium Oxide with an isotopic content of ^{235}U between that of natural uranium and 5 %, the isotopic limits of Specification C 996 shall apply, unless otherwise agreed upon between the buyer and seller. If the ^{236}U content is greater than 30 $\mu\text{g/g}$ of total U, 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 demonstrate compliance with Specification C 996, for instance, through the seller's quality assurance records.

4.2 For commercial uranium oxides not having an isotopic concentration in the range set forth in 4.1, the isotopic requirements shall be as agreed upon between the buyer and the seller.

5. Physical and Chemical Requirements

5.1 *Uranium Content*—The uranium content shall be determined using the procedures described in Test Methods C 696 or C 799, or as agreed upon between the buyer and the seller. The minimum total uranium content shall also be agreed upon between the buyer and the seller.

5.2 *Oxygen-to-Uranium Ratio (O/U)*—The O/U ratio of the Commercial-Grade Uranium Oxide shall be nominally between 2.67 and 3.0. The O/U ratio shall be determined by Test Methods C 696 or by another method as agreed upon by the buyer and the seller.

5.3 *Impurity Content*—The impurity content of the Commercial-Grade Uranium Oxide 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 1000 $\mu\text{g/gU}$. The impurity content shall be determined using the procedures described in Test Methods C 696 or C 1287, or both, or as agreed upon between the buyer and the seller.

5.4 *Equivalent Boron Content*—The total equivalent boron content (EBC) of the Commercial-Grade Uranium Oxide shall not exceed 2.0 $\mu\text{g/gU}$. The list of elements to be considered in the EBC calculation shall be as agreed upon between the buyer and the seller. The method of performing the calculation shall be as indicated in Practice C 1233.

5.5 If the concentrations of any of the elements used in the calculations in 5.3 are reported as a less-than value, this less-than value shall be used for any further calculations involving the concentration of this element.

5.6 *Bulk Density*—Unless otherwise agreed upon between the buyer and the seller, the bulk density of the Commercial-Grade Uranium Oxide shall be a minimum of 575 kg/m^3 , as determined by Test Method B 329, or an alternative agreed upon between the buyer and the seller.

5.7 *Moisture Content*—The moisture content of the Commercial-Grade Uranium Oxide shall not exceed 1 % by weight unless otherwise agreed upon by the buyer and the seller.

5.8 *Ability to Flow*—The Commercial-Grade Uranium Oxide shall be sufficiently free-flowing to permit sampling and powder handling.

5.9 *Particle Size*—Based on visual observation, all of a representative sample of the Commercial-Grade Uranium Oxide shall pass through a 425- μm (No. 40) standard sieve conforming to Specification E 11, or as otherwise agreed upon between the buyer and the seller. Alternatively, as agreed upon between the buyer and the seller, the fraction not passing through a 425- μm (No. 40) standard sieve shall be reported to the buyer. Particle size, size distribution, and method of determination shall be as agreed upon between the buyer and the seller. Packing or agglomeration, or both, during shipping may be a concern.

5.10 *Reduction and Sinterability*—The Commercial-Grade Uranium Oxide shall be reduced to UO_2 , and test pellets shall be produced and measured in accordance with a sintering performance test agreed upon between the buyer and the seller. Reduction and sinterability performance tests described in Annex A1 are presented as a guide.

⁶ Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.