



Standard Specification for Uranium Metal Enriched to More than 15 % and Less Than 20 % ²³⁵U¹

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1. Scope

1.1 This specification covers nuclear grade uranium metal that has either been processed through an enrichment plant, or has been produced by the blending of highly enriched uranium with other uranium, to obtain uranium of any ²³⁵U concentration below 20 % (and greater than 15 %) and that is intended for research reactor fuel fabrication. The scope of this specification includes specifications for enriched uranium metal derived from commercial natural uranium, recovered uranium, or highly enriched uranium. Commercial natural uranium, recovered uranium and highly enriched uranium are defined in Section 3. The objectives of this specification are to define the impurity and uranium isotope limits for commercial grade enriched uranium metal.

1.2 This specification is intended to provide the nuclear industry with a standard for enriched uranium metal which is to be used in the production of research reactor fuel. In addition to this specification, the parties concerned may agree to other appropriate conditions.

1.3 The scope of this specification does not comprehensively cover all provisions for preventing criticality accidents or requirements for health and safety or for shipping. Observance of this standard does not relieve the user of the obligation to conform to all applicable international, federal, state, and local regulations for processing, shipping, or any other way of using uranium metal (see, for example, C 996 regarding references).

2. Referenced Documents

2.1 ASTM Standards:

- C 696 Test Methods for Chemical, Mass Spectrometric, and Spectrochemical Analysis of Nuclear-Grade Uranium Dioxide Powders and Pellets²
- C 799 Test Methods for Chemical, Mass Spectrometric, Spectrochemical, Nuclear, and Radiochemical Analysis of Nuclear-Grade Uranyl Nitrate Solutions²
- C 859 Terminology Relating to Nuclear Materials²
- C 996 Specification for Uranium Hexafluoride Enriched to less than 5 % ²³⁵U²

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.

C 1233 Practice for Determining the Equivalent Boron Content of Nuclear Material²

C 1295 Test Method for Gamma Energy Emission from Fission Products in Uranium Hexafluoride and Uranium Solutions²

C 1347 Practice for Preparation and Dissolution of Uranium Materials for Analysis²

2.2 ANSI Standard

ANSI-ASME NQA-1 Quality Assurance Program Requirements for Nuclear Facility Applications³

2.3 U.S. Government Documents

Code of Federal Regulations, Title 10, Part 50, (Appendix B)⁴

3. Terminology

3.1 *Definitions of Terms Specific to This Standard*—Terms shall be defined in accordance with Terminology C 859, except for the following:

3.1.1 *commercial grade enriched uranium metal*—uranium metal derived from commercial natural uranium, recovered uranium, or uranium obtained from the blending of highly enriched uranium with commercial natural uranium, recovered uranium, or depleted uranium.

3.1.2 *commercial natural uranium*—any form of natural unirradiated uranium (containing $0.711 + 0.004$ g ²³⁵U per 100 g U).

3.1.3 *depleted uranium*—any form of unirradiated uranium with a ²³⁵U content less than commercial natural uranium.

3.1.4 *highly enriched uranium*—any form of uranium having a ²³⁵U content equal to or in excess of 20 %.

3.1.5 *recovered uranium*—any form of uranium that has been exposed in a neutron irradiation facility and either has been subsequently chemically separated from the fission products and transuranic isotopes so generated, or may be used as is, due to low irradiation levels.

3.1.5.1 *Discussion*—The requirements for recovered uranium are intended to be typical of reprocessed spent fuel from research reactors that have achieved burn-up levels of up to 50 % of the originally contained fissile material or may have been utilized in critical facilities. It is recognized that different

³ Available from the American National Standards Institute, 11 W. 42nd St, 13th Floor, New York, NY 10036.

⁴ Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

limits would be necessary to accommodate different fuel histories.

3.1.6 For enriched uranium metal transactions, “buyer” usually represents the research reactor operator or the fuel fabricator, and “seller” usually represents the supplier of the enriched uranium metal.

4. Health Physics Requirements

4.1 For commercial grade enriched uranium metal, the gamma activity from fission products shall not exceed 600 Bq/gU. The measurements are to be made by Test Method C 1295 or equivalent. See Note 1.

NOTE 1—Depending upon the requirements of the fabricator utilizing enriched uranium metal, gamma activity from fission products as high as 6,000 Bq/gU may be acceptable, due to the utilization of reprocessed enriched uranium in producing the enriched uranium metal.

4.2 For commercial grade enriched uranium metal, the total alpha activity from transuranium elements shall be less than 250 Bq/gU.

5. Chemical, Physical, and Isotopic Requirements

5.1 Physical Requirements:

5.1.1 The uranium content of commercial grade enriched uranium metal shall be greater than or equal to 99.85 weight percent.

5.1.2 The product shall be supplied as spherical, cubical, cylindrical or broken pieces, with dimensions of not more than 40 mm or less than 10 mm. The mass of individual pieces shall be between 130 and 300 g.

5.1.3 The individual pieces of product shall be free of loose or excessive oxides or contaminants. A tightly adhering oxide film is allowable.

5.1.4 The following impurity elements shall not exceed these values:

Element	µg/gU	Element	µg/gU
Aluminum	Al 150	Magnesium	Mg 50
Boron	B 1	Manganese	Mn 50
Beryllium	Be 10	Molybdenum	Mo 100
Carbon	C 800	Nickel	Ni 100
Calcium	Ca 100	Phosphorus	P 100
Cadmium	Cd 1	Silicon	Si 250
Chromium	Cr 50	Sodium	Na 25
Cobalt	Co 10	Tin	Sn 100
Copper	Cu 50	Vanadium	V 30
Iron	Fe 250	Tungsten	W 100
Lead	Pb 10	Zirconium	Zr 250
Lithium	Li 10		
Rare Earths (Dy, Eu, Gd, Sm)			3.0

The sum of the impurity elements shall not exceed 1500 µg/gU.

5.1.5 *Equivalent Boron Content*—For research reactor use, the total equivalent boron content (EBC) shall not exceed 4.0

µg/gU. The list of elements to be considered for the EBC calculation shall be agreed upon between the buyer and the seller. The method of performing the calculation and the EBC Factors shall be as indicated in Practice C 1233. For fast reactor use, the above limitation on total EBC does not apply.

5.2 Isotopic Requirements:

5.2.1 The following limits for commercial grade enriched uranium metal shall not be exceeded:

²³² U	0.002 µg/gU
²³⁴ U	0.01 g/gU
²³⁶ U	0.04 g/gU

5.2.2 Uranium isotopic concentrations shall be determined and reported for ²³²U, ²³⁴U, ²³⁵U, and ²³⁶U. The allowable variation for ²³⁵U shall be ± 0.20 weight percent absolute from the nominal ²³⁵U assay.

6. Sampling

6.1 A representative sample of sufficient size to perform tests prescribed shall be taken from each lot. The size of a lot shall be as agreed upon between seller and buyer and shall be from a single melt. Typically, a lot shall not be greater than 10 kg.

6.2 All samples shall be clearly identified including the seller’s lot number.

6.3 All containers used for a lot shall be positively identified as containing material from a particular lot.

6.4 ASTM standard practice for preparation of uranium materials (Practice C 1347), or demonstrated equivalent shall be used as mutually agreed upon between the buyer and seller.

7. Test Methods for Chemical and Isotopic Analysis

7.1 ASTM test methods for chemical and isotopic analysis (Test Methods C 696 or C 799), or demonstrated equivalent, shall be used as mutually agreed upon between the buyer and seller.

8. Packaging, Handling, and Shipping

8.1 Procedures for packaging, handling, and shipping commercial grade enriched uranium metal are as agreed between buyer and seller and shall be in accordance with applicable national or international procedures.

9. Quality Assurance

9.1 Quality assurance requirements shall be agreed upon between the buyer and the seller when specified in the purchase order. Code of Federal Regulations, Title 10, Part 50 (Appendix B) and NQA-1 are referenced as guides.

10. Keywords

10.1 medium enriched uranium; nuclear fuel; research reactor fuel; uranium metal

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