



Portsmouth Information Release Approval Request

I. Document / Information Description

(To be filled out by Requestor)

ID Number: C787-11 Originated Date: 2011

Document Title or Identification: Standard Specification for Uranium Hexafluoride FOR ENRICHMENT

Original Author(s) / Organization: ASTM International

Technical Editor(s) / Organization: N/A

Format: Document: 4 Total # Pages Transparencies / Presentations

Photos: # Prints Electronic Media: ^{type}

Audience: Public Meeting Private Meeting Presentation to Congress

Distribution List Internet Publication Publication/Press Release

Justification: Need public release as requested by DOE

Requestor: *Cara S. Clark* Date: 12/12/12
Legible Signature or Print Name & Signature

II. Patent, Classification and Protected Information Review

(To be completed by the PORTS Classification Office)

	Yes	No	
Patent/Proprietary Review:	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Contains Patentable or Proprietary and/or has clearance patent information
Classification Review:	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Document is Unclassified
	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Document is Classified
Sensitive Information Review:	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Contains Official Use Only (OUO)
	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Contains Export Controlled Information (ECI)
	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Contains Unclassified Controlled Nuclear Information (UCNI)
	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Contains Personal Identifiable Information (PII)
	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Contains other Protected Information, describe:

III. Information Release Approved or Denied

(To be completed by the PORTS Classification Officer)

- Approved for Public Meetings, Widespread Distribution, or Presentation to Congress
- Approved for Publication, Media Broadcast, and/or Public Website
- Approved for Internal Distribution Only
- Approved for Publication on the Internal Network only (access restricted to network users only)
- Not Approved for Release
- Approved with restrictions (describe): _____

A H Thomas 12/13/12
 Classification Officer/Technical Information Officer Signature / Date

Send to OSTI? Yes No

Note: Requestor must retain a record copy of all requests (approved or rejected) and material being released. Classification Officer sends a copy of this form to WEMS Records Management and Document Control.



Standard Specification for Uranium Hexafluoride for Enrichment¹

This standard is issued under the fixed designation C787; 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.

1. Scope

1.1 This specification covers uranium hexafluoride (UF_6) intended for feeding to an enrichment plant. Included are specifications for UF_6 derived from unirradiated natural uranium and UF_6 derived from irradiated uranium that has been reprocessed and converted to UF_6 for enrichment and subsequent reuse. The objectives of this specification are twofold: (1) To define the impurity and uranium isotope limits for Commercial Natural UF_6 feedstock so that the corresponding enriched uranium is essentially equivalent to enriched uranium made entirely from virgin natural UF_6 ; and (2) To define additional limits for Reprocessed UF_6 (or any mixture of Reprocessed UF_6 and Commercial Natural UF_6). For such UF_6 , special provisions may be needed to ensure that no extra hazard arises to the work force, process equipment, or the environment.

1.2 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 specification does not relieve the user of the obligation to conform to all international, federal, state, and local regulations for processing, shipping, or in any other way using UF_6 (see, for example, TID-7016, DP-532, ORNL-NUREG-CSD-6, and DOE O 474.1).

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

2. Referenced Documents

2.1 ASTM Standards:²

C761 Test Methods for Chemical, Mass Spectrometric, Spectrochemical, Nuclear, and Radiochemical Analysis of Uranium Hexafluoride

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.

Current edition approved June 1, 2011. Published July 2011. Originally approved in 1976. Last previous edition approved in 2006 as C787–06. DOI: 10.1520/C0787-11.

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.

C859 Terminology Relating to Nuclear Materials

C996 Specification for Uranium Hexafluoride Enriched to Less Than 5 % ²³⁵U

C1052 Practice for Bulk Sampling of Liquid Uranium Hexafluoride

C1295 Test Method for Gamma Energy Emission from Fission Products in Uranium Hexafluoride and Uranyl Nitrate Solution

C1703 Practice for Sampling of Gaseous Uranium Hexafluoride

2.2 ANSI Standard:

N14.1 Packaging of Uranium Hexafluoride for Transport³

2.3 U.S. Government Documents:

Inspection, Weighing, and Sampling of Uranium Hexafluoride Cylinders, Procedures for Handling and Analysis of Uranium Hexafluoride, Vol. 1, Department of Energy Report ORO-671-1, latest revision⁴

The UF_6 Manual: Good Handling Practices for Uranium Hexafluoride, United States Enrichment Corporation Report USEC-651, latest revision⁵

Nuclear Safety Guide, U.S. Nuclear Regulatory Commission Report TID-7016, Rev. 2, 1978, and ORNL-NUREG-CSD-6⁴

Clarke, H. K., Handbook of Nuclear Safety, Department of Energy Report DP-532⁴

Control and Accountability of Nuclear Materials, DOE Directive O 474.1⁴

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 Terms shall be defined in accordance with Terminology C859, except for the following:

3.1.2 *Commercial Natural UF_6* — UF_6 from natural unirradiated uranium (containing 0.711 ± 0.004 g ²³⁵U per 100 g U).

3.1.2.1 *Discussion*—It is recognized that some contamination with reprocessed uranium may occur during routine

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

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

⁵ Available from United States Enrichment Corporation, 6903 Rockledge Drive, Bethesda, MD 20817.

processing. This is acceptable provided that the UF₆ meets the requirements for Commercial Natural UF₆.

3.1.3 *Reprocessed UF₆*—any UF₆ made from uranium that has been exposed in a neutron irradiation facility and subsequently chemically separated from the fission products and transuranic isotopes so generated.

3.1.3.1 *Discussion*—The requirements for Reprocessed UF₆ given in this specification are intended to be typical of reprocessed spent fuel that has achieved burnup levels of up to 50 000 Megawatt days per tonne of uranium in light water reactors and has been cooled for ten years after discharge. It is recognized that different limits would be necessary to accommodate different fuel histories.

4. Safety, Health Physics, and Criticality Requirements

4.1 The UF₆ concentration shall be not less than 99.5 g UF₆ per 100 g of sample in order to limit the potential hydrogen content for nuclear criticality safety.

4.2 The total absolute vapor pressure shall not exceed the values given below:

380 kPa at 80°C (55 psia at 176°F), or
517 kPa at 93°C (75 psia at 200°F), or
862 kPa at 112°C (125 psia at 235°F)

Additionally, if a measurement is taken over solid UF₆, then the vapor pressure shall not exceed the values given below:

50 kPa at 20°C (7 psia at 68°F), or
69 kPa at 35°C (10 psia at 95°F)

The purpose of the pressure check is to limit the hydrogen fluoride, air, or other volatile components that might cause overpressure when heating the shipping container to obtain a liquid sample or withdraw the contents.

4.3 The total hydrocarbon, chlorocarbon, and partially substituted halohydrocarbon content shall not exceed 0.01 mol % of the UF₆. The reason for the exclusion of these materials is to prevent a vigorous reaction with UF₆ upon heating or with stronger-fluorinating agents which may be present in enrichment plants. It is essential that contamination of the UF₆ containers, such as by vacuum pump oil, be prevented since it is not practical to obtain a sample without heating the UF₆. For fully substituted chlorofluorocarbons a maximum limit may be agreed upon between the parties concerned.

4.3.1 Measures should be taken to minimize contamination by hydrocarbons, chlorocarbons, and partially substituted halohydrocarbons in the receiving cylinder before filling and it is good practice to minimize such contact during UF₆ processing.

4.3.2 If UF₆ has been liquefied, either during filling or during sampling of the final shipping container, compliance can be assumed. If the UF₆ has not been liquefied, compliance must be demonstrated. An alternative means of demonstrating compliance with this requirement, other than by direct measurement, may be agreed upon between the parties concerned.

4.4 For Reprocessed UF₆ the gamma radiation from fission products shall not exceed 1.1×10^5 MeV Bq/kgU (1.1×10^5 MeV/sec kgU). The measurements are made in accordance with Test Method C1295 or equivalent. The purpose of this requirement is to limit the gamma dose from fission products to which plant workers might be exposed to a level less than 20 %

of the gamma dose from aged natural uranium, and to limit the quantity of fission products in effluent from enrichment and fuel fabrication plants.

4.5 For Reprocessed UF₆, the alpha activity from neptunium (Np) and plutonium (Pu) isotopes may be specified in either of two ways as agreed upon between the parties concerned:

4.5.1 The total alpha activity from Np and Pu in the cylinder shall be limited to 25 000 Bq/kgU (1.5×10^6 disintegrations per minute per kilogram of uranium). This criterion is concerned with both the volatile components and those that remain on the inner surfaces and in the heel, so it can be measured practically only by sampling from the inflow during the filling of the shipping container; or

4.5.2 The volatile alpha activity from Np and Pu in the liquid sample from the shipping container shall be limited to 3300 Bq/kgU (0.2×10^6 disintegrations per minute per kilogram of uranium). To prevent nonvolatile particles from being included in this measurement, the liquid sample must be filtered through a porous nickel filter as described in Test Methods C761.

5. Chemical, Physical, and Isotopic Requirements

5.1 Plants preparing UF₆ will have to control the purity of process chemicals and also employ low corrosion equipment to be successful in meeting the specifications for most impurities. Both Commercial Natural UF₆ and Reprocessed UF₆ will have to meet the same specification criteria for most elements. In addition, Reprocessed UF₆ must meet additional specification limits for artificially created radioactive species. For evaluating Commercial Natural UF₆, the measured concentration of ²³⁶U will be used as an indicator for contamination with reprocessed uranium, on the assumption that there is no opportunity for contamination with irradiated uranium that has not been processed to remove the majority of fission products. Provided that this isotope does not exceed the concentration limit for Commercial Natural UF₆ listed in 5.5, the expected concentrations of artificial isotopes would be so far below normal detection limits that measurements to determine compliance with the separate limits are not appropriate. Uranium hexafluoride that fails to meet Commercial Natural UF₆ limits would require further testing to determine its acceptability as Reprocessed UF₆.

5.2 The UF₆ content shall be reported as gUF₆/100 g of sample.

5.3 The total of all the following listed elements that form nonvolatile fluorides, having a vapor pressure of 101.3 kPa or less at 300°C (1 atm or less at 572°F) shall not exceed 300 µg/g of uranium:

aluminum	iron	sodium
arsenic	lead	strontium
barium	lithium	thorium
beryllium	magnesium	tin
bismuth	manganese	zinc
cadmium	nickel	zirconium
calcium	potassium	
chromium	silver	
copper		

5.3.1 If the concentration of an impurity element is given as a less-than value (this is a concentration expressed as being less

than the lower detection limit of the analytical method), this less-than value shall be taken as the concentration of that element in determining the total impurity content.

5.4 The volatile component of the following elements shall not exceed the values listed below:

Element	Value, µg/g of uranium
antimony	1
arsenic	3 (see Note 1)
boron	1
bromine	5
chlorine	100
chromium	10 (see Note 1)
molybdenum	2 (see Note 1)
niobium	1
phosphorus	50
ruthenium	1
silicon	100
tantalum	1
titanium	1
tungsten	2
vanadium	2

NOTE 1—Total chromium, molybdenum, and arsenic are usually expected to be well below 10 µg/gU, 2 µg/gU, and 3 µg/gU, respectively. If the total value of the element (noted hereafter as $E_{(total)}$) is found to be above the limit in 5.4, the volatile component may be determined by either of the following techniques as described in Test Method C761:

by measuring the insoluble component of the Element, and deducing the volatile component by: $E_{(volatile)} = E_{(total)} - E_{(nonvolatile)} = E_{(total)} - E_{(insoluble)}$

or, by vapor transfer of a sample UF₆ (taken according to Practice C1052) from its original sample container to a new container. Measuring the Element in the hydrolysed UF₆ of the new container will yield the volatile component of the Element initially present, providing the transfer has been made in the vapor phase $E_{(volatile)} = E_{(total)} - E_{(nonvolatile)} = E_{(after\ gas\ transfer)}$

If $E_{(total)}$ exceeds the value in 5.4, then agreement in advance between the parties (for example, supplier, receiver) shall be required to accept the material.

5.5 *Minor Isotopes*—These items shall not exceed the limits given as micrograms per gram of total uranium (µg/gU).

	Commercial Natural UF ₆	Reprocessed UF ₆
²³² U	0.00001	0.005
²³⁴ U	62	480.0 (see Note 2)
²³⁶ U	20	8400.0

5.5.1 It is recognized that variability in natural uranium does occur and affects the ²³⁴U level. ²³⁴U levels in the range of 56–62 µg/gU have been identified in a small part of natural uranium production. For compliance with Specification C996 after enrichment, a ²³⁴U content of 56 µg/gU or less in Commercial Natural UF₆ is generally required to yield Enriched Commercial Grade UF₆ that does not exceed 10.0×10^3 µg²³⁴U/g²³⁵U (Specification C996 requires agreement in advance between the parties to accept Enriched Commercial Grade UF₆ above 10.0×10^3 µg²³⁴U/g²³⁵U). A ²³⁴U content of 57–62 µg/gU will yield Enriched Commercial Grade UF₆ that may exceed this level, but will generally comply with the limit in Specification C996 of 11.0×10^3 µg²³⁴U/g²³⁵U. Therefore, prior to any delivery of Commercial Natural UF₆ containing ²³⁴U above 56 µg/gU, the ²³⁴U level shall be reported and shall require agreement in advance between the parties (for example, converter, enricher) to accept the material.

5.5.2 Values at or below the above limit for ²³²U in Commercial Natural UF₆ may be assumed without measurement provided that it can be demonstrated that the material meets the ²³⁶U limits.

5.5.3 For Commercial Natural UF₆, isotopic concentrations shall be reported for ²³⁴U, ²³⁵U, and ²³⁶U unless it can be otherwise demonstrated that the UF₆ conforms to the appropriate isotopic specifications (for example, through the seller's quality assurance records). For Commercial Natural UF₆ from verifiable virgin natural uranium sources the analysis of ²³⁶U is not normally required unless otherwise agreed upon between the buyer and seller.

5.5.4 Unirradiated UF₆ at any ²³⁵U concentration other than that of Commercial Natural UF₆ might be delivered as feed material if this is acceptable to the enricher. Renegotiation of the impurity limits may be needed under these circumstances.

5.5.5 For Reprocessed UF₆, isotopic concentrations shall be measured and reported for ²³²U, ²³⁴U, ²³⁵U, and ²³⁶U.

NOTE 2—If the ²³⁴U level (expressed here in wt %) in reprocessed UF₆ exceeds the following limit: $(0.036 \times \text{wt } \% \text{ } ^{235}\text{U}) - 0.0004$, then in order to ensure compliance with Specification C996, an acceptance between the parties shall be required prior to any delivery. For example, for wt % ²³⁵U = 1 %, then a value above 320 µg ²³⁴U/gU will require an acceptance.

5.6 *Technetium*—⁹⁹Tc shall not exceed the following limits given as micrograms per gram of total uranium (µg/gU).

	Commercial Natural UF ₆	Reprocessed UF ₆
⁹⁹ Tc	0.001	0.500

5.6.1 For Commercial Natural UF₆ from verifiable (for example, through the seller's quality assurance records) virgin natural uranium sources, the analysis of ⁹⁹Tc is not normally required unless otherwise agreed upon between the buyer and seller.

5.6.2 For Reprocessed UF₆ the concentration of ⁹⁹Tc shall be measured and reported.

6. Sampling

6.1 A representative sample of sufficient size to perform the tests prescribed shall be taken while the material is liquid and homogeneous. Relevant sample procedures are given in Practice C1052, USEC Report USEC-651, and DOE Report ORO-671-1.

6.2 Alternatively, if the cylinder is filled in the gas phase, a representative sample may be taken during the transfer according to Practice C1703. It will have to be demonstrated that gas sampling is equivalent to liquid sampling as representative of the bulk material in cylinder. The use of this alternative technique should be agreed between buyer and seller.

6.3 All samples shall be clearly identified including the seller's lot number. It shall be stated whether samples have been taken in liquid or gas phase and whether they have been taken during or after filling.

6.4 All cylinders used for a lot shall be positively identified as containing material from a particular homogeneous lot.

7. Methods of Chemical and Isotopic Analysis

7.1 Chemical and isotopic analysis shall conform to Test Methods C761, or demonstrated equivalent, as mutually agreed upon between the buyer and seller.

8. Packaging, Handling, and Shipping

8.1 Procedures for packaging, handling, and shipping UF₆ are given in ANSI N14.1, USEC Report USEC-651, and DOE Report ORO-671-1, or appropriate national or international procedures.

8.2 Cylinders used for transport of Reprocessed UF₆ shall not be used for Commercial Natural UF₆ unless decontami-

nated internally before filing with Commercial Natural UF₆. Appropriate documentation shall be provided as agreed between buyer and seller to confirm that a cylinder has been used exclusively for Commercial Natural UF₆ or has been internally decontaminated.

9. Keywords

9.1 low enriched uranium; natural uranium; nuclear fuel; reprocessed uranium; uranium enrichment; uranium hexafluoride

ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.

This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org). Permission rights to photocopy the standard may also be secured from the ASTM website (www.astm.org/COPYRIGHT).