Designation: C 996 – 04

# Standard Specification for Uranium Hexafluoride Enriched to Less Than 5 % $^{235}U$[1]

This standard is issued under the fixed designation C 996; 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.

ε[1] NOTE—**DO NOT USE THIS VERSION!!!! C996–04 was replaced with C996–04[e1].**

## 1. Scope

1.1 This specification covers nuclear grade uranium hexafluoride ($UF_6$) that either has 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 $^{235}U$ concentration below 5 % and that is intended for fuel fabrication. The objectives of this specification are twofold: *(1)* To define the impurity and uranium isotope limits for Enriched Commercial Grade $UF_6$ so that, with respect to fuel design and manufacture, it is essentially equivalent to enriched uranium made from natural $UF_6$; and *(2)* To define limits for Enriched Reprocessed $UF_6$ to be expected if Reprocessed $UF_6$ is to be enriched without dilution with Commercial Natural $UF_6$. For such $UF_6$, special provisions, not defined herein, may be needed to ensure fuel performance and to protect the work force, process equipment, and the environment.

1.2 This specification is intended to provide the nuclear industry with a standard for enriched $UF_6$ that is to be used in the production of sinterable $UO_2$ powder for fuel fabrication. 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 specification does not relieve the user of the obligation to conform to all applicable international, federal, state, and local regulations for processing, shipping, or in any other way using $UF_6$ (see, for example, TID-7016, DP-532, and DOE O474.1).

1.4 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]

C 761 Test Methods for Chemical, Mass Spectrometric, Spectrochemical, Nuclear, and Radiochemical Analysis of Uranium Hexafluoride

C 787 Specification for Uranium Hexafluoride for Enrichment

C 859 Terminology Relating to Nuclear Materials

C 1052 Practice for Bulk Sampling of Liquid Uranium Hexafluoride

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

C 1561 Guide for the Measurement of Plutonium and Neptunium in $UF_6$

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

2.2 *ANSI Standards:*[3]

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

ANSI N14.1 Nuclear Materials—Uranium Hexafluoride—Packaging for Transport

2.3 *U.S. Government Documents:*

Inspection, Weighing, and Sampling of Uranium Hexafluoride Cylinders, Procedure for Handling and Analysis of Uranium Hexafluoride, Vol. 1, DOE Report ORO-671-1, latest revision[4]

Nuclear Safety Guide, U.S. NRC Report TID-7016, Rev. 2, 1978

Clarke, H. K., Handbook of Nuclear Safety, DOE Report DP-532 [4]

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

[1] **Invalid Version: See edit note above.** 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.

**Invalid Version: See edit note above.**Current edition approved June 1, 2004. Published July 2004. Originally approved in 1983. Last previous edition approved in 1996 as C 996 – 96.

[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.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th 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.

Control and Accountability of Nuclear Materials, DOE Directive 5633.3B [4]

2.4 *Other Document:*

$UF_6$ Manual: Good Handling Practices for Uranium Hexafluoride, United States Enrichment Corporation Report USEC-651, latest revision[5]

## 3. Terminology

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

3.1.1 *Commercial Natural $UF_6$*—$UF_6$ from natural unirradiated uranium (containing 0.711 ± 0.004 g $^{235}U$ per 100 g U).

3.1.1.1 *Discussion*—It is recognized that some contamination with reprocessed uranium may occur during routine processing. This is acceptable provided that the $UF_6$ meets the requirements for Commercial Natural $UF_6$ as specified in Specification C 787C 787.

3.1.2 *Reprocessed $UF_6$*—any $UF_6$ 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 *Highly Enriched Uranium*—any form of uranium having a $^{235}U$ content of 20 % or greater, which may or may not have been derived from Commercial Natural $UF_6$.

3.1.4 *Enriched Commercial Grade $UF_6$*—$UF_6$ enriched from Commercial Natural $UF_6$ or Derived Enriched $UF_6$ that meets the specification limits for Enriched Commercial Grade $UF_6$.

3.1.5 *Enriched Reprocessed $UF_6$*—$UF_6$ enriched from Reprocessed $UF_6$, any mixture of Reprocessed $UF_6$ and Commercial Natural $UF_6$ or Derived Enriched $UF_6$, exceeding the applicable limits of Sections 4 and 5 for Enriched Commercial Grade $UF_6$. The wide range of irradiation levels, cooling times, reprocessing, conversion, and enrichment processes, and fuel cycle choices for combination with unirradiated $UF_6$, together with the varying acceptance limits of different fuel fabrication facilities, make it not practical to specify the exact radionuclide composition of Enriched Reprocessed $UF_6$.

3.1.6 *Depleted $UF_6$*—any unirradiated $UF_6$ with a $^{235}U$ content less than Commercial Natural $UF_6$.

3.1.7 *Derived Enriched $UF_6$*—any $UF_6$ obtained from the blending of Highly Enriched Uranium with any other uranium.

3.2 For enriched $UF_6$ transactions, "buyer" usually represents the electric power utility company or the fuel fabricator, and "seller" usually represents the isotopic enrichment facility.

## 4. Safety, Health Physics, and Criticality Requirements

4.1 The $UF_6$ concentration shall not be less than 99.5 g $UF_6$ 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 $UF_6$, 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, such as 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 $UF_6$. The reason for the exclusion of these materials is to prevent a vigorous reaction with $UF_6$ upon heating. It is essential that contamination of the $UF_6$ containers, such as by vacuum pump oil, be prevented since it is not practical to obtain a sample without heating the $UF_6$. 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 Enriched Commercial Grade $UF_6$ meeting the requirements of Section 5, (*1*) the gamma activity from fission products is expected to be below the detection limits of the measurement methodology set forth in Test Method C 1295C 1295; and (*2*) the alpha activity from neptunium and plutonium is expected to be below the detection limits of commonly used measurement methodology (Guide C 1561C 1561). Therefore unless otherwise agreed upon between the buyer and seller, measurements are not required, except for Derived Enriched $UF_6$ resulting from blending with reprocessed uranium.

4.5 For Enriched Reprocessed $UF_6$, the gamma radiation from fission products shall not exceed $4.4 \times 10^5$ MeVBq/kgU ($4.4 \times 10^5$ MeV/sec kgU). The measurements are to be made in accordance with Test Method C 1295C 1295, or equivalent.

4.5.1 For Enriched Reprocessed $UF_6$, the alpha activity from neptunium and plutonium shall be less than 3300 Bq/kgU (200 000 dpm/kgU). The measurements shall be made in accordance with Guide C 1561C 1561, or equivalent.

## 5. Chemical, Physical, and Isotopic Requirements

5.1 Both Enriched Commercial Grade $UF_6$ and Enriched Reprocessed $UF_6$ must meet the specification criteria except as differentiated in 4.4, 4.5, 5.4, and 5.5. For certain isotopes, including artificially created radioactive species, two groups of limits are set. Limits for Enriched Commercial Grade $UF_6$ are set so as to have no special impact on the use of this material in existing facilities. For Enriched Reprocessed $UF_6$, higher limits are indicated to correspond with Specification C 787C 787, and lower limits may be agreed upon by the buyer and seller according to the composition of the feed material presented for enrichment.

5.2 The $UF_6$ content shall be reported as g$UF_6$/100 g sample.

5.3 The following impurity elements shall not exceed these values:

| Element | µg/gU |
|---|---|
| Boron | 4 |
| Silicon | 250 |

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