INTERNATIONAL

Designation: ~~C996 – 10~~ C996 – 15

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

This standard is issued under the fixed designation C996; 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 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]

C761 Test Methods for Chemical, Mass Spectrometric, Spectrochemical, Nuclear, and Radiochemical Analysis of Uranium Hexafluoride
C787 Specification for Uranium Hexafluoride for Enrichment
C859 Terminology Relating to Nuclear Materials
C1052 Practice for Bulk Sampling of Liquid Uranium Hexafluoride
C1703 Practice for Sampling of Gaseous Uranium Hexafluoride
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

2.2 *~~ANSI~~ANSI/ASME Standards:*[3]

~~ANSI/ASME~~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] 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 ~~Oct. 1, 2010~~July 1, 2015. Published ~~October 2010~~July 2015. Originally approved in 1983. Last previous edition approved in ~~2004~~2010 as ~~C996 – 04~~C996 – 10.~~E01.~~ DOI: ~~10.1520/C0996-10.~~10.1520/C0996-15.

[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.

2.4 *Other Document:*

The 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:*

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 ^{235}U per 100 g U).

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

3.1.2.1 *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 C787.

3.1.3 *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.

3.1.4 *Highly Enriched Uranium*—any form of uranium having a ^{235}U content of 20 % or ~~greater..~~greater.

3.1.5 *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.

3.1.6 *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.

3.1.7 *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.

4.2.1 If the temperature differs from 20°C or 35°C, a temperature correction must be performed which takes the change in vapor pressure of UF_6 into account. For example, an acceptable correction would be that the pressure must remain below $P_{UF6}(T) + 39.3$ kPa, where $P_{UF6}(T)$ is the vapor pressure of pure UF_6 over solid at temperature T and $P_{UF6}(T)$ is given according to $\text{Log } P_{UF6} = 12.77 - (2562.46/T)$, with P in Pascal and T in K.[6] Other methods or equations to assure that the pressure limits above are met are acceptable provided that validated temperature compensation is made.

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.

4.3.1 Measures should be taken to minimize contamination by hydrocarbons, chlorocarbons and halohydrocarbons in the receiving cylinder before filling.

[6] *Comprehensive Nuclear Materials*, Volume 2, The U-F System, Ed. R.J.M. Konings, p. 209, Elsevier 2012.