



Designation: C1880 – 19

Standard Practice for Sampling Gaseous Uranium Hexafluoride using Alumina Pellets¹

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1. Scope

1.1 This practice is applicable to sampling gaseous uranium hexafluoride (UF_6) from processing facilities, isotope enrichment cascades or storage cylinders, using the sorbent properties of aluminum oxide (Al_2O_3).

1.2 It is based on the ‘ABACC-Cristallini Method’ (1, 2)² and is intended to be used for the determination of uranium (U) isotopic composition required for nuclear material safeguards as well as other applications.

1.3 The application of this practice assures the resulting sample vessel contains no UF_6 and hydrogen fluoride (HF); therefore, it may be handled and categorized for transport under less stringent constraints.

1.4 The scope of this practice does not include provisions for preventing criticality.

1.5 *Units*—The values stated in SI units are to be regarded as the standard. When non-SI units are provided, they are for information only.

1.6 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

¹ This practice 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.

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² The boldface numbers in parentheses refer to a list of references at the end of this standard.

2. Referenced Documents

2.1 ASTM Standards:³

- 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
- C996 Specification for Uranium Hexafluoride Enriched to Less Than 5 % ²³⁵U
- C1052 Practice for Bulk Sampling of Liquid Uranium Hexafluoride
- C1346 Practice for Dissolution of UF_6 from P-10 Tubes
- C1474 Test Method for Analysis of Isotopic Composition of Uranium in Nuclear-Grade Fuel Material by Quadrupole Inductively Coupled Plasma-Mass Spectrometry
- C1477 Test Method for Isotopic Abundance Analysis of Uranium Hexafluoride and Uranyl Nitrate Solutions by Multi-Collector, Inductively Coupled Plasma-Mass Spectrometry
- C1672 Test Method for Determination of Uranium or Plutonium Isotopic Composition or Concentration by the Total Evaporation Method Using a Thermal Ionization Mass Spectrometer
- C1703 Practice for Sampling of Gaseous Uranium Hexafluoride for Enrichment
- C1832 Test Method for Determination of Uranium Isotopic Composition by the Modified Total Evaporation (MTE) Method Using a Thermal Ionization Mass Spectrometer
- C1871 Test Method for Determination of Uranium Isotopic Composition by the Double Spike Method Using a Thermal Ionization Mass Spectrometer
- D1193 Specification for Reagent Water

³ 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.

2.2 Other Documents:

USEC-651 Revision 10 The UF₆ Manual – Good Handling Practices for Uranium Hexafluoride⁴

IAEA-TECDOC-771 Manual on Safe Production, Transport, Handling and Storage of Uranium Hexafluoride⁵

3. Terminology

3.1 Terminology **C859** contains terms, definitions, descriptions of terms, nomenclature, and explanations of acronyms and symbols specifically associated with standards under the jurisdiction of Committee C26 on Nuclear Fuel Cycle.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *sample vessel*—the small vessel, for example a P-10 tube, into which the UF₆ sample is transferred and stored for characterization in the analytical laboratory. It can be made of polychlorotrifluoroethylene (PCTFE), polytetrafluoroethylene (PTFE) or any other material chemically resistant to UF₆. The dimensions of the P-10 tube and its components, gasket, nut and plug, can be found in Practice **C1346**.

3.2.2 *sampling manifold*—a set-up used to connect the sample vessel to the UF₆ processing lines, isotope enrichment cascades or storage cylinders, allowing vacuum pumping or pressurization by the introduction of an inert gas.

4. Summary of Practice

4.1 A tared P-10 tube filled with a weighed quantity of aluminum oxide (Al₂O₃) pellets, hereafter referred to as alumina, is attached to a sampling manifold, and exposed to gaseous UF₆ for a timed period, typically 10 to 30 min, depending on the gas pressure in the facility and the desired amount of U amount to be deposited in the P-10 tube. UF₆ readily reacts in contact with alumina pellets generating predominantly uranyl fluoride (UO₂F₂).

4.2 When the sampling period is over, the P-10 tube and the manifold are evacuated to remove remaining gaseous compounds. Next, the valve that connects the manifold to the processing line is closed and the P-10 tube and the manifold are pressurized to atmospheric pressure with dry nitrogen (N₂) to prevent moisture build-up within them.

4.3 These evacuation and pressurization operations must be repeated twice to assure no UF₆ or HF is present in the vessel, but only solid UO₂F₂ on the alumina support. This is of utmost importance to achieve a less stringent sample vessel categorization for transport.

4.4 The P-10 tube can now be safely removed from the manifold and sealed. The amount of U in the P-10 tube can be determined by re-weighing the P-10 tube.

4.5 Using a P-10 tube loaded with 1 g of alumina pellets, and sampling from UF₆ processing lines, enrichment cascades or storage cylinders under typical conditions will easily allow the adsorption of 100 to 300 mg of U, based on the gas

pressure, temperature and exposure time. The maximum adsorption capacity is approximately 600 mg of U per gram of alumina.

4.6 At the analytical laboratory, the alumina pellets are transferred from the P-10 tube to an Erlenmeyer flask and leached initially with distilled water and finally with nitric acid (HNO₃). The alumina fines produced must be carefully removed from the solution so that it can be prepared for the determination of the U isotopic composition using, for example, Test Methods **C1672**, **C1832**, **C1871**, **C1474**, or **C1477**.

5. Significance and Use

5.1 Facility operators and safeguards inspectors routinely take UF₆ samples from processing lines, isotopic enrichment cascades or storage cylinders to determine its U isotopic composition, most important the $n(^{235}\text{U})/n(^{238}\text{U})$ isotope ratio, needed to calculate the amount of the fissile ²³⁵U in the sample. The current version of the “International Target Values for Measurement Uncertainties in Safeguarding Nuclear Materials” (**3**) contains recommended guidelines for these measurements.

5.2 The conventional sampling practice collects UF₆ samples in the range of 1-10 g and requires the use of liquid nitrogen to condense them in sample vessels, metallic bottles or P-10 tubes. These samples must then be transported to external analytical laboratories for verification of the declared data, especially the isotope ratios. Transport includes, among other things, public roads and intercontinental air shipment. Due to the hazards of UF₆, air transport is becoming increasingly difficult, with many transport operators and regulators refusing to carry the material.

5.3 This sampling practice was developed to meet the following requirements:

5.3.1 Fit for Purpose: to enable the verification of the declarations of amounts of nuclear materials.

5.3.2 Simplicity: to ensure a simple and fast execution.

5.3.3 Flexibility: to be applied in a wide range of facilities.

5.3.4 Robustness: to ensure sufficient material is sampled even when operational parameters slightly change.

5.3.5 Reliability: to provide measurement results in agreement with those obtained using the conventional sampling practice.

5.3.6 Confidentiality: to respect the facility’s operational procedure and confidentiality of data.

5.3.7 Safety: to reduce the risks associated with the sampling, handling and transport of radioactive and hazardous materials.

5.4 This sampling practice offers significant advantages over the conventional sampling practice because it allows handling non-reactive, non-volatile, solid UO₂F₂ instead of highly reactive and volatile UF₆.

5.5 A smaller UO₂F₂ sample can be transported with lower radioactivity level and reduced radiological problems in case of accident. Additionally, there is no risk of airborne uranium particle and HF release.

⁴ Available from Centrus Energy Corp., 6901 Rockledge Drive, Bethesda, MD 20817, <http://centrusenergy.com>.

⁵ Available from International Atomic Energy Agency (IAEA), Vienna International Center, PO Box 100, A-1400 Vienna, Austria, <http://www.iaea.org>.