



Standard Test Method for Gamma Energy Emission from Fission Products in Uranium Hexafluoride and Uranyl Nitrate Solution¹

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1. Scope

1.1 This test method covers the measurement of gamma energy emitted from fission products in uranium hexafluoride (UF₆) and uranyl nitrate solution. It is intended to provide a method for demonstrating compliance with UF₆ Specifications C 787 and C 996 and replace the ion chamber measurement technique.

1.2 The lower limit of detection is 5000 MeV Bq/kg (MeV/kg per second) of uranium and is the square root of the sum of the squares of the individual reporting limits of the nuclides to be measured. The limit of detection was determined on a pure, aged natural uranium (ANU) solution. The value is dependent upon detector efficiency and background.

1.3 The nuclides to be measured are ¹⁰⁶Ru/¹⁰⁶Rh, ¹⁰³Ru, ¹⁴⁴Ce, ¹⁴⁴Pr, ¹⁴¹Ce, ⁹⁵Zr, ⁹⁵Nb, and ¹²⁵Sb. Other gamma energy-emitting fission nuclides that are identified should be measured and reported.

1.4 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

C 761 Test Methods for Chemical, Mass Spectrometric, Spectrochemical, Nuclear, and Radiochemical Analysis of Uranium Hexafluoride²

C 787 Specification for Uranium Hexafluoride for Enrichment²

C 996 Specification for Uranium Hexafluoride Enriched to Less than 5 % ²³⁵U²

3. Summary of Test Method

3.1 A solution of the uranium sample is counted on a high-resolution gamma-ray spectroscopy system. The resulting spectrum is analyzed to determine the identity and activity of the gamma-ray-emitting radioactive fission products. The num-

ber of counts recorded from one or more of the peaks identified with each nuclide is converted to disintegrations of that nuclide per second (Bq). The gamma-ray energy for a nuclide is calculated by multiplying the number of disintegrations per second of the nuclide by the mean gamma-ray energy emission rate of the nuclide. The calculated gamma-ray energy emission rates for all observed nuclides are summed, then divided by the mass of the uranium in the sample to calculate the overall rate of gamma energy production in units of million electron volts per second per kilogram of uranium.

4. Significance and Use

4.1 The fission products in UF₆ are identified and quantified using a high-resolution gamma-ray energy analysis system, which includes a high-resolution germanium detector.

5. Apparatus

5.1 High-Resolution Germanium Detector.

5.1.1 A relative efficiency of 10 % or higher (ratio of area under the 1.33-MeV photopeak of Cobalt-60 to that obtained with a 76- by 76-mm (3- by 3-in.) NaI(Tl) detector, at a source-to-detector distance of 25 cm).

5.1.2 Full width at half maximum (FWHM) resolution of 2.3 keV or less at 1.33 MeV.

5.2 *Gamma-Ray Analysis System*, containing the following components:

5.2.1 High voltage bias power supply.

5.2.2 Spectroscopy amplifier with peak shaping time constants of 1, 2 and 4 μs, baseline restoration, pulse pileup rejection, and live time correction.

5.2.3 Multichannel analyzer with a minimum of 4096 data channels and circuits compatible with the pulse pileup rejection and live time correction circuits of the spectroscopy amplifier.

5.2.4 Computer system and input/output (I/O) devices for storage of calibration data, control of analyzer functions, calculation of results, and report generation.

5.3 *Heavy Metal Shield*, for the detector and sample.

5.4 *Sample Container Fitted with Cap*, internal diameter 56 mm, outside diameter 59 mm, and height 65 mm. The dimensions must be consistent between sample containers to keep the counting geometry constant.

5.5 *Sample Holder*, shall accommodate the sample container and position it so that the detector view of the sample container is reproducible. To minimize the effects of coincident

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² *Annual Book of ASTM Standards*, Vol 12.01.