



Nuclear Reference Material Program
U.S. Department of Energy



Certificate of Analysis
Certified Reference Material 113B
Uranium Hexafluoride Assay and Isotopic Standard,
4.5 % U-235

Description: Certified Reference Material (CRM) 113B is a uranium hexafluoride (UF₆) mass fraction and isotope-amount ratio standard. Each unit of CRM 113B consists of uranium (4.5 % ²³⁵U enriched) UF₆ contained in a 2S cylinder. The material is normally transferred from individual 2S cylinders into approved sample tubes for use as a mass fraction standard. Certified isotope composition and mass fraction values are reported in Table 1.

Table 1. Certified Property Values and Uncertainties ^(a)

Uranium Mass Fraction:	g g⁻¹	0.67579	Uranium Molar Mass:	g mol⁻¹	237.912937
Uncertainty:		0.00022	Uncertainty:		0.000070
Isotope-Amount Ratio:	$n(^{234}\text{U})/n(^{238}\text{U})$	$n(^{235}\text{U})/n(^{238}\text{U})$	$n(^{236}\text{U})/n(^{238}\text{U})$		
Ratio:	0.00040579	0.047310	0.00028983		
Uncertainty:	0.00000031	0.000025	0.00000027		
Isotope-Amount Fraction (•100):	$n(^{234}\text{U})/n(\text{U})$	$n(^{235}\text{U})/n(\text{U})$	$n(^{238}\text{U})/n(\text{U})$	$n(^{238}\text{U})/n(\text{U})$	
Uncertainty:	0.038720	4.5143	0.027655	95.4193	
Isotope-Mass Fraction (•100):	$m(^{234}\text{U})/m(\text{U})$	$m(^{235}\text{U})/m(\text{U})$	$m(^{236}\text{U})/m(\text{U})$	$m(^{238}\text{U})/m(\text{U})$	
Uncertainty:	0.000029	0.0023	0.000025	0.0023	

^(a) Reported numerical uncertainties are expressed as expanded uncertainties (U) at the 95 % level of confidence, where $U = k \cdot u_c$ and k is the coverage factor and u_c is the combined standard uncertainty. The last figure in the reported values and their uncertainties is provided for information purposes only and is not intended to convey a significant degree of reliability.

Intended use: CRM 113B is a uranium mass fraction and isotopic standard primarily for use in the analysis of uranium feed and product materials associated with the uranium enrichment process.

Storage: This material should be stored in its original packaging under normal laboratory environmental conditions.

Period of validity: When stored in its original, unopened container, the certification of this material is valid indefinitely. The certification is nullified if the material or container is damaged, contaminated or otherwise modified. The National Nuclear Security Administration's (NNSA) Nuclear Reference Material Program (NRMP) will notify customers should degradation be detected.

Minimum sample size: The CRM was prepared from material stored in a single 30B cylinder which was filled and dispensed to 2S cylinders as gas phase UF₆. Accordingly, the material is considered homogeneous and thus no minimum sample size is declared.

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January 2026

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Instructions for handling: The material in CRM 113B is radioactive. This radioactive material should be handled only by qualified individuals. 2S cylinders or subsample containers should be handled under proper radiologically-controlled conditions at all times. To minimize personnel exposure, appropriate facilities and personal protective equipment should be used. Refer to the Safety Data Sheet for further information.

Traceability statement: The certified isotope amount ratios and isotope amount fractions are traceable to the SI unit mole. The certified isotope mass fractions and uranium mass fraction are traceable to the SI unit kilogram. The certified uranium molar mass is traceable to the SI units mole and kilogram.

Measurement uncertainty: The expanded uncertainty (U) for a certified property of CRM 113B defines an interval around the value of the property. The magnitude of this interval is obtained by multiplying the combined standard uncertainty by a coverage factor. The coverage factor (k) is the Student's t factor based on effective degrees of freedom to provide a 95 % level of confidence. The combined standard uncertainty for uranium assay consists of both Type A and Type B evaluated components. The standard deviations associated with cylinder-to-cylinder differences, tube-to-tube differences, sample preparation and titration measurements are applied as Type A evaluated components. The standard uncertainties taken from the NBL CRM 99 certificate and cover gas and air buoyancy corrections for UF₆ samples in the P-10 tubes are applied as Type B evaluated components. The combined standard uncertainties for uranium isotope parameters also consist of both Type A and Type B evaluated components. The standard deviations associated with isotopic ratio measurements of the samples and the measurements of the ²³⁵U/²³⁸U ratio of CRM U030A are applied as Type A evaluated components. The standard uncertainties derived from the CRM U030A certified value for the ²³⁵U/²³⁸U ratio are applied as Type B evaluated components.

Additional information: The source material for CRM 113B was UF₆ contained in a single 30B cylinder. Material for the CRM was transferred into fifteen new 2S cylinders by the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio. Samples for certification measurements were taken from all the cylinders and placed into P-10 tubes. The mass of the UF₆ in the P-10 tubes was corrected for the effects of cover gas trapped over the UF₆ in the tube and for air buoyancy as follows:

$$\text{Corrected Sample Mass (g)} = (1.00047) (\text{Observed Sample Mass (g)}) - 0.0058.$$

This equation is applicable for sample masses in the range of 7 g to 13 g [1]. The uranium assay was determined by the NBL high precision titration using NBL CRM 99, Potassium Dichromate Oxidimetric Standard, as the titrant. CRM 112A, Uranium Metal Assay and Isotopic Standard, was used as a control to verify proper performance of the measurement systems; uranium hexafluoride samples from the Safeguards Measurement Evaluation Program were also used to verify proper sample handling and analysis. Uranium assay measurements were performed by two analysts each using independent titration systems. The uranium isotopic composition and the relative atomic mass were determined by thermal ionization mass spectrometry. The following relative atomic masses were used in calculations:

$$^{234}\text{U} - 234.0409456, ^{235}\text{U} - 235.0439231, ^{236}\text{U} - 236.0455619, \text{ and } ^{238}\text{U} - 238.0507826.$$

Uranium isotope ratio measurements were performed by two analysts each using two different mass spectrometers. The first instrument, utilizing a Total Evaporation procedure, was used to generate values for the certification of the ²³⁵U/²³⁸U ratio only. A second instrument, utilizing the NBL-Modified Total Evaporation procedure, was used to generate values for all certified ratios. The minor ratios were corrected internally using the ²³⁵U/²³⁸U ratio of the same sample. Mass discrimination correction factors applied to measured CRM 113B isotopic ratios were determined from multiple analyses of CRM U030A, Uranium Isotopic Standard (3 % enriched), run sequentially with CRM 113B. Measurements of CRM U050, Uranium Isotopic Standard (5 % enriched) and CRM U500, Uranium Isotopic Standard (50 % enriched), were used as controls to verify the measurement system. No measurable ²³³U was detected in CRM 113B.

Project coordination was provided by A.M. Voeks and A.J. Traina. Sample preparation and titrimetric assay measurements were performed by A.M. Voeks, G.J. Orlowicz, K.S. Scheidleman, A.J. Traina and M.I. Spaletto. Isotopic abundance measurements were performed by S. Richter and R.M. Essex; verification measurements on the UF₆ gas mass spectrometer were made by P.V. Croatto. Experimental design for the isotopic certification and measurement of isotopic data were provided by S.A. Goldberg. The statistical plan of analysis for assay certification was prepared by M.M. Smith, and assessment of the data was performed by M.D. Soriano, M.M. Smith and D.T. Baran. Technical guidance for CRM 113B packaging, certification, and issuance was provided by U.I. Narayanan, M.A. Legel and M.I. Spaletto. Project supervision was provided by R.D. Oldham, D.T. Baran, W.G. Mitchell and J.W. Neuhoff. Health physics support was provided by F.P. Orlowicz.

In 2016 NBL transitioned to a program office within the Department of Energy and is now operating within the National Nuclear Security Administration (NNSA) as the Nuclear Reference Material Program (NRMP).

[1] C 761, "Standard Test Methods for Chemical, Mass Spectrometric, Nuclear, and Radiochemical Analysis of Uranium Hexafluoride", Annual Book of ASTM Standards, Vol. 12.01.