New Brunswick Laboratory
U.S. Department of Energy

Certificate of Analysis
CRM U045
Uranium Isotopic Standard
Uranyl Nitrate in Solution Form

Isotopic Ratios	$^{234}U/^{238}U$	$^{235}U/^{238}U$	$^{236}U/^{238}U$
Atom Ratios	**0.00040579 ± 0.00000031**	**0.047310 ± 0.000025**	**0.00028983 ± 0.00000027**

Isotopic Abundance	^{234}U	^{235}U	^{236}U	^{238}U
Atom Fraction (x 100)	**0.038720 ± 0.000029**	**4.5143 ± 0.0023**	**0.027655 ± 0.000025**	**95.4193 ± 0.0023**
Mass Fraction (x 100)	**0.038090 ± 0.000029**	**4.4599 ± 0.0023**	**0.027438 ± 0.000025**	**95.4746 ± 0.0023**

Relative Atomic Mass of Uranium ……237.912937 ± 0.000070

Reported numerical uncertainties are expressed as expanded uncertainties (U) at the 95% level of confidence, where $U = k \cdot u_c$, 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.

This Certified Reference Material (CRM) is an isotopic standard primarily for use in the mass spectrometric analysis of uranium. Each unit of CRM U045 contains approximately 5 mg of uranium dissolved in approximately 5 mL of a 1 *M* nitric acid solution. The solution is contained in a sealed 5-mL glass ampoule. NOTE: *The ampoule should be handled under proper radiologically-controlled conditions at all times. Care should be taken when scoring and breaking the ampoule to avoid injury and possible contamination.*

CRM U045 was prepared from CRM 113-B, Uranium Hexafluoride Assay and Isotopic Standard. The solid uranium hexafluoride was hydrolyzed, converted to U_3O_8 by ignition, dissolved in nitric acid, and ampulated. A number of filled and sealed ampules were selected according to a statistical sampling plan for certification of the uranium isotopic composition.

The uranium isotopic composition and the relative atomic mass of uranium were determined by thermal ionization mass spectrometry. Uranium isotopic ratio measurements were performed by two analysts each using a different mass spectrometer. The first instrument utilized the total evaporation method to generate values used for the certification of the $^{235}U/^{238}U$ ratio. The second instrument utilized the NBL modified total evaporation procedure to generate values for all certified ratios. CRMs U030-A, U050 and U500 were used for mass fractionation corrections and quality control. Traceability for all ratios and abundances was established through the use and incorporation of uncertainties

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associated with CRM U030-A. The isotopic analysis results for CRM U045 and CRM 113-B were in very good statistical agreement, with the exception of a small but statistically significant difference in the $^{236}U/^{238}U$ ratios and ^{236}U abundances. The results from the two materials were combined to yield the final certified values for isotopic composition and their uncertainties. A small amount of ^{233}U was detected using ion counting, yielding a $^{233}U/^{238}U$ value of $2.4 \times 10^{-7} \pm 0.1 \times 10^{-7}$ (95% C.I.). This value is reported for informational purposes and is not certified. The following relative atomic masses were used in relative atomic mass calculations: ^{234}U: 234.0409456, ^{235}U: 235.0439231, ^{236}U: 236.0455619, and ^{238}U: 238.0507826.

The expanded uncertainty (U) for a certified property of CRM U045 defines an interval around the value of the property. The magnitude of this interval is obtained by multiplying the combined standard uncertainty (u_c) by a coverage factor (k). The coverage factor, k, is the Student's t factor based on the effective degrees of freedom to provide a 95% level of confidence. The combined standard uncertainties (u_c) for uranium isotopic parameters consist of Type A components derived from standard deviations associated with isotopic ratio measurements of the samples and the measurements of the $^{235}U/^{238}U$ ratio of NBL CRM U030-A, and Type B components which are based on the standard uncertainties derived from the NBL CRM U030-A certified value for the $^{235}U/^{238}U$ ratio.

Project coordination was provided by A.J. Traina. Sample preparation was performed by I.W. Frank, G.J. Orlowicz, A.J. Traina, and M.I. Spaletto. Isotopic abundance measurements were performed by A.J. Traina, S. Richter and R.M. Essex; experimental design for the isotopic certification experiments and assessment of isotopic data were provided by S.A. Goldberg. The statistical plan of analysis for assay certification experiments was prepared by M.D. Soriano, and assessment of the data was performed by M.D. Soriano and D.T. Baran. Technical guidance for CRM U045 preparation, certification, packaging and issuance was provided by U.I. Narayanan, M.A. Legel and M.I. Spaletto. Health physics support was provided by F.P. Orlowicz. Project supervision was provided by R.D. Oldham, D.T. Baran, S.A. Goldberg, W.G. Mitchell, and J.W. Neuhoff.

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