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TO:	**BETSY ULLRICH** US Nuclear Regulatory Commission King of Prussia, PA
FROM:	T. W. SCHWAGER

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Attached please find the information from the New Brunswick Laboratory in Argonne, IL about the CRM-146 source. This source is listed on their website (***www.nbl.doe.gov***).

Let me know if you need any additional information.

131491

NMSS/RGN1 MATERIALS-006

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To:
From: C. L. Mansfield, Radiological Control Manager
New Brunswick Laboratory
New Brunswick Laboratory CFM 146 as a Sealed Radioactive Source

Department of Energy (DOE) regulations Part 835, "Occupational Radiation Protection" define a sealed radioactive source as:

> "a radioactive source manufactured, obtained, or retained for the purpose of utilizing the emitted radiation. The sealed radioactive source consists of a known or estimated quantity of radioactive material contained within a sealed capsule, sealed between layer(s) of non-radioactive material, or firmly fixed to a non-radioactive surface by electroplating or other means intended to prevent leakage or escape of the radioactive material. Sealed radioactive sources do not include reactor fuel elements, nuclear explosive devices, and radioisotope thermoelectric generators."

The regulatory definition of a radioactive sealed source established three general criteria that must be met. NBL CRM 146 meets these criteria as follows:

1) The source is manufactured for the purpose of utilizing the emitted radiation.

   CRM 146 is intended for use in the calibration and evaluation of gamma-ray counting procedures for the nondestructive determination of ^{235}U isotopic abundance in uranium bulk material. This purpose is accomplished by using measuring the abundance and intensity of the 185.7 keV gamma-ray from ^{235}U through a collimated channel with a gamma-ray detector[1].

2) The source consists of a known or estimated quantity of radioactive material.

   The uranium content in CRM 146 is certified on a mass as well as isotopic basis[2]. The certified values are provided to the user by an NBL Certified Reference Material Certificate of Analysis.

3) The source is contained in a manner that precludes leakage or escape of the radioactive material.

   CRM 146 consists of three sealed cans containing source material as well as an unsealed empty can. The containment device consist of a can, plug, and spacer all machined from solid ASTM-certified aluminum stock at Frederick Manufacturing Division in Frederick, Maryland. The source material was placed in the can followed by a 5 mm thick spacer having the same diameter as the inner diameter of the can. A plug having a diameter of 69 mm, 1 mm less than the inner diameter of the can, was pressed into the can using a hydraulic hand press. The plug and can were then TIG-welded together[3] by a welder from the Argonne National Laboratory Central Shop.

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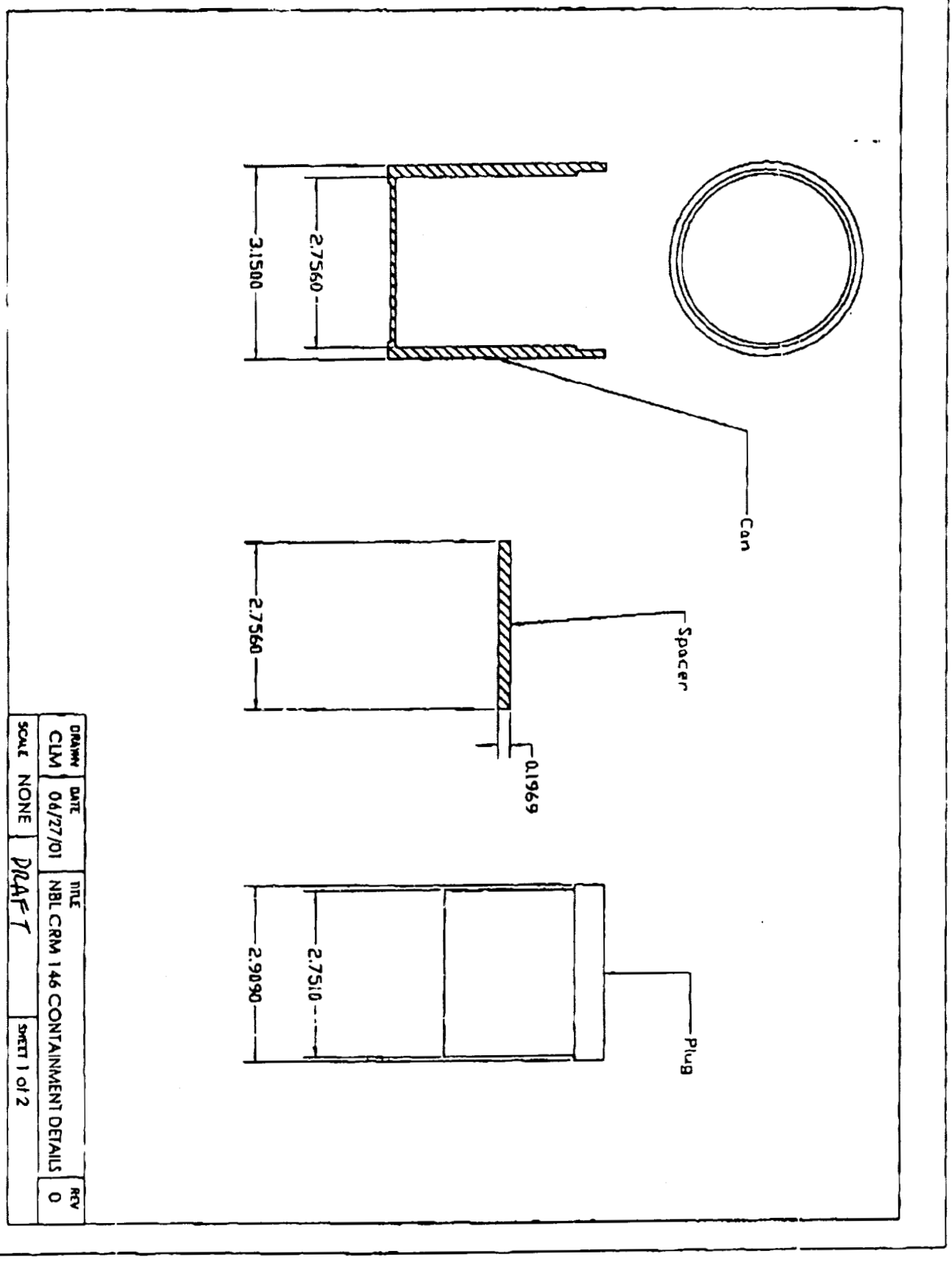
[1] "The Fabrication and Certification of a Uranium Isotopic Standard for Gamma Spectrometry Measurements NBL CRM 146," NBL-354, March 2000, Page 1.
[2] Ibid, Table I, Page 7.
[3] Ibid, Page 4



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SCALE	NONE
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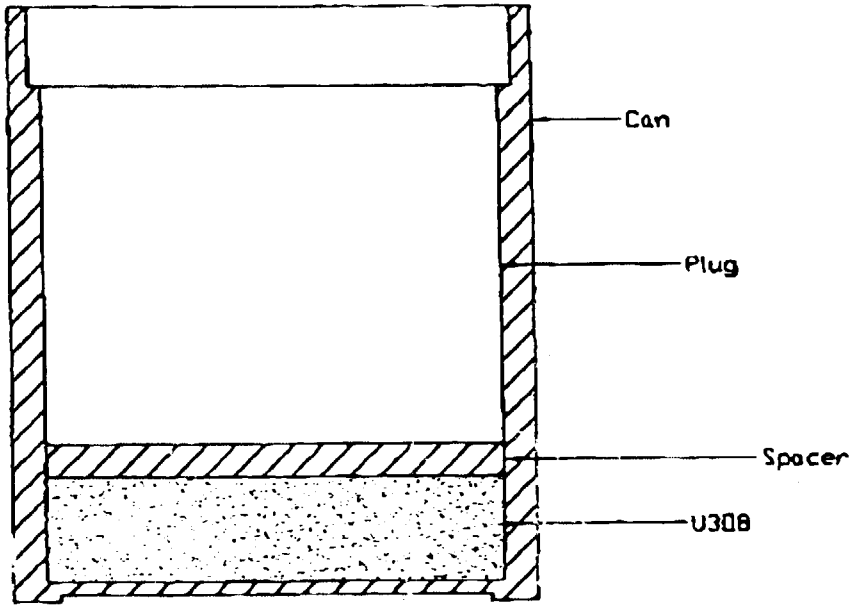
SHEET	1 of 2

Cross-Section



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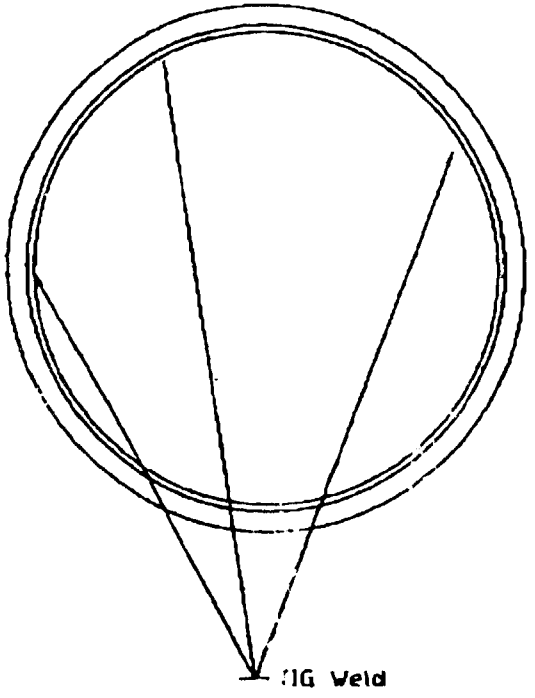

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U.S. Department of Energy
New Brunswick Laboratory

New Brunswick Laboratory Certified Reference Material Certificate of Analysis

CRM 146

Uranium Isotopic Standard For Gamma Spectrometry Measurements

Table I. ^{235}U Isotopic Abundance
Certified Values

Can Identification	NBL 0017	NBL 0018	NBL 0019
^{235}U Atom Fraction (x 100)	20.311 ± 0.020	52.800 ± 0.042	93.2330 ± 0.0053
^{235}U Mass Fraction (x 100)	20.107 ± 0.020	52.488 ± 0.042	93.1703 ± 0.0052

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 issued intended for use in the calibration and evaluation of gamma-ray counting procedures for the nondestructive determination of ^{235}U isotopic abundance in uranium bulk material. Each set of CRM 146 consists of three sealed aluminum cans and one unsealed empty can. Each sealed can is filled with approximately 230 grams of UO_2 powder with nominal ^{235}U isotopic abundances of 20%, 53% and 93%. The cans were manufactured to specific dimensions and each can has a unique engraved identification number and a paper label indicating the nominal ^{235}U isotopic abundance. The certified ^{235}U atom and mass fraction values are listed in Table I. The New Brunswick Laboratory (NBL) prepared CRM 146 as a set to permit measurement of uranium-bearing materials by using the theoretically expected linear relationship between ^{235}U isotopic abundance and the counting rate of the 185.7 keV gamma-ray from ^{235}U. Appropriate correction factors must be applied for calibration of assay systems used to measure other types of uranium samples and containers. Additional material properties are certified and the values provided in Table II for use with other nondestructive assay (NDA) techniques. Table III contains supplemental information; these values are not certified.

NOTE: The CRM 146 set should be stored and handled under proper radiologically-controlled conditions at all times. The cans should be handled with great care to avoid any damage or deformation to the bottoms of the cans, since the bottoms serve as a window for the emitted gamma radiation.

July 30, 1999
Argonne, Illinois

Margaret E.M. Tolbert
Laboratory Director

NBL CRM 146 can be used with NBL CRM 969 (formerly NBS SRM 969) to extend the calibration range for uranium isotopic enrichment measurements from depleted (0.32% ^{235}U) to highly enriched uranium (93% ^{235}U). The National Bureau of Standards (NBS; now the National Institute of Standards and Technology) issued NBS Standard Reference Material (SRM) 969 in June 1986. NBS SRM 969 was produced in cooperation with the Commission of the European Communities Central Bureau for Nuclear Measurement (now the Institute for Reference Materials and Measurements), Geel, Belgium and the U.S. Department of Energy New Brunswick Laboratory, Argonne, Illinois (see Reference).

Lockheed Martin Energy Systems Y-12 Plant, Oak Ridge, Tennessee, provided the source materials for the preparation of CRM 146. NBL accepted the materials based on available analytical data and process knowledge from Y-12. The materials were packaged into aluminum cans at NBL. The CRM 146 cans were packed to a sufficient density to assure that they would meet the "infinitely thick" criteria. NDA tests performed on each set showed a linear correlation coefficient greater than 0.999, indicating that the criterion was met.

The uranium isotopic compositions and their molar masses were determined by thermal ionization mass spectrometry. Uranium isotopic ratio measurements were performed by two analysts each using a different mass spectrometer. Mass discrimination correction factors applied to measured CRM 146 isotopic ratios were determined from multiple analyses of matching NBL Uranium Isotopic Standards (CRM U200, CRM U500 or CRM U930-D), run sequentially with CRM 146 materials. NBL CRM U500, Uranium Isotopic Standard (50% enriched), was used as a control to verify proper performance of the measurement system. No measurable ^{233}U was detected in CRM 146. The following nuclide masses were used in calculations: ^{234}U – 234.0409447, ^{235}U – 235.0439222, ^{236}U – 236.0455610, and ^{238}U – 238.0507835. The uranium mass fraction was determined by the NBL Titrimetric Method (Modified Davies and Gray Titrimetric Method) using potassium dichromate as the titrant. The uranium equivalency of the potassium dichromate titrant was determined by titrating against NBL CRM 112-A, Uranium Metal Assay Standard. CRM 112-A was also used to verify proper performance of the measurement systems. Uranium assay measurements were performed by two analysts each using independent titration systems. The U_3O_8 mass in each can of CRM 146 was determined using a 2-place balance. The balance was monitored through the laboratory balance control program and checked during the packaging of the cans for accuracy and linearity by using calibrated and traceable mass standards.

The expanded uncertainty (U) for a certified property of CRM 146 defines a confidence interval around the value of the property. The magnitude of U is obtained by multiplying the combined standard uncertainty, u_c, by a coverage factor, k. The coverage factor is the Student's t factor based on the effective degrees of freedom to provide a 95% level of confidence. The combined standard uncertainties for uranium isotopic abundances consist of Type A components derived from standard deviations associated with isotopic ratio measurements and Type B components which are based on the standard uncertainties taken from the certified values of the NBL Uranium Isotopic Standards. Uncertainties for the minor isotopic abundances (^{234}U and ^{236}U) and ratios ($^{234}U/^{238}U$ and $^{236}U/^{234}U$) are augmented to accommodate possible bias in the measurement of small signal intensities by including the repeatability of the NBL Uranium Isotopic Standard measurements corrected for mass discrimination and the associated uncertainties of these standards. The combined standard uncertainty for the uranium mass fraction consists of Type A components derived from standard deviations associated with sample and standard measurements. The combined standard uncertainty for the U_3O_8 mass in each can consists of Type A components derived from standard deviations associated with repeated weighings of traceable mass standards and components due to the difference in the measured and reference values taken from the certificate of calibration for the mass standards.

Table II. Additional Certified Values

Can Identification	NBL 0017	NBL 0018	NBL 0019
^{234}U Atom Fraction (x 100)	0.15076 ± 0.00037	0.3756 ± 0.0011	0.9849 ± 0.0028
^{234}U Mass Fraction (x 100)	0.14861 ± 0.00037	0.3718 ± 0.0010	0.9800 ± 0.0029
^{235}U Atom Fraction (x 100)	0.1985 ± 0.0013	0.26495 ± 0.00060	0.2927 ± 0.0022
^{235}U Mass Fraction (x 100)	0.1973 ± 0.0013	0.26451 ± 0.00060	0.2937 ± 0.0022
^{238}U Atom Fraction (x 100)	79.339 ± 0.020	46.560 ± 0.043	5.4895 ± 0.0053
^{238}U Mass Fraction (x 100)	79.547 ± 0.020	46.876 ± 0.043	5.5569 ± 0.0053
$^{234}U/^{238}U$ Atom Ratio	0.0019002 ± 0.0000050	0.008067 ± 0.000028	0.17942 ± 0.00058
$^{235}U/^{238}U$ Atom Ratio	0.25001 ± 0.00031	1.1340 ± 0.0020	16.684 ± 0.017
$^{236}U/^{238}U$ Atom Ratio	0.002501 ± 0.000016	0.005691 ± 0.000013	0.05332 ± 0.00038
Molar Mass of Uranium (g/mol)	237.43002 ± 0.00060	236.4428 ± 0.0012	235.20204 ± 0.00017
Uranium Mass Fraction (x 100)	84.563 ± 0.019	84.286 ± 0.030	84.519 ± 0.074
U_3O_8 Mass (grams)	230.00 ± 0.10	230.04 ± 0.10	230.06 ± 0.10
^{235}U Mass (grams)	39.10 ± 0.04	101.77 ± 0.10	181.16 ± 0.12

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.

Table III. Supplemental Information
(Values Not Certified)

Can Identification	NBL 0017	NBL 0018	NBL 0019
Aluminum Window Thickness (mm)	1.994 ± 0.0052	1.994 ± 0.0052	1.994 ± 0.0062
Can Inner Diameter (mm) (0.01mm tolerance)	70.00	70.00	70.00
Material Fill Height (mm)	15.8	15.8	15.8
U_3O_8 Surface Density (g/cm^2)	5.98	5.98	5.98
U_3O_8 Density (g/cm^3)	3.78	3.78	3.78
Moisture Content in U_3O_8	Insignificant	< 0.05%	Insignificant
Volatile Substances in U_3O_8	< 0.2%	< 0.3%	Insignificant
Detectable Elemental Impurities in U_3O_8 ($\mu g/g$)	456	143	310
Chemical Separation Date	1990	1990	1990

David T. Baran served as project leader for packaging the material and Anna M. Voeks served as project leader for certification measurements. Kimberly Johnson-Miller, Gary A. Sowell and Robert D. Oldham packaged the CRM cans. Alma V. Stiffin and Khalida Schejdelman prepared samples for analysis. Anthony J. Traina and Peter B. Mason performed the isotopic abundance measurements and Steven A. Goldberg provided the experimental design and assessed the isotopic data. Glennda J. Orlowicz and Iris W. Frank performed titrimetric assay measurements. Anna M. Voeks measured moisture content and total volatile substances. David T. Baran and Gary A. Sowell made gamma-ray spectrometry measurements. Francis P. Orlowicz provided health physics support. Elemental impurities were measured at BWX Technologies Naval Nuclear Fuel Division, Lynchburg, Virginia. Michael D. Soriano and Marianne M. Smith prepared the statistical sampling and analysis plan. Michael D. Soriano, Marianne M. Smith and David T. Baran assessed the data for certification. Usha I. Narayanan provided technical guidance for packaging, certification, and issuance of CRM 146. Robert D. Oldham, Wanda G. Mitchell and Jon W. Neuhoff supervised project work.

Reference: *NBS Special Publication 260-96, "Standard Reference Materials: Uranium-235 Isotope Abundance Standard Reference Materials for Gamma Spectrometry Measurements," by B.S. Carpenter et.al., September 1986.*