National Institute of Standards & Technology

Certificate

Standard Reference Material® 4417L

Indium-111 Radioactivity Standard

Lot Number 33

Ampoule 1

This Standard Reference Material (SRM) consists of a solution of a standardized and certified quantity of radioactive indium-111 in a suitably stable and homogeneous matrix. It is intended primarily for the calibration of instruments that are used to measure radioactivity and for the monitoring of radiochemical procedures. A unit of SRM 4417L consists of approximately 5 mL of a solution, whose composition is specified in Table 1 and 2, contained in a flame-sealed borosilicate-glass ampoule [1].

The certified **indium-111** massic activity value, at a **Reference Time of 1600 EST, 20 August 2013**, is:

(9.115 ± 0.111) MBq•g^{-1}

A NIST certified value, as used within the context of this certificate, is a value for which NIST has the highest confidence in its uncertainty assessment. It is a "measurement result" [2] obtained directly or indirectly from a "primary reference measurement procedure" [3]. The certified value is traceable to the derived SI unit, Becquerel (Bq).

Additional physical, chemical, and radiological properties for this SRM, as well as details on the standardization method, are given in Table 1 and 2. Uncertainties for the certified quantities are expanded ($k = 2$). The uncertainties are calculated according to the ISO and NIST Guide [4,5]. Table 3 contains a specification of the components that comprise the uncertainty analyses.

Expiration of Certification: The certification of **SRM 4417L** is valid, within the measurement uncertainty specified, within its half-life-dependent useful lifetime, provided the SRM is handled in accordance with instructions given in this certificate (see "Instructions for Handling and Storage"). The certification is nullified if the SRM is damaged, contaminated, or otherwise modified.

Maintenance of Certification: NIST will monitor this SRM over the period of its certification. If substantive technical changes occur that affect the certification, NIST will notify the purchaser.

Radiological and Chemical Hazard: Consult the Safety Data Sheet (SDS), enclosed with the SRM shipment, for radiological and chemical hazard information.

This SRM was prepared in the Physical Measurement Laboratory, Radiation Physics Division, Radioactivity Group, M.P. Unterweger, Group Leader. The overall production, technical direction and physical measurement leading to certification were provided by R.K. Young and D.B. Golas, Guest Researchers from NRMAP, Incorporated.

Support aspects involved in the issuance of this SRM were coordinated through the NIST Measurement Services Division.

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Table 1. Certified Massic Activity of SRM 4417L, Lot 33, Ampoule 1

Radionuclide	**Indium-111**
Reference time	**1600 EST, 20 August 2013**
Massic activity of the solution	**9.115 MBq•g^{-1}**
Relative expanded uncertainty (k = 2)	**1.22 %**[(a)]

[(a)]The uncertainties on certified values are expanded uncertainties, $U = ku_c$. The quantity u_c is the combined standard uncertainty calculated according to the ISO and NIST Guides [4,5]. The combined standard uncertainty is multiplied by a coverage factor of k = 2 and was chosen to obtain an approximate 95 % level of confidence.

Table 2. Uncertified Information of SRM 4417L, Lot 33, Ampoule 1

Source description	Liquid in a flame-sealed 5-mL NIST borosilicate ampoule [1]
Solution composition	3.1 mol•L^{-1} HCl with 43 μg $InCl_3$ per gram of solution
Solution density	(1.051 ± 0.002) g•mL^{-1} at 20.0 °C[(a)]
Solution mass	(5.2568 ± 0.0003) g[(a)]
Photon-emitting impurities (at reference time)	^{114m}In: (6.4 ± 1.3) kBq•g^{-1} [(a,b)]
Half lives used	^{111}In: (2.8049 ± 0.0004) d[(c)] ^{114m}In: (49.51 ± 0.01) d[(d)]
Calibration method (and instruments)	Measurements of ionization current ratios relative to radium-226 reference sources using NIST pressurized "4π"γ ionization chamber "B" calibrated using an indium-111 solution whose activity was determined by the 4π(e+X)-γ coincidence efficiency-extrapolation technique.

[(a)]The stated uncertainty is two times the standard uncertainty.

[(b)]The estimated lower limits of detection for photon-emitting impurities, expressed as massic photon emission rates, as of 21 August 2013 were:

- 6×10^3 s^{-1}•g^{-1} for energies between 35 keV and 50 keV,
- 3×10^3 s^{-1}•g^{-1} for energies between 55 keV and 155 keV,
- 6×10^3 s^{-1}•g^{-1} for energies between 160 keV and 185 keV,
- 2×10^3 s^{-1}•g^{-1} for energies between 190 keV and 225 keV,
- 6×10^3 s^{-1}•g^{-1} for energies between 230 keV and 260 keV,
- 5×10^2 s^{-1}•g^{-1} for energies between 265 keV and 430 keV,
- 3×10^2 s^{-1}•g^{-1} for energies between 440 keV and 500 keV,
- 2×10^2 s^{-1}•g^{-1} for energies between 510 keV and 1440 keV,
- 2×10^2 s^{-1}•g^{-1} for energies between 1450 keV and 1480 keV, and
- 1×10^2 s^{-1}•g^{-1} for energies between 1490 keV and 2000 keV,

provided that any impurity photons are separated by four keV or more from photons emitted in the decay of indium-111.

[(c)]The stated uncertainty is the standard uncertainty. See reference 6.

[(d)]The stated uncertainty is the standard uncertainty. See reference 7.

Table 3. Uncertainty Evaluation for the Massic Activity of SRM 4417L, Lot 33

	Uncertainty component	Assessment Type[(a)]	Relative standard uncertainty contribution on massic activity of indium-111 (%)
1	Ionization-chamber measurement precision on this solution; standard deviation of the mean for five sets of measurements on seven ampoules	A	0.005
2	"4π"γ ionization-chamber calibration factor	B	0.60
3	Correction for photon-emitting impurities in this solution	B	0.002
4	Decay correction for radium-226 reference source to correct the calibration factor (for half-life uncertainty of 0.44 %)	B	0.008
5	Radium reference source positioning	B	0.05
6	Electrometer response linearity	B	0.1
7	Gravimetric mass measurements	B	0.05
8	Decay correction for indium-111 (for half-life uncertainty of 0.014 %)	B	0.000003
9	Detection limits for photon-emitting impurities	B	0.01
Relative combined standard uncertainty			**0.61**
Relative expanded uncertainty (*k* = 2)			**1.22**

[(a)]Letter A denotes evaluation by statistical methods; B denotes evaluation by other methods.

INSTRUCTIONS FOR HANDLING AND STORAGE

Handling: If the ampoule is transported, it should be packed, marked, labeled, and shipped in accordance with the applicable national, international, and carrier regulations. The solution in the ampoule is a dangerous good (hazardous material) because of both the radioactivity and the strong acid. The ampoule should be opened only by persons qualified to handle both radioactive material and alkaline and/or acidic solutions. Appropriate shielding and/or distance should be used to minimize personnel exposure. Refer to the SDS for further information.

Storage: SRM 4417L should be stored and used at a temperature between 5 °C and 65 °C. The ampoule (or any subsequent container) should always be clearly marked as containing radioactive material.

REFERENCES

[1] NIST Physical Measurement Laboratory; *Storage and Handling of Radioactive Standard Reference Materials, Ampoule Specifications and Opening Procedure*; available at http://www.nist.gov/pml/div682/grp04/srm.cfm.

[2] JCGM 200:2012; *International Vocabulary of Metrology - Basic and General Concepts and Associated Terms (VIM)* (2008 version with Minor Corrections), 3rd edition; Joint Committee for Guides in Metrology: BIPM, Sèvres Cedex, France; p. 19 (2012); available at http://www.bipm.org/utils/common/documents/jcgm/JCGM_200_2012.pdf.

[3] JCGM 200:2012; *International Vocabulary of Metrology - Basic and General Concepts and Associated Terms (VIM)* (2008 version with Minor Corrections), 3rd edition; Joint Committee for Guides in Metrology: BIPM, Sèvres Cedex, France; p. 18 (2012); available at http://www.bipm.org/utils/common/documents/jcgm/JCGM_200_2012.pdf.

[4] JCGM 100:2008; *Guide to the Expression of Uncertainty in Measurement*; (ISO GUM 1995 with Minor Corrections), Joint Committee for Guides in Metrology: BIPM, Sèvres Cedex, France (2008); available at http://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf.

[5] Taylor, B.N.; Kuyatt, C.E.; *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*; NIST Technical Note 1297, U.S. Government Printing Office: Washington, DC (1994); available at http://physics.nist.gov/Pubs/.

[6] Laboratoire National Henri Becquerel; *Table of Radionuclides, Recommended Data* (updated 26 April 2006); available at http://www.nucleide.org/DDEP_WG/DDEPdata.htm (accessed August 2013).

[7] The Evaluated Nuclear Structure Data File (ENSDF), National Nuclear Data Center, Brookhaven National Laboratory, Upton, New York, full evaluation 2012, Nuclear Data Sheets 113, 515 (2012); available at http://www.nndc.bnl.gov/ensdf/index.jsp (accessed August 2013).

Users of this SRM should ensure that the Certificate in their possession is current. This can be accomplished by contacting the SRM Program: telephone (301) 975-2200; fax (301) 948-3730; e-mail srminfo@nist.gov; or via the internet at http://www.nist.gov/srm.