National Institute of Standards & Technology

Certificate

Standard Reference Material® 4323B

Plutonium-238 Radioactivity Standard

This Standard Reference Material (SRM) consists of a solution of a standardized and certified quantity of radioactive plutonium-238 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 consists of a solution, whose composition is specified in Table 1, contained in a flame-sealed 5 mL NIST borosilicate-glass ampoule (see Note 1)*.

The certified **Plutonium-238** massic activity value, at a **Reference Time of 1200 EST, 15 November 1999**, is:

(41.52 ± 0.28) Bq•g^{-1}

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

Expiration of Certification: The certification of **SRM 4323B** is valid indefinitely provided the SRM is handled and stored properly and no evaporation or change in composition has occurred. The solution matrix, in an unopened ampoule, is indefinitely homogeneous and stable within its half-life-dependent useful lifetime provided the SRM is handled in accordance with instructions given in this certificate (see "Instructions for Use"). 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 before the expiration of this certificate, NIST will notify the purchaser. Registration (see attached sheet) will facilitate notification.

This SRM may represent a radiological hazard and a chemical hazard. Consult the Material Safety Data Sheet (MSDS), enclosed with the SRM shipment, for details (see Note 1).

This Standard Reference Material was prepared in the Physics Laboratory, Ionizing Radiation Division, Radioactivity Group, M.P. Unterweger, Group Leader. The overall technical direction and physical measurement leading to certification were provided by L. Lucas of the NIST Radioactivity Group.

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

INSTRUCTIONS FOR USE

Storage: SRM 4323B 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.

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 base or 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 MSDS for further information.

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Certificate Issue Date: 30 July 2009

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* Notes and references may be found on page 4.

Table 1. Properties of SRM 4323B

Certified values

Radionuclide	**Plutonium-238**
Reference time	**1200 EST, 15 November 1999**
Massic activity of the solution	**41.52 Bq•g^{-1}**
Relative expanded uncertainty (*k* = 2)	**0.68 %** (see Note 2)*

Uncertified information

Source description	Liquid in a flame-sealed 5 mL NIST borosilicate-glass ampoule (see Note 1)
Solution composition	3.1 mol•L^{-1} HNO_3 and 0.008 mol•L^{-1} HCl
Solution density	(1.101 ± 0.002) g•mL^{-1} at 21.4 °C (see Note 3)
Solution mass	Approximately 5.5 g
Alpha-particle-emitting impurities	None detected (see Note 4)
Photon-emitting impurities	None detected (see Note 5)
Half-lifes used	^{238}Pu : (87.7 ± 0.1) a (see Note 6) [1]
Calibration methods (and instruments)	Two 4πα liquid-scintillation (LS) counting systems

* Notes and references may be found on page 4.

Table 2. Uncertainty evaluation for the massic activity of SRM 4323B

	Uncertainty component	Assessment Type †	Relative standard uncertainty contribution on massic activity of ^{238}Pu (%)
1	Massic alpha-particle emission rate, corrected for background and decay; standard deviation of the mean for 18 sets of 4πα liquid-scintillation measurements.	A	0.02
2	Half life of ^{238}Pu; standard uncertainty of the half life	B	0.00009
3	Decay scheme data; standard uncertainty of the probability of decay by alpha-particle emission	B	0.001
4	Gravimetric measurements	B	0.10
5	Live-time (see Note 7)*	B	0.10
6	Alpha-particle detection efficiency of the liquid-scintillation counting systems (see Note 8)	B	0.27
7	Alpha-particle-emitting impurities; limit of detection	B	0.10
8	Photon-emitting impurities; limit of detection	B	0.10
Relative combined standard uncertainty			**0.34**
Relative expanded uncertainty (*k* = 2)			**0.68**

† = (A) denotes evaluation by statistical methods; (B) denotes evaluation by other methods.

∗ Notes and references may be found on page 4

NOTES

Note 1. Refer to http://physics.nist.gov/Divisions/Div846/srm.html for assistance and instructions on how to properly open an ampoule. Information on additional storage and handling requirements is also included on the website. The ampoule has the following specifications: Body outside diameter is 16.5 ± 0.5 mm; Wall thickness is 0.60 ± 0.04 mm; Barium content is less than 2.5 %; Lead-oxide content is less than 0.02 %; and Other heavy elements are trace quantities.

Note 2. 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 [2-3]. The combined standard uncertainty is multiplied by a coverage factor of $k = 2$ and was chosen to obtain an approximate 95 % level of confidence.

Note 3. The stated uncertainty is two times the standard uncertainty. See reference [3].

Note 4. The estimated lower limits of detection for alpha-emitting impurities are:

$0.03\ s^{-1} \bullet g^{-1}$ for energies less than 5.25 MeV and

$0.001\ s^{-1} \bullet g^{-1}$ for energies grater than 5.5 MeV.

An atom ratio (plutonium-239/plutonium-238) of 0.00107 was measured by mass spectrometry in 1981. As of the reference time, the massic activity of plutonium-239 is well below the detection limits and is calculated to be approximately $0.0001\ Bq \bullet g^{-1}$.

Note 5. The estimated lower limit of detection for photon-emitting impurities, expressed as massic photon emission rate, are:

$0.000400\ s^{-1} \bullet g^{-1}$ for energies between 6 keV and 39 keV,

$0.000100\ s^{-1} \bullet g^{-1}$ for energies between 48 keV and 95 keV,

$0.000070\ s^{-1} \bullet g^{-1}$ for energies between 103 keV and 147 keV,

$0.000010\ s^{-1} \bullet g^{-1}$ for energies between 157 keV and 762 keV, and

$0.000003\ s^{-1} \bullet g^{-1}$ for energies between 770 keV and 1900 keV,

provided that the photons are separated in energy by 4 keV or more from photons emitted in the decay of plutonium-238.

Note 6. The stated uncertainty is the standard uncertainty. See reference [3].

Note 7. The live time is determined by counting the pulses from a gated oscillator.

Note 8. Includes the uncertainty in the alpha-particle detection efficiency of the liquid-scintillation cocktail and the uncertainty associated with the finite detection threshold of the counting electronics.

REFERENCES

[1] Evaluated Nuclear Structure Data File (ENSDF), online database, National Nuclear Center, Brookhaven National Laboratory (Upton, NY), accessed March 2000. Refer to http://www.nndc.bnl.gov/ensdf/.

[2] International Organization for Standardization (ISO), G*uide to the Expression of Uncertainty in Measurement*; 1993 (corrected and reprinted, 1995). Ordering and purchasing information available at http://physics.nist.gov/cuu/Uncertainty/isoorder.html.

[3] B.N. Taylor and C.E. Kuyatt; *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*, NIST Technical Note 1297, 1994. Available at http://physics.nist.gov/Pubs/guidelines/contents.html.

Certificate Revision History: 30 July 2009 (Extension of certification period); March 2000 (Original certificate date).

Users of this SRM should ensure that the certificate in their possession is current. This can be accomplished by contacting the SRM Program at: telephone (301) 975-2200; fax (301) 926-4751; e-mail srminfo@nist.gov; or via the Internet at http://www.nist.gov/srm.