National Institute of Standards & Technology

Certificate

Standard Reference Material® 4967A

Radium-226 Radioactivity Standard

This Standard Reference Material (SRM) consists of a solution of a standardized and certified quantity of radioactive radium-226 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 4967A consists of approximately 5 mL of a hydrochloric acid and barium chloride solution, whose composition is specified in Table 1 and 2, contained in a flame-sealed borosilicate-glass ampoule [1].

The certified **radium-226** massic activity value, at a **Reference Time of 1200 EST, 01 September 2003**, is:

$$\mathbf{(2482 \pm 30)\ Bq \cdot g^{-1}}$$

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 Guides [4,5]. Table 3 contains a specification of the components that comprise the uncertainty analyses.

Expiration of Certification: The certification of **SRM 4967A** is valid indefinitely, within the measurement uncertainty specified, provided that the SRM is handled and stored properly and that no evaporation or change in composition has occurred. The solution matrix, in an unopened ampoule, is 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 Handling and Storage"). Periodic recertification of this SRM is not required. 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. Registration (see attached sheet) will facilitate notification.

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 NIST Physical Measurement Laboratory, Radiation Physics Division, under the direction of M.P. Unterweger, Group Leader of the Radioactivity Group. The overall production, technical direction, and physical measurement leading to certification were provided by R. Collé and P. Volkovitsky of the NIST Radiation Physics Division, Radioactivity Group. Statistical consultation was provided by S.D. Leigh of the NIST Statistical Engineering Division.

Support aspects involved in the issuance of this SRM were coordinated through the NIST Office of Reference Materials.

Lisa R. Karam, Chief
Radiation Physics Division

Gaithersburg, Maryland 20899
Certificate Issue Date: 03 September 2013
See Certificate Revision History on Last Page

Robert L. Watters, Jr., Director
Office of Reference Materials

Table 1. Certified Massic Activity of SRM 4967A

Radionuclide	**Radium-226**
Reference time	**1200 EST, 01 September 2003**
Massic activity of the solution	**2482 Bq•g^{-1}**
Relative expanded uncertainty (k = 2)	**1.20 %**

Table 2. Uncertified Information of SRM 4967A

Source description	Liquid in a flame-sealed 5 mL borosilicate-glass ampoule [1]
Solution composition	1.0 mol•L^{-1} HCl with 80µg of $BaCl_2$ per gram of solution
Solution density	(1.017 ± 0.002) g•mL^{-1} at 21 °C[(a)]
Solution mass	(5.086 ± 0.003) g[(a)]
Photon-Emitting Impurities	None detected[(b)]
Half-lives used	^{226}Ra: (1600 ± 7) a [6][(c)] ^{222}Ra: (3.8235 ± 0.0003) d [7][(c)]
Calibration methods (and instruments)	Gravimetric dilution of SRM 4963, confirmed by comparison with solution standards, and derivatives thereof, from the NBS/NIST "1947 (1967 recalibrated) series" of radium-226 solution standards. The mass of radium-226 in these solution standards had previously been determined by comparison with the U.S. National Standards for radium-226. Conversion from mass of radium-226 to activity of radium-226 was done using the half-life of radium-226 shown above.[(d)]

[(a)] The stated uncertainty is two times the standard uncertainty. See reference 5.

[(b)] The estimated lower limits of detection for photon-emitting impurities, as of September 2003, expressed as massic photon mission rate, are:

6 x 10^{0} s^{-1}•g^{-1} for energies between 22 keV and 182 keV,
3 x 10^{0} s^{-1}•g^{-1} for energies between 190 keV and 347 keV,
8 x 10^{-1} s^{-1}•g^{-1} for energies between 356 keV and 1455 keV, and
3 x 10^{-1} s^{-1}•g^{-1} for energies between 1465 keV and 2750 keV,

provided that the photons are separated in energy by 4 keV or more from photons emitted in the decay of ^{226}Ra and progeny.

[(c)] The stated uncertainty is the standard uncertainty. See reference 5.

[(d)] For further details on NBS/NIST radium series calibrations refer to reference [8]. The 1967 recalibrations of the "1947 series" and of the "1957 series" were made using pressurized "4π"γ ionization chamber (PIC) "A". The master solution for SRM 4967A was directly compared with the "1947 (1967 recalibrated) series" of radium-226 solution standards using PIC "A", and was compared with the solutions of the "1992 series" of radium solution standards (SRM 4967) using PIC "A", pulse-ionization-chamber radon analyses (see references [9] and [10]), and germanium photon spectrometry. The radium-226 in SRM 4967A was chemically purified approximately 55 years from the reference time. The lead-210 and its daughter radionuclides are still not in equilibrium as of the 2013 certificate issue date.

Table 3. Uncertainty Evaluation for the Massic Activity of SRM 4967A

	Uncertainty component	Assessment Type[a]	Relative standard uncertainty contribution on massic activity of ^{226}Ra (%)
1	Calibration of the "1947 (1967 recalibrated) series" of radium-226 solution standards in terms of mass of radium-226[b]	B	0.34
2	Ratio of the mass of radium-226 in SRM 4967A to the mass of radium-226 in the "1947 (1967 recalibrated) series" of radium-226 solution standards. Weighted mean of the ratios obtained using seven different comparisons.	B	0.15
3	Corrections for the decay of radium-226. Standard uncertainty of the radium-226 half-life.	A	0.007
4	Gravimetric measurements	B	0.10
5	Conversion of radium-226 mass to activity. Standard uncertainty of the radium-226 half-life.[c]	A	0.44
6	Photon emitting impurities. Limit of detection.	B	0.01
Relative combined standard uncertainty			**0.6**
Relative expanded uncertainty (k = 2)			**1.2**

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

[b] For further details on NBS/NIST radium series calibrations refer to reference [8]. The 1967 recalibrations of the "1947 series" and of the "1957 series" were made using pressurized "4π"γ ionization chamber (PIC) "A". The master solution for SRM 4967A was directly compared with the "1947 (1967 recalibrated) series" of radium-226 solution standards using PIC "A", and was compared with the solutions of the "1992 series" of radium solution standards (SRM 4967) using PIC "A", pulse-ionization-chamber radon analyses (see references [9] and [10]), and germanium photon spectrometry. The radium-226 in SRM 4967A was chemically purified approximately 55 years from the reference time. The lead-210 and its daughter radionuclides are still not in equilibrium as of the 2013 certificate issue date.

[c] The U.S National Standards for radium-226 are certified in terms of mass of radium-226, as were all radium-226 SRMs prior to the "1992 series". Beginning with "1992 series", radium-226 solution SRMs are now certified in terms of the massic activity of radium-226. The relative standard uncertainty of the activity of radium-226 per unit mass of radium-226 is determined by the relative standard uncertainty of λ (i.e., of the half-life). The relative standard uncertainties of the atomic weight of radium-226 and of Avogadro's number are negligible.

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. Only persons qualified to handle both radioactive material and alkaline and/or acidic solutions should open the ampoule. To minimize personnel exposure, appropriate shielding and/or distance should be used. Refer to the SDS for further information.

Storage: SRM 4967A 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 (accessed Sep 2013). Note: This SRM is contained in a generic borosilicate-glass ampoule and not in the standard NIST ampoule.

[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, Sevres Cedex, France; p. 19 (2012); available at http://www.bipm.org/utils/common/documents/jcgm/JCGM_200_2012.pdf (accessed Sep 2013).

[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, Sevres Cedex, France; p. 18 (2012); available at http://www.bipm.org/utils/common/documents/jcgm/JCGM_200_2012.pdf (accessed Sep 2013).

[4] JCGM 100:2008; *Guide to the Expression of Uncertainty in Measurement;* (GUM 1995 with Minor Corrections), Joint Committee for Guides in Metrology: BIPM, Sevres Cedex, France (2008); available at http://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf (accessed Sep 2013).

[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://www.nist.gov/pml/pubs/index.cfm (accessed Sep 2013).

[6] Chisté, V; Bé, M.M.; *January 2007, ^{226}Ra*; LNE-LNHB/CEA Table of Radionuclides, available at http://www.nucleide.org/DDEP_WG/Nuclides/Ra-226_tables.pdf (accessed Sep 2013).

[7] Chisté, V; Bé, M.M.; *July 2010, ^{222}Rn*; LNE-LNHB/CEA Table of Radionuclides, available at http://www.nucleide.org/DDEP_WG/Nuclides/Rn-222_tables.pdf (accessed Sep 2013).

[8] Mann, W.B.; Stockman, L.L.; Youden, W.J.; Schwebel, A.; Mullen, P.A.; Garfinkel, S.B.; Preparation of New Solution Standards of Radium, *Journal of Research of the National Bureau of Standards* 62 (1959) 21-26.

[9] Collé, R.; Hutchinson, J.M.R.; Unterweger, M.P.; The NIST Primary Radon-222 Measurement System, *Journal of Research of the National Institute of Standards and Technology* 95 (1990) 155-165.

[10] Hutchinson J.M.R; Cessna, J.; Collé R.; Hodge P.; An International Radon-In-Air Measurement Intercomparison Using a New Transfer Standard, *Applied Radiation Isotopes* 43 (1992) 175-189.

Certificate Revision History: September 2013 (Text and expiration date revised); December 2004 (Original certification date).

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.