National Institute of Standards & Technology

Certificate

Standard Reference Material® 4965a

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 4965a consists of approximately 5 mL of a solution, whose composition is specified in Tables 1 and 2, contained in a flame-sealed borosilicate-glass ampoule [1].

The certified **radium-226** massic activity, at a **Reference Time of 1200 EST, 01 January 2007**, is:

(30.32 ± 0.39) Bq•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 Tables 1 and 2. The uncertainties are calculated according to the ISO/JCGM and NIST Guides [4,5]. Uncertainties for the certified quantities are expanded ($k = 2$). Table 3 contains a specification of the components that comprise the uncertainty analysis.

Expiration of Certification: The certification of **SRM 4965a** 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 or register online) 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 P. Volkovitsky formerly of the NIST Radiation Physics Division, Radioactivity Group with production assistance by D.B. Golas of NRMAP. Photon-emitting impurity analyses were provided by L. Pibida and M. Hammond of the NIST Radiation Physics Division, Radioactivity Group.

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: 16 September 2015

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

Table 1. Certified Massic Activity of SRM 4965a

Radionuclide	**Radium-226**
Reference time	**1200 EST, 01 January 2007**
Massic activity of the solution	**30.32 Bq•g^{-1}**
Relative expanded uncertainty (k = 2)	**1.3 %[(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/JCGM 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 4965a

Source description	Liquid in a flame-sealed 5 mL borosilicate-glass ampoule [1]
Solution composition	1.0 mol•L^{-1} HCl with 50 µg Ba^{+2} per gram of solution (as $BaCl_2$)
Solution density	(1.017 ± 0.002) g•mL^{-1} at 20 °C[(a)]
Solution mass	(5.087 ± 0.001) g[(a)]
Photon-Emitting Impurities	None detected[(b)]
Half-lives used	^{226}Ra: (1600 ± 7) a [(c)] [6]
Calibration methods (and instruments)	Comparative measurements of the SRM 4965a solution against SRM 4967a standard solution using NIST Pulse Ionization Chambers (PIC). Confirmatory measurements against SRM 4965, SRM 4966, and SRM 4967a using NaI(Tl) detector.

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

[(b)] The estimated lower limits of detection for photon-emitting impurities, expressed as massic photon emission rate, on 13 September 2007, were:

0.2 s^{-1}•g^{-1} in the region 40 keV ≤ E ≤ 80 keV;
0.19 s^{-1}•g^{-1} in the region 100 keV ≤ E ≤ 230 keV;
0.27 s^{-1}•g^{-1} in the region 270 ke ≤ E ≤ 700 keV, and
0.33 s^{-1}•g^{-1} in the region 750 keV ≤ E ≤ 1800 keV,

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

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

Table 3. Uncertainty Evaluation for the Massic Activity of SRM 4965a

	Uncertainty component	Assessment Type[(a)]	Relative standard uncertainty contribution on massic activity of ^{226}Ra (%)
1	Precision of PIC measurements: typical standard deviation of the mean for four replicate measurements (one aliquot) of SRM 4965a.	A	0.08
2	Precision of PIC measurements: typical standard deviation of the mean for six replicate measurements (one aliquot) of SRM 4967a	A	0.08
3	Gravimetric (mass) measurements for PIC (bubbler) sources dilutions	B	0.07
4	Losses in radon transfer from bubbler to PIC	B	0.13
5	Extrapolation of PIC spectra to zero energy	B	0.12
6	Decay corrections for radium-226 (for half-life uncertainty of 0.4 %)	B	0.0005
7	Uncertainty in the certified massic activity of SRM 4967a (September 2003), including uncertainty in conversion of radium-226 mass to activity	B	0.60
8	Limit for photon-emitting impurities	B	0.08
9	Live time determination for PIC counting time intervals; includes uncorrected dead time effects	B	0.1
	Relative combined standard uncertainty		**0.65**
	Relative expanded uncertainty (k = 2)		**1.3**

[(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 the radioactivity. 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 4965a 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 2015). 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 2015).

[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 2015).

[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 2015).

[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 2015).

[6] The evaluated Nuclear Structure Data File (ENSDF), September 2007, available at http://www.nndc.bnl.gov/ensdf/ (accessed Sep 2015).

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.