National Institute of Standards & Technology

Certificate

Standard Reference Material 4969

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. The solution, whose composition is specified in Table 1, is contained in a flame-sealed, 5 mL, NIST, borosilicate-glass ampoule (see Note 1)*.

The certified **radium-226** massic activity value, at a **Reference Time of 1200 EST, 15 September 1998**, is:

(3.047 ± 0.05) Bq•g^{-1}

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

The certification of this SRM, within the measurement uncertainties specified, is valid for at least five (5) years after receipt. The solution matrix, in an unopened ampoule, is believed to be indefinitely homogeneous and stable, within its half-life-dependent, useful lifetime. NIST will monitor this material and will report any substantive changes in certification to the purchaser. Should any of the certified values change, purchasers of this SRM will be notified of the change by NIST.

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, Dr. M.P. Unterweger, Acting Group Leader. The overall technical direction and physical measurements leading to certification were provided by Dr. R. Collé. The support aspects involved in the preparation, certification, and issuance of this SRM were coordinated through the Standard Reference Materials Program.

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*Notes and references are in page 4 and 5

Table 1. Properties of SRM 4969

Certified values

Radionuclide	**Radium-226**
Reference time	**1200 EST, 15 September 1998**
Massic activity of the solution	**3.047 Bq•g^{-1}**
Relative expanded uncertainty (*k* = 2)	**1.8 %** (see Note 2)*

Uncertified information

Source description	Liquid in flame-sealed, 5 mL NIST borosilicate ampoule (see Note 1)
Solution composition	1.5 mol•L^{-1} HCl with 100 μg $BaCl_2$ per gram of solution
Solution density	(1.024 ± 0.002) g•mL^{-1} at 21 °C (see Note 3)
Solution mass	(5.122 ± 0.003) g (see Note 3)
Photon-emitting impurities	None detected (see Note 4)
Half-lifes used [1]	^{226}Ra: (1600 ± 7) a (See Note 5)
Calibration method (and instruments)	Gravimetric dilution of SRM 4967, confirmed by intercomparison with the "1992 series" of radium standards (SRMs 4965, 4966, and 4967) using liquid-scintillation (LS) spectrometry and pulse-ionization-chamber radon analyses. The "1992 series" were calibrated against national radium standards in NIST pressurized "4π"γ ionization chamber "A" and were confirmed using LS spectrometry and pulse-ionization-chamber radon analyses.

*Notes and references are in page 4 and 5

Table 2. Uncertainty evaluation for the massic activity for SRM 4969

Uncertainty component		Assessment Type †	Relative standard uncertainty contribution on massic activity of ^{226}Ra (%)
1	Massic LS count rate of SRM 4969, measured relative to the "1992 series" of ^{226}Ra standards corrected for background and decay; standard deviation based on 12 comparative LS measurements against each the three "1992 series" standards	A	0.58
2	Pressurized ionization chamber (PIC) "A" net response of "1992 series" standards, measured relative to eight "1947 (1967 recalibrated) series" radium standards; standard deviation of the mean for 24 sets of measurements	A	0.08
3	Calibration of the "1947 (1967 recalibrated) series" of radium standards (see Note 6)	B	0.34
4	Conversion of ^{226}Ra mass to activity; (for half-life uncertainty of 0.44%) (see Note 7)	B	0.44
5	Correction for decay of ^{226}Ra (for half-life uncertainty of 0.44%)	B	0.006
6	Gravimetric (mass) measurements for LS sources	B	0.05
7	Gravimetric (mass) measurements for PIC "A" sources	B	0.15
8	Live time determinations for LS counting time intervals, includes uncorrected dead time effects	B	0.10
9	Live time determinations for PIC "A" counting time intervals, includes uncorrected dead time effects	B	0.05
10	PIC "A" charge-collection efficiency	B	0.05
11	PIC "A" source positioning	B	0.30
12	Limit for photon-emitting impurities	B	0.01
Relative combined standard uncertainty			**0.9**
Relative expanded uncertainty (*k* = 2)			**1.8**

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

NOTES

Note 1. Refer to http://physics.nist.gov/Divisions/Div846/srm.html for the standardized ampoule dimensions and for assistance and instructions on how to properly open an ampoule. Information on additional storage and handling requirements is also included in the website.

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 (see references [2] and [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 photon-emitting impurities, expressed as massic photon emission rates are:

$7 \times 10^{-3}\ s^{-1} \bullet g^{-1}$ for 22 keV < E < 182 keV
$3 \times 10^{-3}\ s^{-1} \bullet g^{-1}$ for 190 keV < E < 347 keV
$1 \times 10^{-3}\ s^{-1} \bullet g^{-1}$ for 356 keV < E < 605 keV
$8 \times 10^{-4}\ s^{-1} \bullet g^{-1}$ for 613 keV < E < 1455 keV
$3 \times 10^{-4}\ s^{-1} \bullet g^{-1}$ for 1465 keV < E < 2750 keV

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

Note 5. The stated uncertainty is the standard uncertainty. See reference [3].

Note 6. For further details on NBS/NIST radium series calibrations refer to reference [4]. 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 4969 was directly compared with preparations of the “1992 series” of radium standards (SRM 4965. 4966 and 4967) using LS spectrometry. The “1992 series” were directly compared against preparations of the “1947 (1967 recalibrated) series”, the “1978 series” and the “1984 series” of ^{226}Ra standards using pulse-ionization-chamber radon analyses (see references [5] and [6]), LS spectrometry and NaI(Tl) and HPGe spectrometry. The ^{226}Ra in SRMs 4965,4966,4967,4968, and 4969 was chemically purified approximately 50 years ago. The ^{210}Pb to ^{226}Ra activity ratio is now approximately 0.8.

Note 7. The national ^{226}Ra standards are certified for radium mass content, as were all ^{226}Ra SRMs prior to the “1992 series”. The relative standard uncertainty of the specific activity of ^{226}Ra is determined by the relative standard uncertainty of λ (i.e. half-life). The relative standard uncertainties of the atomic weight of ^{226}Ra and of Avogadro’s number are negligible.

REFERENCES

[1] Evaluated Nuclear Structure Data File (ENSDF), online database, National Nuclear Data Center, Brookhaven Laboratory (Upton, NY), October 1999. Refer to http://www.nndc.bnl.gov/ensdf/

[2] International Organization for Standardization (ISO), *Guide to the Expression of Uncertainty in Measurement*, 1993 (corrected and reprinted, 1995). Available from Global Engineering Documents, 12 Inverness Way East, Englewood, CO 80112, U.S.A. Telephone 1-800-854-7179.

[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 from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20407, U.S.A.

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

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

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