National Institute of Standards & Technology

Certificate

Standard Reference Material® 4239

Strontium-90 Radioactivity Standard

This Standard Reference Material (SRM) consists of a solution of a standardized and certified quantity of radioactive strontium-90 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 **strontium-90** massic activity value, at a **Reference Time of 1200 EST, 25 December 2006**, is:

(31.79 ± 0.15) kBq•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 Drs. R. Collé, and L. Laureano-Pérez of the Radioactivity Group, with production assistance by D.B. Golas and O. Palabrica, Research Associates of the Nuclear Energy Institute, with confirmatory measurement assistance by Dr. B.E. Zimmerman, and with impurity analyses by Dr. L. Pibida. The support aspects involved in the preparation, certification, and issuance of this SRM were coordinated through the NIST Measurement Services Division.

Lisa R. Karam, Deputy Chief
Ionizing Radiation Division

Robert L. Watters, Jr., Chief
Measurement Services Division

Gaithersburg, Maryland 20899
March 2008
See Certificate Revision History on Last Page

*Notes and references are in page 4

Table 1. Properties of SRM 4239

Certified values

Radionuclide	**Strontium-90**
Reference time	**1200 EST, 25 December 2006**
Massic activity of the solution	**31.79 kBq•g^{-1}**
Relative expanded uncertainty (*k* = 2)	**0.46 %** (see Note 2)*

Uncertified information

Source description	Liquid in flame-sealed, 5 mL NIST borosilicate ampoule (see Note 1)
Solution composition	1.0 mol•L^{-1} HCl with 26 µg Y^{+3} and 24 µg Sr^{+2} per gram of solution
Solution density	(1.017 ± 0.002) g•mL^{-1} at 23 °C (see Note 3)
Solution mass	(5.0832 ± 0.0003) g (see Note 3)
Alpha-particle-emitting impurities	^{238}Pu and/or ^{241}Am: < 0.1 Bq•g^{-1} (See Note 4)
Photon-emitting impurities	None detected (see Note 5)
Half-lifes used	^{90}Sr : (28.80 ±0.07) a ‡ ^{90}Y : (64.0416 ± 0.0312) h ‡ ^{3}H : (12.32 ± 0.02) a ‡
Nuclear data used in EFFY4 computations (beta-particle maximum energies; branching ratios; transitions) [1]	^{3}H : (18.594 ± 0.008) keV‡; 1, allowed ^{90}Sr: (454.9 ± 1.4) keV‡; 1; unique first forbidden ^{90}Y : (2279.8.1 ± 1.7) keV‡; (0.99983 ± 0.00006); unique first forbidden : (519.1 ± 1.7) keV‡; (0.00017 ± 0.00006); unique first forbidden
Calibration method (and instruments)	The certified massic activity for ^{90}Sr in radioactive equilibrium with ^{90}Y was obtained by 4πβ liquid scintillation (LS) spectrometry with three commercial LS counters. The LS detection efficiency was calculated using the EFFY4 code [2] for the CIEMAT/NIST method with composition matched LS cocktails of a ^{3}H standard as the efficiency detection monitor. Confirmatory measurements were also performed by LS counting using a Triple-to-Double Coincidence Ratio (TDCR) method.

‡ See Note 6

 *Notes and references are in page 4

Table 2. Uncertainty evaluation for the massic activity for SRM 4239

Uncertainty component		Assessment Type †	Relative standard uncertainty contribution on massic activity of ^{90}Sr (%)
1	LS within-measurement precision; typical standard deviation of the mean for 7 samples in a series of one composition measured for 3 to 5 cycles on one measurement occasion; values ranged from 0.007 % to 0.052 %	A	0.02
2	LS measurement precision; reproducibility in massic activity for 3 cocktail compositions, each with 7 samples, measured in 3 counters on 1 or 2 measurement occasions; standard deviation of the mean for ν = 293 effective degrees freedom (normally distributed)	A	0.097
3	Cocktail composition dependencies (for an internal relative standard deviation of 0.06 % for 3 compositions); wholly embodied in components 1 & 2	A	---
4	LS counters dependencies (for an internal relative standard deviation of 0.09 % for 3 counters on one or two occasions); wholly embodied in components 1 & 2	A	---
5	$^{90}Sr/^{90}Y$ disequilibrium in LS cocktails	B	0.05
6	Gravimetric (mass) measurements for LS sources and for ^{3}H standard dilution	B	0.07
7	Live time determinations for LS counting time intervals, includes uncorrected dead time effects	B	0.06
8	Decay corrections for ^{90}Sr (for half life uncertainty of 0.24 %)	B	0.0001
9	$^{90}Sr/^{90}Y$ equilibrium ratio from half-life uncertainties	B	0.00006
10	Decay corrections for ^{3}H (for half life uncertainty of 0.16 %)	B	0.0002
11	Limit for alpha- and photon-emitting impurities	B	0.01
12	Beta endpoint energy, $E_{\beta(max)}$, for ^{90}Sr for an uncertainty of 1.4keV	B	0.007
13	$E_{\beta(max)}$ for ^{90}Y for an uncertainty of 1.7 keV	B	0.001
14	Beta decay branching ratios for ^{90}Y for an uncertainty of 0.006 per decay	B	0.0001
15	Computed β detection efficiencies for ^{90}Sr and ^{90}Y (model dependencies)	B	0.18
Relative combined standard uncertainty			**0.23**
Relative expanded uncertainty (*k* = 2)			**0.46**

† = (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 [3] and [4]). 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 [4]

Note 4: Based on alpha-particle-emitting impurity measurements performed in 1995 on the stock solution used to make this SRM. The estimated limit of detection for alpha-emitting-impurities was:

$0.03\ s^{-1} \bullet g^{-1}$ for energies between 3 and 12 MeV.

Note 5. The estimated lower limits of detection for photon-emitting impurities, expressed as massic photon emission rates, on 31 January 2007, were:

$3\ s^{-1} \bullet g^{-1}$ for 20 keV < E < 2350 keV
$2\ s^{-1} \bullet g^{-1}$ for 2351 keV < E < 3600 keV

Note 6. The stated uncertainty is the standard uncertainty. See reference [4].

REFERENCES

[1] *Table of Radionuclides, Vol. 1 – A=1 to 150*, M.M. Bé, et al., Bureau International des Poids et Measures, Pavillon de Breteuil F-92312 Sèvres Cedex FRANCE (2004). http://www1.bipm.org/utils/common/pdf/monographieRI/Monographie_BIPM-5_Tables_Vol1.pdf

[2] E. Garcia-Toraño, Centro de Investigaciones Energéticas, Medioambientales y Tecnologicas (CIEMAT), private communication on EFFY4, 1994; E. Garcia-Toraño and A. Grau Malonda, EFFY, A New Program to Compute the Counting Efficiency of Beta Particles in Liquid Scintillators, *Computer Phys. Comm.* **36** (1985) 307.

[3] 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.

[4] 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.

Certificate Revision History: March 2008 (Editorial changes); February 2007 (Original certification date).