



National Institute of Standards & Technology

Certificate

Standard Reference Material[®] 4919I

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:

$$(4.261 \pm 0.020) \text{ kBq} \cdot \text{g}^{-1}$$

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 Guides (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.

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

Table 1. Properties of SRM 4919I

Certified values	
Radionuclide	Strontium-90
Reference time	1200 EST, 25 December 2006
Massic activity of the solution	4.261 kBq•g ⁻¹
Relative expanded uncertainty (<i>k</i> = 2)	0.48 % (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 23 µg Y ⁺³ and 20 µg Sr ⁺² per gram of solution
Solution density	(1.017 ± 0.002) g•mL ⁻¹ at 23 °C (see Note 3)
Solution mass	(5.0790 ± 0.0003) g (see Note 3)
Alpha-particle-emitting impurities	²³⁸ Pu and/or ²⁴¹ Am: < 0.02 Bq•g ⁻¹ (See Note 4)
Photon-emitting impurities	None detected (see Note 5)
Half-lives 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 ± 1.7) 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

Table 2. Uncertainty evaluation for the massic activity for SRM 4919I

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 $\nu = 293$ 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 dilution of ⁹⁰ Sr and for ³ H standard dilution and preparation of LS sources	B	0.1
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 uncertainty	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	0.001
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			0.24
Relative expanded uncertainty ($k = 2$)			0.48

[†] = (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 [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:
 $0.005 \text{ s}^{-1} \cdot \text{g}^{-1}$ 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:

$$\begin{aligned} 0.4 \text{ s}^{-1} \text{ g}^{-1} & \text{ for } 30 \text{ keV} < E < 2350 \text{ keV} \\ 0.3 \text{ s}^{-1} \text{ g}^{-1} & \text{ for } 2351 \text{ keV} < E < 3600 \text{ keV} \end{aligned}$$

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 Mesures, Pavillon de Breteuil F-92312 Sèvres Cedex FRANCE (2004).
http://www1.bipm.org/utis/common/pdf/monographieRI/Monographie_BIPM-5_Tables_Vol1.pdf
- [2] E. Garcia-Toraño, Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (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.* Vol. 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.

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