National Institute of Standards and Technology
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Standard Reference Material® 4239a
Strontium-90 Radioactivity Standard
CERTIFICATE

Purpose: The certified values delivered by this Standard Reference Material (SRM) are intended primarily for the calibration of instruments that are used to measure radioactivity and for the monitoring of radiochemical procedures.

Description: A unit of SRM 4239a consists of approximately 5 mL of a solution of a standardized and certified quantity of radioactive Strontium-90 in a suitably stable and homogeneous matrix, contained in a flame sealed borosilicate-glass ampoule [1].

Certified Values: A NIST certified value 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" [2]. Uncertainties for the certified quantities are expanded ($k = 2$). The uncertainties are calculated according to the ISO/JCGM and NIST Guides [3,4]. The certified value is traceable to the derived International System of Units (SI) unit, becquerel (Bq).

Table 1. Certified Massic Activity of SRM 4239a

Radionuclide	**Strontium-90**
Reference time	**1200 EST, 25 December 2019**
Massic activity of the solution	**(29.492 ± 0.088) kBq•g^{-1} [(a)]**
Relative expanded uncertainty ($k = 2$)	**0.30 %[(b)]**

(a) This solution is gravimetrically linked to a ^{90}Sr stock solution (SRM 4234a) used to prepare the previous NIST ^{90}Sr standard SRM 4239. A remeasurement of SRM 4239 at the time of this work in 2020 agreed with the 2008 certified value to within 0.2 %. This determination agrees to the decay corrected SRM 4234a certified value to within 0.002 %.

(b) 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 [3,4]. The combined standard uncertainty is multiplied by a coverage factor of $k = 2$ and was chosen to obtain an approximate 95 % level of confidence.

Non-Certified Values: Non-certified values and additional information are provided in Appendix A.

Period of Validity: The certified values delivered by **SRM 4239a** are 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 certified values are nullified if the material is stored or used improperly, damaged, contaminated, or otherwise modified. Periodic recertification of this SRM is not required.

Maintenance of Certified Values: NIST will monitor this SRM over the period of its validity. If substantive technical changes occur that affect the certification, NIST will issue an amended certificate through the NIST SRM website (https://www.nist.gov/srm) and notify registered users. SRM users can register online from a link available on the NIST SRM website or fill out the user registration form that is supplied with the SRM. Registration will facilitate notification. Before making use of any of the values delivered by this material, users should verify they have the most recent version of this documentation, available through the NIST SRM website (https://www.nist.gov/srm).

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Table 2. Uncertainty Evaluation for the Massic Activity of SRM 4239a

	Uncertainty component	Assessment Type[(a)]	Relative standard uncertainty contribution on massic activity of ^{90}Sr (%)
1	Liquid scintillation (LS) measurement precision, standard deviation of the mean for eight sets of measurements, considering all the within- and between-source components of variance. This estimator was based on three replicate measurements on each of six sources prepared with one of two different LS cocktail compositions and measured in two different LS counters on two separate measurement occasions. The typical standard deviation for the 18 measurements (3 replicates for 6 sources) within a data set was 0.10 %. The results for all 144 results (18 values in 8 sets) fit a Normal distribution.	A	0.042
2	LS cocktail composition dependencies for an internal relative standard deviation of 0.014 % for two compositions (absolute difference of 0.02 %); wholly embodied in component 1.	A	--
3	LS counter dependencies for an internal relative standard deviation of 0.008 % (absolute difference of 0.04 %); wholly embodied in component 1.	A	--
4	^{90}Sr/^{90}Y disequilibrium in LS cocktails	B	0.02
5	Gravimetric (mass) measurements for preparation of LS sources; partially embodied in 1.	B	0.06
6	Live-time determination for LS counting time intervals, includes uncorrected dead times effects	B	0.07
7	Decay correction for ^{90}Sr (for half-life uncertainty of 0.24 %)	B	0.0002
8	^{90}Sr/^{90}Y equilibrium ratio for half-life uncertainties	B	0.00006
9	Decay correction for ^{3}H (for half-life uncertainty of 0.20 %)	B	0.0004
10	Massic activity of ^{3}H standard solution used as efficiency detection monitor	B	0.035
11	Nuclear data for ^{90}Sr and ^{90}Y used for efficiency tracing calculation	B	<0.01
12	Computed β detection efficiencies for ^{90}Sr and ^{90}Y (model dependence)	B	<0.1
Relative combined standard uncertainty			**0.15**
Relative expanded uncertainty (k = 2)			**0.30**

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

Safety: Consult the Safety Data Sheet (SDS), enclosed with the SRM shipment, for radiological and chemical hazard information.

Storage and Handling: SRM 4239a 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. If the ampoule is transported, it should be packed, marked, labeled, and shipped in accordance with the applicable national, international, and carrier regulations. This is **not** a pre-scored ampoule; **the gold color band is only for identification**. The solution in the ampoule is a dangerous good (hazardous material) because of both the radioactivity and the strong acid. The ampoule should be opened only by persons qualified to handle both radioactive material and alkaline and/or acidic solutions. Appropriate shielding and/or distance should be used to minimize personnel exposure. Refer to the SDS for further information.

REFERENCES

[1] NIST Physical Measurement Laboratory; *Storage and Handling of Radioactive Standard Reference Materials, Ampoule Specifications and Opening Procedure*; available at https://www.nist.gov/pml/radiation-physics/ampoule-specifications-and-opening-procedure (accessed Oct 2022). **Note:** This SRM is contained in a generic borosilicate-glass ampoule (identified as NIST-3) and not in the standard NIST ampoule (identified as NIST-1). Refer to R.Collé, Ampoules for Radioactivity Standard Reference Materials, NIST IR 8524 (2019) available at http://www.nist.gov/publications/ampoules-radioactivity-standard-reference-materials (accessed Oct 2022). This is **not** a pre-scored ampoule; **the gold color band is only for identification**.

[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 (JCGM) (2012); available at https://www.bipm.org/fr/committees/jc/jcgm/publications (accessed Oct 2022).

[3] JCGM 100:2008; *Evaluation of Measurement Data — Guide to the Expression of Uncertainty in Measurement* (GUM 1995 with Minor Corrections); Joint Committee for Guides in Metrology (2008); available at https://www.bipm.org/en/publications/guides (accessed Oct 2022).

[4] 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 https://www.nist.gov/pml/nist-technical-note-1297 (accessed Oct 2022).

[5] Chisté, V.; *LNE-LNHB/CEA Table of Radionuclides*, ^{90}Sr; (August 2005); available at http://www.lnhb.fr/nuclides/Sr-90_tables.pdf (accessed Oct 2022).

[6] Chisté, V.; Bé, M.M.; *LNE-LNHB/CEA Table of Radionuclides*, ^{90}Y; (May 2005); available at http://www.lnhb.fr/nuclides/Y-90_tables.pdf (accessed Oct 2022).

[7] Chechev, V.P.; *LNE-LNHB/CEA Table of Radionuclides*, ^{3}H; (June 2006); available at http://www.lnhb.fr/nuclides/H-3_tables.pdf (accessed Oct 2022).

Certain commercial equipment, instruments, or materials may be identified in this Certificate to adequately specify the experimental procedure. Such identification does not imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.

Users of this SRM should ensure that the Certificate in their possession is current. This can be accomplished by contacting the Office of Reference Materials 100 Bureau Drive, Stop 2300, Gaithersburg, MD 20899-2300; telephone (301) 975-2200; e-mail srminfo@nist.gov; or the Internet at https://www.nist.gov/srm.

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APPENDIX A

This SRM was prepared by the NIST Physical Measurement Laboratory, Radiation Physics Division, under the direction of B.E. Zimmerman, Group Leader of the Radioactivity Group. Overall technical direction and physical measurement leading to certification were provided by R. Collé and L. Laureano-Pérez of the NIST Radiation Physics Division, Radioactivity Group. Photon-emitting-impurity analyses were provided by L. Pibida 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.

Non-Certified Values: Non-certified values are suitable for use in method development, method harmonization, and process control but do not provide metrological traceability to the SI or other higher-order reference system. Non-certified values are provided in Table A1.

Table A1. Non-Certified Values for SRM 4239a[(a)]

Source description	Liquid in a flame-sealed 5 mL borosilicate-glass ampoule [1]
Solution composition	Nominal 25 $\mu g \cdot g^{-1}$ Sr^{+2} and 34 $\mu g \cdot g^{-1}$ Y^{+3} in 1.02 $mol \cdot L^{-1}$ HCl
Solution density	(1.018 ± 0.002) $g \cdot mL^{-1}$ at 21 °C[(b)]
Solution mass	(5.084 ± 0.003) g[(b)]
Photon-emitting impurities	None detected[(c)]
Alpha-particle-emitting impurities	^{238}Pu and/or ^{241}Am: <0.12 $Bq \cdot g^{-1}$[(d)]
Half-lives used[(e)]	^{90}Sr: (28.80 ± 0.07) a ^{90}Y: (2.6684 ± 0.0013) d ^{3}H: (12.312 ± 0.025) a
Calibration methods (and instruments)	The certified massic activity for ^{90}Sr in radioactive equilibrium with ^{90}Y was obtained by 4πβ liquid scintillation (LS) spectrometry with two commercial LS counters. The LS detection efficiency was calculated using the MICELLE2 code for the CIEMAT/NIST method with composition matched LS cocktails of a ^{3}H standard as the efficiency detection monitor and two different LS cocktail compositions.

[(a)] References on Page 3.

[(b)] The stated uncertainty is two times the standard uncertainty [4].

[(c)] The estimated limits of detection for photon-emitting impurities, expressed as massic photon emission rates (numbers of photons per second per gram), based on impurity measurement performed on 31 January 2007 on previous SRM are:

$4\ s^{-1} \cdot g^{-1}$ for energies between 40 keV and 507 keV, and

$2\ s^{-1} \cdot g^{-1}$ for energies between 515 keV and 1900 keV,

provided that the photons are separated in energy by 4 keV or more.

[(d)] 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:

$0.04\ s^{-1} \cdot g^{-1}$ for energies between 3 and 12 MeV.

[(e)] The stated uncertainty is the standard uncertainty. See reference 5-7.

Maintenance of Non-Certified Values: NIST will monitor this material to the end of its period of validity. If substantive technical changes occur that affect the non-certified values during this period, NIST will update this Certificate and notify registered users. SRM users can register online from a link available on the NIST SRM website or fill out the user registration form that is supplied with the SRM. Registration will facilitate notification. Before making use of any of the values delivered by this material, users should verify they have the most recent version of this documentation, available through the NIST SRM website (https://www.nist.gov/srm).

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