National Institute of Standards & Technology

Certificate

Standard Reference Material® 4427L

Yttrium-90 Radioactivity Standard

Lot Number 20

Ampoule 1

This Standard Reference Material (SRM) consists of a solution of a standardized and certified quantity of radioactive yttrium-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. A unit of SRM 4427L 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 **yttrium-90** massic activity value, at a **Reference Time of 1200 EST, 9 December 2016**, is:

(2.615 ± 0.025) MBq•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, the 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. Uncertainties for the certified quantities are expanded ($k = 2$). The uncertainties are calculated according to the ISO and NIST Guides [4,5]. Table 3 contains a specification of the components that comprise the uncertainty analyses.

Expiration of Certification: The certification of **SRM 4427L** is valid, within the measurement uncertainty specified, 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"). 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.

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 Physical Measurement Laboratory, Radiation Physics Division, Radioactivity Group, M.P. Unterweger, Group Leader. The overall production, technical direction and physical measurement leading to certification were provided by W. Regits and K. Neal, Guest Researchers from NRMAP, Incorporated.

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

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Table 1. Certified Massic Activity of SRM 4427L, Lot 20, Ampoule 1

Radionuclide	**Yttrium-90**
Reference time	**1200 EST 9 December 2016**
Massic activity of the solution	**2.615 MBq•g^{-1}**
Relative expanded uncertainty (*k* = 2)	**0.94 %**[(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 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 4427L, Lot 20, Ampoule 1

Source description	Liquid in a flame-sealed 5-mL NIST borosilicate ampoule [1]
Solution composition	1.0 mol•L^{-1} HCl with 419 µg YCl_3 per gram of solution
Solution density	(1.015 ± 0.002) g•mL^{-1} at 20.0 °C[(a)]
Solution mass	(5.0765 ± 0.0003) g[(a)]
Photon-emitting impurities	None detected[(b)]
Beta-particle emitting impurities	None detected[(c)]
Nuclear data used in EFFY4 computations (beta-particle maximum energies; branching ratios; transitions) [6]	^{3}H: (18.594 ± 0.008) keV[(d)]; 1, allowed ^{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
Half-lives used	^{3}H: (12.312 ± 0.025) a[(d)] ^{90}Y: (2.6684 ± 0.0013) d
Calibration method (and instruments)	The certified massic activity for ^{90}Y was obtained by 4πβ liquid scintillation (LS) spectrometry with two commercial LS counters. The LS detection efficiency was calculated using the MICLLE2 code [7,8] for the CIEMAT/NIST method with composition matched LS cocktails of a ^{3}H standard as the efficiency detection monitor.

[(a)]The stated uncertainty is two times the standard uncertainty.
[(b)]The estimated lower limits of detection for photon-emitting impurities, expressed as massic photon emission rates, as of 8 December 2016 were:

1.7×10^{3} s^{-1}•g^{-1} for energies between 30 keV and 40 keV,
2.8×10^{2} s^{-1}•g^{-1} for energies between 45 keV and 85 keV,
1.5×10^{2} s^{-1}•g^{-1} for energies between 90 keV and 150 keV,
1.0×10^{2} s^{-1}•g^{-1} for energies between 155 keV and 290 keV,
6.6×10^{1} s^{-1}•g^{-1} for energies between 295 keV and 870 keV, and
3.6×10^{1} s^{-1}•g^{-1} for energies between 880 keV and 2000 keV.

[(c)]Liquid-scintillator measurements for β-impurities were performed on the low-level solution approximately 146 days after the reference date. The estimated lower limit for detection of ^{90}Sr, as of the reference time, is less than 10 Bq•g^{-1}.

[(d)]The stated uncertainty is the standard uncertainty. See reference 6.

Table 3. Uncertainty Evaluation for the Massic Activity of SRM 4427L, Lot 20

	Uncertainty component	Assessment Type[a]	Relative standard uncertainty contribution on massic activity of yttrium-90 (%)
1	Liquid-scintillation (LS) measurement precision; standard deviation for 4 sets of measurements (each with a typical standard deviation of the mean of 0.12 %) for n = 6 sources, using two scintillators and measured in two LS counters (considering both within- and between-source and between-counter components of variance)	A	0.44
2	Gravimetric measurements for LS sources and for ^{3}H standard sources	B	0.07
3	Gravimetric measurements for dilutions of SRM 4427L to make LS	B	0.05
4	Live time determinations for LS counting time intervals, includes uncorrected dead time effects	B	0.06
5	Decay corrections for ^{90}Y (for half-life uncertainty of 0.05 %)	B	0.02
6	Decay corrections for ^{3}H (for half-life uncertainty of 0.20 %)	B	0.00004
7	Limit for photon-emitting impurities	B	0.10
8	$E_{\beta(max)}$ for ^{90}Y for an uncertainty of 1.7 keV	B	0.001
9	Beta decay branching ratios for ^{90}Y for an uncertainty of 0.006 per decay	B	0.0001
10	Computed β detection efficiency for ^{90}Y (model dependencies)	B	0.05
Relative combined standard uncertainty			**0.47**
Relative expanded uncertainty (*k* = 2)			**0.94**

[a]Type A denotes evaluation by statistical methods; Type 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 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.

Storage: SRM 4427L 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.

[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, Sèvres Cedex, France; p. 19 (2012); available at http://www.bipm.org/utils/common/documents/jcgm/JCGM_200_2012.pdf.

[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, Sèvres Cedex, France; p. 18 (2012); available at http://www.bipm.org/utils/common/documents/jcgm/JCGM_200_2012.pdf.

[4] JCGM 100:2008; *Guide to the Expression of Uncertainty in Measurement*; (ISO GUM 1995 with Minor Corrections), Joint Committee for Guides in Metrology: BIPM, Sèvres Cedex, France (2008); available at http://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf.

[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 www.nist.gov/pml/nist-technical-note-1297.

[6] Laboratoire National Henri Becquerel; *Table of Radionuclides, Recommended Data* (^{3}H updated 4 September 2006 and ^{90}Y updated 4 January 2007); available at http://www.nucleide.org/DDEP_WG/DDEPdata.htm (accessed October 2016).

[7] K. Kossert, A. Grau Carles, *Study of a Monte Carlo rearrangement model for the activity determination of electron-capture nuclides by means of liquid scintillation counting.* Appl. Radiat. Isotop. 66 (2008) 998-1005.

[8] K. Kossert, A. Grau Carles, *Improved method for the calculation of the counting efficiency of electron-capture nuclides in liquid scintillation samples*. Appl. Radiat. Isotop. 68 (2010) 1482-1488.

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.