



National Institute of Standards & Technology

Certificate

Standard Reference Material[®] 4427L

Yttrium-90 Radioactivity Standard

Lot Number 17

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 Table 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, 1 November 2013**, is:
 (4.555 ± 0.026) 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, becquerel (Bq).

Additional physical, chemical, and radiological properties for this SRM, as well as details on the standardization method, are given in Table 1 and 2. Uncertainties for the certified quantities are expanded ($k = 2$). The uncertainties are calculated according to the ISO and NIST Guide [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 R.K. Young and D.B. Golas, 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 17, Ampoule 1

Radionuclide	Yttrium-90
Reference time	1200 EST 1 November 2013
Massic activity of the solution	4.555 MBq·g⁻¹
Relative expanded uncertainty (<i>k</i> = 2)	0.58 %^(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 17, Ampoule 1

Source description	Liquid in a flame-sealed 5-mL NIST borosilicate ampoule [1]
Solution composition	1.0 mol·L ⁻¹ HCl with 360 µg YCl ₃ per gram of solution
Solution density	(1.016 ± 0.002) g·mL ⁻¹ at 20.0 °C ^(a)
Solution mass	(5.0777 ± 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 three commercial LS counters. The LS detection efficiency was calculated using the EFFY4 code [7] 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 30 October 2013 were:

- 9.0 × 10² s⁻¹·g⁻¹ for energies between 25 keV and 230 keV,
- 1.5 × 10³ s⁻¹·g⁻¹ for energies between 235 keV and 360 keV,
- 2.5 × 10³ s⁻¹·g⁻¹ for energies between 370 keV and 500 keV,
- 3.7 × 10³ s⁻¹·g⁻¹ for energies between 510 keV and 710 keV,
- 5.9 × 10³ s⁻¹·g⁻¹ for energies between 720 keV and 1730 keV,
- 3.7 × 10³ s⁻¹·g⁻¹ for energies between 1740 keV and 1840 keV,
- 2.4 × 10³ s⁻¹·g⁻¹ for energies between 1850 keV and 1910 keV, and
- 9.5 × 10² s⁻¹·g⁻¹ for energies between 1920 keV and 2000 keV.

^(c)Liquid-scintillator measurements were performed on the low-level solution approximately 66 days after the reference date. The estimated lower limit for detection of ⁹⁰Sr, as of the reference time, is 0.1 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 17

	Uncertainty component	Assessment Type ^(a)	Relative standard uncertainty contribution on massic activity of yttrium-90 (%)
1	Liquid-scintillation (LS) measurement precision; standard deviation for seven sets of data measured on five different occasions. Each set is comprised of results from 10 measurements on a set of five LS cocktails prepared from either one of two dilutions or directly from the low-level solution, and one of two scintillators, as measured on one of three LS counters.	A	0.06
2	Typical standard deviation of the mean on the average of the results obtained from the measurements on a set of five LS vials	A	0.03
3	Gravimetric (mass) measurements for LS sources and for ³ H standard dilution	B	0.05
4	Dilutions of SRM 4427L to make LS counting solutions	B	0.05
5	Live time determinations for LS counting time intervals, includes uncorrected dead time effects	B	0.06
6	Decay corrections for ⁹⁰ Y (for half life uncertainty of 0.05 %)	B	0.24
7	Decay corrections for ³ H (for half life uncertainty of 0.16 %)	B	0.0004
8	Limit for photon-emitting impurities	B	0.1
9	E _{β(max)} for ⁹⁰ Y for an uncertainty of 1.7 keV	B	0.001
10	Beta decay branching ratios for ⁹⁰ Y for an uncertainty of 0.006 per decay	B	0.0001
11	Computed β detection efficiency for ⁹⁰ Y (model dependencies)	B	0.05
Relative combined standard uncertainty			0.29
Relative expanded uncertainty (k = 2)			0.58

^(a)Letter A denotes evaluation by statistical methods; 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/utis/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/utis/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/utis/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 <http://physics.nist.gov/Pubs/>.
- [6] Laboratoire National Henri Becquerel; *Table of Radionuclides, Recommended Data* (³H updated 4 September 2006 and ⁹⁰Y updated 4 January 2007); available at http://www.nucleide.org/DDEP_WG/DDEPdata.htm (accessed October 2013).
- [7] E. García-Toraño, Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT), private communication on EFFY4, 1994; E. García-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.

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>.