National Institute of Standards & Technology

Certificate

Standard Reference Material® 4288B

Technetium-99 Radioactivity Standard

This Standard Reference Material (SRM) consists of a solution of a standardized and certified quantity of radioactive technetium-99 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 consists of a solution, whose composition is specified in Table 1, contained in a flame-sealed 5 mL borosilicate-glass ampoule (see Note 1)*.

The certified **Technetium-99** massic activity value, at a **Reference Time of 1200 EST, 1 May 2008**, is:

$$\mathbf{(31.55 \pm 0.21)\ kBq \bullet g^{-1}}$$

Additional physical, chemical, and radiological properties for this SRM, as well as details on the standardization method, are given in Table 1. Uncertainties for the certified quantities are expanded ($k = 2$). The uncertainties are calculated according to the ISO and NIST Guide (see Note 2). Table 2 contains a specification of the components that comprise the uncertainty analyses.

Expiration of Certification: The certification of **SRM 4288B** is valid indefinitely provided the SRM is handled and stored properly and no evaporation or change in composition has occurred. The solution matrix, in an unopened ampoule, is indefinitely homogeneous and stable within its half-life-dependent useful lifetime provided the SRM is handled in accordance with instructions given in this certificate (see "Instructions for Use"). 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 before the expiration of this certificate, NIST will notify the purchaser. Registration (see attached sheet) will facilitate notification. 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, M.P. Unterweger, Group Leader. The overall technical direction and physical measurement leading to certification were provided by R. Collé and L. Laureano-Pérez of the NIST Radioactivity Group; with production assistance by D.B. Golas, Research Associate of the Nuclear Energy Institute; with calibration assistance by L. Cumberland; with confirmatory measurement assistance by B.E. Zimmerman and R. Fitzgerald; and with impurity analyses by M. Hammond.

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

INSTRUCTIONS FOR USE

Storage: SRM 4288B 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.

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 base or 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 MSDS for further information.

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Certificate Issue Date: April 2010

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* Notes and references may be found on page 4.

Table 1. Properties of SRM 4288B

Certified values

Radionuclide	**Technetium-99**
Reference time	**1200 EST, 1 May 2008**
Massic activity of the solution	**31.55 kBq•g^{-1}**
Relative expanded uncertainty (*k* = 2)	**0.66 %** (see Note 2)*****

Uncertified information

Source description	Liquid in a flame-sealed 5 mL borosilicate-glass ampoule (see Note 1)
Solution composition	Approximately 0.001 mol•L^{-1} KOH
Solution density	(0.997 ± 0.002) g•mL^{-1} at 22.5 °C (see Note 3)
Solution mass	(4.9945 ± 0.0003) g (see Note 3)
Photon-emitting impurities	None detected (see Note 4)
Half-lifes used	^{99}Tc : (2.111 ± 0.012) × 10^{5} a (see Note 5) [1]
Calibration methods (and instruments)	The certified massic activity for ^{99}Tc was obtained by 4πβ liquid scintillation (LS) spectrometry with three commercial LS counters. The LS detection efficiency was calculated using the TRACER 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 performed by: (i) 4πβ(LS) - γ(NaI) live-timed anti-coincidence (LTAC) counting; and (ii) an LS-based 4πβ triple-to-double coincidence ratio (TDCR) method. (see Note 6)

* Notes and references may be found on page 4.

Table 2. Uncertainty evaluation for the massic activity of SRM 4288B

Uncertainty component		Assessment Type †	Relative standard uncertainty contribution on massic activity of ^{99}Tc (%)
1	LS measurement repeatability; reproducibility in massic activity for 2 different cocktail compositions, with 6 samples in each, measured in 3 counters on 1 or 2 measurement occasions; standard deviation of the mean for n = 8 data sets, normally distributed. The LS within-measurement precision for a given data set, in terms of the standard deviation of the mean for 6 samples measured for 3 to 5 cycles on three measurement occasions, ranged from 0.09 % to 0.12 %	A	0.06
2	Background; wholly embodied in 1	A	---
3	LS counters dependencies wholly embodied in components 1 & 2	A	---
4	Gravimetric (mass) measurements for preparation of sources	B	0.1
5	Live time determinations for LS counting time intervals, includes uncorrected dead time effects	B	0.06
6	^{3}H decay corrections for half life uncertainty of 0.16 % [1]*	B	0.002
7	^{99}Tc decay corrections for half-life uncertainty of 0.57 % [1]	B	3×10^{-7}
8	Limit for photon-emitting impurities	B	0.004
9	Computed β detection efficiencies (model dependencies and computed β spectra)	B	0.3
Relative combined standard uncertainty			**0.33**
Relative expanded uncertainty (*k* = 2)			**0.66**

† = (A) denotes evaluation by statistical methods; (B) denotes evaluation by other methods.

* Notes and references may be found on page 4.

NOTES

Note 1. Refer to http://physics.nist.gov/Divisions/Div846/srm.html for assistance and instructions on how to properly open an ampoule. Information on additional storage and handling requirements is also included on the website. This SRM is contained in a generic borosilicate-glass ampoule and not in the standard NIST ampoule.

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 [3-4]. 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. The estimated lower limit of detection for photon-emitting impurities, expressed as massic photon emission rate, on 1 March 2008 is:

$1.2\ s^{-1}{\bullet}g^{-1}$ for energies between 30 keV and 3600 keV,

provided that the photons are separated in energy by 4 keV or more from photons emitted in the decay of technetium-99.

Note 5. The stated uncertainty is the standard uncertainty. See reference [4].

Note 6. The certified value was in agreement with the confirmatory determinations to within -0.22 % and +0.06 %, respectively, for the LTAC and TDCR methods. The relative $k = 2$ expanded uncertainties on the two confirmatory determinations are approximately 0.7 % and 0.3 %, respectively.

REFERENCES

[1] L.K. Peker, *Nuclear Data Sheets* 73, 1 (1994), Evaluated Nuclear Structure Data File (ENSDF), online database, National Nuclear Center, Brookhaven National Laboratory (Upton, NY), accessed April 2008. Refer to http://www.nndc.bnl.gov/ensdf/.

[2] P. Cassette (Laboratoire National Henri Becquerel, Gif-sur-Yvette, France), private communication on TRACER code (Jan. 2006).

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

[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 at http://physics.nist.gov/Pubs/guidelines/contents.html.

Users of this SRM should ensure that the certificate in their possession is current. This can be accomplished by contacting the SRM Program at: telephone (301) 975-2200; fax (301) 926-4751; e-mail srminfo@nist.gov; or via the Internet at http://www.nist.gov/srm.