National Institute of Standards & Technology

# Certificate

## Standard Reference Material® 4332E

### Americium-243 Radioactivity Standard

This Standard Reference Material (SRM) consists of a solution of a standardized and certified quantity of radioactive americium-243 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 **Americium-243** massic activity value, at a **Reference Time of 1200 EST, 1 October 2008**, is:

**(38.49 ± 0.35) Bq•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 4332E** 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, and impurity analyses by L. Pibida.

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

**INSTRUCTIONS FOR USE**

**Storage:** SRM 4332E 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 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: 22 February 2010

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* Notes and references may be found on page 4.

Table 1. Properties of SRM 4332E

**Certified values**

| | |
|---|---|
| **Radionuclide** | **Americium-243** |
| **Reference time** | **1200 EST, 1 October 2008** |
| **Massic activity of the solution** | **38.49 Bq•g$^{-1}$** |
| **Relative expanded uncertainty ($k$ = 2)** | **0.90 %** (see Note 2)* |

Uncertified information

| | |
|---|---|
| Source description | Liquid in a flame-sealed 5 mL borosilicate-glass ampoule (see Note 1) |
| Solution composition | 1.1 mol•L$^{-1}$ $HNO_3$ |
| Solution density | (1.035 ± 0.002) g•mL$^{-1}$ at 22.4 °C (see Note 3) |
| Solution mass | (5.1713 ± 0.0003) g (see Note 3) |
| Photon-emitting impurities | None detected (see Note 4) |
| Half-lifes used | $^{243}$Am : (7370 ± 17) a (see Note 5) [1]<br>$^{239}$Np : (2.356 ± 0.003) d [1]<br>$^{3}$H : (12.32 ± 0.02) a [1] |
| Nuclear data used in CN2003 computations (beta-particle maximum energies; branching ratios; transitions) [1] | $^{3}$H : (18.594 ± 0.008) keV$^{\dagger}$; 1, allowed<br>$^{239}$Np : (210.7 ± 0.5) keV$^{\dagger}$; (0.0156 ± 0.03)$^{\dagger}$; allowed<br>(330.9 ± 0.5) keV$^{\dagger}$; (0.3893 ± 0.03)$^{\dagger}$; non-unique first forbidden<br>(392.4 ± 0.5) keV$^{\dagger}$; (0.0943 ± 0.03)$^{\dagger}$; allowed<br>(437.0 ± 0.5) keV$^{\dagger}$; (0.4315 ± 0.03)$^{\dagger}$; allowed<br>(646.8 ± 0.5) keV$^{\dagger}$; (0.0001 ± 0.03)$^{\dagger}$; allowed<br>(665.2 ± 0.5) keV$^{\dagger}$; (0.004 ± 0.03)$^{\dagger}$; allowed<br>(714.6 ± 0.5) keV$^{\dagger}$; (0.0652 ± 0.03)$^{\dagger}$; allowed |
| Calibration methods (and instruments) | The certified massic activity for $^{243}$Am was obtained by 4παβ liquid scintillation (LS) spectrometry with three commercial LS counters. The LS β detection efficiency was calculated using the CN2003 code [2] for the CIEMAT/NIST method with composition matched LS cocktails of a $^{3}$H standard as the efficiency detection monitor. (see Note 6) |

$^{\dagger}$ See Note 5

* Notes and references may be found on page 4.

Table 2. Uncertainty evaluation for the massic activity of SRM 4332E

| | Uncertainty component | Assessment Type † | Relative standard uncertainty contribution on massic activity of $^{243}$Am (%) |
|---|---|---|---|
| 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 0.11 % to 0.21 % | A | 0.32 |
| 2 | Background; wholly embodied in component 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 % | B | 0.0001 |
| 7 | $^{243}$Am decay corrections for half-life uncertainty of 0.23 % [1]* | B | $3 \times 10^{-7}$ |
| 8 | Computed β detection efficiencies (model dependencies and computed β spectra) | B | 0.3 |
| **Relative combined standard uncertainty** | | | **0.45** |
| **Relative expanded uncertainty ($k$ = 2)** | | | **0.90** |

† = (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 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 October 2008 is:

$0.02\ s^{-1} \cdot g^{-1}$ for energies between 30 keV and 50 keV,
$0.03\ s^{-1} \cdot g^{-1}$ for energies between 60 keV and 130 keV,
$0.09\ s^{-1} \cdot g^{-1}$ for energies between 140 keV and 210 keV,
$0.02\ s^{-1} \cdot g^{-1}$ for energies between 220 keV and 290 keV, and
$0.002\ s^{-1} \cdot g^{-1}$ for energies between 300 keV and 1800 keV

provided that the photons are separated in energy by 4 keV or more from photons emitted in the decay of $^{243}$Am or progeny.

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

Note 6. Based on comparative LS measurements, the certified value of the massic activity for SRM 4332E was in agreement with that for the previously issued SRM 4332D to within 1.0 %, with a $k = 2$ combined uncertainty on the two massic activities of 1.2 %

## REFERENCES


[1] E. Browne, *Nuclear Data Sheets* 98, 665 (2003), Evaluated Nuclear Structure Data File (ENSDF), online database, National Nuclear Center, Brookhaven National Laboratory (Upton, NY), accessed December 2008. Refer to http://www.nndc.bnl.gov/ensdf/ (last accessed January 2010).

[2] Gunther, E., Physikalisch-Technische Bundesanstalt (Braunschweig, Germany). Private communication, 2003.

[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 (last accessed January 2010).

[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 (last accessed January 2010).


*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.*