



# Certificate

## Standard Reference Material<sup>®</sup> 4370d

### Europium-152 Radioactivity Standard

This Standard Reference Material (SRM) consists of a solution of a standardized and certified quantity of radioactive Europium-152 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 4370d 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 **Europium-152** massic activity, at a **Reference Time of 1200 EST, 19 July 2018**, is:

$$(18.70 \pm 0.22) \text{ kBq}\cdot\text{g}^{-1}.$$

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 Tables 1 and 2. Uncertainties for the certified quantities are expanded ( $k = 2$ ). The uncertainties are calculated according to the ISO/JCGM and NIST Guides [4,5]. Table 3 contains a specification of the components that comprise the uncertainty analysis.

**Expiration of Certification:** The certification of **SRM 4370d** is 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 solution matrix, in an unopened ampoule, is 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 Handling and Storage”). Periodic recertification of this SRM is not required. 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 or register online) will facilitate notification.

**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 February 1987 in the Center for Radiation Research, Ionizing Radiation Division, Radioactivity Group, under the direction of D.D. Hoppes, Group Leader. Re-measurement was done in July 2018 in 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 L. Lucas, R. Collé and L. Laureano-Perez of the NIST Radiation Physics Division.

Support aspects involved in the issuance of this SRM were coordinated through the NIST Office of Reference Materials.

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Table 1. Certified Massic Activity of SRM 4370d

<b>Radionuclide</b>	<b>Europium-152</b>
<b>Reference time</b>	<b>1200 EST, 19 July 2018</b>
<b>Massic activity of the solution</b>	<b>18.70 kBq•g<sup>-1</sup> <sup>(a)</sup></b>
<b>Relative expanded uncertainty (<i>k</i> = 2)</b>	<b>1.2 % <sup>(b)</sup></b>

- (a) This solution is a recertification of SRM 4370c, which was originally standardized by 4π pressurized ionization chamber in 1987. The certified massic activity was based on a decay correction of the original certification to the new reference time. Confirmatory measurements performed in NIST chamber “A” during July 2018 agreed with decay-corrected certified value to 0.04 %.
- (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 [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 4370d

Source description	Liquid in a flame-sealed 5 mL borosilicate-glass ampoule [1]
Solution composition	277 μg•g <sup>-1</sup> Eu <sup>+3</sup> in 1 mol•L <sup>-1</sup> HCl
Solution mass	(5.0338 ± 0.0019) g <sup>(a)</sup>
Photon-emitting impurities (activity ratio at reference time)	<sup>154</sup> Eu/ <sup>152</sup> Eu : (1.2 ± 0.1) × 10 <sup>-3</sup> (b)
Half-lives used [6]	<sup>152</sup> Eu: (13.517 ± 0.009) a <sup>(c)</sup> <sup>154</sup> Eu: (8.601 ± 0.010) a
Calibration methods (and instruments)	The certified massic activity for <sup>152</sup> Eu was determined by 4πγ ionization chamber measurements in February 1987 using NIST chamber “A” and decay corrected to the 2018 reference time. Confirmatory measurements in July 2018 with NIST chamber “A” agreed with the decay-corrected certified value to 0.04 %.

- (a) The standard deviation is 0.0019 g based on mass measurements of 15 ampoules.
- (b) The limit of detection, expressed as a percentage of the gamma-ray-emission rate of the 1408-keV gamma rays emitted in the decay of Europium-152, is:  
0.1 % for energies between 90 keV and 1900 keV,  
provided that the impurity photons are separated in energy by 5 keV or more from photons emitted in the decay of <sup>152</sup>Eu and <sup>154</sup>Eu.
- (c) The stated uncertainty is the standard uncertainty. See reference 6.

Table 3. Uncertainty Evaluation for the Massic Activity of SRM 4370d

Uncertainty component		Assessment Type <sup>(a)</sup>	Relative standard uncertainty contribution on massic activity of <sup>152</sup> Eu (%)
1	1987 ionization chamber measurements on 17 sources against radium reference source RRS200	A	0.02
2	Ionization chamber calibration for RRS200	B	0.55
3	Radium reference sources ratios	B	0.05
4	Gravimetric measurements	B	0.15
5	Photon-emitting impurities	B	0.10
6	Decay correction to 2018 reference time for half-life uncertainty of 0.12 %.	B	0.19
<b>Relative combined standard uncertainty</b>			<b>0.61</b>
<b>Relative expanded uncertainty (<i>k</i> = 2)</b>			<b>1.2</b>

<sup>(a)</sup> Letter A denotes evaluation by statistical methods; Letter B denotes evaluation by other methods.

## INSTRUCTIONS FOR USE AND HANDLING

**Storage:** SRM 4370d 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 Safety Data Sheet 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 Jun 2019).
- [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): BIPM, Sevres Cedex, France; p. 19 (2012); available at [https://www.bipm.org/utils/common/documents/jcgm/JCGM\\_200\\_2012.pdf](https://www.bipm.org/utils/common/documents/jcgm/JCGM_200_2012.pdf) (accessed Jun 2019).
- [3] JCGM 200:2012; *International Vocabulary of Metrology - Basic and General Concepts and Associated Terms (VIM)*; (2008 version with Minor Corrections), 3rd edition; JCGM: BIPM, Sevres Cedex, France; p. 18 (2012); available at [https://www.bipm.org/utils/common/documents/jcgm/JCGM\\_200\\_2012.pdf](https://www.bipm.org/utils/common/documents/jcgm/JCGM_200_2012.pdf) (accessed Jun 2019).
- [4] JCGM 100:2008; *Guide to the Expression of Uncertainty in Measurement*; (GUM 1995 with Minor Corrections), JCGM: BIPM, Sevres Cedex, France (2008); available at [https://www.bipm.org/utils/common/documents/jcgm/JCGM\\_100\\_2008\\_E.pdf](https://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf) (accessed Jun 2019).
- [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 <https://www.nist.gov/pml/nist-technical-note-1297> (accessed Jun 2019).
- [6] Martin, M.J. <sup>152</sup>Eu Nuclear Data Sheets 114, 1497 (2013), Reich, C. W. <sup>154</sup>Eu Nuclear Data Sheets 110, 2257 (2009).

*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) 948-3730; e-mail srmmsds@nist.gov; or via the Internet at <https://www.nist.gov/srm>.*