National Institute of Standards & Technology

Certificate

Standard Reference Material® 4233f

Cesium-137 Radioactivity Standard

This Standard Reference Material (SRM) consists of a solution of a standardized and certified quantity of radioactive cesium-137 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 4233f 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 **Cesium-137** massic activity, at a **Reference Time of 1200 EST, 04 August 2018**, is:

(221.1 ± 1.7) kBq•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 4233f** 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 Use and Handling"). 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) 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 October 2005 in the Physics Laboratory, Ionizing Radiation Division, Radioactivity Group, under the direction of M.P. Unterweger, Group Leader. Re-measurement was done in August 2018 in the NIST Physical Measurement Laboratory, Radiation Physics Division, Radioactivity Group under the direction of B.E. Zimmerman, Group Leader.

Overall technical direction and physical measurement leading to certification were provided by L. Lucas, R. Collé and L. Laureano-Pérez of the NIST Radiation Physics Division, Radioactivity Group. Photon-emitting-impurity analyses were provided by L. Pibida also of the Radioactivity Group.

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 4233f

Radionuclide	**Cesium-137**
Reference time	**1200 EST, 04 August 2018**
Massic activity of the solution[(a)]	**221.1 kBq•g^{-1}**
Relative expanded uncertainty (k = 2)[(b)]	**0.78 %**

[(a)] This solution is a recertification of SRM 4233e, which was originally standardized by 4πγ pressurized ionization chamber (chamber "A") in 2005. Massic activity was decay-corrected to the new reference time. Confirmatory measurements performed in NIST chamber "A" during August 2018 agreed with the decay-corrected certified value –0.12 %.

[(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 4233f

Source description	Liquid in a flame-sealed 5 mL borosilicate-glass ampoule [1]
Solution composition	26 µg•g^{-1} CsCl in 1 mol•L^{-1} HCl
Solution mass	(5.0668 ± 0.0009) g[(a)]
Solution density	(1.015 ± 0.002) g•mL^{-1} at 20 °C[(a)]
Photon-emitting impurities	None detected[(b)]
Half-lifes used [6]	^{137}Cs: (30.05 ± 0.08) a[(c)] ^{226}Ra: (1600 ± 7) a
Calibration methods (and instruments)	The certified massic activity for ^{137}Cs was obtained by decay and ionization chamber positioning corrections to an original 2005 calibration using NIST pressurized 4πγ ionization chamber "A" that was calibrated using a ^{137}Cs solution whose activity was determined by a 4π (e + X) - γ coincidence efficiency extrapolation technique. Confirmatory measurements with chamber "A" in August 2018 were in agreement to –0.12 %.

[(a)] The stated uncertainty is two times the standard uncertainty [5].

[(b)] The estimated limits of detection for photon-emitting impurities, as of 03 October 2005 (3 days after the reference time for SRM 4233e), expressed as massic photon emission rates (numbers of photons per second per gram), are:

< 40 s^{-1}•g^{-1} for energies between 40 keV and 1350 keV, and

< 4 s^{-1}•g^{-1} for energies between 1350 keV and 3600 keV.

provided that the photons are separated in energy by 4 keV or more from photons emitted in the decay of ^{137}Cs.

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

Table 3. Uncertainty Evaluation for the Massic Activity of SRM 4233f

	Uncertainty component	Assessment Type[(a)]	Relative standard uncertainty contribution on massic activity of ^{137}Cs (%)
1	Ionization chamber measurement precision; relative standard deviation of the mean considering all within-trial (for 20 to 100 repeated measurements) and between-trial (for 4 separate trials) components of variance	A	0.13
2	NIST ionization chamber "A" calibration factor	B	0.32
3	Source position correction factor	B	0.13
4	Decay correction for ^{226}Ra reference source to correct calibration factor (for half-life uncertainty of 0.44 %).	B	0.004
5	^{137}Cs decay correction for half-life uncertainty of 0.30 % for decay of 12.84 a	B	0.088
6	NIST ionization chamber "A" charge collection	B	0.07
7	Gravimetric measurements	B	0.03
8	Detection limits to photon-emitting impurities	B	0.01
Relative combined standard uncertainty			**0.39**
Relative expanded uncertainty (k = 2)			**0.78**

[(a)] Letter A denotes evaluation by statistical methods; letter B denotes evaluation by other methods.

INSTRUCTIONS FOR USE AND HANDLING

Storage: SRM 4233f 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 the SDS 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 Oct 2019). Note: This SRM is contained in the standard NIST ampoule. This is **not** a pre-scored ampoule.

[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 (accessed Oct 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 (accessed Oct 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 (accessed Oct 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 Oct 2019).

[6] Chechev, V.P.; *LNE-LNHB/CEA Table of Radionuclides*, ^{137}Cs; (February 2006); available at http://www.lnhb.fr/nuclides/Cs-137_com.pdf (accessed Oct 2019).

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 srminfo@nist.gov; or via the Internet at https://www.nist.gov/srm.