



# National Institute of Standards & Technology

## Certificate

### Standard Reference Material® 4416L

#### Gallium-67 Radioactivity Standard

Lot Number 37

Ampoule 9

This Standard Reference Material (SRM) consists of a solution of a standardized and certified quantity of radioactive gallium-67 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 4416L 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 **gallium-67** massic activity value, at a **Reference Time of 1200 EST, 20 September 2016**, is:  
 **$(10.91 \pm 0.11) \text{ MBq}\cdot\text{g}^{-1}$**

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, the 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 and NIST Guides [4,5]. Table 3 contains a specification of the components that comprise the uncertainty analyses.

**Expiration of Certification:** The certification of **SRM 4416L** 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 W. Regits and K.A. Neal, Guest Researchers from NRMAP, Incorporated.

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

Lisa R. Karam, Chief  
Radiation Physics Division

Gaithersburg, Maryland 20899  
March 2017

Robert L. Watters, Jr., Chief  
Measurement Services Division

Table 1. Certified Massic Activity of SRM 4416L, Lot 37, Ampoule 9

<b>Radionuclide</b>	<b>Gallium-67</b>
<b>Reference time</b>	<b>1200 EST, 20 September 2016</b>
<b>Massic activity of the solution</b>	<b>10.91 MBq•g<sup>-1</sup></b>
<b>Relative expanded uncertainty (<math>k = 2</math>)</b>	<b>0.98 %<sup>(a)</sup></b>

<sup>(a)</sup>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 4416L, Lot 37, Ampoule 9

Source description	Liquid in a flame-sealed 5-mL NIST borosilicate ampoule [1]
Solution composition	2 mol•L <sup>-1</sup> HCl with 102 µg Ga <sup>+3</sup> per gram of solution (as GaCl <sub>3</sub> )
Solution density	(1.034 ± 0.002) g•mL <sup>-1</sup> at 20.0 °C <sup>(a)</sup>
Solution mass	(5.1653 ± 0.0003) g <sup>(a)</sup>
Photon-emitting impurities	None detected <sup>(b)</sup>
Half life used	<sup>67</sup> Ga: (3.2613 ± 0.0005) d <sup>(c)</sup>
Calibration method (and instruments)	Measurements of ionization current ratios relative to radium-226 reference sources using NIST pressurized "4π"γ ionization chamber "B" calibrated with a gallium-67 solution whose activity was determined by 4π(e+X)-γ-anti-coincidence efficiency-extrapolation technique, using liquid scintillation for the e+X detection and NaI for the γ-ray detection, with confirmatory measurements by 4πγ(NaI) integral counting

<sup>(a)</sup>The stated uncertainty is two times the standard uncertainty.

<sup>(b)</sup>The estimated lower limits of detection for photon-emitting impurities, expressed as massic photon emission rates, as of 28 September 2016 were:

$6 \times 10^2 \text{ s}^{-1}\cdot\text{g}^{-1}$  for energies between 20 keV and 75 keV,  
 $1 \times 10^3 \text{ s}^{-1}\cdot\text{g}^{-1}$  for energies between 80 keV and 105 keV,  
 $6 \times 10^2 \text{ s}^{-1}\cdot\text{g}^{-1}$  for energies between 110 keV and 165 keV,  
 $1 \times 10^3 \text{ s}^{-1}\cdot\text{g}^{-1}$  for energies between 170 keV and 200 keV,  
 $4 \times 10^2 \text{ s}^{-1}\cdot\text{g}^{-1}$  for energies between 230 keV and 280 keV,  
 $1 \times 10^3 \text{ s}^{-1}\cdot\text{g}^{-1}$  for energies between 285 keV and 310 keV,  
 $2 \times 10^2 \text{ s}^{-1}\cdot\text{g}^{-1}$  for energies between 320 keV and 370 keV,  
 $6 \times 10^2 \text{ s}^{-1}\cdot\text{g}^{-1}$  for energies between 380 keV and 400 keV,  
 $1 \times 10^2 \text{ s}^{-1}\cdot\text{g}^{-1}$  for energies between 410 keV and 900 keV,  
 $7 \times 10^1 \text{ s}^{-1}\cdot\text{g}^{-1}$  for energies between 910 keV and 1440 keV,  
 $9 \times 10^1 \text{ s}^{-1}\cdot\text{g}^{-1}$  for energies between 1450 keV and 1470 keV, and  
 $6 \times 10^1 \text{ s}^{-1}\cdot\text{g}^{-1}$  for energies between 1480 keV and 2000 keV,

provided that any impurity photons are separated by four keV or more from photons emitted in the decay of gallium-67.

<sup>(c)</sup>The stated uncertainty is the standard uncertainty. See reference 6.

Table 3. Uncertainty Evaluation for the Massic Activity of SRM 4416L, Lot 37

	Uncertainty component	Assessment Type <sup>(a)</sup>	Relative standard uncertainty contribution on massic activity of gallium-67 (%)
1	Ionization-chamber measurement precision for the low-level solution (SRM 4416L, Lot 37); standard deviation of the mean for five sets of measurements on ten ampoules	A	0.06
2	"4 $\pi$ " $\gamma$ ionization-chamber calibration factor	B	0.47
3	Effect of carrier concentration and density changes on ionization-chamber response	B	0.04
4	Decay correction for radium-226 reference source to correct the calibration factor (for half-life uncertainty of 0.44 %)	B	0.001
5	Radium reference source positioning	B	0.05
6	Radium-226 reference sources ratio	B	0.04
7	Electrometer response linearity	B	0.1
8	Gravimetric mass measurements	B	0.05
9	Decay correction for gallium-67 (for half-life uncertainty of 0.015 %)	B	0.0007
10	Detection limits for photon-emitting impurities	B	0.003
<b>Relative combined standard uncertainty</b>			<b>0.49</b>
<b>Relative expanded uncertainty (<math>k = 2</math>)</b>			<b>0.98</b>

<sup>(a)</sup>Type A denotes evaluation by statistical methods; Type 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 4416L 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/utls/common/documents/jcgm/JCGM\\_200\\_2012.pdf](http://www.bipm.org/utls/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/utls/common/documents/jcgm/JCGM\\_200\\_2012.pdf](http://www.bipm.org/utls/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/utls/common/documents/jcgm/JCGM\\_100\\_2008\\_E.pdf](http://www.bipm.org/utls/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 <https://www.nist.gov/pml/nist-technical-note-1297>.
- [6] The Evaluated Nuclear Structure Data File (ENSDF), National Nuclear Data Center, Brookhaven National Laboratory, Upton, New York, full evaluation 2005, Nuclear Data Sheets 106, 159 (2005); available at <http://www.nndc.bnl.gov/ensdf/index.jsp> (accessed September 2016).

*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](mailto:srminfo@nist.gov); or via the internet at <http://www.nist.gov/srm>.*