National Institute of Standards & Technology

Certificate

Standard Reference Material 4407LY
Iodine-125 Radioactivity Standard

This Standard Reference Material (SRM) consists of radioactive iodine-125 as sodium iodide, non-radioactive potassium iodide, sodium sulphite, and lithium hydroxide dissolved in 5 mL of distilled water. The solution is contained in a flame-sealed NIST borosilicate-glass ampoule. The SRM is intended for the calibration of ionization chambers and solid-state gamma-ray spectrometry systems.

Radiological Hazard: The SRM ampoule contains iodine-125 with a total activity of approximately 10 MBq. Iodine-125 decays by electron capture and during the decay process X-rays and gamma rays with energies from 4 keV to 36 keV are emitted. Many of these photons escape from the SRM ampoule and can represent a radiation hazard. Approximate unshielded dose rates at several distances (as of the reference time) are given in note [a]*. Appropriate shielding and/or distance should be used to minimize personnel exposure. The SRM should be used only by persons qualified to handle radioactive material.

Chemical Hazard: The SRM ampoule contains lithium hydroxide (LiOH) with a concentration of 0.005 mole per liter of water. The solution is corrosive and represents a health hazard if it comes in contact with eyes or skin. If the ampoule is to be opened to transfer the solution, the recommended procedure is given on page 2. The ampoule should be opened only by persons qualified to handle both radioactive material and alkaline solution.

Storage and Handling: The SRM should be stored and used at a temperature between 5 and 65 °C. The solution in an unopened ampoule should remain stable and homogeneous until at least October 2001. The ampoule (or any subsequent container) should always be clearly marked as containing radioactive material. 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 the radioactivity.

Preparation: This Standard Reference Material was prepared in the Physics Laboratory, Ionizing Radiation Division, Radioactivity Group, L.R. Karam, Group Leader. The overall technical direction and physical measurements leading to certification were provided by D.B. Golas and O.T. Palabrica, Nuclear Energy Institute Research Associates. The support aspects involved in the preparation, certification, and issuance of this SRM were coordinated through the Standard Reference Materials Program by J.W.L. Thomas.

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*Notes and references are on pages 5 and 6.

Recommended Procedure for Opening the SRM Ampoule

1) If the SRM solution is to be diluted, it is recommended that the diluting solution have a composition comparable to that of the SRM solution.

2) Wear eye protection, gloves, and protective clothing and work over a tray with absorbent paper in it. Work in a fume hood. In addition to the radioactive material, the solution contains strong base and is corrosive.

3) Shake the ampoule to wet all of the inside surface of the ampoule. Return the ampoule to the upright position.

4) Check that all of the liquid has drained out of the neck of the ampoule. If necessary, gently tap the neck to speed the process.

5) Holding the ampoule upright, score the narrowest part of the neck with a scribe or diamond pencil.

6) Lightly wet the scored line. This reduces the crack propagation velocity and makes for a cleaner break.

7) Hold the ampoule upright with a paper towel, a wiper, or a support jig. Position the scored line away from you. Using a paper towel or wiper to avoid contamination, snap off the top of the ampoule by pressing the narrowest part of the neck away from you while pulling the tip of the ampoule towards you.

8) Transfer the solution from the ampoule using a pycnometer or a pipet with dispenser handle. NEVER PIPETTE BY MOUTH.

9) Seal any unused SRM solution in a flame-sealed glass ampoule, if possible, to minimize the evaporation loss.

See also reference [4]*.

*Notes and references are on pages 5 and 6.

PROPERTIES OF SRM 4407LY-number ~

Certified values

Radionuclide	**Iodine-125**
Reference time	**1200 EST, 18 October 2000**
Massic activity of the solution [b]	**1.915 MBq·g^{-1}**
Relative expanded uncertainty (k=2)	**0.80%** [c] [d]
Solution mass	**(mass ~ ± 0.0003) g** [e]
Solution density	**(0.998 ± 0.002) g·mL^{-1} at 20 °C** [e]*

Uncertified values

Physical Properties:			
Source description	Liquid in flame-sealed NIST borosilicate-glass ampoule		
Ampoule specifications	Body outside diameter Wall thickness Barium content Lead-oxide content Other heavy elements	(16.5 ± 0.5) mm (0.60 ± 0.04) mm Less than 2.5% Less than 0.02% Trace quantities	
Chemical Properties:			
Solution composition	Chemical Formula	Concentration (mol·L^{-1})	Mass Fraction (g·g^{-1})
	H_2O LiOH Na_2SO_3 KI $Na^{125}I$	55 6×10^{-3} 4×10^{-4} 7×10^{-4} 2×10^{-8}	1.00 1×10^{-4} 5×10^{-5} 1×10^{-4} 3×10^{-9}
Radiological Properties:			
Photon-emitting impurities	Iodine-126: (2.6 ± 0.4) Bq·g^{-1} [b] [f]		
Half lives used	Iodine-125: (59.400 ± 0.010) d [g] [5] Iodine-126: (13.11 ± 0.05) d [g] [5]		
Calibration method and measuring instrument(s)	Sum-peak coincidence counting [6] using two NaI(Tl) crystals (one 0.8 mm thick and one 1.6 mm thick) with beryllium windows (0.13 mm-thick)		

*Notes and references are on pages 5 and 6.

EVALUATION OF THE UNCERTAINTY OF THE MASSIC ACTIVITY [c]*

Input Quantity x_i, the source of uncertainty (and individual uncertainty components where appropriate)	Method Used To Evaluate $u(x_i)$, the standard uncertainty of x_i (A) denotes evaluation by statistical methods (B) denotes evaluation by other methods	Relative Uncertainty Of Input Quantity, $u(x_i)/x_i$, (%) [h]	Relative Sensitivity Factor, $\lvert\partial y/\partial x_i\rvert \cdot (x_i/y)$ [i]	Relative Uncertainty Of Output Quantity, $u_i(y)/y$, (%) [j]
Determination of counts in singles and sum peaks	Estimated (B)	0.08	1.0	0.08
Correction for photon escape	Estimated (B)	0.08	1.0	0.08
Decay-scheme parameters	Estimated (B)	0.13	1.0	0.13
Half life of iodine-125	Standard uncertainty of the half life (A)	0.02 [k]	0.08 [m]	0.002
Gravimetric measurements	Estimated (B)	0.20	1.0	0.20
Live-time [n]	Estimated (B)	0.10	1.0	0.10
Source Positioning	Estimated (B)	0.25	1.0	0.25
Extrapolation of massic activity (corrected for background and decay) versus count rate, to zero count rate	Standard uncertainty of the y-axis intercept obtained from the least-squares fit to 30 points (A)	0.12	1.0	0.12
Solution stability	Estimated (B)	0.04	1.0	0.04
Photon-emitting impurities	Estimated (B) [p] Limit of detection (B) [q]	6.8 100.	0.0000013 0.000004	0.00001 0.0004
Relative Combined Standard Uncertainty of the Output Quantity, $u_c(y)/y$, (%)				0.40
Coverage Factor, k				x 2
Relative Expanded Uncertainty of the Output Quantity, U/y, (%)				0.80

*Notes and references are on pages 5 and 6.

NOTES

[a] The Sievert is the SI unit for dose equivalent. See reference [1]. One μSv is equal to 0.1 mrem.

Distance from Ampoule (cm):	1	30	100
Approximate Dose Rate (μSv/h):	55	<1	

[b] **Massic activity** is the preferred name for the quantity activity divided by the total mass of the sample. See reference [1].

[c] The reported value, y, of massic activity (activity per unit mass) at the reference time was not measured directly but was derived from measurements and calculations of other quantities. This can be expressed as $y = f(x_1, x_2, x_3, \ldots x_n)$, where f is a mathematical function derived from the assumed model of the measurement process.

The value, x_i, used for each input quantity i has a **standard uncertainty**, $u(x_i)$, that generates a corresponding uncertainty in y, $u_i(y) \equiv |\partial y/\partial x_i| \cdot u(x_i)$, called a **component of combined standard uncertainty** of y.

The **combined standard uncertainty** of y, $u_c(y)$, is the positive square root of the sum of the squares of the components of combined standard uncertainty.

The combined standard uncertainty is multiplied by a **coverage factor** of $k = 2$ to obtain U, the **expanded uncertainty** of y.

Since it can be assumed that the possible estimated values of the massic activity are approximately normally distributed with approximate standard deviation $u_c(y)$, the unknown value of the massic activity is believed to lie in the interval $y \pm U$ with a level of confidence of approximately 95 percent.

For further information on the expression of uncertainties, see references [2] and [3].

[d] The value of each component of combined standard uncertainty, and hence the value of the expanded uncertainty itself, is a best estimate based upon all available information, but is only approximately known. That is to say, the "uncertainty of the uncertainty" is large and not well known. This is true for uncertainties evaluated by statistical methods (e.g., the relative standard deviation of the standard deviation of the mean for the massic response is approximately 50%) and for uncertainties evaluated by other methods (which could easily be over estimated or under estimated by substantial amounts). The unknown value of the expanded uncertainty is believed to lie in the interval $U/2$ to $2U$ (i.e., within a factor of 2 of the estimated value).

[e] The stated uncertainty is two times the standard uncertainty.

[f] Estimated limits of detection for photon-emitting impurities, as of 8 November 2000 (21.5 days after the reference time), expressed as massic photon emission rates, are:
7.5×10^{0} $s^{-1} \cdot g^{-1}$ for energies between 39 keV and 55 keV,
7.5×10^{-1} $s^{-1} \cdot g^{-1}$ for energies between 55 keV and 125 keV, and
1.5×10^{-1} $s^{-1} \cdot g^{-1}$ for energies between 125 keV and 2650 keV.

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

[h] Relative standard uncertainty of the input quantity x_i.

[i] The relative change in the output quantity y divided by the relative change in the input quantity x_i. If $|\partial y/\partial x_i| \cdot (x_i/y) = 1.0$, then a 1% change in x_i results in a 1% change in y. If $|\partial y/\partial x_i| \cdot (x_i/y) = 0.05$, then a 1% change in x_i results in a 0.05% change in y.

[j] Relative component of combined standard uncertainty of output quantity y, rounded to two decimal places. The relative component of combined standard uncertainty of y is given by $u_i(y)/y \equiv |\partial y/\partial x_i| \cdot u(x_i)/y = |\partial y/\partial x_i| \cdot (x_i/y) \cdot u(x_i)/x_i$. The numerical values of $u(x_i)/x_i$, $|\partial y/\partial x_i| \cdot (x_i/y)$, and $u_i(y)/y$, all dimensionless quantities, are listed in columns 3, 4, and 5, respectively. Thus, the value in column 5 is equal to the value in column 4 multiplied by the value in column 3. The input quantities are independent, or very nearly so. Hence the covariances are zero or negligible.

[k] The relative standard uncertainty of $\lambda \cdot t$ is determined by the relative standard uncertainty of λ (i.e., of the half life). The relative standard uncertainty of t is negligible.

[m] $|\partial y/\partial x_i| \cdot (x_i/y) = |\lambda \cdot t|$

[n] The live time is determined by counting the pulses from a gated crystal-controlled oscillator.

[p] The standard uncertainty given is for the detected impurity. $|\partial y/\partial x_i| \cdot (x_i/y)$ = {(response per Bq of impurity)/(response per Bq of I-125)}•{(Bq of impurity)/(Bq of I-125)}.

[q] The standard uncertainty for each undetected impurity that might reasonably be expected to be present is estimated to be equal to the estimated limit of detection for that impurity, i.e. $u(x_i)/x_i$ = 100%. $|\partial y/\partial x_i| \cdot (x_i/y)$ = {(response per Bq of impurity)/(response per Bq of I-125)}•{(Bq of impurity)/(Bq of I-125)}. Thus $u_i(y)/y$ is the relative change in y if the impurity were present with a massic activity equal to the estimated limit of detection.

REFERENCES

[1] International Organization for Standardization (ISO), *ISO Standards Handbook - Quantities and Units*, 1993. Available from the American National Standards Institute, 11 West 42nd Street, New York, NY 10036 U.S.A. 1-212-642-4900.

[2] International Organization for Standardization (ISO), *Guide to the Expression of Uncertainty in Measurement*, 1993. Available from the American National Standards Institute, 11 West 42nd Street, New York, NY 10036 U.S.A. 1-212-642-4900. (Listed under ISO miscellaneous publications as "ISO Guide to the Expression 1993".)

[3] B. N. Taylor and C. E. Kuyatt, *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*, NIST Technical Note 1297, 1994. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20407 U.S.A.

[4] National Council on Radiation Protection and Measurements Report No. 58, *A Handbook of Radioactivity Measurements Procedures*, Second Edition, 1985. Available from the National Council on Radiation Protection and Measurements, 7910 Woodmont Avenue, Bethesda, MD 20814 U.S.A.

[5] Evaluated Nuclear Structure Data File (ENSDF), October 2000.

[6] J.S. Eldridge and P. Crowther, *Nucleonics* **22**, Number 6 (1964) 56.