National Institute of Standards & Technology

Certificate

Standard Reference Material® 4351

Human Lung Environmental Radioactivity Standard

This Standard Reference Material (SRM), which has been developed in cooperation with member laboratories of the International Committee for Radionuclide Metrology, consists of approximately 45 g of freeze-dried human lung tissue under vacuum in a 125 mL glass bottle. This SRM is intended for checking the measurement of radionuclides by members of the Transuranium Registry and other laboratories studying the movement and effects of heavy alpha-particle-emitting elements within and upon the human body. This should prove valuable to those scientists who may wish to evaluate analytical methods, or to use a "real" sample matrix in interlaboratory intercomparisons.

Certified Values: The certified properties for the human lung environmental radioactivity standard are presented in Table 1. NIST certified values, as used within the context of this certificate, are values for which NIST has the highest confidence in its uncertainty assessment. They are consensus values, obtained from a thorough statistical evaluation based on different activity measurement methods as obtained by NIST and outside collaborating laboratories. Each reporting laboratory maintains its own traceability to the derived SI unit, the becquerel (Bq).

Expiration of Certification: The certification of **SRM 4351** is valid indefinitely, within the measurement uncertainty specified, provided the SRM is handled and stored properly and that no change in composition has occurred. This matrix is considered to be stable; however, its stability has not been rigorously assessed. This SRM should be handled in accordance with instructions given in this certificate (see "Instructions for Handling and Storage"). Accordingly, periodic recertification of this SRM is not required. The certification is nullified if the SRM is damaged, contaminated, or otherwise modified.

Maintenance of SRM 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. 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 the Center for Radiation Research, Nuclear Radiation Division, Radioactivity Group. Coordination of the technical measurements leading to the certification of this SRM was performed by D.D. Hoppes, formerly of NIST.

Statistical consultation was provided by W.S. Liggett, Jr., formerly of NIST.

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

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Certificate Revision History on Last Page

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Office of Reference Materials

INSTRUCTIONS FOR HANDLING AND STORAGE

Handling and Storage: The SRM should be stored in a dry location. A working sample should be a whole bottle aliquant. The bottle should be shaken before opening in a chemical hood, opened carefully, releasing the vacuum in the bottle first and then recapped tightly as soon as the subsamples have been removed (if subsampling is done). The sample should be weighed as soon as possible after the bottle is opened. This SRM material should have a virtually indefinite storage life if kept at temperatures below 0 °C. Once opened the raw material may deteriorate biologically. The bottle (or any subsequent container) should always be clearly marked. If the SRM is transported, it should be packed, marked, labeled, and shipped in accordance with applicable national, international, and carrier regulations.

Details of SRM Preparation: This material consists of human lung tissue, chronically contaminated with ^{239}Pu and ^{240}Pu during the lifetimes of two individuals, diluted by a factor of approximately 1500 with lung tissue from uncontaminated individuals. The materials were radiation-sterilized, freeze-dried, pulverized, blended, cryogenically milled, and reblended. The $^{239+240}$Pu activity is roughly 85 % from the two above-mentioned occupationally exposed individuals and 15 % from the diluent material.

Certified Values: Each certified value was determined by two laboratories.

Table 1. Certified Properties of SRM 4351

Radionuclides	**See Table 2**
Reference time	**01 October 1982**
Certified massic activities	**See Table 2**
Uncertainties	**See Table 2**

Table 2. Certified Massic Activity Values for SRM 4351

Radionuclide	Massic Activity ($Bq \cdot g^{-1}$)	Number of Assays	Relative Expanded Uncertainty[a] (%)	Method Code[c]
^{232}Th	2.1×10^{-4}	16	13	1a, 2b
^{234}U	1.00×10^{-4}	5	25	1a, 2b
^{238}U	1.01×10^{-4}	5	11	1a, 2b
$^{239+240}$Pu	1.1×10^{-3}	14	+110[b] -50	1a, 2b
	Activity Ratio	**Number of Assays**	**Relative Expanded Uncertainty[a] (%)**	**Method Code[c]**
^{238}Pu/$^{239+240}$Pu	1.5×10^{-2}	10	18	1a, 2b

[a] For the nuclides ^{234}U, ^{238}U, and ^{232}Th, the total uncertainty given is a 95 percent confidence interval for the mean of all measurements on the material. The same is true for the ratio of ^{238}Pu/($^{239+240}$Pu).

[b] The uncertainty indicated is the 95 % tolerance interval for coverage of at least 95 % of measured values of this lot of bottled human lung samples. If measurements were made on all samples (with precision and accuracy no worse than that of the measurements used to certify this SRM), then at least 95 % of these measured values would fall within the indicated tolerance interval with confidence 95 %. The tolerance interval is obtained by transforming the measured whole-bottle concentrations to normally distributed data. This transformation consists of subtracting 4.17×10^{-4} $Bq \cdot g^{-1}$ and taking the cube root. The transformed data have a mean of 8.74×10^{-2} $(Bq \cdot g^{-1})^{1/3}$ and a standard deviation of 1.15×10^{-2} based on 12 samples.

[c] Analytical Methods

1. Dry-ashing
2. HNO_3 wet-ashing
   a. KF – pyrosulfate fusion [1]
   b. $NaNO_3$ $LiNO_3$ [2]

Information Values: Information values for massic activity are provided in Table 3, and information values for particle size distribution [3] are provided in Table 4. An information value is considered to be a value that will be of interest to the SRM user, but insufficient information is available to assess the uncertainty associated with the value or only a limited number of analyses were performed [4]. Information values cannot be used to establish metrological traceability. The following activities are not certified. These sample standard deviations were computed from the available measurements, which do not allow adequate checking of the assumptions needed for statement of uncertainty.

Table 3. Information Massic Activity Values for SRM 4351

Radionuclide	Massic Activity ($Bq \cdot g^{-1}$)	Standard Deviation (%)	Range of Measurements ($Bq \cdot g^{-1}$) x 10^4	Number of Assays
^{228}Th	2.2 x 10^{-4}	56	0.5 to 4.3	12
^{230}Th	2.0 x 10^{-4}	16	1.5 to 2.7	8
^{241}Am	1.1 x 10^{-4}	64	0.2 to 1.9	8

If additional data become available, other radioactivity concentrations may be certified and purchasers will be notified. To aid in these certifications, users are requested to send their measurement results for uncertified radioactivities, together with the method used to the technical contacts on page 1.

Table 4. Particle Size Distribution of the Freeze-Dried Lung Matrix By Air Jet Sieve for SRM 4351

Weight (%)	Diameter (µm)
81	< 75
9	75 to 90
8	90 to 150
2	> 150

Homogeneity Assessment: This material has been designated an SRM, in spite of significant inhomogeneities in some of the radioactive constituents, because of its unique character. Workers in the field have indicated that despite the relatively large uncertainties, it will constitute the only reference source of heavy alpha-particle-emitting radionuclides naturally introduced into the human lung.

There is significant inhomogeneity in $^{239+240}Pu$, ^{238}Pu, and ^{241}Am. The inhomogeneity is due primarily to fine particulates containing ^{239}Pu + ^{240}Pu [3]. The uranium and thorium in this SRM are not necessarily affected by the same factors that cause inhomogeneity of the plutonium and americium isotopes. No inhomogeneity of uranium or thorium isotopes was detected. However, some inhomogeneity might have escaped detection because of very low count rates. This SRM can be used by analysts to check radioanalytical methods for $^{239+240}Pu$ to an accuracy somewhat better than a factor of two for a single measurement.

Table 5. Participating Laboratories and Technical Points of Contact

Laboratory Acronym	Laboratory	City/State	Technical Contact
LANL	Los Alamos National Laboratory University of California	Los Alamos, NM	Dr. J.F. McInroy, Dr. H.A. Boyd, Mr. B.C. Eutsler
NIST	National Institute of Standards and Technology (formerly National Bureau of Standards) U.S. Department of Commerce	Gaithersburg, MD	Dr. J.M.R. Hutchinson, Dr. K.G.W. Inn

REFERENCES

[1] Sill, C.W.; Hindman, F.D.; Anderson, J.I.; *Simultaneous Determination of Alpha-emitting Nuclides of Radium through Californium in Large Environmental and Biological Samples*; Anal. Chem., Vol. 51, p. 1307 (1979).

[2] Los Alamos National Laboratory, Industrial Hygiene Group; *Plutonium in Tissue Analytical Procedure*; McInroy, J.F., ed., Los Alamos, New Mexico (1980).

[3] McInroy, J.F.; Boyd, H.A.; Eutsler, B.C.; Stewart, M.W.; Tietjen, G.L.; *Particle Size Distribution in the Lung of an Occupationally Exposed Individual*; Biomedical and Environmental Research Program of the LASL Health Division, D.F. Petersen and E.M. Sullivan, ed., LA-6898-PR, Vol. 42 (1977).

[4] May, W.; Parris, R.; Beck II, C.; Fassett, J.; Greenberg, R.; Guenther, F.; Kramer, G.; Wise, S.; Gills, T.; Colbert, J.; Gettings, R.; MacDonald, B.; *Definitions of Terms and Modes Used at NIST for Value-Assignment of Reference Materials for Chemical Measurements*; NIST Special Publication 260-136; U.S. Government Printing Office: Washington, DC (2000); available at: http://www.nist.gov/srm/publications.cfm (accessed Nov 2015).

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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; or via the Internet at http://www.nist.gov/srm.