U. S. Department of Commerce
Malcolm Baldrige
Secretary

National Bureau of Standards
Ernest Ambler, Director

National Bureau of Standards Certificate

Standard Reference Material 4276B

MIXED-RADIONUCLIDE SOLUTION STANDARD
for the
EFFICIENCY CALIBRATION OF GERMANIUM-SPECTROMETER SYSTEMS

Antimony-125-Tellurium-125m
Europium-154
Europium-155

Source identification	SRM 4276B-
Source description	Liquid in NBS borosilicate-glass ampoule (1)*
Solution composition	30 μg Sb^{+3} and 30 μg Eu^{+3} per gram of 4 M hydrochloric acid
Mass	5.236 grams
Reference time	1200 EST May 1, 1983

This standard is intended for use in measuring the full-energy-peak efficiencies of spectrometer systems for x and gamma rays from 27 to 1596 keV, provided that the responses to radiations approximately 5 keV apart can be resolved. Emission rates are specified at 18 energies for photon radiations from a mixture of antimony-125-tellurium-125m, europium-154, and europium-155. Uncertainties are estimated and combined at a level corresponding to a standard deviation of the mean, with the intent that the user can propagate this uncertainty along with the other uncertainties in the spectrometer calibration. For a more conservative overall uncertainty corresponding to that given on other NBS radioactivity certificates, multiply the combined uncertainty by three.

Table 1 gives the energies, emission rates, and uncertainties for selected radiations. A footnote indicates how emission rates will change with time. If there are any changes in measured emission rates that would correspond to an emission rate 0.5 percent different from that calculated from Table 1, or in measured half lives that would cause a corresponding difference after five years, notification will be sent to purchasers of the standard.

Table 2 lists the estimates of component uncertainties which have been added in quadrature to give the combined uncertainty in each emission rate.

Notes on the use of this standard are appended. One of the tables in the supplemental notes gives relative emission rates for radiations close in energy to the certified radiations; for spectrometer systems of poorer resolution, it may be necessary to use a combined emission rate for some multiple peaks.

This Standard Reference Material was prepared in the Center for Radiation Research, Ionizing Radiation Division, Radioactivity Group, Dale D. Hoppes, Group Leader.

Gaithersburg, MD 20899
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Stanley D. Rasberry, Chief
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TABLE 1

X-Ray and Gamma-Ray Energies, Emission Rates [2,3], and Uncertainties for Standard Reference Material 4276B

Radionuclide	Photon Energy (keV)	Emission Rate ($\times s^{-1}g^{-1}$) or ($\gamma s^{-1}g^{-1}$) 1200 EST May 1, 1983	Combined Estimated Uncertainty (%)*
^{125}Sb-^{125m}Te	Kα, 27.4	4.680×10^3	1.3
^{154}Eu-^{155}Eu	Kα, 42.8	3.480×10^3 [4]	1.3
^{155}Eu	86.6	1.951×10^3	0.8
^{155}Eu	105.3	1.379×10^3	1.1
^{154}Eu	123.1	4.768×10^3	0.7
^{125}Sb	176.4	5.136×10^3	0.6
^{154}Eu	248.0	8.081×10^2	0.6
^{125}Sb	427.9	2.232×10^3	0.7
^{125}Sb	463.4	7.848×10^2	0.7
^{154}Eu	591.7	5.784×10^2	0.6
^{125}Sb	600.6	1.326×10^3	0.6
^{125}Sb	635.9	8.473×10^2	0.6
^{154}Eu	723.3	2.347×10^3	0.6
^{154}Eu	873.2	1.425×10^3	0.7
^{154}Eu	996.4	1.220×10^3	1.0
^{154}Eu	1004.8	2.115×10^3	0.7
^{154}Eu	1274.4	4.076×10^3	0.6
^{154}Eu	1596.5	2.072×10^2	0.7

* Estimated total uncertainties have the significance of one standard deviation of the mean. Components of these estimates are given in Table 2.

TABLE 2

Estimates of the Component Uncertainties for
Photon-Emission-Rate Values for SRM 4276B

TYPICAL UNCERTAINTY COMPONENTS (%)

Photon Energy (keV)	Number of Determi-nations	Std. Dev. of the Mean	Effici-ency	Peak Analysis	Pile-up Compen-sation	Geometry	Other*	Combined Uncer-tainty**
27.4	6	0.3	1.0	0.7	0.3	0.1	0.2	1.31
42.8	6	0.06	1.0	0.7	0.1	0.1	0.5	1.3
86.6	6	0.12	0.65	0.3	0.1	0.1	0.05	0.74
105.3	6	0.09	1.0	0.3	0.1	0.1	0.05	1.1
123.1	6	0.08	0.6	0.4	0.1	0.08	0.05	0.74
176.4	6	0.09	0.5	0.2	0.2	0.1	0.05	0.59
248.0	6	0.04	0.5	0.3	0.1	0.08	0.05	0.60
427.9	6	0.23	0.7	0.2	0.2	0.08	0.05	0.79
463.4	7	0.22	0.58	0.2	0.2	0.08	0.05	0.69
591.7	6	0.12	0.45	0.3	0.1	0.08	0.05	0.57
600.6	7	0.20	0.42	0.4	0.2	0.08	0.05	0.65
635.9	6	0.19	0.42	0.2	0.2	0.08	0.05	0.55
723.3	6	0.05	0.54	0.2	0.1	0.08	0.05	0.59
873.2	5	0.12	0.63	0.3	0.1	0.08	0.05	0.72
996.4	5	0.11	0.54	0.75	0.1	0.08	0.05	0.94
1004.8	5	0.06	0.54	0.4	0.1	0.08	0.05	0.69
1274.4	5	0.06	0.45	0.1	0.1	0.08	0.05	0.48
1596.5	6	0.43	0.40	0.1	0.2	0.15	0.05	0.64

* Includes contributions for the half lives for the Te x ray, for the decay schemes for Gd x ray, and for gravimetric factors in the source preparation.

** Components of the uncertainty have been added in quadrature. This is the overall uncertainty for a typical detector, and some of the values are slightly greater than those given in the last column in Table 1.

NOTES

(1) Approximately five milliliters of solution. Ampoule specifications:

body diameter	16.5 ± 0.5 mm
wall thickness	0.60 ± 0.04 mm
barium content	less than 2.5 percent
lead oxide content	less than 0.02 percent
other heavy elements	trace quantities

(2) These values are based on gamma-ray spectrometry measurements made at the National Bureau of Standards, which are described in the reference: B.M. Coursey, D.D. Hoppes, and F.J. Schima, "Determination of the Photon Emission Rates of the NBS Long-Lived Mixed-Radionuclide Standard", Nuclear Instruments and Methods 193, 1 (1982).

(3) Emission rates at later times can be calculated using the following evaluated half-life values and decay constants:

	Half Life	Decay Constant
^{125}Sb	1008 ± 2 days	6.876×10^{-4} days^{-1}
^{154}Eu	3140 ± 12 days	2.207×10^{-4} days^{-1}
^{155}Eu	1739 ± 4 days	3.986×10^{-4} days^{-1}

(4) For the 42.8-keV Gd K_α x rays, the emission rate N_t is given by

$$N_t = N_o \times (0.6724\ e^{-2.207 \times 10^{-4} t} + 0.3276\ e^{-3.986 \times 10^{-4} t}),$$

where N_o is the emission rate given in Table 1, and t is the time in days from 1200 EST May 1, 1983.

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