U. S. Department of Commerce
Malcolm Baldrige
Secretary

National Bureau of Standards
Ernest Ambler, Director

National Bureau of Standards

Certificate

Standard Reference Material 4251B

Radioactivity Standard

Radionuclide	Barium-133
Source identification	4251B-
Source description	Liquid in NBS borosilicate-glass ampoule (1)*
Solution composition	Approximately 118 μg $BaCl_2$ per gram of 1 molar hydrochloric acid (2)
Mass	grams
Radioactivity concentration	4.524×10^5 Bq g^{-1} ($s^{-1}g^{-1}$)
Reference time	1400 EST June 10, 1981
Random uncertainty	0.06 percent (3)
Systematic uncertainty	1.38 percent (4)
Total uncertainty (Random plus systematic)	1.44 percent
Photon-emitting impurities	None observed (5)
Half life	10.48 ± 0.04 years (6)
Measuring instrument	NBS pressurized "4π"γ ionization chamber calibrated by 4π(e,x)-γ coincidence and anti-coincidence efficiency-extrapolation technique

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

Washington, D.C. 20234
December, 1981

George A. Uriano, Chief
Office of Standard Reference Materials

(over)

*Notes on back

FOOTNOTES

(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) Solution density 1.016 ± 0.002 g/ml at 25.3°C.

(3) Half the 99-percent confidence interval of the mean (2.7 times the standard error computed from 50 ionization-chamber measurements).

(4) Linear sum of estimated uncertainty limits due to calibration of the pressurized "4π"γ ionization chamber, which is the linear sum of estimated uncertainty limits due to:

a) half the 99-percent confidence interval of the mean of eight coincidence and anti-coincidence measurements	0.25 percent
b) dead time	0.05 percent
c) resolving time	0.05 percent
d) background	0.37 percent
e) half life	0.03 percent
f) gravimetric measurements	0.20 percent
g) half the 99-percent confidence interval of the mean of the ionization-chamber measurements	0.03 percent
h) efficiency extrapolation	0.40 percent

(5) Limits of detection as a percentage of the gamma-ray-emission rate of the 384-keV gamma rays emitted in the decay of the barium-133 are

0.1 percent between 20 and 379 keV

0.01 percent between 389 and 1900 keV

provided that the impurity photons are separated in energy by five keV or more from photons emitted in the decay of barium-133.

(6) NBS Special Publication No. 626, December 1981, p. 132.

NOTES ON BARIUM-133 NUCLEAR DECAY DATA

The attached data are from the current Evaluated Nuclear Structure Data File, maintained by the Nuclear Data Project at the Oak Ridge National Laboratory, and published in the National Council on Radiation Protection and Measurements Report No. 58. NBS measurements for the probability per decay for the gamma rays with energies of 276-, 303-, 356- and 384-keV agree with the tabulated values to about 1 percent, but show a discrepancy of up to 5.5% for the photons of other energies.

Corrections for the summing of correlated gamma and x rays must be considered if this standard is to be counted with high efficiency.

(1) Nucl. Instr. and Meth. 130, 189 (1975).
(2) Nucl. Instr. and Meth. 147, 405 (1977).

A half life of 10.48 ± 0.04 years is suggested. This value is an average based on half-life values reported by four laboratories in NBS Special Publication No. 626, December 1981, p. 132.

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133BA EC DECAY I(MIN) = 0.10%

Radiation Type	Energy (keV)	Intensity (%)	Δ(g-rad/μCi-h)
Auger-L	3.55	135 6[a]	0.0102
ce-K- 1	17.170 16	10.5 4	0.0038
Auger-K	25.5	14.0 16	0.0076
ce-K- 2	43.636 11	3.72 15	0.0035
ce-K- 3	45.012 5	46.9 10	0.0450
ce-L- 1	47.441 16	1.43 20	0.0014
ce-MNO- 1	51.938 16	0.43 20	0.0005
ce-L- 2	73.907 11	0.59 11	0.0009
ce-L- 3	75.283 5	7.64 24	0.0122
ce-MNO- 2	78.404 11	0.194 6	0.0003
ce-M- 3	79.780 5	1.78 14	0.0030
ce-NOP- 3	80.766 5	0.32 4	0.0005
ce-K- 4	124.620 15	0.123 9	0.0003
ce-K- 6	240.412 12	0.327 12	0.0017
ce-K- 7	266.866 15	0.70 6	0.0040
ce-L- 7	297.137 15	0.103 15	0.0007
ce-K- 8	320.020 17	1.31 5	0.0089
ce-K- 9	347.866 15	0.153 5	0.0011
ce-L- 8	350.291 17	0.218 7	0.0016
X-ray L	4.29	17 5	0.0015
X-ray $K\alpha_2$	30.6251 3	34.0 8	0.0222
X-ray $K\alpha_1$	30.9728 3	62.9 12	0.0415
X-ray Kβ	35	22.6 6	0.0168
γ 1	53.155 16	2.17 4	0.0025
γ 2	79.621 11	2.66 8	0.0045
γ 3	80.997 5	33.5 5	0.0578
γ 4	160.605 15	0.62 4	0.0021
γ 5	223.25 3	0.460 13	0.0022
γ 6	276.397 12	7.09 13	0.0417
γ 7	302.851 15	18.40 20	0.119
γ 8	356.005 17	62.1 7	0.471
γ 9	383.851 15	8.91 10	0.0729

a) The format used for the uncertainties in the listed values can be illustrated by the following examples.

1.2 56 = 1.2 ± 5.6
1.23 56 = 1.23 ± 0.56
1.234 56 = 1.234 ± 0.056

FROM: A Handbook of Radioactivity Measurements Procedures, NCRP Report No. 58, Nov., 1978.

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