

National Bureau of Standards

Certificate

Standard Reference Material 4340

Beta-Particle Solution

Radionuclide	Plutonium-241
Source identification	SRM 4340
Source description	5 mL of solution in a flame-sealed borosilicate-glass ampoule
Chemical composition	Carrier free in 5 M HNO ₃
Radioactivity concentration	148.4 Bq g ⁻¹ (1)*
Reference time	1200 EST July 1, 1986
Overall uncertainty	1.0 percent (2)
Radionuclidic impurities	²⁴¹ Pu progeny only (3)
Measuring instrument	4π α (LS)- γ -coincidence counting of ²⁴¹ Am daughter ingrowth (4)
Half life	14.35 \pm 0.10 years (5)

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
May 1986

Stanley D. Rasberry, Chief
Office of Standard Reference Materials

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NOTES

(1) This standard was prepared from a quantitative dilution of a solution that was calibrated using $4\pi\alpha$ (LS)- γ -coincidence counting to measure the ingrowth of daughter americium-241. The ingrowth of americium-241 has been followed since the time of purification of the plutonium-241 in 1977. The activity of the plutonium-241 is calculated from the activity of the americium-241 using half lives of 14.35 y and 432.2 y, respectively.

(2) The overall uncertainty was formed by taking three times the quadratic combination of standard deviations of the mean, or approximations thereof, for the following:

a) 47 coincidence measurements	0.02 percent
b) gravimetric measurements	0.05 percent
c) deadtime	0.05 percent
d) resolving time	0.10 percent
e) background	0.05 percent
f) pulse-height extrapolation	0.25 percent
g) half lives	0.13 percent
h) impurities	0.10 percent

(3) The material from which this standard was prepared was examined for alpha-particle-emitting impurities using a silicon surface-barrier detector, for beta-particle-emitting impurities using a liquid-scintillation counter, and for gamma-ray-emitting impurities using a Ge(Li) detector system. The only alpha-particle, beta-particle and gamma-ray emissions observed could be attributed to the decay of plutonium-241 and progeny (primarily americium-241). The estimated upper limits for radioactive impurities, relative to the activity of plutonium-241, are:

Alpha particles whose energies differ by at least 50 keV from those emitted by plutonium-241 or americium-241.	1×10^{-5}
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Beta particles whose end point energies exceed 50 keV.	2×10^{-3}
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Gamma rays whose energies exceed 65 keV and differ by a least 5 keV from those emitted by progeny.	2×10^{-6}
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(4) In addition to the α - γ -coincidence measurements, the ^{241}Pu activity concentration value was confirmed to within 0.4 percent using the method of $4\pi\beta$ -liquid-scintillation efficiency-tracing with ^3H . [Coursey, B.M. et al. *Int. J. Appl. Radiat. Isotopes*, 37, 403 (1986)]. For 10 mL of scintillator and 50 μL of sample, the nominal efficiencies for the ^3H and ^{241}Pu beta particles were, respectively, 50 percent and 45 percent, for the two-phototube system with a coincidence requirement.

(5) Nuclear_Data_Sheets 44, 407 (1985).

SUPPLEMENTAL INFORMATION SHEET TO ACCOMPANY SRM 4340

The following table lists the alpha-particle- and beta-particle-emission rates per gram for this standard as a function of time. The values given in the table occur on the first day of the month shown.

MONTH	YEAR	Emission Rate (/s/g)				MONTH	YEAR	Emission Rate (/s/g)			
		Pu-241(β)	Pu-241(α)	Am-241(α)	U-237(β)			Pu-241(β)	Pu-241(α)	Am-241(α)	U-237(β)
JULY	1986	148.4	0.004	2.775	0.004	APRIL	1989	129.9	0.003	3.374	0.003
AUGUST	1986	147.8	0.004	2.794	0.004	MAY	1989	129.4	0.003	3.391	0.003
SEPTEMBER	1986	147.2	0.004	2.814	0.004	JUNE	1989	128.9	0.003	3.408	0.003
OCTOBER	1986	146.6	0.004	2.833	0.004	JULY	1989	128.4	0.003	3.425	0.003
NOVEMBER	1986	146.0	0.004	2.852	0.004	AUGUST	1989	127.9	0.003	3.441	0.003
DECEMBER	1986	145.4	0.004	2.871	0.004	SEPTEMBER	1989	127.4	0.003	3.458	0.003
JANUARY	1987	144.9	0.004	2.890	0.004	OCTOBER	1989	126.8	0.003	3.475	0.003
FEBRUARY	1987	144.3	0.004	2.909	0.004	NOVEMBER	1989	126.3	0.003	3.491	0.003
MARCH	1987	143.7	0.004	2.928	0.004	DECEMBER	1989	125.8	0.003	3.507	0.003
APRIL	1987	143.1	0.004	2.947	0.004	JANUARY	1990	125.3	0.003	3.524	0.003
MAY	1987	142.5	0.004	2.966	0.004	FEBRUARY	1990	124.8	0.003	3.540	0.003
JUNE	1987	142.0	0.003	2.984	0.003	MARCH	1990	124.3	0.003	3.556	0.003
JULY	1987	141.4	0.003	3.003	0.003	APRIL	1990	123.8	0.003	3.572	0.003
AUGUST	1987	140.8	0.003	3.021	0.003	MAY	1990	123.3	0.003	3.588	0.003
SEPTEMBER	1987	140.3	0.003	3.040	0.003	JUNE	1990	122.8	0.003	3.604	0.003
OCTOBER	1987	139.7	0.003	3.058	0.003	JULY	1990	122.3	0.003	3.620	0.003
NOVEMBER	1987	139.1	0.003	3.076	0.003	AUGUST	1990	121.8	0.003	3.636	0.003
DECEMBER	1987	138.6	0.003	3.094	0.003	SEPTEMBER	1990	121.3	0.003	3.652	0.003
JANUARY	1988	138.0	0.003	3.112	0.003	OCTOBER	1990	120.9	0.003	3.667	0.003
FEBRUARY	1988	137.5	0.003	3.130	0.003	NOVEMBER	1990	120.4	0.003	3.683	0.003
MARCH	1988	136.9	0.003	3.148	0.003	DECEMBER	1990	119.9	0.003	3.699	0.003
APRIL	1988	136.4	0.003	3.166	0.003	JANUARY	1991	119.4	0.003	3.714	0.003
MAY	1988	135.8	0.003	3.184	0.003	FEBRUARY	1991	118.9	0.003	3.729	0.003
JUNE	1988	135.3	0.003	3.202	0.003	MARCH	1991	118.4	0.003	3.745	0.003
JULY	1988	134.7	0.003	3.219	0.003	APRIL	1991	118.0	0.003	3.760	0.003
AUGUST	1988	134.2	0.003	3.237	0.003	MAY	1991	117.5	0.003	3.775	0.003
SEPTEMBER	1988	133.7	0.003	3.254	0.003	JUNE	1991	117.0	0.003	3.791	0.003
OCTOBER	1988	133.1	0.003	3.272	0.003	JULY	1991	116.6	0.003	3.806	0.003
NOVEMBER	1988	132.6	0.003	3.289	0.003	AUGUST	1991	116.1	0.003	3.821	0.003
DECEMBER	1988	132.0	0.003	3.306	0.003	SEPTEMBER	1991	115.6	0.003	3.836	0.003
JANUARY	1989	131.5	0.003	3.323	0.003	OCTOBER	1991	115.2	0.003	3.851	0.003
FEBRUARY	1989	131.0	0.003	3.340	0.003	NOVEMBER	1991	114.7	0.003	3.865	0.003
MARCH	1989	130.5	0.003	3.357	0.003	DECEMBER	1991	114.2	0.003	3.880	0.003