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National Bureau of Standards Certificate

Standard Reference Material 4218-C

Europium-152

Point-Source Activity Standard

This Standard Reference Material consists of europium-152 deposited, as the chloride, on polyester tape approximately 0.006-cm thick and covered by another layer of the same tape. The tape is mounted on an aluminum annulus 3.8-cm inside diameter and 5.4-cm outside diameter.

This standard is a dried deposit from an accurately weighed aliquot of a solution whose activity was measured by photon counting of other accurately weighed and dried aliquots in the National Bureau of Standards 4π, 20.32-cm-diameter, NaI(Tl) well crystals.

The activity of this point source of europium-152 at 1200 EST on May 1, 1978, was

$$* \quad s^{-1} \pm 1.4\%*.$$

The uncertainty in the activity, 1.4 percent, is the linear sum of 0.11 percent, which is the limit of the random error of the sodium iodide measurements at the 99-percent confidence level (4.604 S_m, where S_m is the standard error computed from five measurements), and 1.3 percent, which is the sum of the estimated upper limits of conceivable systematic errors.

The photon spectrum was examined with Ge(Li) and pure Ge spectrometers and the material was found to contain europium-154 and gadolinium-153 whose activities, as of the calibration date, were 0.4 percent and 0.15 percent, respectively, of the europium-152 activity. No other photon-emitting impurities were observed. The limit of the photon-emission rate at any given energy due to other impurities is estimated to be less than 0.1 percent of the emission rate of the 1408-keV gamma ray of europium-152, provided that the impurity photons are separated in energy by 5 keV or more from photons of equal or greater intensity emitted by europium-152, europium-154, or gadolinium-153.

The europium-152 activity, A, was obtained using the formula

$$A = T/\ [e_1 + f_2.e_2 + f_3.e_3],$$

where T is the total count rate, derived from an extrapolation to zero energy, f_2(= 0.004) and f_3(= 0.0015) are the ratios of the activities of europium-154 and gadolinium-153, respectively, to that of europium-152, and e_1(= 0.959), e_2(= 0.885) and e_3(= 0.874) are the total detection efficiencies for europium-152, europium-154 and gadolinium-153, respectively, calculated using the known decay schemes and the experimentally determined total efficiency curve for the 20.32-cm-diameter well crystals.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

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SRM 4218-C-

TABLE I

Recommended values of gamma-ray probabilities and half-life for ^{152}Eu. The values marked with an asterisk are for gamma rays emitted from ^{154}Eu and correspond to a $^{154}Eu/^{152}Eu$ activity ratio of 0.004 (0.4%). The dagger signifies two lines separated by less than 1 keV. The uncertainties are given at the 68% confidence limit.

PHOTON ENERGY (keV)	*PHOTON PROBABILITY PER DECAY*	*UNCERTAINTY (%)*
121.8	0.2837	0.83
123.1	0.0017*	--
244.7	0.0751	0.71
247.9	0.0003*	--
344.3	0.2658	0.68
411.1	0.02234	0.57
444.0†	0.03121	0.56
778.9	0.1296	0.53
964.0†	0.1462	0.40
1085.8	0.1016	0.45
1112.1	0.1356	0.41
1408.0	0.2085	0.40

ISOTOPE	*HALF-LIFE (y)*
^{152}Eu	13.3 ± 0.1
^{154}Eu	8.6 ± 0.1
^{153}Gd	0.663 ± 0.003

SUMMING CORRECTIONS

If the efficiency of a Ge(Li) spectrometer is to be determined for a measurement geometry where the effective solid angle, as a fraction of 4π steradians, is on the order of 0.01 or greater, the effects of summation of coincident quanta should be considered [1,2]. The following formulae are satisfactory for summing corrections up to approximately ten percent[1]. For larger summing corrections second order effects must also be taken into account[2].

If two quanta, 1 and 2, are emitted in coincidence, then the relative summation loss from peak 1 is given by[1]

$$v(1) = \frac{w_{\gamma c}(1,2) \cdot \varepsilon_t(2)}{w_\gamma(1)} \leq \varepsilon_t(2),$$

where $w_{\gamma c}(1,2)$ is the probability of simultaneous emission of both quanta, $w_\gamma(1)$ is the probability of emission of quantum 1, and $\varepsilon_t(2)$ is the total detection efficiency for quantum 2. The measured count rate N(1) is to be divided by 1-v(1)]. A corresponding correction is also to be made for all other quanta that are emitted in coincidence with quantum 1. Note that $\varepsilon_t(2)$ is the probability that quantum 2 causes a pulse of any magnitude in the detector, rather than just the probability of a count in the full-energy peak. [The latter efficiency is denoted by $\varepsilon(2)$.] For a large-volume detector in the energy region above 100 keV, the value of ε_t varies slowly with energy and therefore need only be determined at a few points. The quotients $w_{\gamma c}(1,2)/w_\gamma(1)$ are obtained from the decay scheme are presented in Table II for the major gamma rays from ^{152}Eu. It was assumed that angular correlations and triple coincidences can be neglected.

Similarly, for a transition 3 in parallel with a cascade 1-2, the count rate in the full-energy peak of 3 increases due to summation. The relative increase is given by[1]

$$z(3) = \frac{w_{\gamma c}(1,2) \cdot \varepsilon(1) \cdot \varepsilon(2)}{w_\gamma(3) \cdot \varepsilon(3)},$$

and the measured count rate N(3) is to be divided by [1+z(3)]. Here it is ε, rather than ε_t, that is important. The quotients $w_{\gamma c}(1,2)/w_\gamma(3)$ are presented in Table III for the major gamma rays from ^{152}Eu.