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Released 1995

**Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830**

**Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
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DOCUMENT NO.
HW-29028

FILE DESIGNATION

300 N

DATE
August 12, 1953
COPY NO. AND SERIES
15

TITLE

COUNTING CONTRIBUTION OF PLUTONIUM ON BGO
AND GSC INSTRUMENTS

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COUNTING CONTRIBUTION OF PLUTONIUM ON BGO AND GSC INSTRUMENTS

This is in response to your request for data on the contribution by plutonium to the counts obtained on decontamination study samples on the beta (BGO) and gamma (GSC) instruments. In determining the effectiveness of decontamination processes, such a reference level of apparent F.P. activity in the completely decontaminated product is essential. Inasmuch as some growth of americium into the product is unavoidable, it is necessary that the counts associated with Am-241 activity also be known.

This study has shown that for americium-free plutonium, mounted on stainless steel, the normalized second shelf BGO count through 25 mg/cm² of platinum amounts to 700 ± 100 c/m/mg of plutonium. Product material has been counted under the same conditions and has been found to yield from 1000 to 1800 c/m/mg, depending upon age since separation. Even small concentrations of americium in the product contribute appreciably to the apparent beta count, since americium contributes ~5x10⁵ c/m/mg through 25 mg/cm² platinum. In aged product this contribution can exceed that due to plutonium, so the possibility of americium growth in the sample should always be considered in setting reference counting levels. When counted without the 25 mg absorber, plutonium yields 1.7x10⁴ c/m/mg, and americium yields 2.6x10⁶ c/m/mg.

A similar study of the plutonium count obtained on the gamma scintillation counter has shown that for the standard geometry recently established (7/1/53), the count through the minimum 1.7 g/cm² absorber amounts to 416 c/m/mg, while that through 8.9 g/cm² total absorber is 48 c/m/mg. No dependence upon americium content or upon power level is found.

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EMISSIONS FROM PLUTONIUM AND AMERICIUM

Samples containing plutonium and americium (either or both) may be expected to yield counts on the BGO as a result of the x-ray and gamma emissions from these isotopes. Pu-241 emits a soft beta (~ 21 Kev) which does not penetrate the mica window, and the same is true of the conversion electrons associated with the gamma emissions from Pu-239, Pu-240, and Am-241 (1). Counts in the BGO can result, however, from electrons arising from x-ray or gamma interactions with a thin absorber or with the mica window and the counter walls. The very abundant uranium Xrays (17.2 and 21.9 Kev) associated with Pu-239 and Pu-240 decay may be considered the primary source of the BGO counts observed from the pure product when no absorber is used (Table II). These are substantially absorbed by 25 mg/cm² of platinum, so that when counting through the standard 25 mg/cm² absorber, the residual counts contributed by the product components in the sample will, to a large extent, be those arising from the very abundant 60 Kev Am-241 gammas, and from the less abundant Pu-239 53 Kev, 100 Kev, 124 Kev, and 384 Kev gammas. Thus, while the contribution from the product mixture is greatly reduced by the use of the 25 mg absorber, the relative sensitivity of this count to Am-241 content is increased. From the data of Table II one can determine whether or not consideration of the americium content of the sample will be necessary in any given case.

In gamma scintillation counting the minimum absorber of 1.7 g/cm² is sufficient to negate any effects from any low energy gammas and from all Xrays. Thus, the product contribution to the GSC count is independent of the americium content. The small count observed for purified plutonium can probably be attributed to the low-abundance 384 Kev gammas from Pu-239. This count is greatly reduced by 7.2 g/cm² additional absorber (Table IV).

EXPERIMENTAL DATA

Beta Counting:

In the present study two 500 ul stainless steel mounts of each of two fractions of an 18-month old 680 MWD/T sample were separately counted. Previous assays of the Am-241 and plutonium contents of the samples were corroborated on a total alpha activity basis. These are shown below.

TABLE I

Fraction	d/m/mount			mg/mount	
	Pu*	Am	Total	Pu	Am
Pu #136 (A&B)	6.1x10 ⁵	2.5x10 ³	6.1x10 ⁵	0.0385	3.6x10 ⁻⁵
Am #136 (A&B)	2.9x10 ⁵	5.7x10 ⁴	3.5x10 ⁵	0.0185	8.1x10 ⁻⁴

*By difference

These samples were counted on the second shelf of the BGO instrument, both without absorber and with 25 mg/cm² platinum absorber. By the solution of the resultant simultaneous equations, the counts due to americium and those due to plutonium were separately calculated. No measure of the plutonium "beta" count as a function of isotope ratio has been made.

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TABLE II

	Avg. total count/500 ul			c/m/mg	
	Pu + Am	Pu	Am	Pu Isotopes	Am-241
No absorber:					
Pu fractions	667	658*	9*		
Am fractions	528	316*	212*		
Total	1195	974	221	1.71x10 ⁴ (both: 2.09x10 ⁴	2.61x10 ⁶ c/m/mg Pu)
25 mg/cm ² Pt:					
Pu fractions	28±4	~27*	<2*		
Am fractions	53±3	~13*	~40*		
Total	~81	~40	~42	700±100 (both: ~1440	5x10 ⁵ c/m/mg Pu)

*Calculated from the c/m/mg values.

It thus appears that the americium content of any product sample may account for a substantial portion of the product contribution to the BGO count, and that thus the extent of the total contribution is dependent upon the americium content of the product stream. For the size samples here taken, the net count obtained through 25 mg of Pt was too low to yield precise data; however, the total count (per mg plutonium) compares well with those obtained for larger samples (see below).

An earlier determination on BiPO₄-separated 600 MWD/T P-1 samples had shown the following overall (i.e., Pu + Am) counts on the BGO instrument:

TABLE III

Absorber	c/m/mg Pu (2nd shelf)
24.9 mg/cm ² gold	1485
Same, 6 mos. later	1850
50 mg/cm ² gold	570

The above data were obtained on relatively thick samples containing 5.4 mg of plutonium on one-inch watch glasses.

More recent counts on two purified plutonium samples mounted on stainless steel indicated 1710 c/m/mg for an 0.45 mg sample and 1050 c/m/mg for a 1.33 mg sample. The latter sample is believed to have been the more freshly separated, but this is not certain. The present data indicate that such is likely.

Gamma Counting:

The counts obtained on the GSC for the above mounts of the plutonium and americium fractions (Sample #136) did not show any significant sensitivity to the americium content, but the precision at the low counting rates obtained was insufficient to yield good correlation with the plutonium content. A larger sample of mixed plutonium and americium, 1.17 mg of 600 MWD/T product, was counted for various geometry and absorber combinations, and the data are shown in Table IV.

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TABLE IV

<u>Sample Position</u>	<u>Absorber</u>	<u>c/m/mg Pu</u>
------------------------	-----------------	------------------

Old basis:

"Contact"

(Pedestal up)

1.7

925

8.9

75

(Pedestal down)

1.7

560

8.9

53

These counts normalized to correspond to 10% yield to Cs-137 counted in the contact position

New basis: (7/1/53)

"Standard" position

(Pedestal down)

1.7

416

8.9

48

These counts normalized to 3.36% yield to Cs-137, std. pos.

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Reference

- (1) Freedman, M.S., Wagner, F., Jr., and Engelkemsir, D.W., Phy. Rev., 88, No. 5, p. 1155 (1952).