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A LARGE AREA GAS PROPORTIONAL
DETECTOR FOR LOW ENERGY PHOTONS

by

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ABSTRACT

A large area gas proportional detector used for the measurement of Pu^{239} is described. The detector includes a guard system for background reduction.

A comparison of a NaI(Tl) thin crystal detector and the gas proportional detector for minimum detectable activity is included.

SUMMARY

The gas proportional detector presently developed for use in the whole body counter at the Rocky Flats Division of The Dow Chemical Company, produces better resolution and lower background than the scintillation detector system. The proportional detector system does not produce comparable sensitivity to the thin crystal scintillation system.

Since the proportional detector system does not have equal sensitivity to the scintillation system and is more difficult to use in a routine operation, the thin crystal scintillation system is normally used in the whole body counter.

The resolution of the gas proportional detector for the 13.6-keV photon peak associated with the alpha particle decay of Pu^{239} is 13%. The background of the detector for a 1.1-keV region centered at 16.9 keV is 0.65 c/m. The detector operates as a flow counter with P-10 gas at atmospheric pressure.

INTRODUCTION

There are two types of detector systems that are currently being used in the Rocky Flats whole body counter for the measurement of low-energy photons.

These are the NaI(Tl) thin crystal detector and the gas proportional flow counter. The scintillation detector consists of a NaI(Tl) canned crystal mechanically coupled to a suitable photomultiplier tube. The gas proportional detector has an electric field which is capable of gas multiplication of ionization produced by photoelectric conversion of low-energy photons.

The gas proportional detector has been investigated by many people for application to the detection of low-energy photons. The goal of these investigations is to improve the sensitivity of the detector to a comparable level of the NaI(Tl) system while retaining the low background and superior resolution presently available.

GENERAL DISCUSSION

The external measurement of plutonium in vivo requires a detector capable of measuring low-energy photons at very low counting rates. Since the energies of the photons associated with the decay of plutonium are of low energy the tissue of the body between the source and the detector becomes a significant absorber. The external detector must have a very low background with good absorption capability, two characteristics which are not easily obtained simultaneously.

Preliminary investigations at Rocky Flats with gas proportional detectors have indicated that stable operation of large area detectors may be achieved more easily with side window rectangular detectors than with cylindrical end window configurations.

Detector

The detector consists of three rectangular sections arranged in a vertical array. Each section is 22 by 34 by 5 cm separated by a sheet of 0.001-inch double aluminized Mylar* film. The detector is constructed of $\frac{1}{4}$ -inch Plexiglas** sheet

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with a 30-micron layer of aluminum deposited on the interior surfaces. The window material is 0.001-inch double aluminized Mylar film. The window area is 540 cm². The total volume of the detector is about 11 liters.

Anode

The detector anode consists of a plane array of four 0.001-inch gold-plated stainless steel wires supported at each end of the detector housing by a 1/16-inch copper wire mounted on standoff insulators made of Teflon* plastic.

The number of anode wires was determined experimentally to produce the best possible resolution at 13.6 kev.

Counting Gas

P-10 gas, a mixture of 90% argon and 10% methane, is used for the counting gas in the detector. The gas flows at a rate of 2 liters/minute which constitutes a change of 20% of the total volume per minute. Although argon does have a relatively low photon absorption capability as compared to krypton or xenon, its lower fluorescent yield (10% as

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compared to 67% for krypton and 85% for xenon) produces a spectrum which is much easier to analyze. This characteristic plus its relatively low cost makes P-10 gas useful as a detecting medium.

Electronics

A nuvistor preamplifier (Figure 1) has been included as an integral part of the detector assembly. This produces maximum pulse amplitude output, since the close proximity of the preamplifier to the detector anode reduces the capacity in the anode output circuit. An external amplifying system is used to produce pulse amplitudes suitable for analysis and for operation of the anticoincidence system (Figure 2).

The electronic resolution of the system is 2.7% at the 13.6-kev line position. The resulting resolution of the detector system at 13.6 kev is 13%. (See Figure 3.)

Detector Background

Background data was obtained for a spectrum 1.1 kev wide centered at 16.9 kev.

Background Counting Rate

	Without Guard Detector (c/m)	With Guard Detector (c/m)
Outside steel room	55	8
Inside steel room	14	0.65

The total background reduction factor for the whole body counter at Rocky Flats with a guard detector and steel room is 82.

Minimum Detectable Activity

The NaI(Tl) thin crystal detector system and gas proportional detector system have been compared for sensitivity using a point source and identical thicknesses of tissue equivalent absorbers.

Source = 240 micrograms of Pu^{239}

Counting time = 40 minutes

<u>Absorber Thickness</u>	<u>NaI(Tl) 4 in x 4 mm</u>	<u>Gas Proportional 540 cm²</u>
0 inch	2.4 nc	4.2 nc
$\frac{1}{2}$ inch	6.4 nc	11.6 nc
1 inch	15.5 nc	31.4 nc

The minimum detectable activity (MDA) has been calculated on the basis of the following formula:

$$\text{MDA} = \frac{1}{gkt} (2n \sqrt{bt} + n^2) \quad (a)$$

n = number of standard deviations for desired confidence level

b = background counting rate

t = counting time

g = geometry

k = dpm/unit quantity

(a) Unpublished paper - E. E. Overall, Rocky Flats Division, The Dow Chemical Company, (1965)

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Figure 1. PREAMPLIFIER SCHEMATIC

Figure 2. SYSTEM ELECTRONICS

Figure 3. A TYPICAL PHOTON SPECTRUM FOR Pu^{239}

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