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**LOS ALAMOS SCIENTIFIC LABORATORY**  
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AN ENERGY MEASUREMENT OF  $\text{PuF}_4$  NEUTRONS  
AND THE NEUTRON DOSE RATE FROM  
 $\text{PuF}_4$  PROCESSING EQUIPMENT

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LAMS-2692  
HEALTH AND SAFETY  
TID-4500 (17th Ed.)

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**REPORT WRITTEN:** May 1962

**REPORT DISTRIBUTED:** June 11, 1962

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 $\text{PuF}_4$  PROCESSING EQUIPMENT

by

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**Contract W-7405-ENG. 36 with the U. S. Atomic Energy Commission**

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## ABSTRACT

By use of the multisphere neutron spectrometer, the neutrons emitted from a sample of  $\text{PuF}_4$  were analyzed for average neutron energy. The results indicate an average neutron energy of  $1.25 \pm 0.25$  Mev. The room background had a fast neutron energy of  $1.00 \pm 0.25$  Mev, with a reasonably large contribution from scattered neutrons. A 110 gram sample of  $\text{PuF}_4$  gave a dose rate reading of about 9 mrem/hr at a distance of 30 cm, which corresponds to a neutron yield of  $8.0 \times 10^5$  n/sec. The room background was about 0.5 mrem/hr.

Neutrons originating in the  $\text{PuF}_4$  processing equipment were measured with the 10 inch sphere neutron survey instrument. Comparable readings were obtained with the converted PeeWee neutron survey instrument by using a correction factor of 30, or a fast neutron energy of 0.5 or 0.4 Mev. Either of these factors enables a monitor to obtain a more accurate dose rate with the PeeWee than was previously possible.

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## Chapter 1

### AN ENERGY MEASUREMENT OF $\text{PuF}_4$ NEUTRONS

#### 1.1 Introduction

Neutrons emitted from a sample of  $\text{PuF}_4$  as a result of the alpha-neutron reaction are reported to have an average neutron energy of 1.4 Mev.<sup>1</sup> If the amount of moderation of neutrons in the sample is small, the result will be a neutron spectrum showing little or no contribution from scattered neutrons. The multisphere neutron detector technique can be used to determine the extent of moderation, and the changes in the spectrum due to neutron scattering in the  $\text{PuF}_4$  processing equipment room.

The neutron dose delivered by neutrons is determined by the neutron energy. To evaluate the health hazard from neutron exposure to  $\text{PuF}_4$ , the neutron energy spectrum of  $\text{PuF}_4$  was studied. The neutron background in the  $\text{PuF}_4$  processing area consists of many multiscattered neutrons and neutrons direct from the source, resulting in a considerable change in the neutron spectrum. To evaluate the dose rate delivered by  $\text{PuF}_4$  and by the room-scattered neutrons, separate

evaluations of the neutron energy spectra were made.

### 1.2 Procedure

A sample of  $\text{PuF}_4$  was removed from the glove box and placed near the center of the room, about 4 feet from the floor and 30 cm from the multisphere neutron counter. The sample contained 110 grams of Pu and was approximately  $3/4$  inch deep in a 500 ml plastic flask. Using the complete series of spheres, data were taken on the  $\text{PuF}_4$  sample. Since the room background is significant, a set of data was obtained for the room background in the same location after the  $\text{PuF}_4$  sample was removed. For each sphere the counting rate was obtained from the room background and subtracted from the counting rate with the  $\text{PuF}_4$  in position. Both sets of data were analyzed using the technique described in IDO-16655.<sup>2</sup>

By use of a single 10 inch sphere with the multisphere neutron counter,<sup>3</sup> data were also obtained for the  $\text{PuF}_4$  sample and for the room background. A third check of the room background was made with a semi-portable 10 inch sphere neutron survey instrument.

### 1.3 Results

The  $\text{PuF}_4$  sample resulted in an average neutron energy of  $1.25 \pm 0.25$  Mev, with essentially no contribution from scattered neutrons. The percentage of scattered neutrons is very close to that obtained with a source in the same type geometry. Table I shows that the  $\text{PuF}_4$  dose rate is about 9 mrem/hr, which corresponds to a point source of

about  $8.0 \times 10^5$  n/sec at this distance.

TABLE I  
Neutron Dose Rate from  $\text{PuF}_4$  and Room Background

Detector	Dose rate, $\text{PuF}_4$ , <sup>a</sup> mrem/hr	Dose rate, room bkg., mrem/hr
Multisphere counter	9.0	0.42
10 in. sphere	9.4	0.61
10 in. sphere survey instrument		$\sim 0.5$ <sup>b</sup>

<sup>a</sup>The  $\text{PuF}_4$  sample contained 110 grams of Pu. The center of the sample was 30 cm from the center of the detector.

<sup>b</sup>Because of statistical fluctuations in the meter, this reading is only approximate.

The room background had an average fast neutron energy of  $1.00 \pm 0.25$  Mev with a considerable contribution from scattered neutrons. The calculated dose rates were: fast neutrons - 0.28 mrem/hr, intermediate energy neutrons - 0.13 mrem/hr, and thermal neutrons - 0.01 mrem/hr.\* The single sphere technique gave a total dose rate slightly higher than the multisphere technique (see Table I). When scattered

\* Neutron energies are:  
Thermal = thermal to 0.4 ev  
Intermediate = 0.4 ev to  $\sim 100$  kev  
Fast =  $\sim 100$  kev to 7 Mev

neutrons become appreciable, the dose rate readings for the 10 inch single sphere are always higher than the multisphere technique because of the overestimate of scattered neutron dose rate inherent in the single sphere technique.

#### 1.4 Conclusion

The neutron energy of the fast neutrons ( $1.25 \pm 0.25$  Mev) agrees quite well with an expected neutron energy of 1.4 Mev. The  $\text{PuF}_4$  sample appears to be reasonably free of moderated neutrons. The estimated neutron exposure rate at the surface of the flasks used in this experiment is  $\sim 500$  mrem/hr, using inverse square calculations. (This sample contained only 110 grams of Pu; larger samples would have higher surface dose rates.)

Neutron sources of  $8.0 \times 10^5$  n/sec are handled with great care to avoid unnecessary exposure, and these  $\text{PuF}_4$  samples should be handled with the same degree of care. The room background does not appear to present a problem.

## Chapter 2

### DETERMINATION OF THE NEUTRON DOSE RATE FROM THE PUF<sub>4</sub> PROCESSING EQUIPMENT

#### 2.1 Introduction

The converted PeeWee neutron survey instrument has been in use at Los Alamos for many years with considerable success. To interpret the readings obtained with fast neutrons, it is necessary to know the average energy of these neutrons.<sup>4</sup> If this information is not known, an estimated average fast neutron energy must be applied to the readings. To facilitate obtaining more accurate neutron dose rate information at Room 501, DP West Site, a study was made of the neutron dose rate as determined by the 10 inch sphere neutron survey meter.<sup>3</sup> The response of the converted PeeWee instrument was then compared to these readings, and a correction factor calculated for application to future readings in this room with the converted PeeWee instrument. The average fast neutron energy to be applied to readings taken in this room was also determined.

The converted PeeWee used in this experiment was a Model 48A PeeWee proportional alpha instrument modified for use with a boron-lined

probe. All readings in this report were made with a 1 inch thick cylindrical polyethylene moderator over the probe. A 20 mil cadmium absorber was placed over the polyethylene moderator to reduce the thermal response.

## 2.2 Results

The neutron survey was made in the aisle between the  $\text{PuF}_4$  processing equipment and the outside wall. Four points were selected: three points were approximately 2 feet, and one point was approximately 3 feet from the outer stainless steel shell of the processing equipment (see Fig. 1). The points at 2 feet were chosen to give neutron fluxes and dose rates of decreasing intensity. The 10 inch sphere survey instrument was used as the standard for the neutron dose rate at each point. When the scattered neutrons become appreciable, this instrument indicates dose rates which are higher than the actual dose rate. Since there is very little scattering material between the source and the detector, the relative abundance of scattered neutrons is probably small enough to result in an overestimate of not more than 10% in the neutron dose rate determined by the 10 inch sphere technique.

Table II shows the data obtained. Note that the assumption of an average energy of 0.4 Mev gives results comparable to the 10 inch sphere reading. An average energy of 0.5 Mev results in a slight overestimate of the dose rate. The dose rate obtained by dividing the neutron flux determined with the converted PeeWee by a correction factor of 30 is also found to be quite accurate.

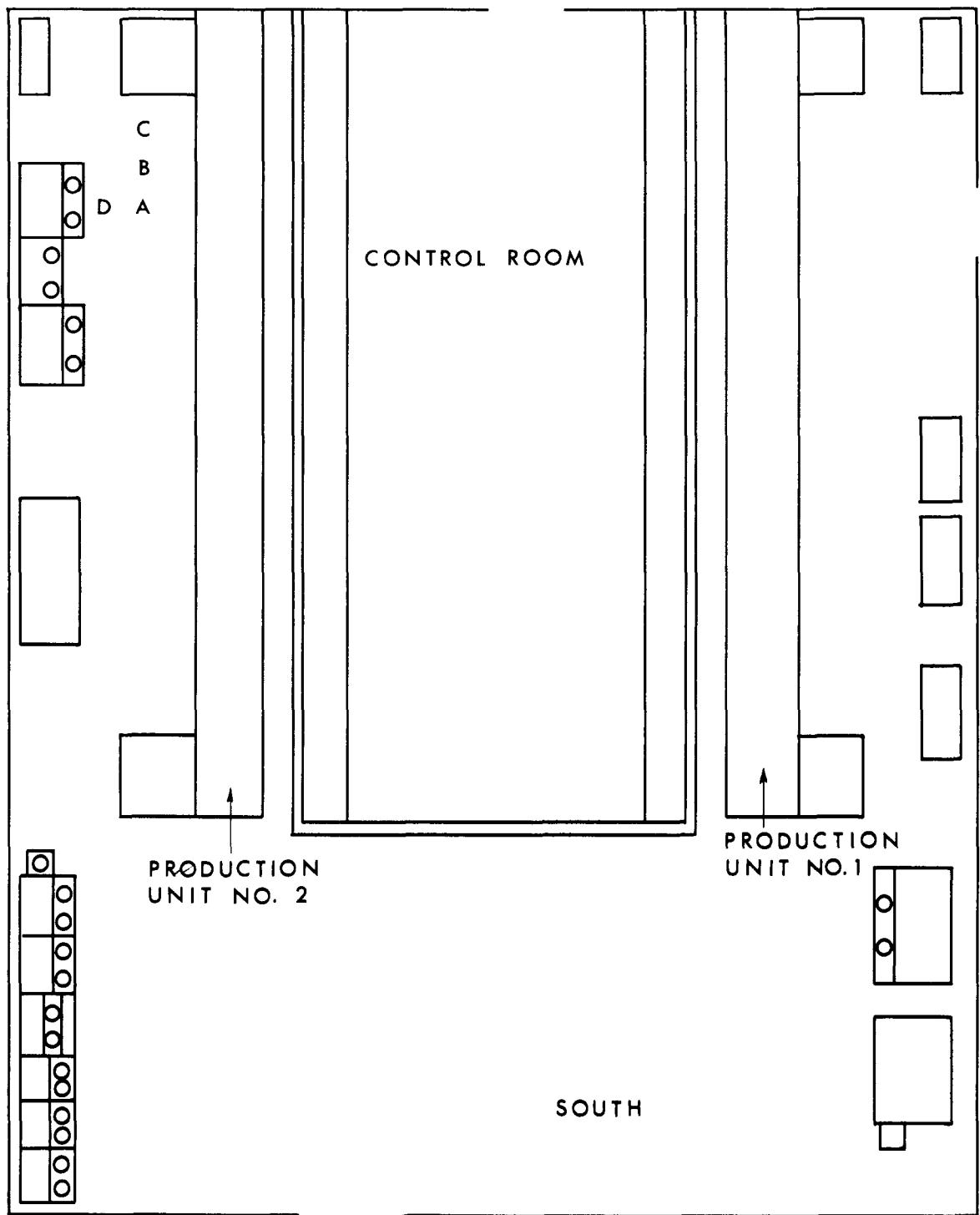


Fig. 1. Survey locations in Room 501, DP West Site

TABLE II

Determination of Correction Factor

Area	Converted PeeWee instrument					10 inch sphere instrument dose rate, mrem/hr
	Initial reading, n/cm <sup>2</sup> /sec	Dose rate, mrem/hr				
		Assuming 1.0 Mev	Assuming 0.5 Mev	Assuming 0.4 Mev	n/cm <sup>2</sup> /sec ÷30*	
A	250	17	9.5	8.1	8.3	8
B	205	14	7.8	6.6	6.8	7
C	145	10	5.5	4.6	4.8	5
D	120	8.2	4.6	3.9	4.0	3.5

\* Correction factor = 30.

### 2.3 Conclusion

The converted PeeWee instrument can be used reasonably accurately to make surveys in this room by assuming a 0.5 or 0.4 Mev average fast neutron energy. To be on the safe side, 0.5 Mev should be used. The converted PeeWee can also be used quite accurately by dividing the indicated n/cm<sup>2</sup>/sec by the factor 30. For quick routine surveys the latter method is preferred. It must be pointed out that the correction factors 30 or 0.5 Mev given in this report apply only for the neutrons coming from this processing equipment and are not to be used for other sources of neutrons or other areas.

An uncorrected closed window GM reading of about 0.5 mr/hr was

obtained at Area A (see Fig. 1). Since the correction factor is not readily known, no assumptions or conclusions are drawn from this. However, additional studies of the gamma to neutron dose rate ratio are planned.

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