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MASTER

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SUBJECT: BREMSSTRAHLUNG ABSORPTION MEASUREMENTS FROM $Sr^{90}TiO_3$

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ABSTRACT

The absorption in lead of Bremsstrahlung X radiation from a $Sr^{90}TiO_3$ pellet in the proximity of Hastelloy "C" was measured. The tenth value layer of the more energetic components of the X-ray continuum was determined to be 1.60 inches.

INTRODUCTION

The application of thermoelectric power conversion devices powered by the thermal energy available from the beta decay of Sr^{90}-Y^{90} is being investigated. The Sr^{90}-Y^{90} fuel unit is to be composed of sintered pellets of $Sr^{90}TiO_3$ encapsulated in Hastelloy "C". Lead will be used in the biological shield. Nuclear gamma radiation is not present in this decay sequence; however, Bremsstrahlung X rays are generated within the titanate pellet and the Hastelloy "C" capsule. The absorption of this radiation in lead was measured to obtain data for the design of the shield.

EXPERIMENTAL

The physical arrangement that was used to simulate the conditions to be encountered in the power conversion unit is shown in Figure 1. The radioactive pellet contained 1,000 curies of Sr^{90} in 65 grams of titanate powder which had been compacted and sintered to a specific gravity of ~ 4.5. The only radioactive contamination was Ce^{144} which amounted to 305 millicuries at the time of the absorption experiment.

A Cutie Pie Model 740 (Victoreen Instrument Company) and a Survey Meter No. 2610A (Nuclear Instrument and Chemical Company) were used to measure the gamma field. These instruments were calibrated by the ORNL Health Physics Division using standardized radium gamma sources. The results of two absorption studies made under slightly different conditions are given on the following pages.

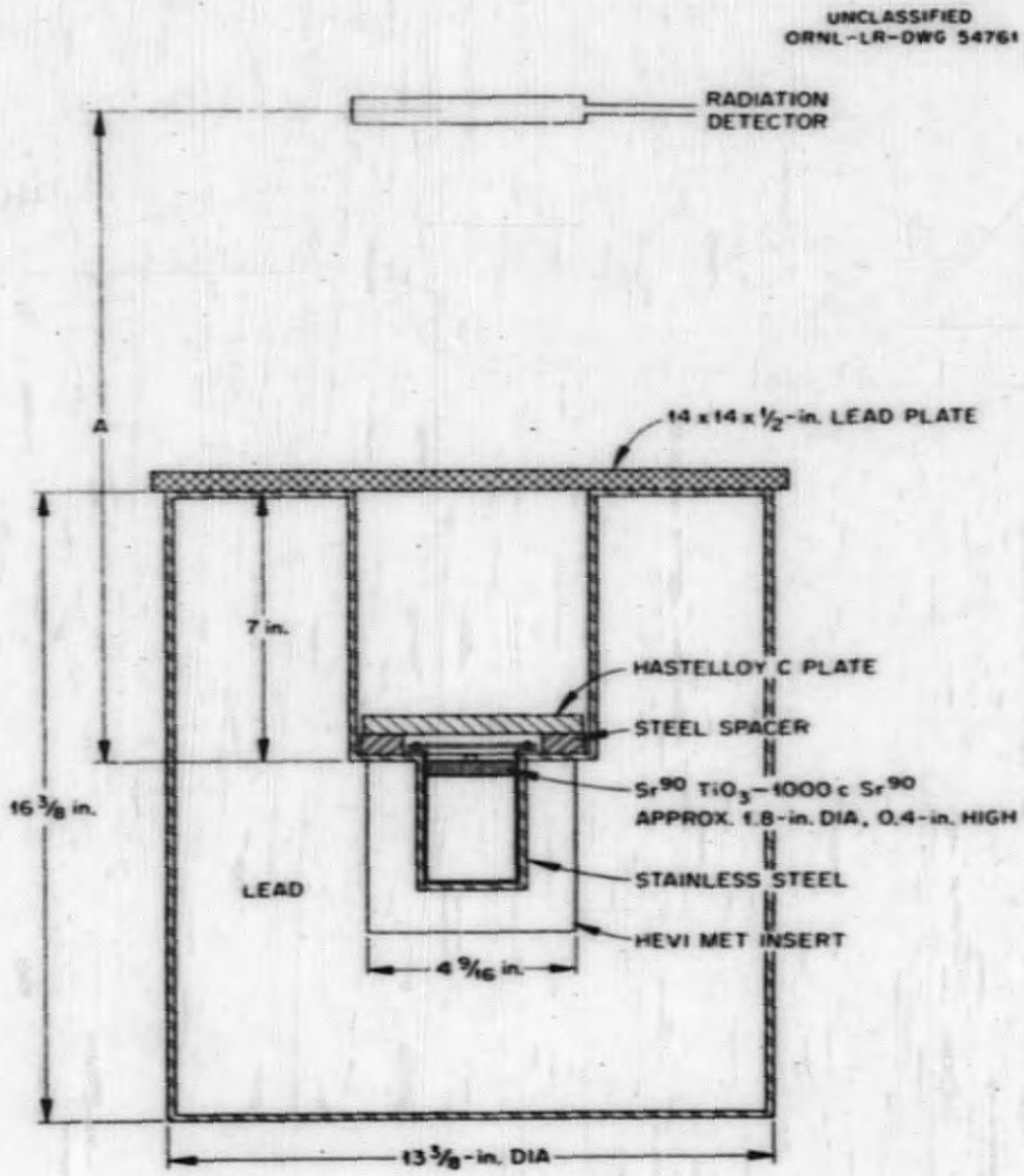
UNCLASSIFIED
ORNL-LR-DWG 54761
RADIATION DETECTOR
A
14 x 14 x ½-in. LEAD PLATE
7 in.
HASTELLOY C PLATE
STEEL SPACER
Sr^{90} TiO_3—1000 c Sr^{90}
APPROX. 1.8-in. DIA, 0.4-in. HIGH
16 3/8 in.
LEAD
STAINLESS STEEL
HEVI MET INSERT
4 9/16 in.
13 3/8-in. DIA

Fig. 1

Case I A = 16.375 in., Hastelloy "C" = 0.125-in. thick.

Lead (in.)	Cutie Pie (mr/hr)	Survey Meter (mr/hr)
0.5	3800	
1.0	1175	
1.5	410	
2.0	160	
2.5	72	
3.0	32	
3.5	14	
4.0		6.85
4.5		3.45
5.0		1.20
5.5		0.60
6.0		0.30
6.5		0.11

The tenth value layer for lead in Case I is 1.63 in. and the half value layer is 0.49 in. The data are plotted in Figure 2.

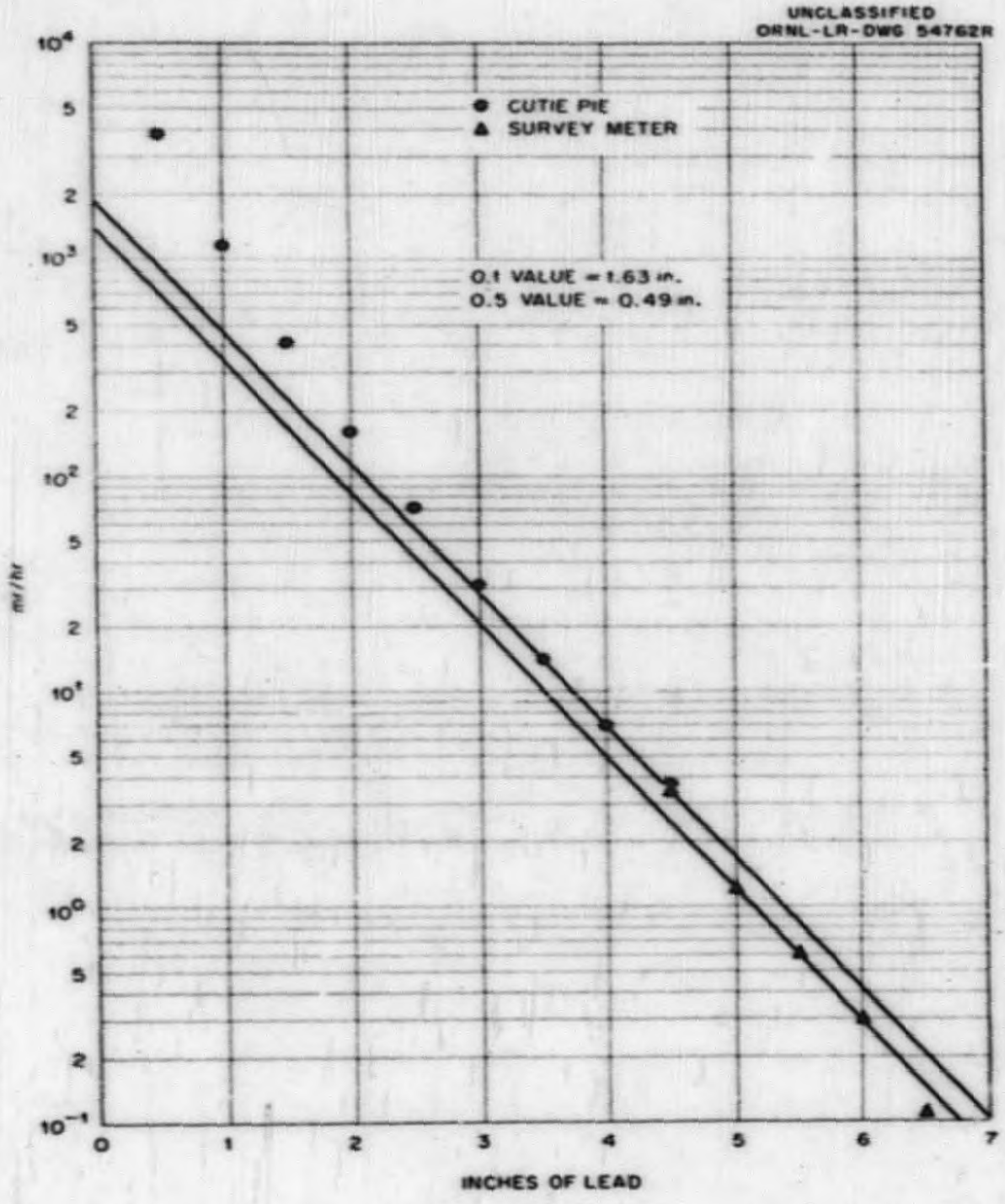
UNCLASSIFIED
ORNL-LR-DWG 54762R
CUTIE PIE
SURVEY METER
0.1 VALUE = 1.63 in.
0.5 VALUE = 0.49 in.
mr/hr
INCHES OF LEAD

FIG. 2

Case II A = 19.25 in., Hastelloy "C" = 0.5-in. thick.

Lead (in.)	Cutie Pie (mr/hr)	Survey Meter (mr/hr)
0.5	2000	
1.0	570	
1.5	210	
2.0	85	
2.5	35	
3.0		18.85
3.5		9.15
4.0		4.55
4.5		1.60
5.0		0.81
5.5		0.38
6.0		0.18

The tenth value layer for lead in Case II is 1.56 in. and the half value layer is 0.47 in. The data are plotted in Figure 3.

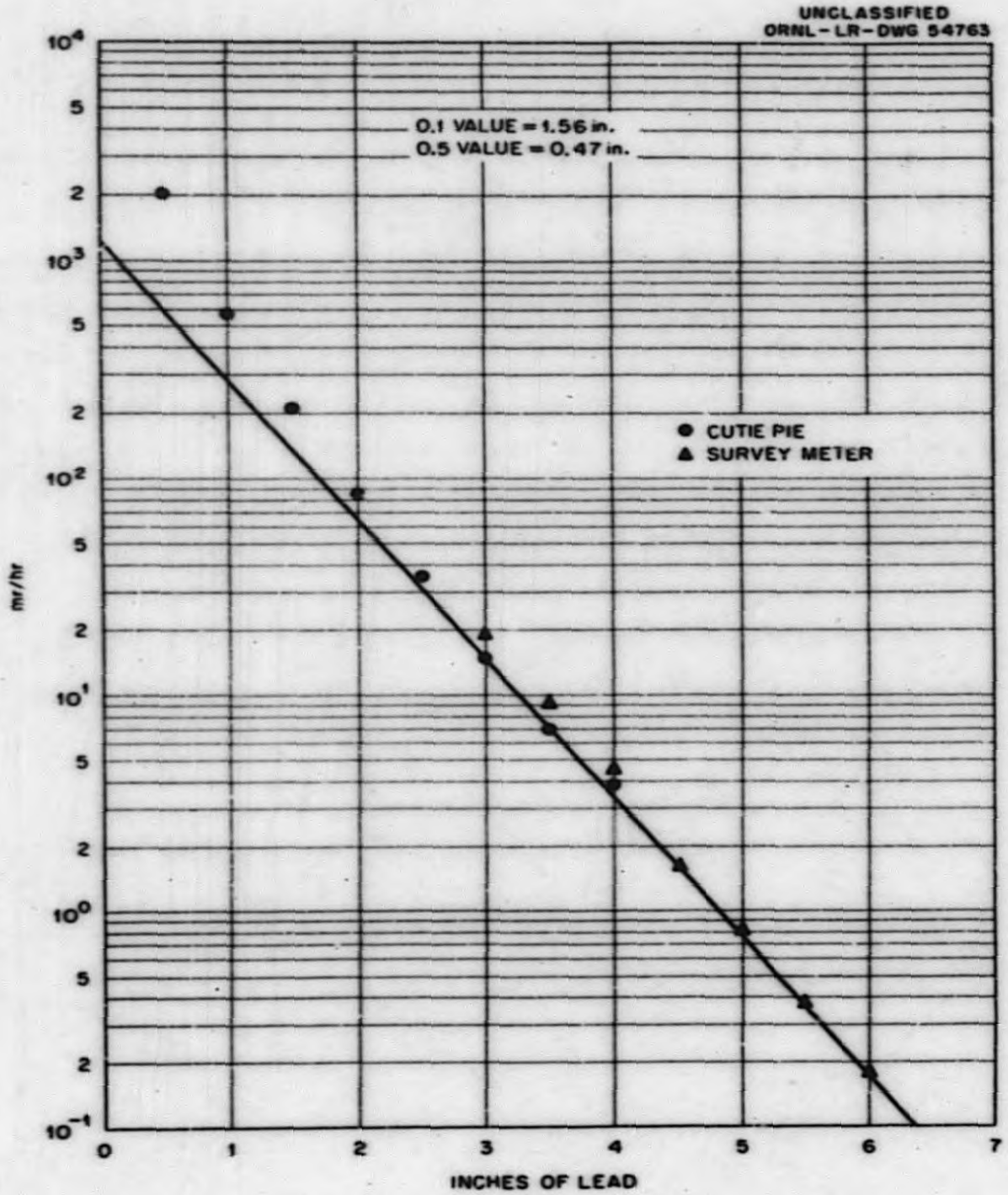
UNCLASSIFIED
ORNL-LR-DWG 54763
0.1 VALUE = 1.56 in.
0.5 VALUE = 0.47 in.
CUTIE PIE
SURVEY METER
mr/hr
INCHES OF LEAD

FIG. 3

DISCUSSION

It is evident that the 0.5-in. Hastelloy "C" plate above the Sr^{90} source (Case II), rather than 0.125 in. as in Case I, has very little if any effect on the Bremsstrahlung spectrum. The more energetic components of the X-ray continuum resulted in a lead absorption coefficient characteristic of a 1.25 Mev gamma ray. The observed tenth value layer for the absorption of this high energy component was 1.63 in. of lead in the case of the 0.125-in. plate and 1.56 in. of lead in the case of the 0.5-in. plate. The radiation from the 1,000-curie pellet was 57.8 mr/hr at 41.6 cm from the pellet through 2.6 in. of lead shielding, which is equivalent to 10 mr/hr at one meter from the pellet.

The contribution of the 305 millicuries of Ce^{144} to the high-energy Bremsstrahlung component was calculated. The only significant contributions are made by the Pr^{144} daughter, and are as follows:

0.8%	-	2.18 Mev gamma
0.25%	-	1.48 Mev gamma
27.0%	-	1.0 Mev X ray (from 3.0 Mev beta)

The calculated reading at one meter through 2.6 in. of lead due to these three factors is 0.25 mr/hr.

END