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ATTENUATION OF BETA RADIATION WITH "ABC COCOON" AND "G.E. COCOON" (STRIPPABLE PLASTIC FILMS)

C. D. Watson, G. A. West, J. C. Suddath

DATE ISSUED: OCT 12 1950

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1.0 Abstract

The thicknesses of ABC (lead-filled) Cocoon and G. E. Cocoon (strippable disposable plastic films) required for essentially complete attenuation of beta radiation from radioactive phosphorus (P^{32}) and iodine (I^{131}) have been determined and compared to a reference material, lead sheet.

2.0 Introduction

The Unit Operations Section of the Chemical Technology Division has used, in appropriate instances, G. E. strippable plastic Cocoon* to protect surfaces from radioactive contamination and to furnish upon "stripping" a convenient means of decontamination. Recently, a new type strippable Cocoon containing powdered lead and called ABC Cocoon was marketed with the added feature of shielding radiation, especially beta radiation.

A five gallon sample quantity of ABC Cocoon was obtained and shielding measurements made with β radiation sources, iodine, I^{131}, and phosphorus, P^{32}.

This paper reports the attenuation of β radiation from I^{131} and P^{32} with ABC Cocoon as compared to G. E. Cocoon and lead sheet. Other investigations are planned, using very old mixed fission products.

3.0 Summary

The thicknesses of ABC (lead-filled) Cocoon and G. E. Cocoon (strippable disposable plastic films) required for essentially complete attenuation of β radiation from approximately 0.4 millicuries of radioactive phosphorus (P^{32}) and 1 millicurie of iodine (I^{131}) have been determined and compared to a reference material, lead sheet. The required thicknesses were:

* R. M. Hollingshead Corporation, Camden, New Jersey.

Summary (continued)

Radiation Source	Radiation Level Mrep/hr.		Thickness of Shielding Media Required in Mils		
	Initial	Final	Lead	ABC Cocoon	G. E. Cocoon
P^{32} β, 1.7 mev 0.4 millicurie	10,500	1	16	148	289
I^{131} β, 0.6 mev γ, 0.37 mev 1 millicurie	2,400	7	8	68	120

One mil of ABC Cocoon (dried film density, 1.43 grams/cu. cm.*) in the tests was equivalent in shielding to approximately 2 mils of G. E. Cocoon (dried film density, 0.75 grams/cu. cm.) and to approximately 0.087 mils of lead sheet (11.34 grams/cu. cm.) - see Figure 1, Figure 2 and Table 1.

For shielding P^{32} radiation, the material cost of ABC Cocoon is from $0.10 to $0.20/sq. ft. cheaper than G. E. Cocoon - see Figure 3. The two types of cocoon are approximately equal in material cost for shielding I^{131} - see Figure 4.

A material cost comparison with lead sheet follows:

* As shipped, ABC Cocoon is stated to produce a dried film density of 2.5 grams/cu. cm. Inadequate agitation was probably responsible for the lower density actually obtained.

Summary (continued)

Source	ABC Cocoon	G. E. Cocoon	Lead Sheet*
P^{32}	$1.11/sq. ft.	$1.36/sq. ft.	$0.30/sq. ft.
I^{131}	$0.51/sq. ft.	$0.48/sq. ft.	$0.30/sq. ft.

It was estimated that total costs (including labor plus overhead) for applying sufficient ABC or G. E. Cocoon for complete attenuation would be:

Source	ABC Cocoon	G. E. Cocoon
P^{32}	$1.59/sq. ft.	$2.64/sq. ft.
I^{131}	$ 0.75/sq. ft.	$1.02/sq. ft.

A "break down" of these costs are presented in Table II.

Equal weights of the shielding media did not provide equal amounts of radiation shielding - see Figure 5 and Figure 6. On a weight basis, G. E. Cocoon appears to shield radiation from the I^{131} source more efficiently than lead or ABC Cocoon over the range 100 to 250 gm/sq. ft. - see Figure 6. This is probably caused by distance (thickness) from the source material, rather than actual absorption.

* 1/32" thick lead sheet costs $0.30/sq. ft. This thickness is more than is necessary for complete attenuation, but it is cheaper than lead foil less than 16 mils thick.

Summary (continued)

Both types of cocoon, when wet sprayed on thoroughly dried patches of P^{32} and I^{131} solutions proved to be poor shielding media because activity was transmitted to their outer dried layers by the solvent carrier necessary for spray gun applications. For this reason, data summarized herein were determined with pre-sprayed and dried cocoon sheets stripped from Masonite boards.

4.0 Experimental

Prefabricated dried sheets of each type cocoon were prepared prior to the shielding tests on masonite boards. (This was necessary because wet (with solvent) films of cocoon in contact with dried P^{32} or I^{131} sources transmit substantial portions of such activity to their outer layers.)

Cocoon sheets were prepared as follows:

Type	Average Size	Average Thickness	Average Weight
ABC Cocoon	7" x 7"	11.4 mils thick	38.5 grams/ft.^{2}
G. E. Cocoon	7" x 7"	8.5 mils thick	15 grams/ft.^{2}

Experimental (continued)

A typical testing procedure included:

(1) Application of liquid source material P^{32} (10,500 Mrep/hr.) and I^{131} (2,400 Mrep/hr.) to separate metal placques 6" x 6", followed by drying in a hood.

(2) Determination of dried activity radiation levels with a "paper shell cutie pie", and/or Victoreen.*

(3) Determination of attenuation obtained with various thicknesses of each type of cocoon and lead sheet.

5.0 Discussion

The attenuation of the P^{32} and I^{131} radiation sources by ABC and G. E. Cocoon** is compared with lead sheet in Figure 1 and Figure 2. These data are presented in a Data Summary Sheet, Table 1.

The P^{32} radiation was reduced from 10,500 Mrep/hr. to 16 Mrep/hr. with 114 mils of ABC Cocoon and to approximately 1 Mrep/hr. by 150 mils; 228 mils of G. E. Cocoon were required to reduce the same radiation source to 16 Mrep/hr., and 288 mils were required to reduce the radiation to approximately 1 Mrep/hr. See Figure 1.

* Radiation instruments used for monitoring areas subject to contamination.

**Physical property data are compared in Table III.

Discussion (continued)

The I^{131} radiation was reduced from 2,400 Mrep/hr. to 16 Mrep/hr. with 46 mils of ABC Cocoon and to 7 Mrep/hr. with 69 mils. Additional sheets did not appreciably reduce the reading below 7 Mrep/hr. evidently because of the gamma radiation present. The G. E. Cocoon reduced the I^{131} from 2,400 Mrep/hr. to 16 Mrep/hr. when 68 mils were applied and to approximately 7 Mrep/hr. when 102 mils were applied. See Figure 2.

A comparison was made using lead foil, 2 mils thick. Eight sheets (16 mils, total) of lead reduced the P^{32} beta radiation to approximately 1 Mrep/hr., and four sheets (8 mils, total) were required for complete attenuation (approx. 7 M rep) of the beta radiation from the I^{131} source.

6.0 Conclusions and Recommendations

ABC Cocoon and G. E. Cocoon are capable of essentially completely attenuating the β radiation source P^{32} (10,500 Mrep/hr.) and I^{131} (2,400 Mrep/hr.).

In the tests, ABC Cocoon (dried film density 1.43 grams/cc.) was shown to be equivalent in shielding for the P^{32} source to approximately 2 mils of G. E. Cocoon and 0.087 mils of lead sheet; however, should it be possible to realize a dried film density of 2.5 grams/cc., as stated by the vendor, these figures would be approximately doubled. This would not affect material cost of ABC Cocoon per gallon, but would mean that approximately twice as much shielding would be realized at the same cost.

Conclusions and Recommendations (continued)

Lead sheet (1/32") will shield the same radiation sources at approximately one-fourth and three-fifths the material cost of ABC and G. E. Cocoon, respectively.

It is not possible to predict accurately the usefulness of ABC Cocoon for shielding β radiation generally because each application presents different problems. However, ABC Cocoon can be applied very easily with a spray gun technique which is an advantage over lead sheet in overlaying or shielding irregularly shaped objects. In addition, the strippable properties of ABC Cocoon provides a convenient method of decontamination.

Further investigations of ABC Cocoon is warranted, especially if dried film densities of 2.5 grams/cc can be realized. However, it appears now that ABC Cocoon is definitely superior to common maintenance paints and somewhat better than G. E. Cocoon for coating surfaces subject to contamination with β activity.

The usefulness of ABC Cocoon for coating large solution carriers will be investigated with the hope that very old activities of the level - 5 mr/hr - 10 mr/hr may be successfully shielded out by this means to meet Interstate Commerce Commission regulations.

FIGURE 1

Attenuation of P^{32} Radiation with ABC Cocoon,

G. E. Cocoon and Lead Foil

Mrep/hr. Versus Thickness of Absorber in Mils

Radiation Source: P^{32} (β - 1.7 mev), 10,500 Mrep/hr.

△ - ABC (Lead Filled) Cocoon
⊙ - G. E. Cocoon
□ - Lead Foil

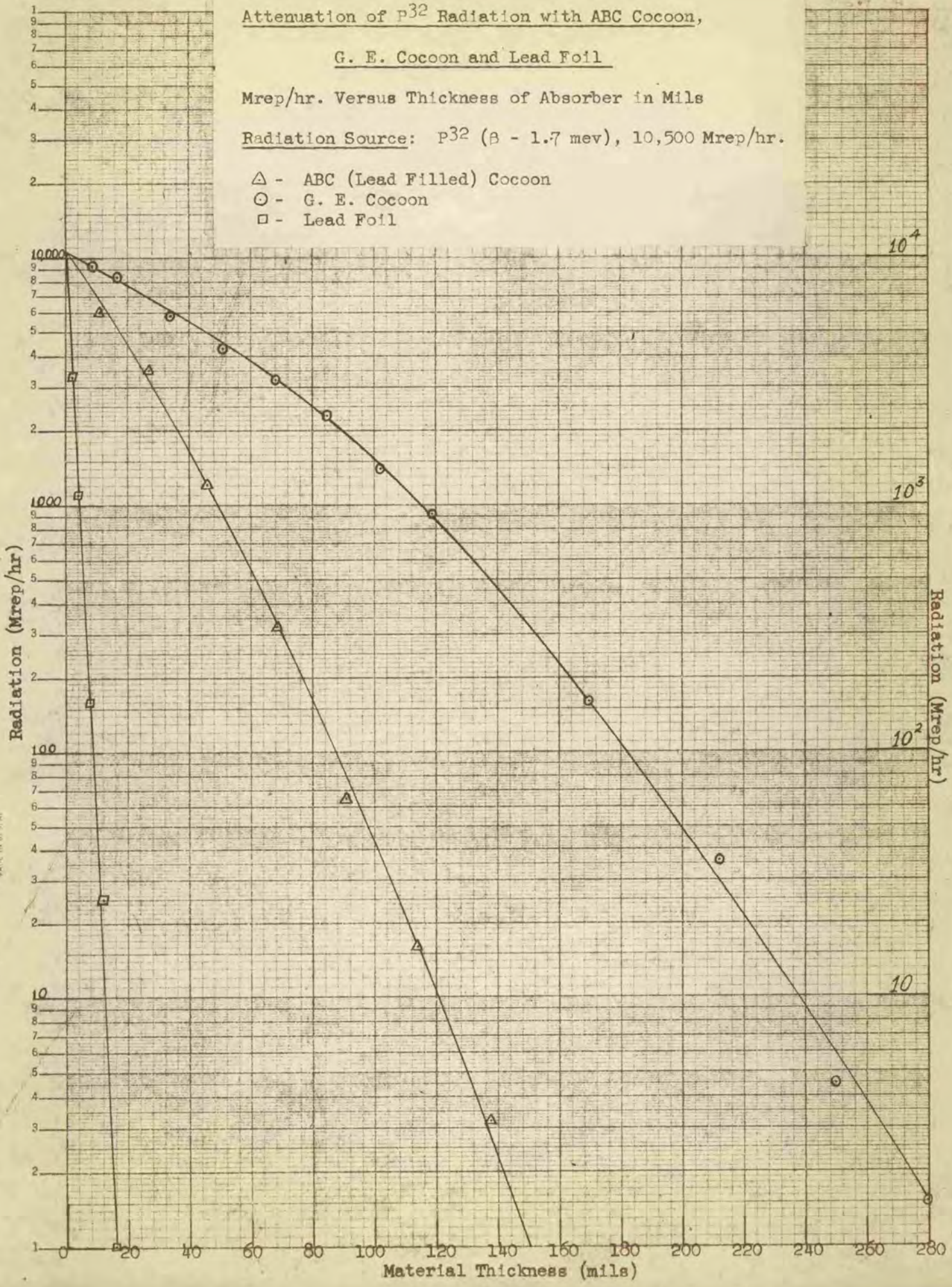

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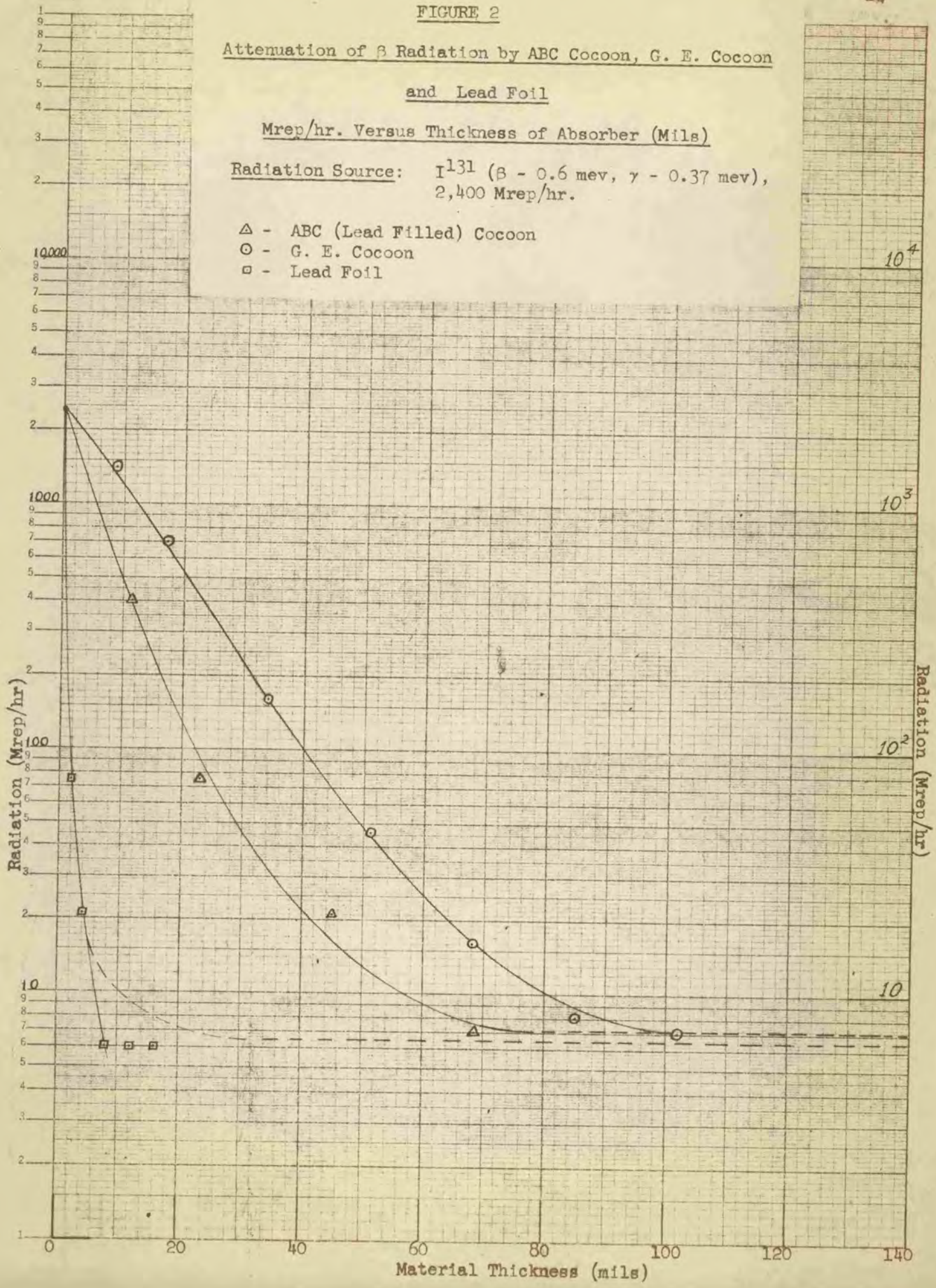
FIGURE 2

Attenuation of β Radiation by ABC Cocoon, G. E. Cocoon and Lead Foil

Mrep/hr. Versus Thickness of Absorber (Mils)

Radiation Source: I^{131} (β - 0.6 mev, γ - 0.37 mev), 2,400 Mrep/hr.

△ - ABC (Lead Filled) Cocoon
⊙ - G. E. Cocoon
▫ - Lead Foil



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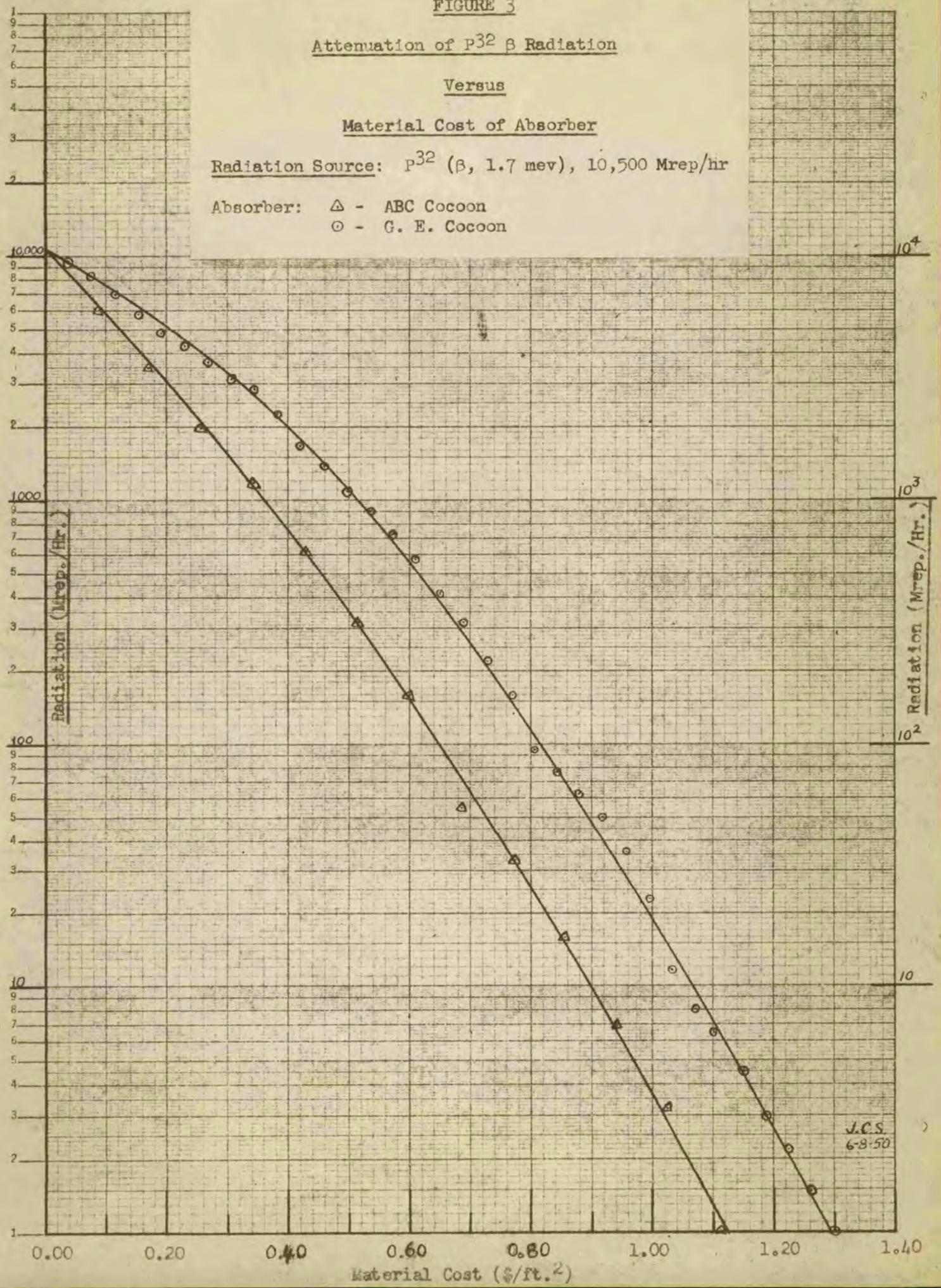

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FIGURE 4

Attenuation of I^{131} β Radiation

Versus

Material Cost of Absorber

Radiation Source: I^{131} (β - 1.7 mev), 2,400 Mrep/hr.

Absorber: △ - ABC Cocoon
⊙ - G. E. Cocoon

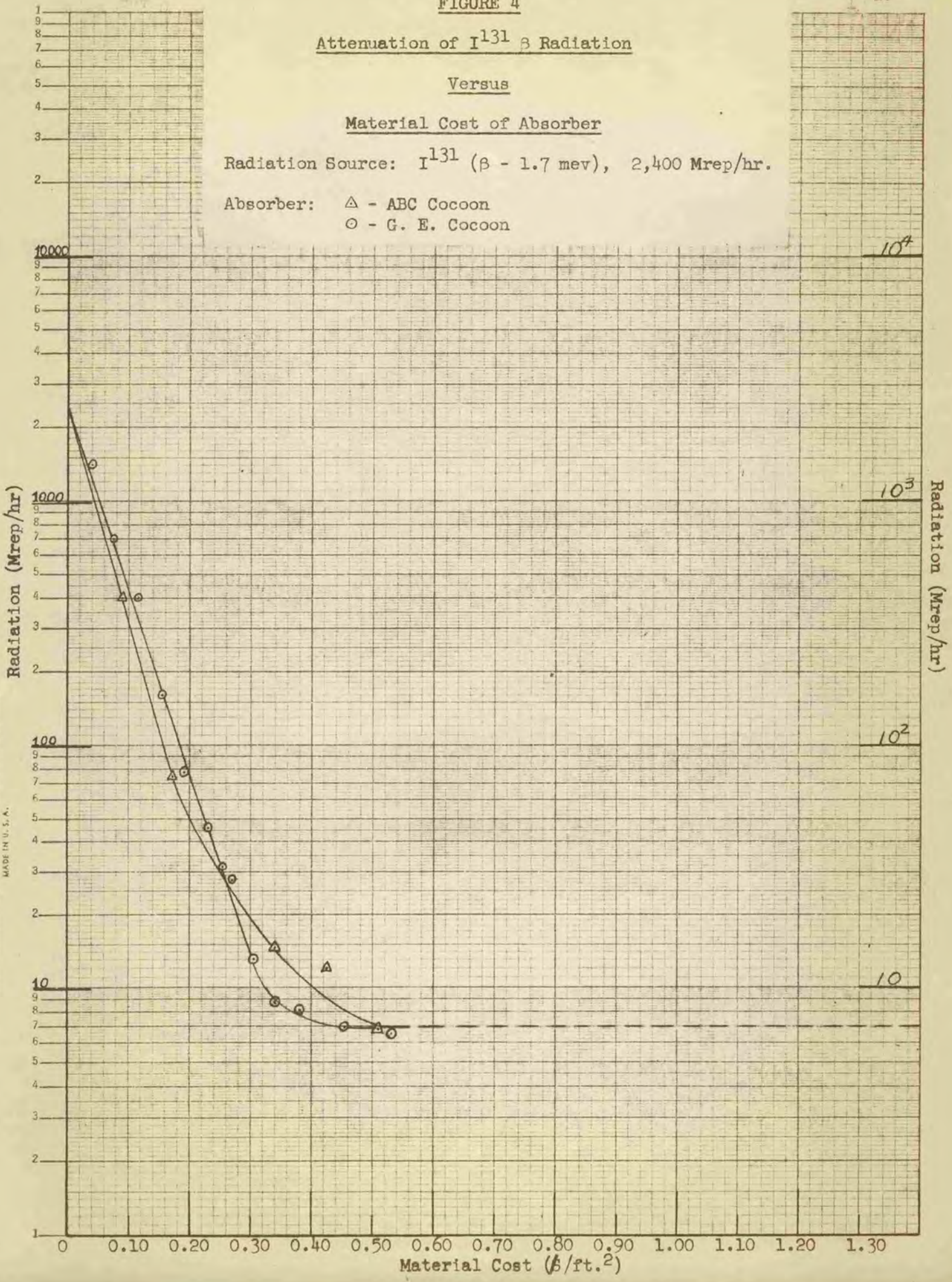

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FIGURE 5

Attenuation of P^{32} β Radiation by ABC Cocoon,

G. E. Cocoon and Lead Sheet

Radiation (Mrep/hr.) Versus Weight of Absorber (gms/sq. ft.)

Radiation Source: P^{32} (β - 1.7 mev), 10,500 Mrep/hr.

Absorber: Δ - ABC (Lead Filled) Cocoon
⊙ - G. E. Cocoon
⊡ - Lead Foil

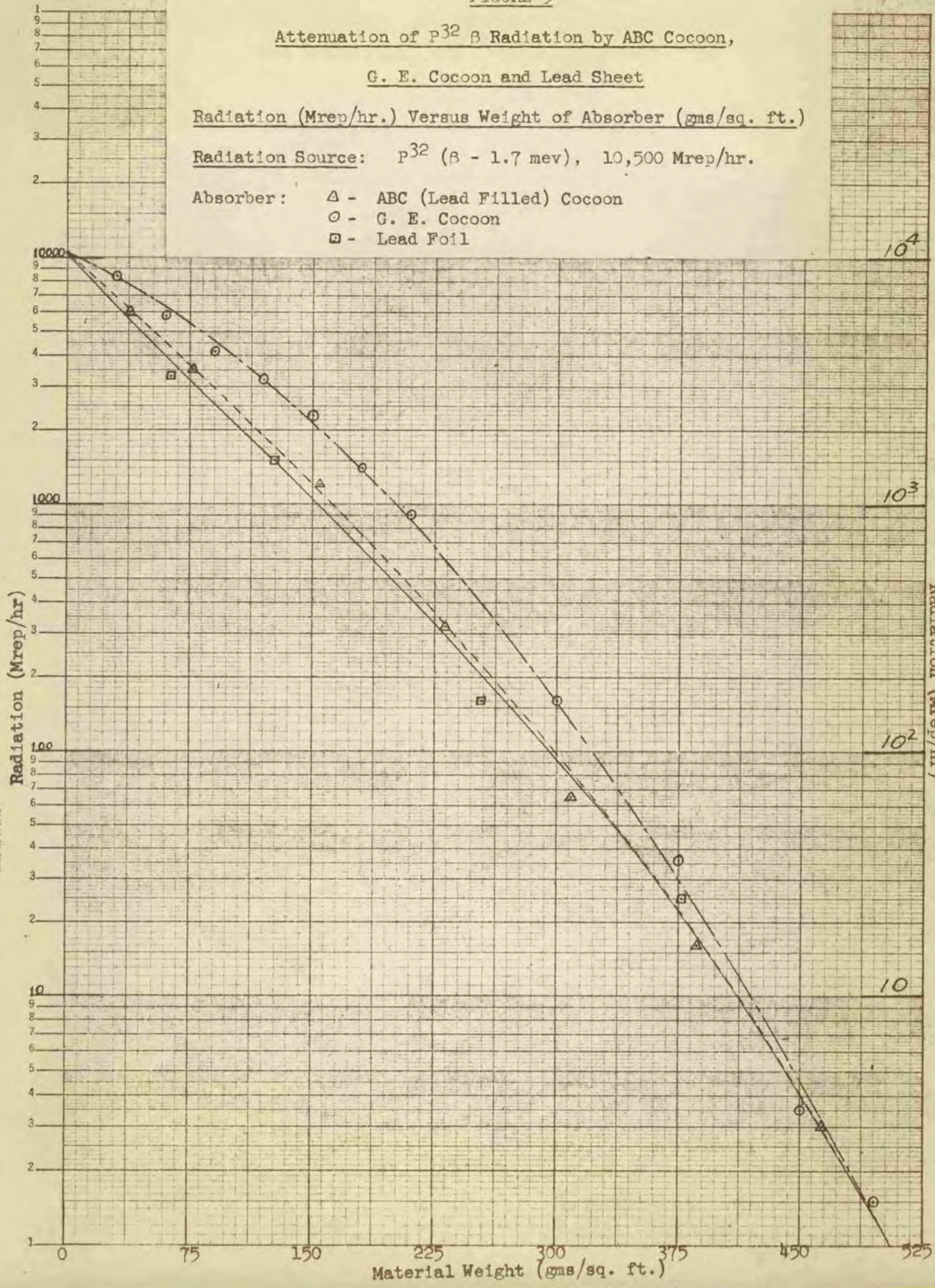

FIGURE 6

Attenuation of I^{131} β Radiation by ABC,

G. E. Cocoon and Lead Sheet

Radiation (Mrep/hr.) Versus Weight of Absorber (gms/sq. ft.)

Radiation Source: I^{131} (β - 0.6 mev, γ - 0.37 mev), 2,400 Mrep/hr.

Absorber - △ - ABC (Lead Filled) Cocoon
⊙ - G. E. Cocoon
⊡ - Lead Foil

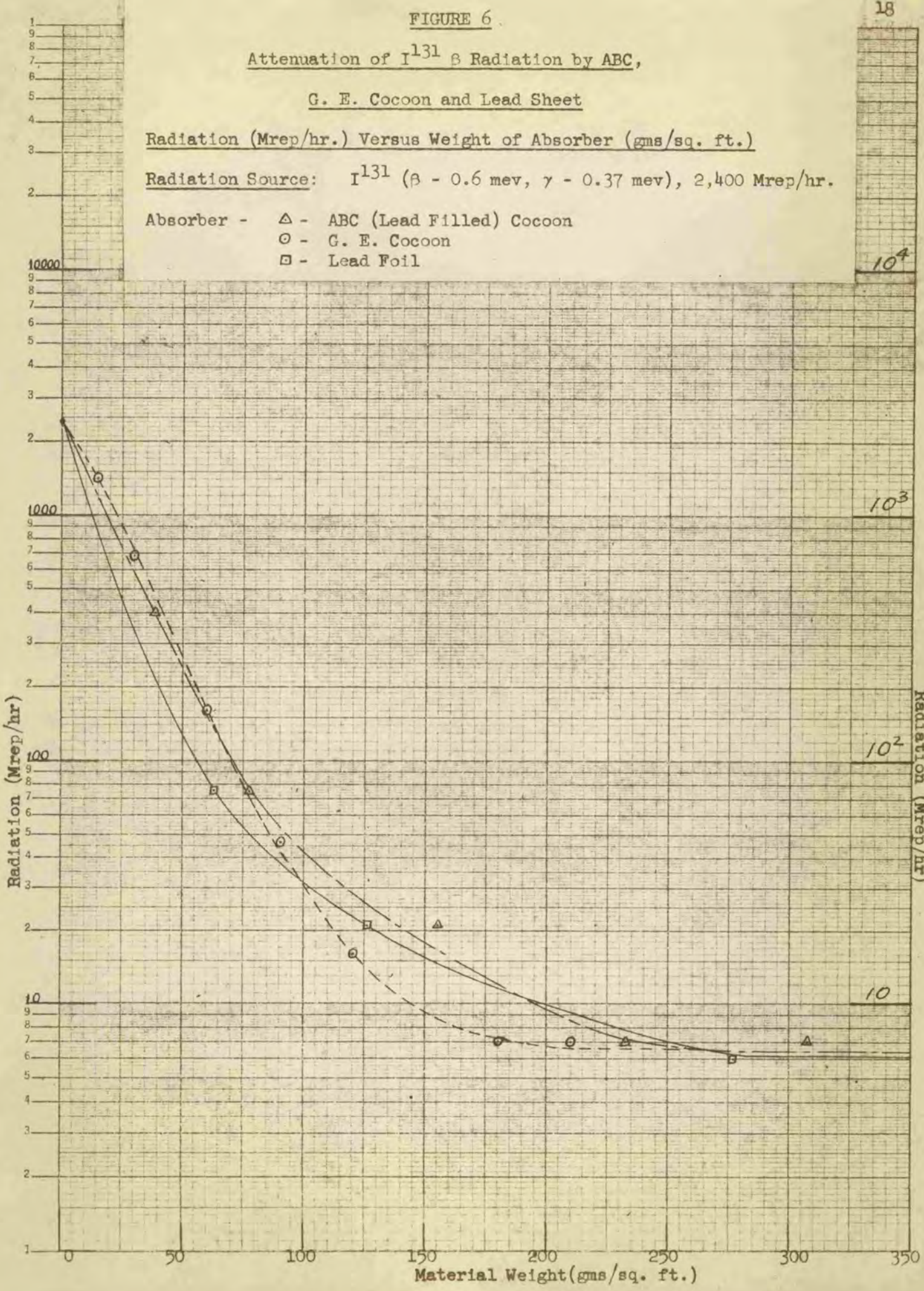

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Table I

DATA SUMMARY SHEET

Attenuation of Beta Radiation by Strippable ABC and G. E. Plastic Cocoon Compared with Lead Foil

Conditions: Radiation sources, P^{32}, β - 1.7 mev, 10,500 M rep/hr. (0.4 millicurie)
I^{131}, β - 0.6 mev, γ - 0.37 mev, 2,400 M rep/hr. (1.0 millicurie)
Shielding Media: lead foil - density, 11.34 grams/cu. cm.
ABC Cocoon - dried film density, 1.43 grams/cu.cm.
G. E. Cocoon - dried film density, 0.75 grams/cu. cm.

Activity applied to 6" x 6" metal placques and dried without heating in a hood.

No. of Cocoon or Lead Sheets	Total Thickness (Mils)	Radiation* (Mrep/hr.) P^{32}	Radiation* (Mrep/hr.) I^{131}	Material Cost (¢/sq. ft.)	Total Weight per sq. ft. (gms)
ABC Cocoon					
0	-	10,500	2,400	-	-
1	11.4	6,000	400	0.085	38.5
2	22.8	3,500	75	0.17	77
4	45.6	1,200	21	0.34	154
6	68.4	320	7**	0.51	231
8	91.2	65	7	0.68	308
10	114	16	5	0.85	385
12	136.8	3.2	5	1.02	462
13	148.2	1.0**	5	1.11	500.5
G. E. Cocoon					
0	-	10,500	2,400	-	-
1	8.5	9,300	1,400	0.04	15
2	17	8,400	690	0.08	30
4	34	5,800	160	0.16	60
6	51	4,300	46	0.24	90
8	68	3,200	16.5	0.32	120
10	85	2,300	8	0.40	150
12	102	1,400	7	0.48	180
14	119	910	6.5**	0.56	210
20	170	160	4.8	0.80	300
25	212.5	36	4.2	1.00	375
30	255	4.5	4.0	1.20	450
33	280.5	1.5	4.0	1.32	495
34	289	1*	4.0	1.36	510
Lead Foil					
0	-	10,500	2,400		-
1	2	3,300	75		63.2
2	4	1,100	21		126.4
4	8	160	6**		252.8
6	12	25	6		379.2
8	16	1**	6		505.6

Remarks

* Milli - Roentgen Equivalent Physical = M rep, a designation to indicate approximate comparative values of β radiation obtained with instrument calibrated with a gamma (γ) radiation source. No field monitoring devices were available for accurately determining total β radiation.

**β radiation considered to be completely attenuated at these radiation levels.

*** Iodine, I^{131}, is a beta and gamma emitter at approximately 7 M rep/hr. the β radiation was considered to be essentially absorbed.

Table II

Overall Cost Estimation for Completely Attenuating P^{32} and I^{131}

With ABC and G. E. Cocoon

(Basis - 100 sq. ft. surface, preparation and cleanup time included)

ABC Cocoon

	Source	P^{32}	I^{131}
	Thickness of film	137 mils	68 mils
	Material Cost	$1.11/ft.^{2}	$0.55
Labor	Spraying (3 gal/hr.)	0.18	0.06
Labor	Preparation and Cleanup	0.06	0.06
	Overhead	0.24/ft.^{2}	0.12
	Total Cost	1.59/ft.^{2}	0.75/ft.^{2}

G. E. Cocoon

	Source	P^{32}	I^{131}
	Thickness of film	289 mils	102 mils
	Material Cost	$1.36/ft.^{2}	$ 0.48
Labor	Spraying (2 gal/hr.)	0.58	0.21
Labor	Preparation and Cleanup	0.06	0.06
	Overhead	0.64/ft.^{2}	0.27
	Total Cost	2.64/ft.^{2}	1.02/ft.^{2}

Table III

Physical Property Data for A. B. C. Cocoon and G. E. Cocoon

Property	*A. B. C. Cocoon	*G. E. Cocoon
Density of Dry Film	2.5 gm/cc. ** 1.43 gm/cc.	0.712 gm/cc. **0.75 gm/cc.
Specific Gravity	1.28	0.865 Calculated from wt/gal. wet
Moisture Vapor Transmission Rate	0.450 gm/100 in.^{2}/24 hr.	0.25 gm/100 in.^{2}/24 hr.
Tensile Strength	1034 psi	1450 - 1550 psi
Elongation	200%	300%
Total Solids (by weight)	70%	23.66%
Weight per Gallon Wet	10.625 lbs./gal.	7.22 lb./gal.

* All data as quoted by manufacturer, unless otherwise stated.

** Observed at ORNL.