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C-46 Criticality Hazards
M-3679 (23rd Ed.)

Interaction of Two Metal Slabs of Plutonium in Plexiglas

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THE DOW CHEMICAL COMPANY

DOW

ROCKY FLATS PLANT DENVER, COLORADO

U.S. ATOMIC ENERGY COMMISSION CONTRACT AT (29-1)-1106

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OF PLUTONIUM IN PLEXIGLAS

by

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ABSTRACT

Neutron multiplication measurements were made on two identical metal slabs of plutonium moderated and reflected by Plexiglas.

ACKNOWLEDGMENTS

These tests were made possible by the cooperation of Mr. I. B. Venable. Special thanks are extended to Mr. W. W. Wright and Mr. R. A. Vandegrift for their help in making arrangements for these experiments.

Date JAN 7 1960 ERRATA - RFP-174

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The assumed correction to the radial leakage of Figure 2 is invalid. Therefore, Figure 4 and the remarks on page 8 regarding Figure 4 should be disregarded.

1. INTRODUCTION

Neutron multiplication measurements were performed on two identical finite metal slab assemblies separated and reflected by Plexiglas.

The purpose of these measurements was:

(1) to determine the isolation separation for two metal slabs in a hydrogeneous medium, and

(2) to determine the moderating effect upon two identical interacting slabs separated by a hydrogeneous medium.

2. EXPERIMENTAL MATERIALS

The measuring equipment used in these experiments included scalers coupled to B^{10}-lined counters encased in polystyrene moderators. An unmoderated LiI(Eu) scintillator was also used.

2.1 Materials

2.1.1 Moderator and Reflector

A. Plexiglas ~1.19 g/cm^3

B. Styrofoam spacers for the core approximate density = 0.026 g/cm^3

2.1.2 Fuel

A. Plutonium metal discs 12.5 in. in diameter, Thickness from 0.0357 in. to 0.0632 in. Average density ~ 15.8 g/cm^3.

3. PROCEDURE AND RESULTS

Figure 1 is a schematic of the interacting slab assemblies. Regions A and A' are the interacting metal slabs of equal thickness. Region B was varied from zero thickness to 6 in. of Plexiglas. Regions C and C' were the end reflectors and D the lateral reflector.

Figure 2 provides a plot of the extrapolated critical values for the total slab thickness (sum of A and A') as a function of the separation. The slight rise in the total thickness at a separation of 0.5 in. indicates that for two finite slabs the leakage predominates. This region is then followed by a drop in the total thickness indicating that the moderating effect of the Plexiglas became important. This region is then followed by a sharp rise in the thickness indicating that leakage and absorption of the neutrons are decisive.

An attempt was made in Figure 3 to determine the magnitude of the effect of leakage from the lateral surfaces of the finite slab assembly. This was accomplished by constructing the slab assemblies as illustrated in Figure 1 with one exception. Region B previously made of Plexiglas was replaced with a low density Styrofoam to simulate a void. It is believed that this method slightly over-corrects for the effect of edge leakage.

Figure 3 is a plot of total slab thickness as a function of Styrofoam thickness.

Figure 4 is a plot of total slab thickness as a function of Plexiglas separation thickness. In this figure, the effects of lateral leakage described in Figure 3 are included.

Figure 4 was drawn in the following manner: The difference of the ordinates for Figures 2 and 3, for various separation thicknesses, can be attributed to the effect of lateral leakage. This difference is then subtracted from each corresponding ordinate of Figure 3. The resultant values for total slab thickness are then plotted as functions of the separation distance of the two slabs, thus giving rise to Figure 4. The shape (not the magnitude of the axis) of this curve would approximate the shape of a curve for two interacting slabs of infinite cross section.

It is interesting to note that the shape of this relation, given in Figure 4, approximates that derived by E. R. Woodcock[1] for two equal and infinite Oralloy slabs. It is apparent that the effect of moderation reduces the total single reflected slab thickness by a factor of approximately 3.5 when 1.75 in. of Plexiglas are used as a separator.

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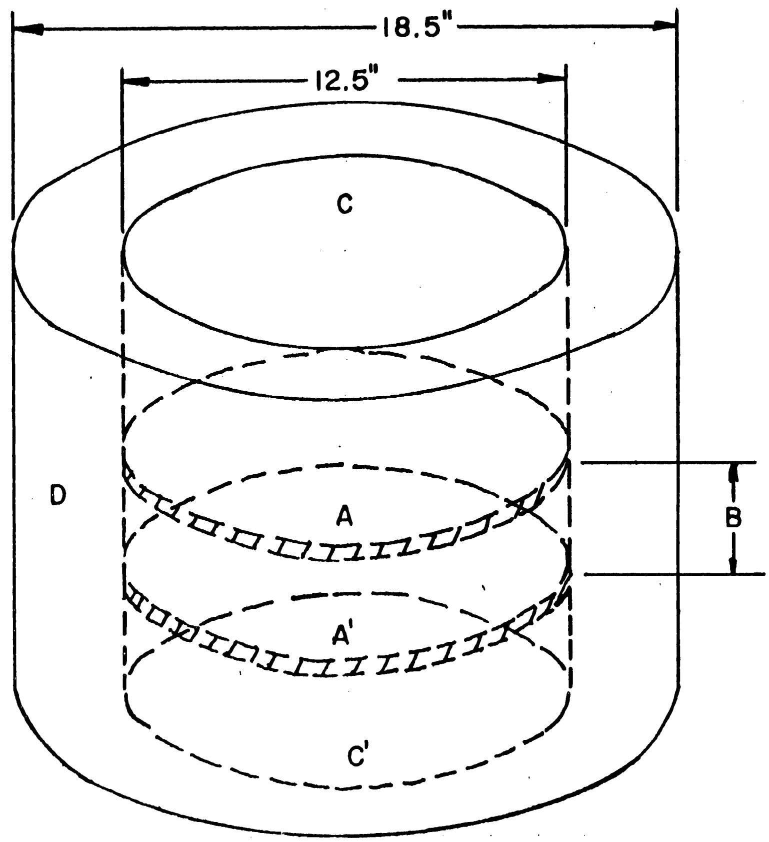
(1)E. R. Woodcock, "Critical Assemblies of Infinite Slabs of Highly Enriched Uranium and Water", UKAEA Report ASHB Report 17, July, 1959.

Figure 5 has been reproduced from RFP-169.[2] The isolation separation thickness derived in these experiments has been plotted in Figure 5. It can be seen that two identical interacting metal slabs, each at 79% of critical, have about the same isolation thickness as do two aqueous solution slabs, each at 92% of critical. It appears that for two identical metal slabs, each at 92% of critical, the isolation thickness would be approximately 1.5 in. greater than for the solution slabs. The above assumption is based on the equality of Plexiglas and water as separating media.

This effect can be expected since the average energy of the leakage flux for the metal slabs is greater than that for the aqueous solution slabs and consequently a greater thickness of water is necessary in the former to compensate for this effect.

(2) C. L. Schuske, and A. N. Nickel, "Isolation Thickness of Water for Uranyl Fluoride Solution Systems", USAEC Report RFP-169, December 21, 1959.

INTERACTING METAL SLABS



A and A' — Equal Thickness Plutonium Metal Slabs

B — Plexiglass Separation Thickness

C and C' — Plexiglass End Reflector 4 Inches Thick

D — Plexiglass Lateral Reflector 3 Inches Thick

FIGURE 1

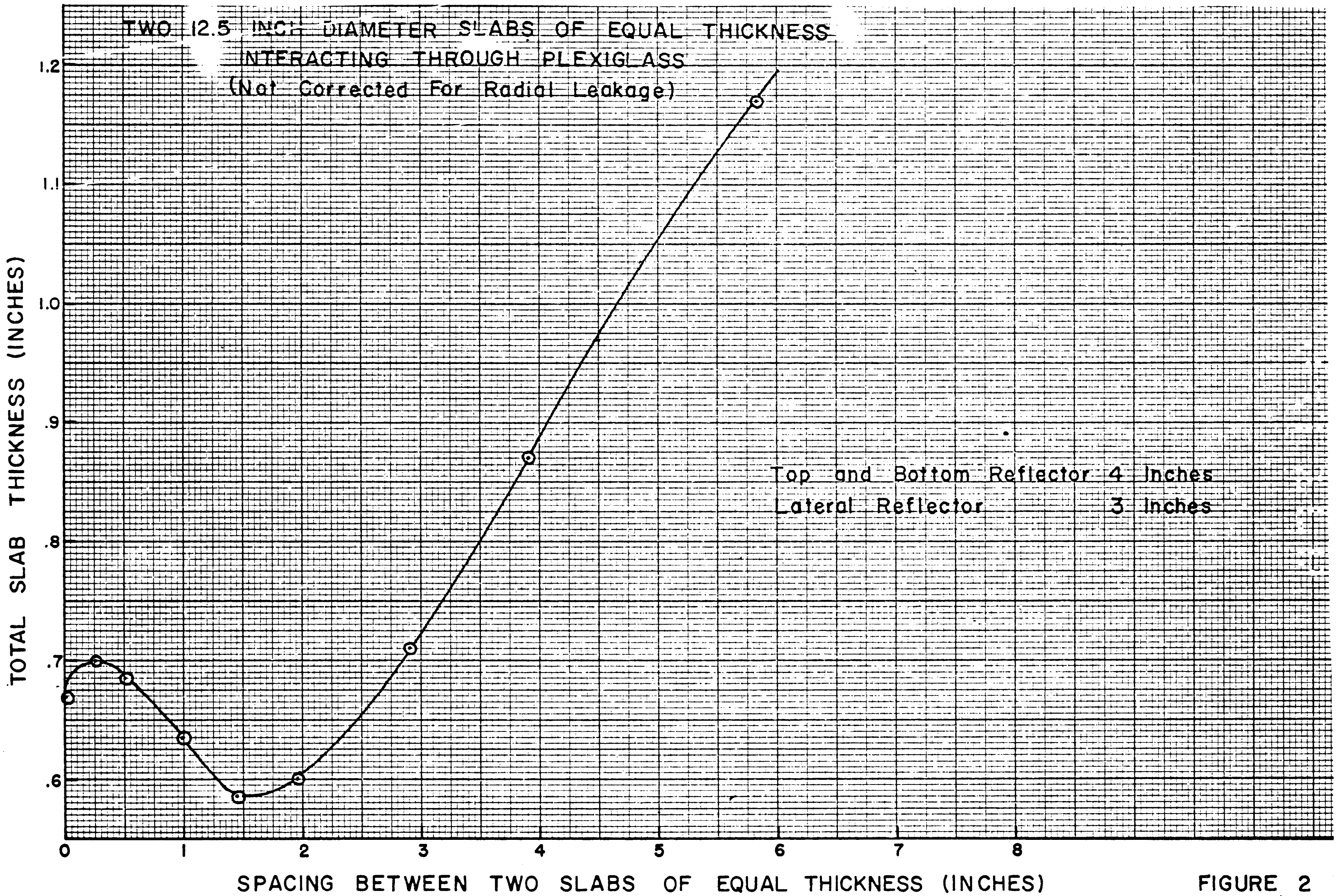
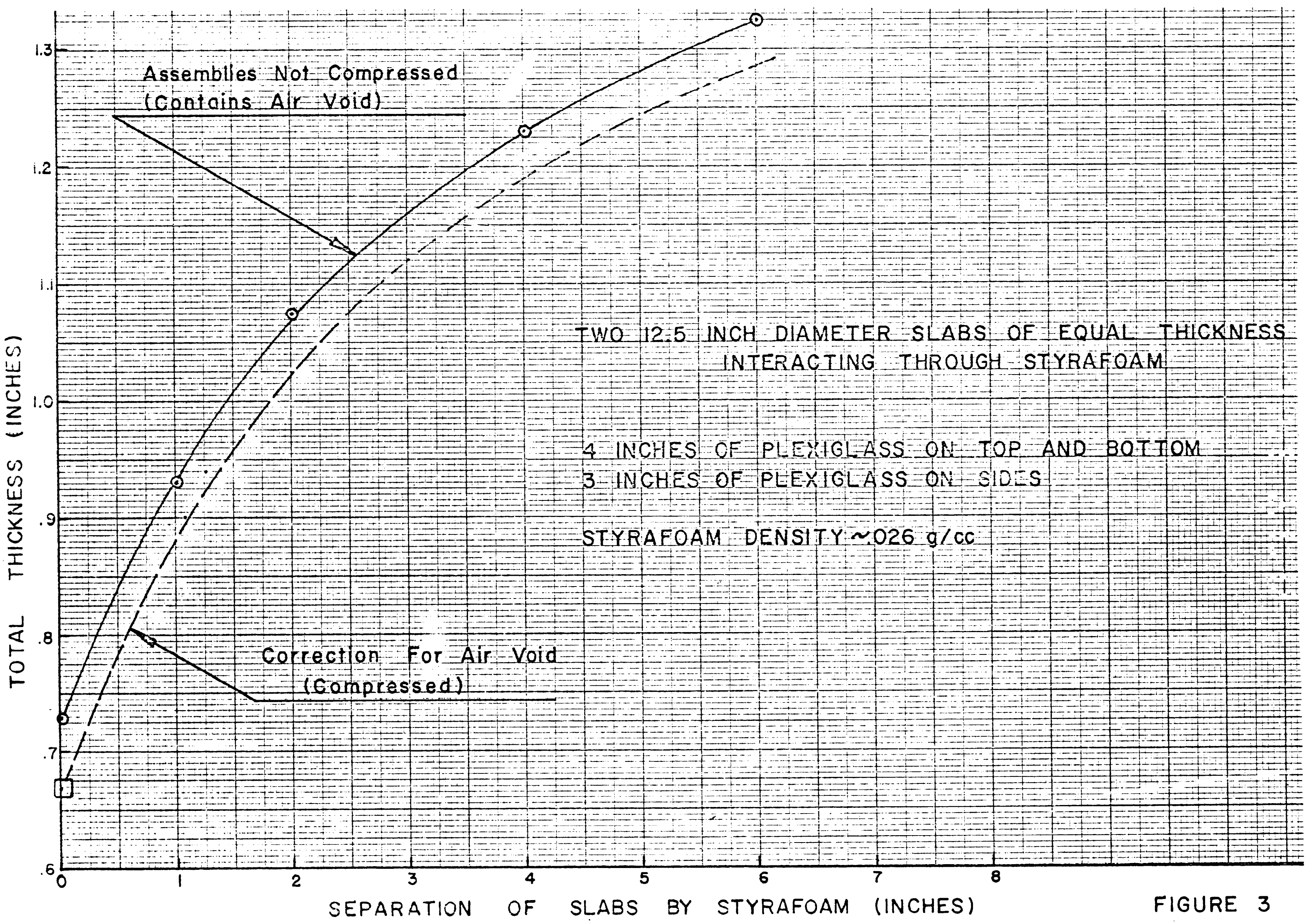

TWO 12.5 INCH DIAMETER SLABS OF EQUAL THICKNESS
INTERACTING THROUGH PLEXIGLASS
(Not Corrected For Radial Leakage)
Top and Bottom Reflector 4 Inches
Lateral Reflector 3 Inches
TOTAL SLAB THICKNESS (INCHES)
1.2
1.1
1.0
.9
.8
.7
.6
0
1
2
3
4
5
6
7
8
SPACING BETWEEN TWO SLABS OF EQUAL THICKNESS (INCHES)

FIGURE 2



Assemblies Not Compressed
(Contains Air Void)
Correction For Air Void
(Compressed)
TWO 12.5 INCH DIAMETER SLABS OF EQUAL THICKNESS
INTERACTING THROUGH STYRAFOAM
4 INCHES OF PLEXIGLASS ON TOP AND BOTTOM
3 INCHES OF PLEXIGLASS ON SIDES
STYRAFOAM DENSITY ~.026 g/cc
TOTAL THICKNESS (INCHES)
1.3
1.2
1.1
1.0
.9
.8
.7
.6
0
1
2
3
4
5
6
7
8
SEPARATION OF SLABS BY STYRAFOAM (INCHES)

FIGURE 3

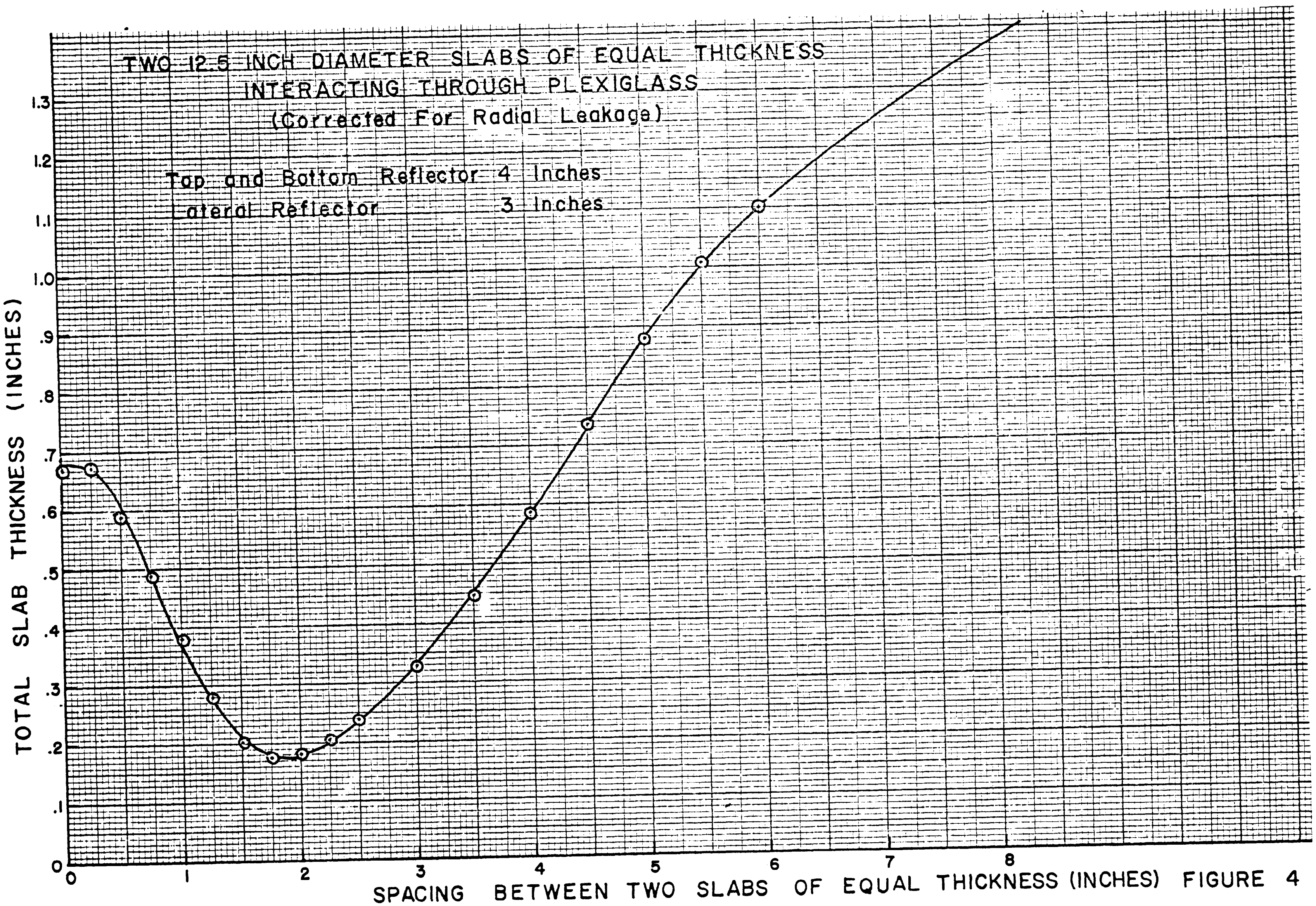

TWO 12.5 INCH DIAMETER SLABS OF EQUAL THICKNESS
INTERACTING THROUGH PLEXIGLASS
(Corrected For Radial Leakage)
Top and Bottom Reflector 4 Inches
Lateral Reflector 3 Inches
TOTAL SLAB THICKNESS (INCHES)
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
1.1
1.2
1.3
0
1
2
3
4
5
6
7
8
SPACING BETWEEN TWO SLABS OF EQUAL THICKNESS (INCHES)

FIGURE 4

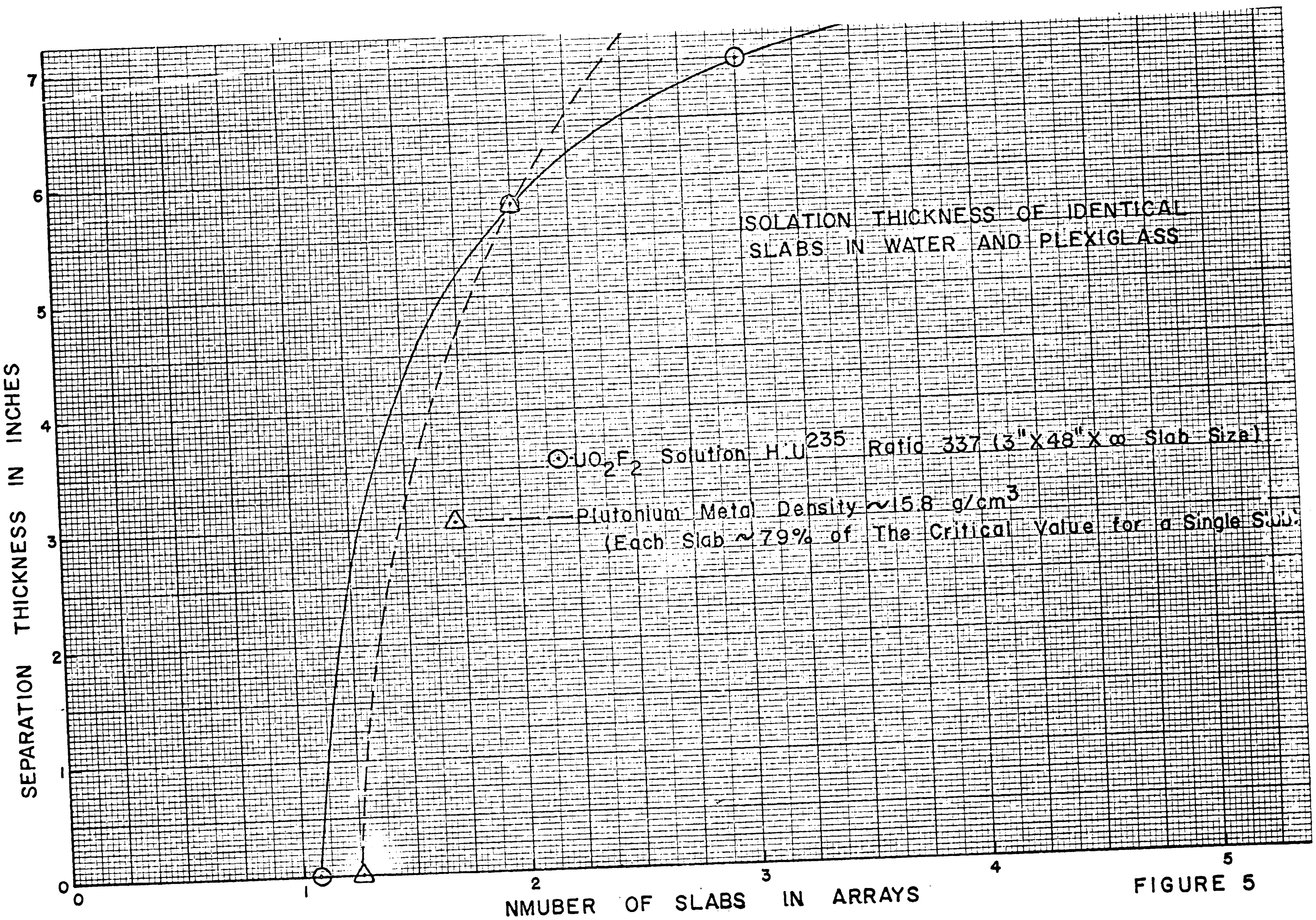

ISOLATION THICKNESS OF IDENTICAL SLABS IN WATER AND PLEXIGLASS
UO2F2 Solution H:U235 Ratio 337 (3" X 48" X ∞ Slab Size)
Plutonium Metal Density ~15.8 g/cm3
(Each Slab ~79% of The Critical Value for a Single Slab)
SEPARATION THICKNESS IN INCHES
NMUBER OF SLABS IN ARRAYS
0
1
2
3
4
5
6
7

FIGURE 5