RFP-213

UC-46 - CRITICALITY STUDIES
TID-4500, 16th Ed.

THE DOW CHEMICAL COMPANY
ROCKY FLATS PLANT
DENVER, COLORADO

U. S. Atomic Energy Commission Contract AT(29-1)-1106

PLEXIGLAS REFLECTED ASSEMBLIES OF PLUTONIUM

by

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Date Distributed: January 10, 1961

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ABSTRACT

This report contains a compilation of critical extrapolations of subcritical neutron multiplication measurements made on assemblies of plutonium metal tamped with Plexiglas.

In addition to this compilation the report also presents recent data on a 20-in. x 20-in. slab of metal, Plexiglas tamped. A simple empirical equation of the form $(\sqrt{A} - \sqrt{A_o})(h - h_o) = C$ was found which fits the data and predicts the infinite slab and cylinder dimensions.

ACKNOWLEDGMENTS

These tests were made possible by the generous cooperation and assistance of Mr. I. B. Venable and staff.

1. INTRODUCTION

A series of subcritical measurements made on plutonium metal assemblies Plexiglas tamped are reported. This report also contains a recent measurement on a 20-in. x 20-in. slab of metal Plexiglas tamped. A total of seven experimental values were found to fit (within the experimental error) an empirical equation of the form $(\sqrt{A} - 1.75)(h - 0.25) = 4.30$. The constants in the equation are, $\sqrt{A_o} = 1.75$, the length of a side of an infinite cylinder of square cross section, $h_o = 0.25$, the infinite slab thickness and $C = 4.30$ an empirical constant. This type of equation was previously found to fit data for a variety of cases ranging from aqueous solution systems of uranyl fluoride[1] to uranium metal tamped with water.[2]

2. EXPERIMENTAL MATERIALS

The measuring equipment used in these experiments included scalers coupled to B^{10} lined counters in polystyrene moderators.

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(1) C. L. Schuske, J. W. Morfitt, "An Empirical Study of Some Critical Mass Data", USAEC Report Y-533, December 6, 1949. (Unclassified)

(2) R. Gwin, W. T. Mee, "Critical Assemblies of Uranium Metal", USAEC Report Y-1248, March, 1959. (Unclassified)

2.1 Materials

2.1.1 Reflector

Plexiglas density ~1.2 g/cm^3.

(Rohm and Haas Type R)

2.1.2 Fuel

Plutonium Metal

Densities range from 15.7$^+$ to 16.0 g/cm^3.

3. PROCEDURE AND RESULTS

A 20-in. x 20-in. slab of metal was constructed of layers of metal pieces ranging from 0.064 in. thick to 0.199 in. thick. The slab was tamped on the top and bottom with nominal 4 in. of Plexiglas and the edges were tamped with 2 in. of Plexiglas. The entire array was compressed by means of a mechanical jack to minimize air voids between the thin layers of metal making up the slab. The final density of this array was approximately 15.8$^+$ g/cm^3. The experiment was performed in a glove box to preclude the spread of contamination. The critical thickness of this 20-in. x 20-in. slab as measured by a $^1/_M$ plot is 0.495 in. The experimental error in this measurement is estimated to be less than 10%.

Figure 1 and Table I contain compilations of experimental points.[3,4,5] Since these data consist of two data points of circular cross section[3,5] and the remaining points square to approximately square cross sections it was concluded that a curve with the abscissa in terms of the square root of the cross sectional area and the ordinate as array height h could best represent all of the data. The general error is estimated at about ±10% for all references except a circular cylindrical data point given in UCRL-4957[5] as ±4% error.

Since all of the data points form a smooth curve an attempt was made to derive an empirical equation to fit these data. A simple equilateral hyperbola of the form $(\sqrt{A} - 1.75)(h - 0.25) = 4.30$ was found to fit the data within the allowed experimental error. The parameters of $\sqrt{A_o} = 1.75$ in. and $h_o = 0.25$ in. represent the infinite cylinder dimensions (square cross section) and the infinite slab thickness respectively. The authors do not attempt to place a limit of error on either of these parameters.

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(3) C. L. Schuske, A. Goodwin, Jr., G. H. Bidinger, D. F. Smith, "Interaction of Two Metal Slabs of Plutonium in Plexiglas", USAEC Report RFP-174, December 28, 1959. (Declassified)

(4) C. L. Schuske, G. H. Bidinger, A. Goodwin, Jr., D. F. Smith, "Plutonium Plexiglas Assemblies", USAEC Report RFP-178, January 20, 1960. (Declassified)

(5) F. A. Kloverstrom, "Spherical and Cylindrical Plutonium Critical Masses", USAEC Report UCRL-4957, September, 1957. (Unclassified)

TABLE I

Experimental Data

Array Dimensions (in.)	Sq. Root of Cross Sectional Area $\sqrt{A}$ (in.)	Exp. Height h (in.)	Emp.* Height h (in.)	Lateral Tamper (in.)	Radial Tamper (in.)	Array Density (g/cm^3)	Est. Exp. Error	Source of Data
Approx. Square	7.18	1.0	1.04	~4	~4	15.7^+	~10%	RFP-178
2.5 x 2.75**	2.62	5.0	5.19	~4	~4	15.7^+	~10%	RFP-178
2.75 x 5.0**	3.71	2.5	2.44	~4	~4	15.7^+	~10%	RFP-178
Square	5.0	1.5	1.57	~4	~4	15.7^+	~10%	RFP-178
Circle Diameter ~3.89	3.44	2.76	2.82	3.94	3.94	15.8	±4%	UCRL-4957
Circle Diameter ~12.54	11.11	0.675	0.709	~4	~3	15.7^+	~10%	RFP-174
Square	20.0	0.493	0.486	~4	~2	15.8^+	<10%	Recent Work

* Empirical heights calculated from $(\sqrt{A} - 1.75)(h - 0.25) = 4.30$.

** Same experimental point used twice in Figure 1.

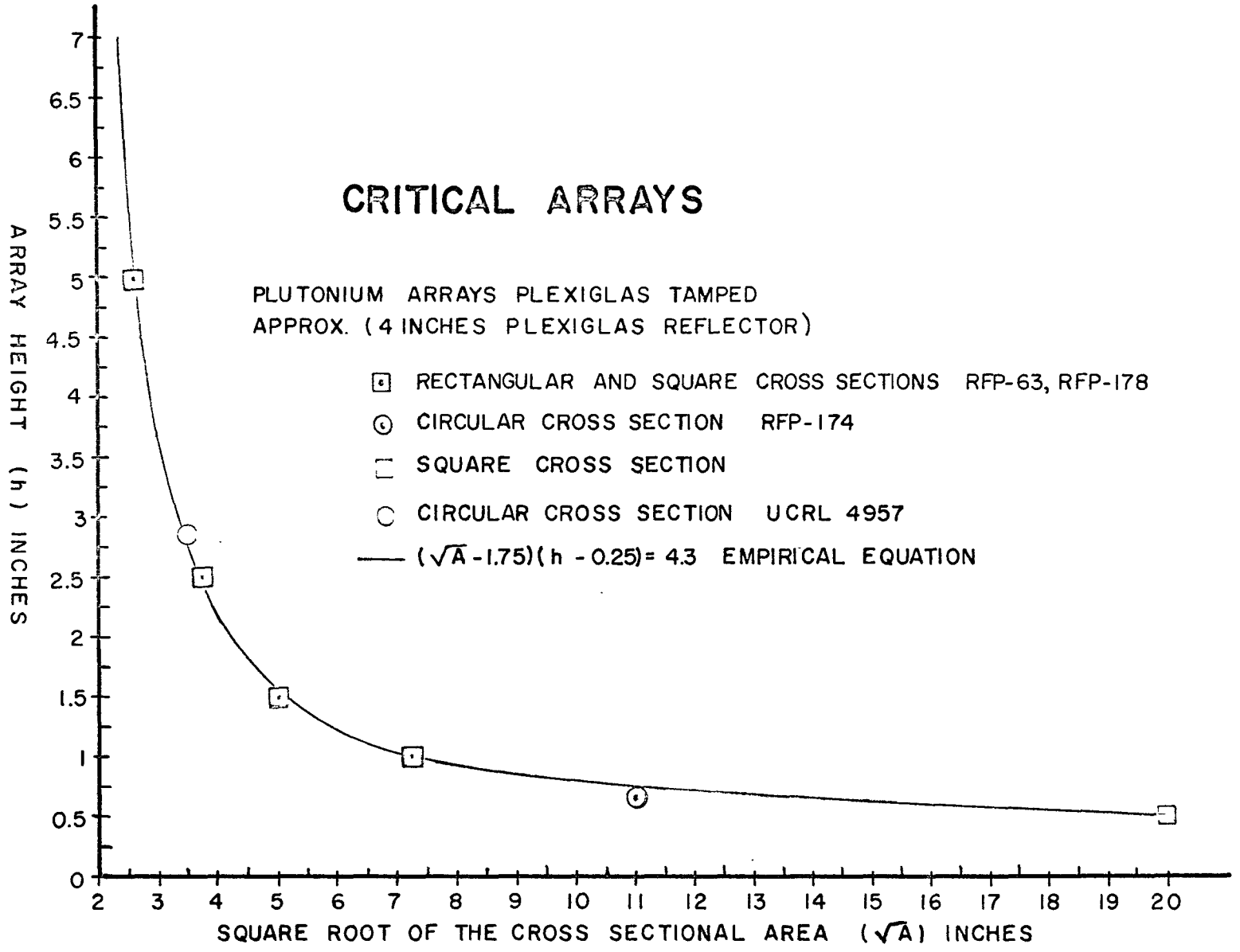
CRITICAL ARRAYS
PLUTONIUM ARRAYS PLEXIGLAS TAMPED
APPROX. (4 INCHES PLEXIGLAS REFLECTOR)
RECTANGULAR AND SQUARE CROSS SECTIONS RFP-63, RFP-178
CIRCULAR CROSS SECTION RFP-174
SQUARE CROSS SECTION
CIRCULAR CROSS SECTION UCRL 4957
$(\sqrt{A}-1.75)(h-0.25)=4.3$ EMPIRICAL EQUATION
ARRAY HEIGHT (h) INCHES
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
SQUARE ROOT OF THE CROSS SECTIONAL AREA ($\sqrt{A}$) INCHES

Figure 1