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C-46 Criticality Hazards

M-3679 (23rd Ed.)

Plutonium Plexiglas Assemblies

by
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THE DOW CHEMICAL COMPANY

ROCKY FLATS PLANT

DENVER, COLORADO

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

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(M-3679 23rd Ed.)

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THE DOW CHEMICAL COMPANY
ROCKY FLATS PLANT
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PLUTONIUM PLEXIGLAS ASSEMBLIES

by

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ABSTRACT

Neutron multiplication measurements were made on tamped and untamped cylindrical assemblies. The assemblies consisted of plutonium metal sheet moderated with Plexiglas. Experiments were performed to evaluate the effects of inhomogeneity.

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1. INTRODUCTION

Neutron multiplication measurements were made on cylindrical disc assemblies constructed of alternate layers of Plexiglas and plutonium sheet. Both bare and tamped assemblies were investigated. H:Pu atomic ratios were varied from 0 to 30.8 for the tamped arrays and from 0 to 72.2 for the untamped arrays.

The thickness of the plutonium sheet was varied in order to study the effects of inhomogeneity at H:Pu atomic ratios of 6 and 11.6.

2. EXPERIMENTAL MATERIALS

The measuring equipment used in these experiments included scalers Atomic model 1050-A coupled to G.E. B¹⁰ lined counters, and LiI(Eu) scintillators.

2.1 Materials

2.1.1 Moderator and Reflector

Plexiglas ~ 1.19 g/cm³

2.1.2 Fuel

Plutonium metal discs 12.5 in. in diameter.

Average density ~ 15.8 g/cm³.

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3. PROCEDURE AND RESULTS

Figure 1 is a schematic of the plutonium-Plexiglas assemblies. Tables I and II summarize the experimental results.

The H:Pu atomic ratios were calculated on the assumption that the metal and the Plexiglas were homogeneously mixed. The tamped arrays were reflected with approximately 4 in. of Plexiglas on the ends of the cylindrical cores, and the lateral surfaces were tamped with 3 in. of Plexiglas.

Figures 2 and 3 are examples of the reciprocal multiplication plots to illustrate the magnitude of the extrapolations of the data to the critical state.

Figure 4 contains a plot of critical mass of plutonium as a function of the H:Pu atomic ratios for the 12.5-in. diameter untamped cylindrical arrays. Also included in Figure 4 are two values of critical mass which approximate the critical masses for homogeneous mixtures of Plexiglas and fuel.

Figures 5 and 6 describe the technique used in estimating the correction to Figure 4 due to the effects of inhomogeneity. The homogeneous masses were obtained by plotting several sheet thicknesses for the same moderation and extrapolating to zero sheet thickness.

It can be seen that at H:Pu ratios of less than 6, the effect of inhomogeneity was not significant (not measurable by our experimental techniques). At an H:Pu ratio of

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approximately 12, the homogeneous mass was about 4% less than for an assembly of 0.0576-in. thick sheet (see Figure 4). Thinner sheet was not available during this series of experiments to evaluate the homogeneous mass at H:Pu ratios above 12. Thinner sheet was needed because critical masses at high values of H:Pu ratios were too small to permit the use of the large mass (one-sheet) increments available to us for these tests.

The critical mass at an H:Pu ratio of 72 was obtained by sandwiching 36-mil sheet between 2-in. thicknesses of Plexiglas. One observes that the effect of inhomogeneity is quite considerable.

Figure 7 is a plot of critical mass as a function of H:Pu atomic ratios for reflected 12.5-in. diameter cylinders. The end reflectors were approximately 4 in. thick, and the lateral reflector was 3 in. thick. No measurements were made to evaluate the effect of inhomogeneity for the reflected cases as was done for the untamped case.

Figure 8 is an attempt to convert the experimental measurements for the 12.5-in. diameter untamped cylinders to spherical cores. The method used was to assume the constant buckling relation: $B^2 = \frac{J^2}{(R + \delta)^2} + \frac{\pi^2}{(H + 2\delta)^2}$. The extrapolation lengths (δ) used in these conversions were obtained from diffusion calculations made at Rocky Flats. These values are

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presented in Table III. Discussions with H. C. Paxton, of LASL, were also helpful in making this conversion.⁽¹⁾

The calculated spherical masses (non-homogeneous) given in Figure 8 are dependent on the extrapolation length used. For example, a 10% change in the extrapolation length resulted in a 2.8% change in the critical mass at an H:Pu ratio of 1.6. The critical mass is affected less, for a 10% change in δ , at higher H:Pu ratios. Also included in Figure 8 is an approximation of homogeneous spherical masses as previously discussed for cylinders. The authors hesitate estimating the magnitude of the errors involved in making the conversion from cylinders to spheres due to the dependence of the critical mass on the extrapolation length.

Figure 9 was extracted from RFP-63 and an additional point is added from the present measurements.⁽²⁾ Thus, this curve has been extended by a point for a 12.5-in. diameter slab of metal where the square root of the cross sectional area is 11.06 in. The corresponding value of the critical thickness is 0.675 in.

(1) Private communication from H. C. Paxton, LASL, November 23, 1959.

(2) C. L. Schuske, M. G. Arthur, D. F. Smith, "Criticality Measurements on Plutonium Metal Preliminary to the Design of a Melting Crucible", USAEC Report RFP-63, June 1, 1956. (Secret)

TABLE I

Untamped Cylinders - 12.5-in. Diameters

H:Pu	Extrapolated Critical Height (cm)	Mass in Experiment (kg)	Extrapolated Critical Mass (kg)	ρ_{Pu_3} (g/cm ³)	Plutonium Sheet Thickness (in.)	Plexiglas Sheet Thickness (in.)
1.62	9.57	40.42	56.46	7.423	0.1152	0.115
5.52	14.98	35.17	39.93	3.27	0.0632	0.243
5.89	15.59	29.40	38.44	3.10	0.1152	0.472
6.07	15.83	29.40	38.12	3.03	0.0576	0.243
11.39	18.89	20.21	26.64	1.77	0.0576	0.472
11.62	21.77	22.05	30.14	1.74	0.1728	1.442
11.69	20.03	22.05	27.59	1.73	0.1152	0.970
16.78	20.57	16.54	20.42	1.248	0.0576	0.715
35.60	25.60	10.67	12.55	0.614	0.0366	0.970
39.84	40.94	14.48	18.42	0.551	0.0632	1.940
72.25	66.34	12.92	16.36	0.309	0.0366	1.940
6.07*			37.8	3.03		
11.6*			24.7	1.74		

*Homogeneous cylinders; extrapolated critical values

TABLE II

Tamped Cylinders - 12.5-in. Diameters

<u>H:Pu</u>	<u>Extrapolated Critical Height (cm)</u>	<u>Mass in Experiment (kg)</u>	<u>Extrapolated Critical Mass (kg)</u>	<u>ρ_{Pu_3} (g/cm³)</u>	<u>Plutonium Sheet Thickness (in.)</u>	<u>Plexiglas Sheet Thickness (in.)</u>
0	1.70	14.48	21.94	15.8	0.670	0
0.500	2.39	17.21	22.56	11.75	0.350	0.243
0.992	2.94	18.18	22.13	9.35	0.342	0.472
2.36	4.35	16.55	21.21	5.98	0.0632	0.115
4.89	6.03	14.48	17.69	3.60	0.0632	0.243
9.11	7.71	10.34	13.55	2.15	0.0632	0.472
16.09	9.37	8.30	9.70	1.30	0.0366	0.472
30.78	11.48	5.93	6.46	0.706	0.0366	0.970

[REDACTED]

TABLE III

Conversion from Untamped Cylinders to Spheres
(Uncorrected for Homogeneity)

<u>H:Pu</u>	<u>Cylindrical Critical Mass (kg)</u>	<u>Extrapolation Lengths δ (cm)</u>	<u>Calculated Spherical Critical Mass (kg)</u>
0	61.5*	1.87	16.1*
1.62	56.46	1.96	28.56
6.07	38.12	2.18	28.99
11.39	26.64	2.34	22.28
16.78	20.42	2.42	16.54
35.6	12.55	2.5	11.35

(Corrected for Homogeneity)

6.07	37.8	2.18	28.60
11.6	24.7	2.35	20.52

*A. Goodwin, Jr., C. L. Schuske, "Plutonium Graphite Assemblies", USAEC Report RFP-123, September 29, 1958.
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PLEXIGLAS AND PLUTONIUM METAL ASSEMBLIES

Figure 1

[REDACTED]

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