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2

PRELIMINARY REPORT OF CRITICAL EXPERIMENTS
IN SLAB GEOMETRY

Summary

The critical parameters of aqueous UO_2F_2 solutions enriched to about 90% in U-235 in various arrays of interacting slab geometries have been determined for a single concentration. Since three nominally 3-in.-thick aluminum slab vessels and one nominally 6-in.-thick aluminum slab vessel were available, a number of configurations could be arranged for study.

In one group of experiments the critical solution height was determined as a function of side-to-side separation of various configurations of slabs, both bare and water reflected, except for the top, to a height equal to the critical solution height.

The critical solution height in a nominally 6-in.-thick aluminum slab was measured as a function of the separation of the slab and a 48 x 48 x 1/2-in.-thick steel plate. The results of this experiment gave an indication of the effects on the critical height being measured of the walls of the 9.5-ft-dia. steel tank in which some of the experiments were performed.

In one group of experiments, Plexiglas was used to replace the first inch of water reflector on the two outer sides of two 3-in.-thick slabs separated 4 in. edge-to-edge. Plexiglas was also used to replace the first inch of water between two 3-in. slabs at separations of 2 and 4 inches.

The critical heights of a nominally 6-in.-thick aluminum slab were used as the sensitive parameters in measuring the relative effectiveness of two common insulating materials as a neutron reflector. The critical height was determined as a function of thickness of insulation on the two faces of the slab.

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I. Critical Parameters of U-235 Enriched Aqueous Solution in Interacting Multiple Slab Geometry

An experimental investigation of the critical parameters of UO_2F_2 aqueous solutions in interacting multiple slab geometry is being conducted. In the experiments reported here the U-235 enrichment was about 90% and the solution concentration was 0.07628 g U-235/cc corresponding to an H:U-235 ratio of 337. Three nominally 3-in.-thick type 2S aluminum vessels and one nominally 6-in.-thick type 2S aluminum vessel were used in various configurations for these experiments. Each of the four vessels was 3 ft 11.5 in. wide. A calibration, using water, gave average inside thicknesses of 5.84, 3.023, 2.997, and 2.997 in. for the nominal 6-in. and three 3-in. vessels, respectively. The wall thicknesses of the vessels were 1/8-in.

Figure 1 contains schematic diagrams of the type of interacting assemblies used in these experiments. Some of the experiments were conducted inside a 9.5-ft-dia. steel tank that could be filled with water to the desired level for reflected experiments. Most of the bare experiments, however, were conducted outside the tank to avoid neutron reflection from the walls. The data obtained from experiments inside the tank as well as outside the tank are presented in Table 1.

Figure 2 is a plot of the data corresponding to the array shown schematically in Fig. 1-a, for both the bare and water reflected cases.

A comparison of some data obtained with the three 3-in.-thick vessels inside the 9.5-ft-dia. steel tank and outside the tank is shown in Fig. 3. For this comparison two slabs were adjacent, simulating a 6-in.-thick slab, and the third slab was spaced. The schematic diagram corresponding to this case is Fig. 1-b. Two values were obtained, outside the tank, for the critical height of the two 3-in.-thick slabs when adjacent as shown by the two upper asymptotes. The critical height depended on which two of the three vessels were used for the measurement. The difference in the critical heights, however, if added to the lower height, would increase the reactivity by only about 2%.

Figure 4 is a plot of the data obtained using the 6-in. vessel and three combinations of the 3-in. vessels.

II. Effect of Steel and Plexiglas as Neutron Reflectors

Some experiments were performed to obtain a measure of the reflecting properties of cold rolled steel and Plexiglas. The experimental arrangement for the steel reflector experiments was such that the 48 x 48 x 1/2-in.-thick steel plate could be placed at various distances from the slab. The

FIGURE 1

x - edge to edge separation
 h - critical solution height

Fig. 1. Schematic Diagrams of Interacting Assemblies

Table 1. Critical Parameters of Enriched Aqueous Solution
in Arrays of Interacting Multiple Slab Geometry

Solution Concentration: 0.06987 g U-235/g solution
0.07629 g U-235/cc
H/U-235 Ratio = 337

Side-to-Side Separation (in.)	Critical Conditions		
	Sol'n Height (cm)	Volume (liters)	Mass U-235 (kg)

ASSEMBLIES INSIDE 9.5 ft DIAMETER STEEL TANK

Three 3-in.-thick aluminum slabs separated equally (Fig. 1-a),
with no water reflector.

0.0	25.50	70.46	5.375
1.0	34.44	95.18	7.260
3.0	58.78	162.42	12.389
4.5	85.52	236.33	18.027
5.5	107.37	296.70	22.632
6.0	120.40	332.69	25.380

Three 3-in.-thick aluminum slabs separated equally (Fig. 1-a),
with water reflector to a height equal to the fuel height.

0.0	17.32	47.87	3.652
1.0	19.13	52.86	4.032
3.0	32.92	90.97	9.886
4.5	61.06	168.75	12.872
5.5	111.68	308.62	23.542
6.0	Not critical at 119 cm.		

Two 3-in.-thick aluminum slabs adjacent with 3rd slab spaced
(Fig. 1-b), and with no water reflector.

6.0	45.03	124.44	9.492
12.0	58.19	160.81	12.267
18.0	68.30	188.73	14.396
30.0	83.11	229.67	17.519
	101.09	278.56	21.249

ASSEMBLIES OUTSIDE 9.5 ft DIAMETER STEEL TANK

One 6-in. slab and two adjacent 3-in. slabs (Fig. 1-d).

2.0	25.43	92.42	7.050
6.0	32.79	119.20	9.093
15.0	44.88	163.15	12.445
20.0	50.27	182.72	13.938

Table 1. (cont'd)

30.0	59.72	217.07	16.558
48.0	73.23	266.19	20.305
66.0	82.12	298.49	22.772
	115.82	420.92	32.107

One 6-in.-thick aluminum slab and two 3-in.-thick aluminum slabs equally spaced on each side.

0.0	19.63	71.35	5.443
10.0	44.25	160.84	12.269
20.0	62.56	227.40	17.346
32.0	81.56	296.46	22.614

One 6-in.-thick aluminum slab and one 3-in.-thick aluminum slab (Fig. 1-c).

2.0	32.39	87.72	6.691
15.0	65.81	178.26	13.598
30.0	92.48	250.50	19.108
48.0	113.84	308.36	23.522

Two 3-in. aluminum slabs adjacent and one 3-in. slab; slabs 1 and 3 are adjacent (Fig. 1-b).

0.0	24.89	69.79	5.324
12.0	58.55	161.79	12.341
30.0	86.69	239.56	18.274
	115.82	319.98	24.408

Two 3-in. aluminum slabs adjacent and one 3-in. slab spaced. Slabs 2 and 3 are adjacent.

12.0	59.74	165.09	12.593
30.0	93.52	258.44	19.714
	126.87	350.59	26.743

FIGURE 12

FIGURE 3

COMMON CRITICAL HEIGHT OF A 6" SLAB
 & A 3" SLAB AS A FUNCTION OF THEIR
 EDGE-TO-EDGE SEPARATION

9

CRITICAL HEIGHT OF VARIOUS INTERACTING
SYSTEMS OF SLABS VS. EDGE-TO-EDGE
SEPARATION OF THE COMPONENTS.

$$H:U-235 = 337$$

FIGURE 4

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critical solution height of the slab is shown plotted as a function of side-to-side separation of the slab and steel plate in Fig. 5.

A measure of the relative effectiveness of Plexiglas as a neutron reflector was obtained by replacing the first inch of water reflector on the outside faces of two 3-in. slabs with Plexiglas. The slabs were separated 4 inches. In two other experiments the first inch of water between the two slabs was replaced with Plexiglas, the slab separation being 2 and 4 inches, respectively. These points are shown on Fig. 6, which is a curve of critical solution height vs separation distance for the two 3-in.-thick slabs having an effectively infinite water reflector along the bottom and adjacent to the sides to a height equal to the critical solution height. These data are contained in Table 2.

III. Neutron Reflecting Properties of Some Insulating Materials

Since insulating materials are used quite frequently in uranium processing plants it is of interest to know their relative neutron reflecting properties. Two common insulating materials, magnesia and insulating cement were investigated. Available for these experiments were 2-in.- and 4-in.-thick slabs of magnesia and 1-in.-thick slabs of insulation cement. By using various combinations of these slabs the critical heights of a 6-in. slab were determined as a function of insulation thickness. Two values were obtained for the critical height when 6-in.-thick insulation was used since the critical height depends on whether the more dense 2-in. insulation slabs were adjacent to the reactor or not. In one experiment the slab was reflected on the outer faces with one inch of Plexiglas. These data are presented in Table 3 and in Fig. 7.

FIGURE 5

CRITICAL HEIGHT OF A 6" THICK SLAB
VS.
EDGE-TO-EDGE DISTANCE FROM A
 $4 \times 4 \times \frac{1}{2}$ " THICK STEEL PLATE

FIGURE 6

CRITICAL HEIGHT OF TWO PROTON
REFLECTED 3" SLABS

VS.
SEPARATION

$$H:U-235 = 337$$

CRITICAL HEIGHT - CM.

- - WATER REFLECTOR ONLY
- △ - TWO 1" THICK SHEETS OF PLEXIGLAS, 55.8 CM. HIGH, BETWEEN THE TWO SLABS
- ▽ - TWO 1" THICK SHEETS OF PLEXIGLAS, 30.48 CM. HIGH, BETWEEN THE TWO SLABS
- - 1" THICK SHEET OF PLEXIGLAS, 55.88 CM. HIGH, ON THE SIDE OF EACH SLAB AWAY FROM THE CENTER.

SEPARATION - INCHES

Table 2. Neutron Reflecting Properties of Steel and Plexiglas.

Separation (in.)	Critical Conditions		
	Sol'n Height (cm)	Volume (liters)	Mass U-235 (kg)

Critical parameters as a function of separation of reactor and 1/2-in.-thick steel plate.

Reactor: Two 3-in.-thick aluminum slabs adjacent.

0.0	55.25	101.5	7.74
3.0	63.22	116.1	8.86
6.0	70.49	129.5	9.88
12.0	81.28	149.1	11.38
24.0	92.30	169.6	12.93
36.0	97.13	178.4	13.61
	101.19	185.9	14.18

Comparison of water and Plexiglas as neutron reflectors. Water adjacent to bottom and sides to a height equal to the critical solution height in each case.

Reactor: Two 3-in.-thick aluminum slabs at various side-to-side separations.

0.0	22.99	42.22	3.22
1.0	24.56	45.12	3.44
2.0	32.08	58.94	4.50
3.0	42.11	77.36	5.90
4.0	65.10	119.58	9.12
4.0	56.16 ^a	103.16	7.86
4.0	57.07 ^b	104.84	8.00
2.0	30.33 ^c	55.72	4.25

- a. 1-in.-thick Plexiglas reflector on outside lateral surfaces to height of 22 in.
- b. Two 1-in. pieces Plexiglas 22-in. high between slabs.
- c. Two 1-in. pieces Plexiglas 12-in. high between slabs.

Table 3. Neutron Reflecting Properties of Some Common Insulating Materials.

Reactor: Two 3-in.-thick aluminum slabs
simulating a 6-in. slab.

Magnesia Density: 2-in. thick pieces = 0.32 g/cc
4-in. thick pieces = 0.24 g/cc

Insulation Thickness (in.)	Critical Conditions		
	Sol'n Height (cm)	Sol'n Volume (liters)	Mass (kg)
Reflector Material - Magnesia			
2.0	56.39	103.6	7.90
4.0	54.97	101.0	7.70
6.0	46.84 ^a	86.0	6.56
6.0	49.73 ^b	91.4	6.97
Reflector Material - Magnesia and Insulation Cement			
1.0	58.72 ^c	107.9	8.23
3.0	47.09 ^d	86.5	6.60
5.0	46.21 ^e	84.9	6.48
Reflector Material - Plexiglas			
1.0	30.84	56.64	4.32

- a. 2-in. thick pieces were against reactor.
- b. 4-in. thick pieces were against reactor.
- c. Reflector here was 1-in. thick pieces of insulation cement.
- d. The 1-in. thick cement was backed with 2-in. pieces of magnesia.
- e. The 1-in. thick cement was backed with 4-in. pieces of magnesia.

FIGURE 7

THE EFFECT OF COMMON INSULATING MATERIALS ON THE CRITICAL HEIGHT OF A 6" SLAB.

48" x 6" x h" SLAB - UO_2F_2
 $H : U-235 = 337$

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