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Abstract

Experiments were performed with 2.09% U²³⁵-enriched uranium metal plates in a light-water-moderated and -reflected assembly. Each plate was 30 in. long, 3-1/8 in. wide, and 1/4 in. thick and contained 7.09 kg of uranium. In the first assemblies the plates were arranged in rows with edges adjacent, and the spacing between rows was varied from 5/8 to 1-1/8 in. The optimum spacing was about 7/8 in. With the spacing between rows maintained at 7/8 in., the spacing between the edges of the plates was varied from 0 to 5/8 in. The optimum spacing between edges was 5/16 in. The minimum critical mass in these assemblies was 6.74 kg of U²³⁵.

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Critical Experiments with 2.09% U^{235} -Enriched
Uranium Metal Plates in Water

Experiments were performed with 2.09% U^{235} -enriched uranium metal plates in a light-water-moderated and -reflected assembly. Each plate was 30 in. long, 3-1/8 in. wide, and 1/4 in. thick and contained 7.09 kg of uranium metal. Some plates 1-1/2 in. wide were also available. All of the plates were copper plated and coated with varnish to prevent oxidation.

Two methods of assembly of the plates were used. They were initially assembled in rows of four with edges in contact in an aluminum frame which contained an aluminum bottom grid plate about 1-1/4 in. thick. This resulted in 1/4-in.-thick slabs of fuel 12.5 in. wide and 30 in. long standing on end in the grid plate and spaced 3/4 in. apart. The grid plate and frame rested on a plexiglas table in a tank of water.

The plates were also stacked horizontally on the table, in which case they were separated with plexiglas spacers. The volume fraction of plexiglas in the assemblies was about 0.20. In order to prevent trapping of air in the assemblies, the lattices were tilted up on one end. This resulted in nonuniform top reflectors except in those cases where the water thicknesses above the assemblies were effectively infinite. In these horizontal-plate assemblies the spacing between rows of fuel plates was varied from 5/8 in. to 1-1/8 in. In one assembly, which had a 7/8-in. spacing between rows, the spacing between the edges of the fuel plates was varied from 0 to 5/8 in.

Both methods of assembly resulted in almost parallelepipedal geometries. Whenever the last row of fuel plates contained less than four plates, these plates were centered in the row if possible.

In the initial assembly, that is, with the plates positioned vertically, two fission counters placed in the center of the array 15 in. from the top of the fuel plates were used to determine the source neutron multiplication. The neutron source was placed about 3 in. from the center of the assembly also 15 in. from the top of the fuel plates. The counter-source geometry, along with the loading pattern, is shown in Fig. 1. The inverse multiplication curve obtained is shown in Fig. 2. The assembly was subcritical with 49 plates assembled in 12 rows of four plates with one full plate centered in the next row and infinitely reflected on all sides. A half plate was added on the opposite side of the assembly from the full plate and the system was critical with 2.4 cm of top reflector, indicating that the critical number of plates was between 49 and 49-1/2. The value of the top reflector in this assembly was estimated from the measurements to be equivalent to about one plate.

A fission counter in the center of the assembly was used for a vertical flux traverse, the results of which are shown in Fig. 3. The normalizing counter was another fission counter centered at the side core-reflector boundary. The value of the vertical buckling estimated from a cosine fit to the flux traverse is 0.0015 cm^{-2} .

The results of the measurements on the horizontal assemblies on the plexiglas table are shown in Table 1. The minimum critical mass was 6.74 kg. When the total number of plates in each of these assemblies was reduced by a half plate in the top row, the resulting system was found to be subcritical with an infinite water reflector. The variation of the number of plates at criticality with spacing between rows of plates and spacing between edges of plates in a row are shown in Figs. 4 and 5, respectively. For a zero edge-to-edge spacing of plates, the optimum spacing between rows of plates is about $7/8$ in. For the $7/8$ -in. spacing between rows of plates the optimum edge-to-edge spacing is $5/16$ in.

LEGEND

- INITIAL LOADING
- ▨ FIRST ADDITION
- ▧ SECOND ADDITION
- ▩ THIRD ADDITION
- ▬ FOURTH ADDITION
- FINAL LOADING - SUPERCRITICAL WITH
2.4 cm OF TOP REFLECTOR

Fig 1. Counter - Source Geometry and Loading Pattern for
Critical Experiment with 2.09% U^{235} -Enriched Metal Plates.

Fig. 2. Source Neutron Multiplication as a Function of the Number of 2.09% U^{235} -Enriched Uranium Metal Plates in a Vertical Assembly.

Fig. 3. Fission Flux Measurements Along Vertical Center Line of 2.09% U^{235} -Enriched Uranium Metal Plate Assembly.

Table 1. Results of Measurements of Horizontal Assemblies

Spacing Between Rows (in.)	Spacing Between Plates in Row (in.)	Water: Metal Volume Ratio	Total Number of Plates	^{235}U Mass (kg)	Maximum ^a Fuel Height (cm)	Minimum ^b Fuel Height (cm)	Arrangement of Plates	Water Height at Criticality ^c (cm)
5/8	0	2.5	54	8.03	33.0	29.5	13 rows of 4 plates, 2 plates centered in next row	38.2
3/4	0	3.0	49	7.26	34.0	31.1	12 rows of 4 plates, 1 plate centered	40.5
7/8	0	3.5	47	6.97	35.0	32.0	11 rows of 4 plates, 3 plates centered	42.0
7/8	1/4	3.8	45-1/2	6.74	35.0	32.0	11 rows of 4 plates, 1 plate centered, 1/2 plate off center	39.8
7/8	3/8	3.9	45-1/2	6.74	35.0	32.0	11 rows of 4 plates, 1 plate centered, 1/2 plate off center	40.1
7/8	5/8	4.2	47	6.97	35.0	32.0	11 rows of 4 plates, 3 plates centered	41.0
1	0	4.0	48	7.12	39.8	35.6	12 rows of 4 plates	60.9
1-1/8	0	4.5	51	7.57	45.8	42.6	12 rows of 4 plates, 3 plates centered	58.8

a. Maximum distance from plexiglas table to upper surface of fuel in top row.

b. Minimum distance from plexiglas table to upper surface of fuel in top row.

c. Height above plexiglas table.

Fig. 4. Number of 2.09% U^{235} -Enriched Uranium Metal Plates Required for Criticality as a Function of Spacing Between Rows of Plates: Horizontal Assemblies with Zero Edge-to-Edge Spacing Between Plates.

Fig. 5. Number of 2.09% U^{235} -Enriched Uranium Metal Plates Required for Criticality as a Function of Edge to-Edge Spacing of Plates in a Row: Horizontal Assemblies with $7/8$ -in. Spacing Between Rows.

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