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3.7. CRITICAL PARAMETERS OF UNREFLECTED ARRAYS OF INTERACTING CYLINDERS CONTAINING AQUEOUS SOLUTIONS OF U^{235}

J. K. Fox L. W. Gilley

A study of the critical parameters of aqueous solutions of 93.2% U^{235}-enriched uranyl fluoride in arrays of interacting cylinders was initiated several years ago. Experiments have been performed recently which extend these studies to include various unreflected arrays of aluminum cylinders containing solutions with $H:U^{235}$ atomic ratios of 297 and 309. (Previous work[1] with more than two cylinders was limited to an $H:U^{235}$ ratio of about 45.) The cylinders, which were coated on the inside with Heresite for protection against corrosion, had 6-, 8-, and 9.5-in. diameters and $\frac{1}{16}$-in.-thick walls. They were assembled in triangular, hexagonal, or line arrays that were isolated as far as possible from any reflecting material. In this respect, they differ from earlier unreflected experiments which were performed in a 9.5-ft-dia steel tank.

The results of measurements with 6- and 8-in.-dia cylinders for solutions with an $H:U^{235}$ atomic ratio of 309 are given in Table 3.7.1 and Fig. 3.7.1. Since single 6- or 8-in.-dia cylinders are not critical, the critical heights of arrays of these cylinders increase rapidly as the edge-to-edge spacings of the cylinders are increased. Because an isolated 8-in.-dia cylinder is more nearly critical than a 6-in.-dia cylinder, arrays of 8-in.-dia cylinders require wider spacings to approach an infinite critical height.

Interacting arrays of unreflected 9.5-in.-dia cylinders containing solutions with an $H:U^{235}$

[1] J. K. Fox, L. W. Gilley, and D. Callihan, *Critical Mass Studies, Part IX, Aqueous U^{235} Solutions*, ORNL-2367 (Feb. 5, 1958); see also J. K. Fox and L. W. Gilley, *Appl. Nuclear Phys. Ann. Prog. Rep. Sept. 10, 1956*, ORNL-2081, p 63.

Table 3.7.1. Critical Parameters of an Aqueous Solution of 93.2% U^{235}-Enriched Fluoride Contained in Unreflected 6- and 8-in.-dia Aluminum Cylinders in Hexagonal and Triangular (Equilateral) Arrays

Solution concentration: 0.0812 g of U per g of solution; 0.0836 g of U^{235} per cc of solution
$H:U^{235}$ atomic ratio: 309
Specific gravity: 1.105

Edge-to-Edge Cylinder Spacing (in.)	Cylinder Diameter (in.)	Critical Values: Height (in.)	Critical Values: Volume (liters)	Critical Values: Mass (kg of U^{235})
Seven-Cylinder Hexagonal Array				
0.3	6	12.2	39.5	3.30
1.0	6	22.4	72.4	6.05
2.0	6	77*	~250	~21
1.0	8	11.3	65.1	5.44
3.0	8	17.8	103	8.62
6.0	8	35.4	205	17.1
7.0	8	46.9	271	22.6
Three-Cylinder Triangular Array				
0.15	8	16.3	40.5	3.39
1.0	8	31.2	77.2	6.46
2.0	8	**		

*Extrapolated from fuel height of 63 in.

**Extrapolation indefinite (probably not critical at any height).

atomic ratio of 297 have been studied in a variety of configurations. The data are shown in Table 3.7.2. Figure 3.7.2 presents a plot of critical height as a function of edge-to-edge spacing for various in-line arrays of these cylinders. The graph demonstrates that the effect obtained by adding a cylinder decreases as the total number of cylinders in line increases, as expected. The addition of a sixth cylinder to an existing row of

Table 3.7.2. Critical Parameters of an Aqueous Solution of 93.2% U^{235}-Enriched Uranyl Fluoride Contained in Unreflected 9.5-in.-dia Cylinders in Line, Triangular, Square, and Hexagonal Arrays

Solution concentration: 0.0841 g of U per g of solution; 0.0868 g of U^{235} per cc of solution

$H:U^{235}$ atomic ratio: 297

Specific gravity: 1.109

Edge-to-Edge Cylinder Spacing (in.)	Critical Values		
	Height (in.)	Volume (liters)	Mass (kg of U^{235})
Two-Cylinder Line Array			
1.0	24.1	56.1	4.87
3.0	31.7	73.9	6.41
6.0	44.5	104	9.03
8.0	54.0	126	10.9
Three-Cylinder Line Array			
2.0	22.3	78.1	6.78
6.0	33.2	116	10.1
10.0	43.8	153	13.3
15.0	60.1	211	18.3
Four-Cylinder Line Array			
3.0	22.7	106	9.20
6.0	30.0	138	12.0
10.0	38.5	180	15.6
Five-Cylinder Line Array			
3.0	21.7	127	11.0
6.0	28.3	165	14.3
10.0	36.2	211	18.3
Six-Cylinder Line Array			
3.0	21.3	149	12.9
10.0	34.8	243	21.1
Three-Cylinder Triangular Array			
1.0	13.4	47.0	4.08
4.0	20.3	70.8	6.15
8.0	28.1	98.2	8.52
12.0	36.3	127	11.0
18.0	49.7	174	15.1
22.0	60.1	211	18.3
Four-Cylinder Square Array			
3.0	15.8	73.8	6.40
10.0	27.2	127	11.0
22.0	47.4	220	19.1
30.0	62.5	292	25.3
Seven-Cylinder Hexagonal Array			
3.0	12.1	98.6	8.56
10.0	20.1	164	14.2
22.0	32.9	268	23.3

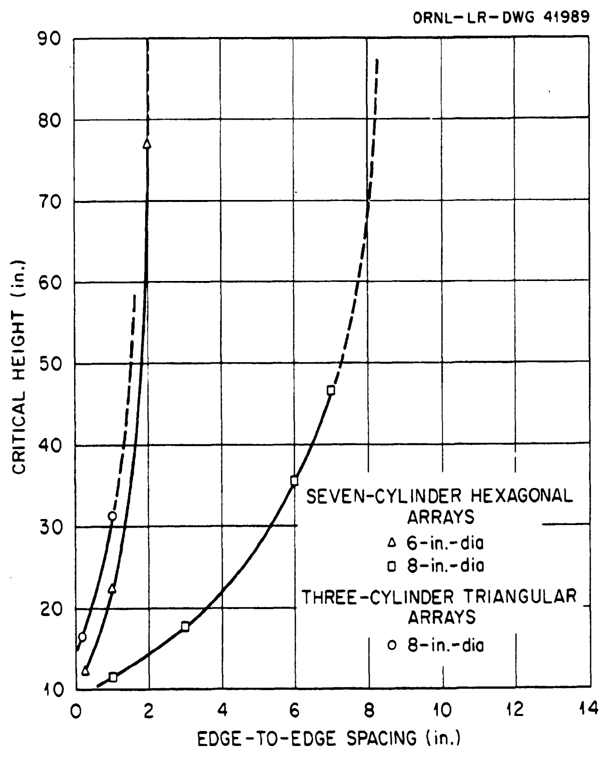

Fig. 3.7.1. Critical Solution Height as a Function of Edge-to-Edge Spacing of Unreflected Triangular and Hexagonal Arrays of 6- and 8-in.-dia Aluminum Cylinders Containing Aqueous Solutions of 93.2% U^{235}-Enriched Uranyl Fluoride ($H:U^{235}$ Atomic Ratio = 309).

five increased the over-all reactivity by approximately 26 cents. The effect of the addition appears to be insensitive to the edge-to-edge spacing.

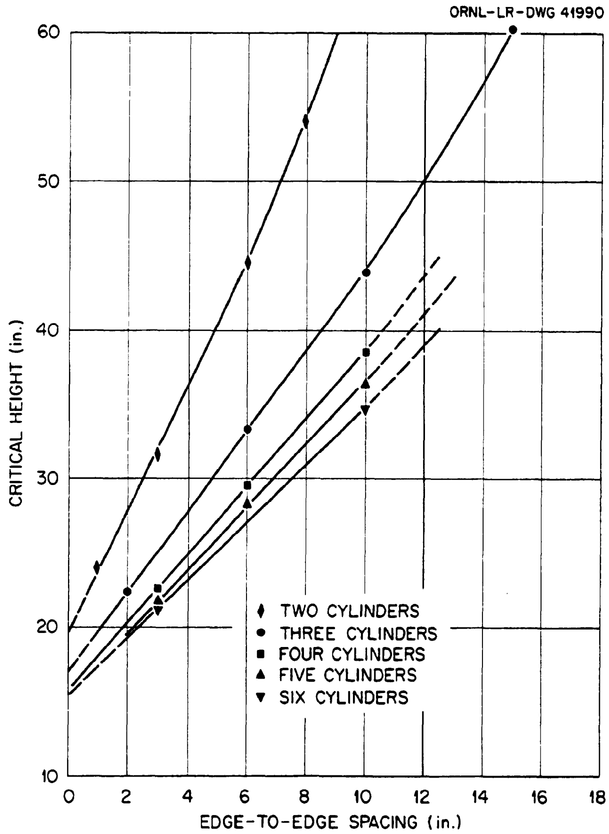

Fig. 3.7.2. Critical Solution Height as a Function of Edge-to-Edge Spacing of Unreflected Straight-Line Arrays of 9.5-in.-dia Aluminum Cylinders Containing Aqueous Solutions of 93.2% U^{235}-Enriched Uranyl Fluoride ($H:U^{235}$ Atomic Ratio = 297).

Figure 3.7.3 shows the variation in critical height as a function of the cylinder edge-to-edge spacing for the triangular, square, and hexagonal arrays of 9.5-in.-dia cylinders. In this figure, as opposed to the data in Fig. 3.7.1 for smaller cylinders, the variation is linear out to a spacing of about 20 in.

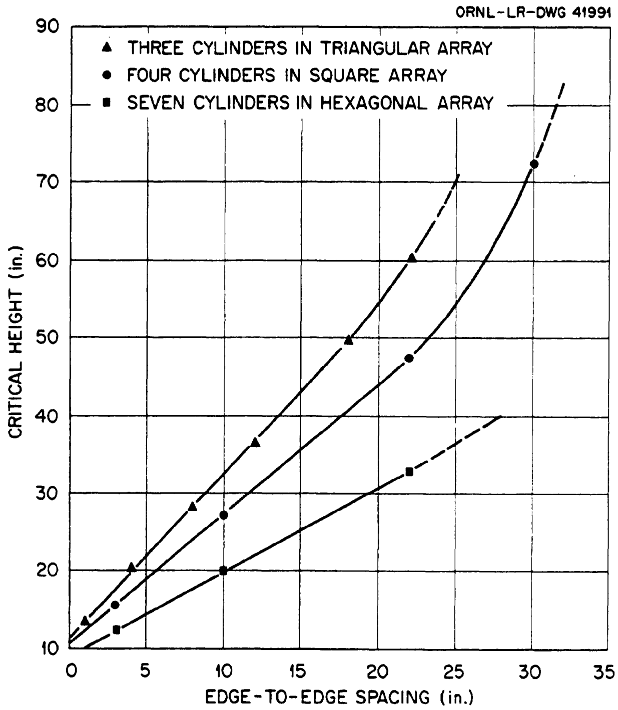

Fig. 3.7.3. Critical Solution Height as a Function of Edge-to-Edge Spacing of Unreflected Triangular, Hexagonal, and Square Arrays of 9.5-in.-dia Aluminum Cylinders Containing Aqueous Solutions of 93.2% U^{235}-Enriched Uranyl Fluoride ($H:U^{235}$ Atomic Ratio = 297).