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A SMALL GRAPHITE-REFLECTED UO_2 CRITICAL ASSEMBLY, Part II

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ABSTRACT

An unmoderated, graphite reflected, critical assembly of UO_2, enriched to 93.2 wt% in U^{235} is described. The UO_2 pellets, density 9.71 g/cm^3, were contained in 253 1.27-cm-dia and 30.48-cm-long stainless steel tubes which, in turn, were packed with a center-to-center spacing of 1.506 cm in an aluminum container 25.96 cm in diameter. The thickness of the graphite which was required to make the assembly critical ranged from 22.86 cm on the bottom to 27.90 cm in one section on the side. Fission distribution measurements axially through the assembly and radially through the reflector showed a peak in the radial reflector a factor of 15 greater than at the center of the core. The U^{235}-fission cadmium ratio measured in the side reflector ranged from 3 to 7.6.

A SMALL GRAPHITE-REFLECTED UO_2 CRITICAL ASSEMBLY, Part II

INTRODUCTION

A second small unmoderated critical assembly of U^{235}-enriched UO_2 reflected by graphite, constructed in the Oak Ridge Critical Experiments Facility, has provided additional data in support of reactor calculations. This assembly differs from the earlier one in that the UO_2 fuel rods are spaced 1.506 cm, center-to-center, whereas previously the same number of rods were close packed. The reflector configuration required to make the assembly critical was established and representative fission rate distributions and associated cadmium ratios were measured.

MATERIAL AND EQUIPMENT

The core of the assembly, nominally 25.5 cm in diameter and 30.5 cm high, was a triangular lattice of 253 fuel rods consisting of UO_2 pellets closely fitted into type 347 stainless steel tubes. The density of the pellets was 9.71 g/cm^3 and the U^{235} content of the uranium was 93.2 wt%. The rods were described in the earlier report.[1] The tubes and the graphite bottom reflector, invariable in thickness in this assembly, were mounted in a type 1100 aluminum can, the center-to-center triangular lattice spacing of the tubes being fixed at 1.506 cm by grid plates at the top and bottom. The grid plates were spaced by four type 347 stainless steel tubes which surrounded four equally spaced peripheral fuel tubes. The thicknesses of the graphite reflector on the top and side were the variables that were adjusted in steps to make the assembly critical. The properties of the assembled core and of the reflector are given in Tables I and II. The core and one of the core grid plates are shown in Figs. 1 and 2 and a sketch of the assembly is shown in Fig. 3. Not shown in the sketch are six equally spaced radial holes through the graphite side reflector. Each of these holes is 1.27 cm in diameter, and their axes are located 7.63 cm below the midplane of the core. There is also a vertical hole of the same diameter through the top reflector centered on the axis of the core. As in the previous experiment the core and bottom reflector were inserted into the top and side reflector to achieve criticality.

EXPERIMENTAL RESULTS

The assembly had a reactivity of -1¢ with the central fuel tube absent and with the graphite reflector arranged as shown in Fig. 3. The dimensions of the reflector are given in Table II. At this time one of the radial holes in the side reflector was empty. The remaining five and the axial hole through the top reflector contained 0.95-cm-dia graphite plugs. The reactivity value of one of these plugs was about 2¢.

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1. J. T. Mihalczo, "A Small Graphite-Reflected UO_2 Critical Assembly," ORNL-TM-450 (Dec. 1962).

Table I - Core Properties

Core	
Mass of U^{235} (kg)	61.15
Mass of UO_2 (kg)	74.54
Mass of Stainless Steel Tubes, Type 347 (kg)	11.43
Core Tank (open top)	
Material	Type 1100 Aluminum
Side Wall Thickness (cm)	0.254
Bottom Thickness (cm)	0.364
Outside Diameter (cm)	25.96
Outside Length (cm)	54.04
Mass (kg)	3.387
Grid Plates (2)	
Material	Type 1100 Aluminum
Thickness (cm)	0.317
Mass (g)	139 (each)
Grid Plate Spacer Tubes (4)	
Material	Type 347 Stainless Steel
Outside Diameter (cm)	1.37
Wall Thickness (cm)	0.076
Length (cm)	27.94
Weight (g)	37.5 (each)
Fuel Tube Clips[a] (10)	
Material	Type 1100 Aluminum
Mass (g)	2.3 (each)

a. These clips were at the core midplane to hold outer fuel elements in position.

Table II - Reflector* Properties

Side Reflector - Graphite (Type ATL)		
Height (cm)	Lower Section	46.63
	Upper Section	7.63
Thickness (cm)	Lower Section	27.90
	Upper Section	25.53
Inside Diameter (cm)	Lower Section	26.13
	Upper Section	26.14
Mass (kg)	Lower Section	388.6
	Upper Section	55.0
Top Reflector - Graphite (Type ATL)		
Thickness (cm)	Lower Section	15.25
	Upper Section	8.36
Diameter (cm)	Lower Section	76.2
	Upper Section	50.8
Mass (kg)	Lower Section	124.1
	Upper Section	28.5
Bottom Reflector - Graphite (Type ATL)		
Thickness (cm)		22.86
Diameter (cm)		25.42
Mass (kg)		19.21
Additional Bottom Reflector		
Bottom of Core Tank - Aluminum (Type 1100)		
Thickness (cm)		0.364
Diameter (cm)		25.96
Mass (kg)		0.504
Core Support Plates		
Aluminum (Type 1100)		
Thickness (cm)	Lower Section	0.63
	Upper Section	1.94
Diameter (cm)	Lower Section	45.72
	Upper Section	21.60

Table II - Continued

Mass (kg)	Lower Section	2.787
	Upper Section	1.920
Stainless Steel (Type 304)		
Thickness (cm)		2.38
Diameter (cm)		45.72
Mass (kg)		7.76
Reflector Support Plate - Iron		
Thickness (cm)		1.27
Outside Dimensions (cm)		121.9 x 121.9
Inside Diameter (cm)		26.67
Mass (kg)		136.7

* See Fig. 3 for relative location of the various components of the reflector. It is noted that both the top and the side reflectors are in two sections and that the core is supported by three plates, two of aluminum and one of stainless steel, located one above another.

Fig. 1. Core Assembly

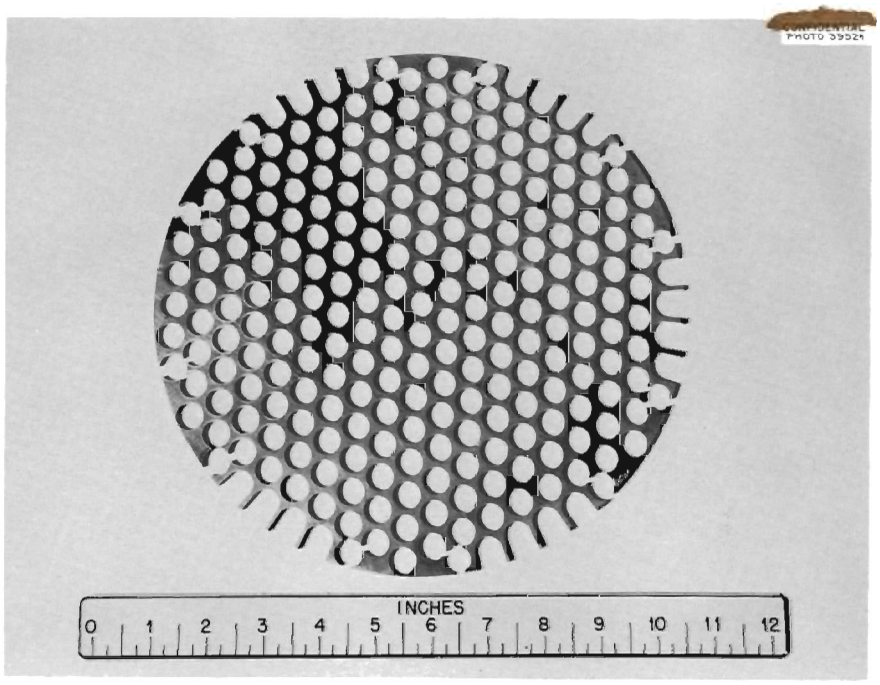

Fig. 2. Fuel Tube Grid Plate

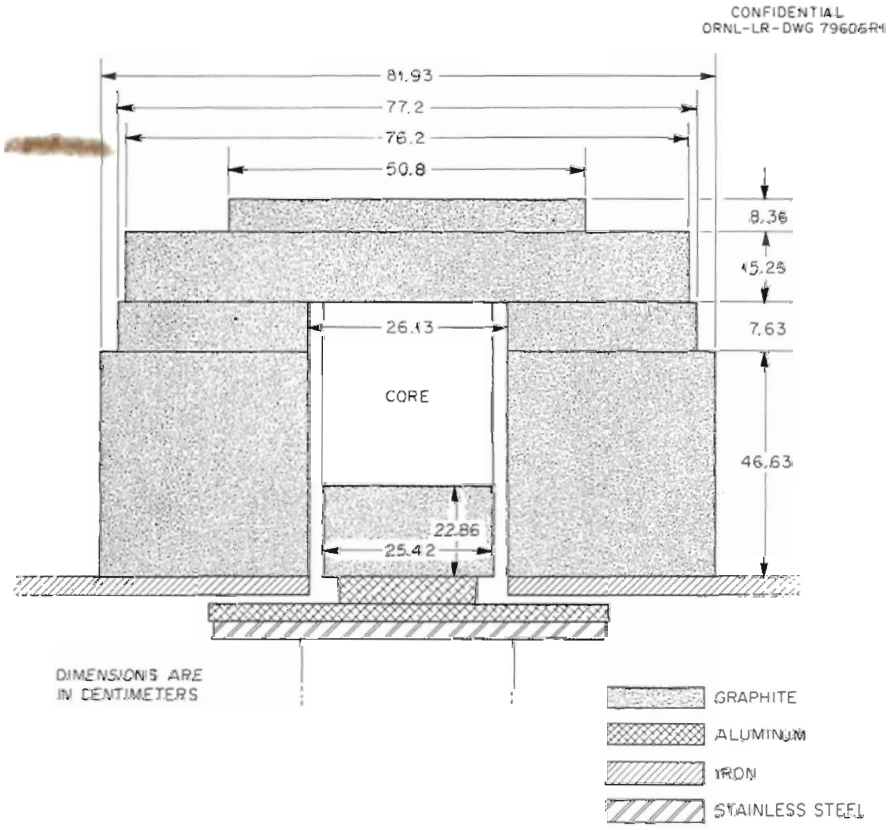

Fig. 3. Reactor-Core Assembly.

The flux distribution and the U^{235} -fission cadmium ratio through the 27.90 cm-thick side reflector were measured along a radius 7.6 cm below the midplane of the core using 0.75-cm-dia by 0.010-cm-thick U(93.2) metal foils as detectors. Table III summarizes the results of the foil measurements which are plotted in Fig. 4. No self-shielding correction has been made to the foil data. Fission rate distribution were also measured with a 2.5-cm-long by 0.64-cm-dia U^{235} fission counter along the vertical axis of the core. The fission rate as a function of the distance from the bottom of the core is plotted in Fig. 5 and given in Table IV.

Table III - Radial Fission Rate and Cadmium Ratio Distribution in the Side Reflector 7.6 cm Below Core Midplane

Distance from Core (cm)[a]	Relative Fission Rate	Cadmium Ratio[b]
0.5	0.65	2.97
3.0	1.08	
6.0		4.91
6.5	1.45	
8.5	1.53	
11.7	1.52	
12.0		6.01
14.5	1.44	
17.0	1.27	
18.0		6.60
20.7	0.95	
24.0		7.67
24.5	0.54	
26.5	0.33	

a. Measured from the core-reflector interface.
b. The detectors were 0.010-cm-thick by 0.75-cm-dia U(93.2) metal foils. Cadmium covers were 0.051 cm thick. No correction has been made for self-shielding in the foils.

Table IV - Axial U^{235}-Fission Rate Distribution

Distance from Bottom of Core[a] (cm)	Relative Fission Rate	
	Counter[b]	Foils[c]
5.0	0.12	
7.5	0.09	
10.0	0.12	
12.6	0.10	
15.1	0.11	
17.7	0.11	
20.2	0.10	
22.8	0.10	
25.3	0.13	
27.8	0.40	
30.4	0.67	
32.9	0.88	
35.4	0.99	
39.7	0.94	1.0
40.5	1.01	
42.8	1.02	0.97
45.8	0.87	0.86
48.1	0.69	
50.7	0.44	
53.2	0.23	

a. Measured from the bottom of the stainless steel fuel tubes.
b. The detector was a U^{235} fission counter 2.5-cm long by 0.64 cm in diameter.
c. The foils are described in Table III, Footnote b.

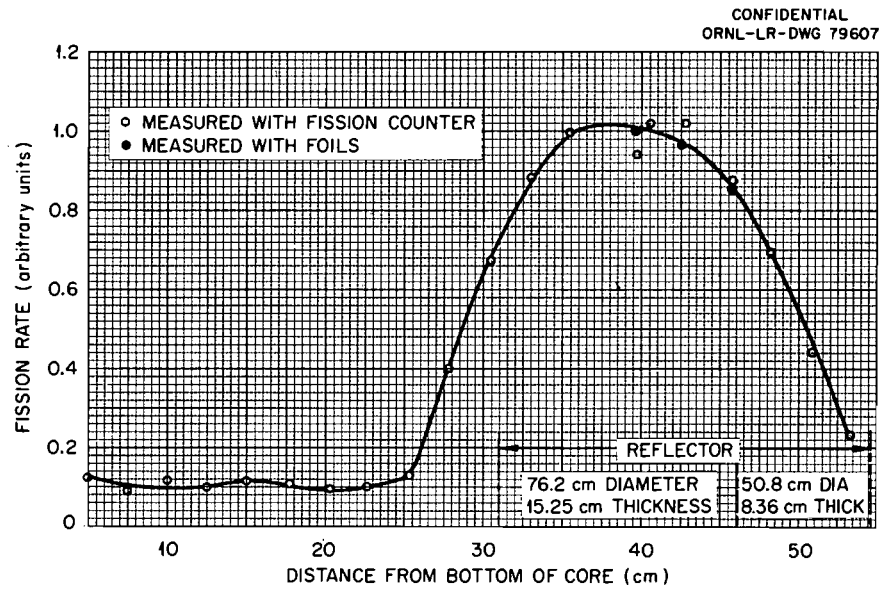

Fig. 4. Axial Fission Rate Distribution.

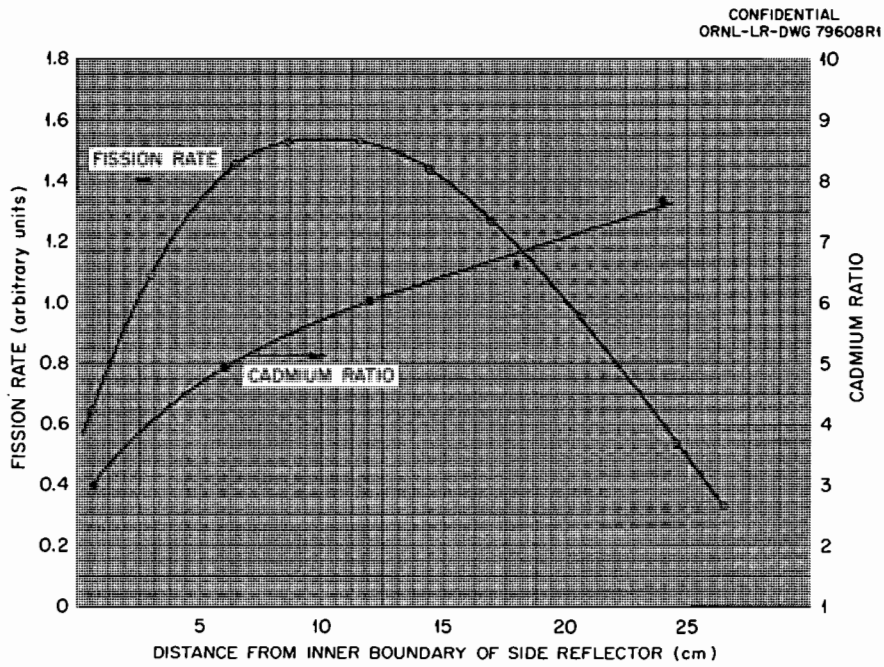

Fig. 5. Radial Fission Rate and Cadmium Ratio Distribution in the Side Reflector 7.6 cm Below Core Mid-Plane.

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