REFERENCE 158

J. T. MIHALCZO, "CRITICAL EXPERIMENTS AND CALCULATIONS WITH ANNULAR CYLINDERS OF U(93.2) METAL," IN "NEUTRON PHYSICS DIVISION ANNUAL PROGRESS REPORT FOR PERIOD ENDING AUGUST 1, 1963," OAK RIDGE NATIONAL LABORATORY REPORT ORNL-3499 (OCTOBER 1963), VOL. 1, PP. 62-63.

2. Critical Experiments

2.6. CRITICAL EXPERIMENTS AND CALCULATIONS WITH ANNULAR CYLINDERS OF U(93.2) METAL

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A series of critical experiments with annular cylinders of uranium metal was performed to verify the adequacy of the S_n method of solving the transport equation for this geometry. The uranium has a density of 18.76 g/cc and is enriched to 93.2% in the U^{235} isotope. Unreflected annuli with outside diameters as large as 15 in. and inside diameters as small as 7 in. were assembled to delayed critical, and the prompt-neutron decay constant was measured by the Rossi-α technique.[1] In the Rossi-α measurements two detectors were used with a Technical Measurement Corporation 256-channel analyzer having a time-of-flight logic unit. A signal from a plastic scintillator sensitive to neutrons and gamma rays triggered the time analyzer, and the time distribution of neutrons detected by a small U^{235} spiral fission counter was measured. The resulting values of the decay constant, together with the measured reactivities of the various assemblies, are shown in Table 2.6.1.

Multiplication constants of the experimental configurations were calculated by multigroup transport theory using the S_n method[2] in the S_8 approximation, the TDC computer code,[3] and the six-group cross-section values of Hansen and Roach[4] for the U^{235} and U^{238} isotopes. Fission of U^{234} and of U^{236} was included, and the absorption and scattering properties of these isotopes were assumed to be the same as those of U^{238}. The calculated values of the multiplication constant, which are included in Table 2.6.1, are in agreement with the measured reactivities.

The prompt-neutron decay constants obtained from the Rossi-α measurements with the annular cylinders at delayed critical are somewhat smaller than those obtained for solid uranium metal assemblies since the flight time of the neutrons across the center void constitutes a large fraction of the prompt-neutron lifetime.[5] At delayed critical the prompt-neutron decay constant is inversely proportional to the prompt-neutron lifetime, and the proportionality constant, the effective delayed-neutron fraction, is taken to be 0.0067. The prompt-neutron lifetime for the 11-in.-OD by 7-in.-ID assembly is 9.8×10^{-9} sec, which is to be compared with 6.2×10^{-9} sec for solid uranium metal assemblies.

The effect of inserting graphite (National Carbon type ATL; $\rho = 1.7$ g/cc) and beryllium ($\rho = 1.83$ g/cc) into the center cavity was also determined, and comparisons of the experimental results with calculated values are included in Table 2.6.1. The calculations of these experiments by the TDC code used the 16-group cross-section values of Hansen and Roach,[3] with U^{234} and U^{238} treated as above.

In general, the agreement between calculation and experiment is good and demonstrates the adequacy of the S_n method in the S_8 approximation for assemblies with large central voids.

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[1] J. Orndoff, *Nucl. Sci. Eng.* **2**, 450 (1957).

[2] B. G. Carlson and G. I. Bell, *Proc. Intern. Conf. Peaceful Uses Atomic Energy, 2nd, Geneva, 1958* **16**, 535–49 (1959).

[3] B. Carlson, C. F. Lee, and J. Worlton, *The DSN and TDC Neutron Transport Codes*, LAMS-2346 (1960).

[4] G. E. Hansen and W. H. Roach, *Six and Sixteen Group Cross Sections for Fast and Intermediate Critical Assemblies*, LAMS-2543 (1961).

[5] J. T. Mihalczo, *Trans. Am. Nucl. Soc.* **6**, 60 (1963).

Table 2.6.1. Experimental and Calculated Results for Cylindrical Annuli of U(93.2) Metal

Dimensions		Average Height[a] (in.)	Mass (kg of U)	Content of Center Cavity	Reactivity[b] (cents)	Calculated k_{eff}	Prompt-Neutron Decay Constant[c] (sec^{-1})
Outside Diameter (in.)	Inside Diameter (in.)						
11	7[d]	7.31	157.9	Air	−16.5	0.9900	$(0.686 \pm 0.008) \times 10^6$
13	7	5.74	165.6	Air	− 4.2	1.0014	$(0.883 \pm 0.009) \times 10^6$
13	7	5.26	151.9	C	+15.6	1.0013	
13	9[e]	6.08	128.7	C	− 5.3	1.0033	
15	7	4.23	179.0	Air	−13.5	0.9981	$(0.950 \pm 0.010) \times 10^6$
15	7	4.10	173.6	C	−24.6	0.9963	
15	7	3.98	168.6	Be	− 6.3	1.0035	
15	9	5.93	205.6	Air	−26.7	1.0027	$(0.840 \pm 0.008) \times 10^6$
15	9	5.35	185.3	C	−11.5	0.9980	

[a] Irregular top; fuel height increment, 0.062 in.; fuel radial increment, 1.0 in. The uncertainty in the average height is less than 0.03 in.

[b] Upon complete reassembly the change in the reactivity was less than ±5 cents. Reactivities of the assemblies have been corrected for support structure.

[c] Error from least-squares analysis of the counter data.

[d] A 7-in.-diam, 1.38-in.-thick disk was located at the bottom of the cavity, and a 7-in.-diam, 1.25-in.-thick disk was located with its top surface 0.13 in. below the top of the annulus.

[e] 1-in. carbon reflector.