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E. I. du Pont de Nemours and Co.
Savannah River Laboratory
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SECTION I

PHYSICS EXPERIMENTS FOR CANDU LATTICES

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INTRODUCTION

In FY-1966 a series of experiments with mockups of burned-up D_2O reactor fuels were performed in the Process Development Pile (PDP) and Subcritical Experiment (SE). There is a continuing analysis of these experiments. Preparations are also underway for new experiments to be performed in the PDP in June to measure $1/\eta\ d\eta/dT$ and the effects of asymmetric control rod placement.

SUMMARY

Analyses of measurements with the mocked-up burned-up fuel in the PDP have been largely completed and the results compared with calculations by the HAMMER code. It appears that the methods used to represent rod clusters as rings for HAMMER computations may overestimate resonance capture. The $1/\eta\ d\eta/dT$ experiments are on schedule.

DISCUSSION

$1/\eta\ d\eta/dT$ Experiment

The copper tubes have been loaded with natural uranium slugs, and preparations are in progress for installing these assemblies into the PDP. The experiments are scheduled to begin about the first of June.

Lattice Parameter Analyses

Calculation of Lattice Parameters

All lattice computations were performed with the SRL HAMMER code. SRL HAMMER is a one-dimensional IBM-360 code for integral-transport calculations of heterogeneous lattices. The computations are based on 54 fast energy groups (above 0.62 ev) and 30 thermal energy groups (below 0.62 ev). Effective resonance neutron cross sections are calculated by the Nordheim ZUT and TUZ codes. Up to 20 spatial regions are allowed. Reaction rates for the 84 total energy groups are collapsed into four (or fewer) energy groups, and the cross sections, migration areas, and bucklings are evaluated from the solution of the few group diffusion equation (FLOG).

Lattice Computations - Cylindrical Model

In order to calculate rod-cluster assemblies by HAMMER, it is necessary to construct a suitable one-dimensional model of the cluster. A model consisting of concentric cylindrical rings of fuel and D_2O was selected since it was expected to be more accurate than homogenization of the whole cluster into a single large rod. The rings were chosen to approximate the essential physics characteristics of the cluster, i.e., the fuel was distributed spatially so as to give nearly the proper thermal neutron distributions, and the fuel surfaces were positioned so as to give approximately the correct resonance capture. However, some compromises were required in trying to mock up both thermal and resonance effects simultaneously.

A pictorial presentation of the model is given in Figure 1, which shows its application to the 31-rod cluster. Hexagonal microcells were constructed by drawing lines joining the rod centers. Each microcell was then divided into a fuel region and a mixed region of coolant, clad, and void. Starting from the center, the fuel and D_2O mixture rings were constructed from the microcell regions in such a fashion as to conserve areas and average atom densities. The area of the complete cluster (Regions 1-8 in Figure 1) was simply the sum of the microcell areas.

Resonance Capture, Comparison of Experiment to Calculations

Values of ρ, the ratio of epicadmium to subcadmium neutron capture in ^{238}U, as calculated by HAMMER using the preceding model are listed in Table I. A hand computation was made to correct for the fact that the effective surface of the fuel in the ring model differs slightly from the effective surface of the fuel in the actual rod cluster. In this computation the effective surfaces were calculated directly for both models; the corresponding resonance integrals for ^{238}U were obtained from the standard expression,

$$RI = A + B\sqrt{S/M},$$

using Hellstrand's values of A and B; and the calculated values of ρ_{28} were multiplied by the ratio RI_{Rods}/RI_{Ring}. The corrections ranged from 3% to 7% for the 19-rod cluster and were less than 1% for the 31-rod cluster.

Computed corrections were also applied to the copper and manganese foils to correct for thermal neutron self-shielding effects. The experimental values of ρ were obtained from these numbers. The experimental ρ values are seen to be generally lower than the computed values. The discrepancy is in the same direction as and of comparable magnitude to the discrepancy between computed and measured bucklings.

Total U-238 capture (C^*), normalized to U-235 fission, is also shown in Table I. The U-235 fissions were assayed by activating U-235-Al foils and also by taking the difference in counts between natural and depleted uranium foil pairs. The agreement between the experiments and the computations is seen to be fairly good except for the U-235-Al measurements on the 19-rod clusters of Type E fuel, where a loading error is suspected. Since C^* is dominated by thermal rather than resonance effects, it is not inconsistent that there should be reasonable agreement here and lack of agreement in ρ. Table I also includes a comparison of computed and measured values of δ, the ratio of U-238 to U-235 fissions in the clusters.

TABLE I

RESONANCE CAPTURE AND FAST FISSION IN CLUSTERS OF URANIUM OXIDE RODS

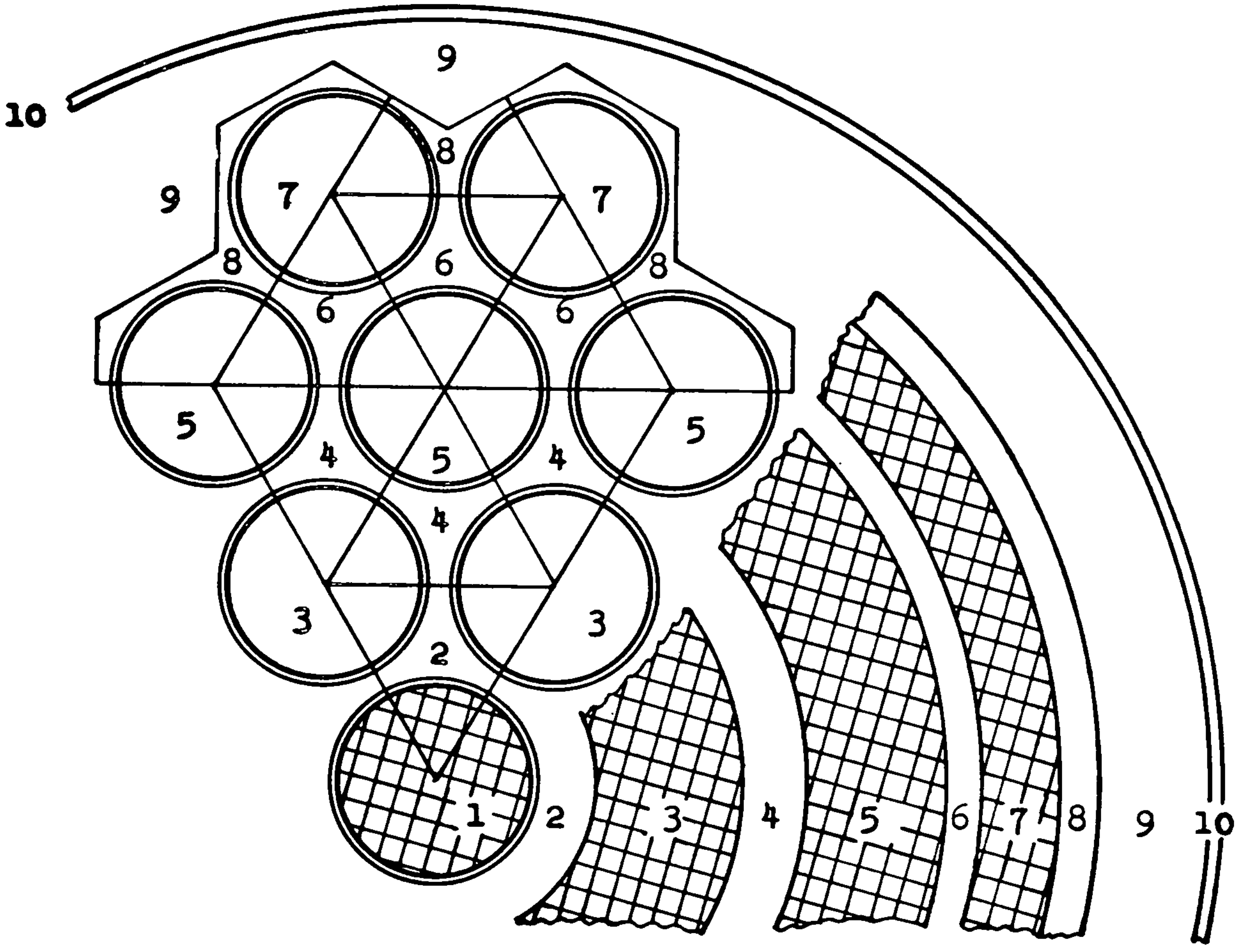
		ρ					δ_o (1)		C^* (2)		
		HAMMER		Exp						Exp.	
Fuel Type(3)	Coolant	Cylind.	Corr.	Avg.	Cu	Mn	HAMMER	Expt.	HAMMER	Nat.-Depl.	U-235-Al
19-A	D_2O	.373	.390	.368	.368	-	.0468	.049	2.085	2.18	2.21
19-B	HB-40	.348	.372	.337	.337	-	.0467	.048	2.072	2.10	2.12
19-C	HB-40	.410	.438	.437	.437	-	.0550	.056	2.150	2.18	2.21
19-C	D_2O	.436	.456	.400	.400	-	.0556	.056	2.203	2.17	2.23
19-C	Air	.404	.417	.391	.391	-	.0568	.054	2.166	-	-
19-E	HB-40	.339	.362	.335	.366	.304	.0456	.045	0.8707	0.863	0.805
19-E	D_2O	.362	.380	.366	.357	.375	.0458	.041	0.8882	0.913	-
19-E	Air	.336	.347	.347	.341	.353	.0471	.050	0.8740	0.870	0.763
31-C	D_2O	.694	.691	.655	.655	-	.0696	.060	2.582	2.53	2.59
31-C	HB-40	.588	.585	.571	.571	-	.0691	.065	2.427	2.45	2.42
31-E	D_2O	.563	.560	.510	.500	.520	.0563	-	1.009	0.988	-
31-E	HB-40	.476	.473	.428	.423	.433	.0559	-	0.958	0.942	0.835

(1) δ_o is 238/235 fission ratio in natural U foils.

(2) C^* is the ratio of total ^{238}U captures to ^{235}U fissions in fuel cluster.

(3) See earlier reports for full fuel descriptions.

Fig. 1. Model for Conversion of Cluster to Equivalent Rings for HAMMER Computations (Applied to 31-Rod Cluster)



Region	Material
1,3,5,7	Fuel
2,4,6,8	Coolant, Clad, Void
9	Coolant
10	Al

Volumes and average densities are conserved for each region

SECTION II

AECL IN-CORE FLUX MONITORS

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An irradiation test of in-core flux monitors is being made in one of the Savannah River Plant reactors to determine the life characteristics of a selection of flux detectors and of the mineral insulation used in their construction. Self-powered flux detectors are relatively new; therefore, confidence in their use hinges to a great extent on proven performance at large integrated exposures. The chief points of interest are 1) integrity of the conductors and sheath during life, 2) life of insulation, and 3) sensitivity. The higher flux density available at SRP (vis-à-vis Chalk River) will shorten the irradiation time for a given exposure and should also show whether or not any new high intensity effects appear.

Fabrication and installation of the detector rod in the reactor has been completed and testing is in progress. There were no special tests in April. No significant changes in the detector or cable outputs from those reported in DPST-66-83-8 have occurred. The data being collected will be reported in a separate topical report at the conclusion of the tests.

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