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PHYSICS EXPERIMENTS WITH FUEL ASSEMBLIES SIMULATING BURNED-UP FUEL

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INTRODUCTION

A series of experiments are scheduled for the Process Development Pile (PDP) and Subcritical Experiment (SE) facilities at the Savannah River Laboratory to investigate the physics behavior of burned-up fuel in the CANDU and similar heavy-water power reactors. These experiments are to make use of specially fabricated fuel assemblies containing plutonium and uranium in approximately the isotopic compositions expected for a fuel irradiation of 5000 MED/ton.

SUMMARY

Fabrication of the simulated burned-up fuel rods was completed by Nuclear Fuel Services, and the final shipment of the fuel was received at SRL on April 13, 1966. SRL had meanwhile completed all the necessary hardware for assembling the rods into clusters and had machined the irradiation specimens to provide flat end faces so as to eliminate air gaps. SRL chemical analyses of the as-delivered fuel are also almost complete.

Most of the month was devoted to irradiation measurements in the Subcritical Experiment (SE). These experiments, performed on each batch of fuel as it was received, are intended to determine neutron reaction rates and spectra and through them the detailed lattice parameters. The irradiations are about 95% complete and data analysis is in progress. The SE experiments were performed on the most rapid schedule possible so as to free the fuel for the program of buckling measurements in the PDP, which is now well underway.

DISCUSSION

The last shipment of the PuO_2-depleted UO_2 rods was received on Wednesday, April 13, 1966. With this delivery Nuclear Fuel Services (NFS) of Erwin, Tennessee, completed its contract for supplying the simulated burned-up fuel. Samples from each of the fuel types have been submitted to the Analytical Division of the Savannah River Laboratory for analyses in order to corroborate the data supplied by NFS.

Hardware for fuel cluster assemblies is completed and is now being used in the PDP and the SE. The specially canned specimens for the irradiation experiments were opened at SRL and modified to provide flat end faces and to eliminate airgaps. They were then reassemblied and recanned.

The major experimental activity during the month was the series of irradiation experiments in the SE. The scope of these experiments is outlined in Tables I and II (repeated from last month's report). Table I gives the identification, by isotopic composition, of each of five fuel types available. All are 0.500-inch D oxide rods in 0.547-inch-OD aluminum cans, and all are very nearly identical except for fissionable isotope content. The activation measurements desired for each lattice are listed in Table II. Each measurement is indicated by an X. Two successive runs are required to obtain all of the desired data. No cadmium whatsoever was used in one of these two runs. Foils were accurately machined to a diameter of 0.500 inches. Special foil materials containing a mixture of lutetium and manganese and a dispersion of indium in aluminum and plutonium in aluminum alloy were provided by Chalk River for the experiments. The "Use" column of Table II is interpreted as follows: δ^{28} is related to fast fission, C^* to conversion ratio, ρ^{28} to resonance capture, r and T to characterization of the spectrum (epithermal flux ratio and neutron temperature), and f and $\Sigma\hat{a}_{eff}$ to thermal flux profiles within the lattice cell.

After satisfactory exposure and counting conditions were verified, the different lattices were run in quick succession. As seen from Table III, the irradiation of all but one of the lattices is now finished, including a repeat measurement on one lattice for the purpose of checking consistency. This emphasis on completion of the activations was prompted by the need to finish the irradiation before conflicting PDP demands for the limited fuel stocks would curtail operations. The completion of the irradiations, as can be seen from the table, has been at the expense of completing the analysis of the data. Although the data reduction (decay, dead time, foil weight, and averaging) is in hand, very little interpretation of the data in terms of the lattice parameters of Table II has yet been undertaken. The data will be released after the first full analysis is completed.

Buckling measurements on the burned-up fuel mockups are currently being carried out in the PDP. The list of experiments planned was given in last month's report. In addition to that listing, some measurements will be also performed with natural UO_2 rod assemblies. In all cases, the center-to-center distance between the rods in the test fuel assemblies will be 0.607 inch. The measurements are to be of the successive substitution type with the maximum number of assemblies used for a given fuel type depending on the material available and the range of usable critical water height.

The buckling experiments with the 19-rod clusters will be completed by April 30. Work on the 31 rod test assemblies will be done during May and June.

TABLE I

EXPERIMENTAL FUELS

Fuel Type	Isotopic Composition - weight % of Total U + Pu				
	^{235}U	^{239}Pu	^{240}Pu	^{241}Pu	^{242}Pu
A	0.30	0.24	0.062	0.009	0.001
B	0.30	0.25	0.016	0.002	0.001
C	0.30	0.35	0.023	0.002	0.001
D	0.50	0.00	0.00	0.00	0.00
E	0.712	0.00	0.00	0.00	0.00

TABLE II

FOIL IRRADIATIONS

Foil Type	Foil Locations				Conditions		Activation Meas.	Use
	Fuel	Cell Boundary	Mod.	Ref.	Bare	Cd Cov.		
Dep. U	x	-	-	x	x	x	Fiss. Prod.	δ^{28}, f
Dep. U	x	-	-	x	x	x	^{239}Np	C*, ρ^{28}, f
Nat. U	x	-	-	x	x	x	Fiss. Prod.	C*, δ^{28}, f
Nat. U	x	-	-	x	x	x	^{239}Np	C*, ρ^{28}, f
Cu	x	-	-	x	x	x	^{64}Cu	ρ^{28}
In	x	x	-	-	x	x	^{116m}In	r
W	x	x	-	-	x	x	^{187}W	r
Mn/Lu	x	x	x	x	x	x	^{56}Mn, ^{177}Lu	T, Σ^a_{eff}, f

TABLE III

SE LATTICES FOR ACTIVATION MEASUREMENTS

Cluster Size	Fuel Batch	Pu Content		Test Coolant	Status of Data		
		Total	% 240		Foils Counted	Data Reduced	Lattice Parameters
19 rod	C	0.372	6	D_2O	Yes	Yes	Partial
19	C	0.372	6	Air	Yes	Yes	Partial
19	C	0.372	6	HB-40	Yes	Yes	Partial
19	A	0.309	19	D_2O	Yes*	Yes	No
19	B	0.266	6	HB-40	No	--	--
31	C	0.372	6	D_2O	Yes	Partial	No
31	C	0.372	6	HB-40	Yes	No	No
19	E	-	-	D_2O	Yes	Yes	No
19	E	-	-	HB-40	Yes	Yes	No
19	E	-	-	Air	Yes	Yes	No
31	E	-	-	D_2O	Yes	Partial	No
31	E	-	-	HB-40	Yes	Partial	No

NB: All measurements to be made at a 9.33" Δ lattice pitch with fuel rods on 0.607" center-to-center spacing.

*Repeat of this lattice as a check.

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