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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

The simulated burned-up fuel is being fabricated by Nuclear Fuel Services. It consists of three mixtures of PuO_2 and UO_2 and of one of depleted UO_2 alone. A companion fuel composed of natural UO_2 is already available at SRL. Fuel compositions are listed in Table I. As of the end of February, Nuclear Fuel Services had delivered the depleted fuel and two of the PuO_2-UO_2 compositions. The largest and final batch of fuel, consisting of 0.25% ^{239}Pu containing 6% ^{240}Pu is scheduled for delivery in installments during March with the final delivery to be made April 4. These deliveries are a number of months later than originally scheduled, which has necessitated a general revision of the experimental program to be able to complete all the work originally scheduled within the fiscal year. The revised program of experiments was worked out in cooperation with the Chalk River physicists. Also, standardized techniques acceptable to both the SRL and Chalk River physics groups were developed for performing activation measurements of the lattice parameters. At the end of the month the program of activation studies was started in the SE with the fuel available at that time.

DISCUSSION

The compositions of the fuels to be used in the simulated burned-up fuel studies are listed in Table I. All of these fuels will consist of 0.500 ±0.002" sintered oxide pellets at 95% theoretical density. These pellets will be loaded into aluminum cladding tubes (6063 T6) with an ID of 0.507" and a wall thickness of 0.02". The initial experiments to be performed with this fuel are activation measurements in the SE aimed at determining the fast-to-slow fission ratio, δ^{28}, the cadmium ratio for ^{238}U, ρ^{28}, the ratio of fissions in ^{235}U to capture in ^{238}U, C*, the thermal neutron distributions (and hence the thermal utilization, f, and the effective lattice cross section, Σ^a_{eff}), and finally the spectral parameters, T, the neutron temperature and r, the Westcott epithermal factor. The foil irradiations which will

be used for determining these factors are listed in Table II. Standardized techniques for performing the foil irradiation experiments were developed during visits by N. P. Baumann and D. J. Pellarin to Chalk River and a visit by Dr. R. E. Green to Savannah River. The listing of the SE lattices in which the foil irradiations will be performed is given in Table III. This portion of the program has been considerably expanded from the original experimental schedule. Also, the lattices on which the measurements will be made have been rearranged to permit an early start on the experiments in spite of the late fuel delivery.

In order to compensate for the increased number of activation measurements in the SE, the program of SE buckling measurements (which in some respect duplicated the PDP program) has been cut to temperature coefficient studies investigating 19-rod clusters of Type "B" fuel with D_2O coolant at 9.33" and 11.12" triangular lattice pitches over the temperature range from 20 to 80°C.

The PDP experimental schedule remains close to that originally developed except that the late fuel deliveries have delayed the actual measurements until April 1. (Reloading of the driver lattice will start about March 25.) The program changes which have been made involve a definite elimination of the buffer region, which had earlier been discussed as a possibility, and the use of a constant rod spacing of 0.607" to match the SE studies. The detailed schedule is given in Table IV. The PDP experiments will run until the end of the fiscal year.

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
Nat.	0.712	0.00	0.00	0.00	0.00

TABLE II

FOIL IRRADIATIONS

Foil Type	Foil Locations				Conditions			
	Fuel	Cell Boundary	Mod.	Ref.	Bare	Cd Cov.	Activation Meas.	Use
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
		Total	% 240	
19 rod	C	0.372	6	D_2O
19	C	0.372	6	Air
19	C	0.372	6	HB-40
19	A	0.309	19	D_2O
19	B	0.266	6	HB-40
31	C	0.372	6	D_2O
31	C	0.372	6	HB-40
19	Nat.	-	-	D_2O
19	Nat.	-	-	HB-40
19	Nat.	-	-	Air
31	Nat.	-	-	D_2O
31	Nat.	-	-	HB-40*

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

*To be done as time permits.

TABLE IV

PDP SUBSTITUTION EXPERIMENTS

Test Lattice							
Lattice Pitch, Δ	Cluster Size	Fuel Type	Pu Content Total	Pu Content % 240	Test Coolant	Rod Pitch, Δ	Substitutions No. Clusters
9.33"	19	B	0.266	6	D_2O	0.607	1, 3, 7
9.33	19	A	0.309	19	D_2O	0.607	1, 3
9.33	19	C	0.372	6	D_2O	0.607	1, 3, 7
9.33	19	D	Depleted UO_2		D_2O	0.607	1, 3, 7
9.33	19	B	0.266	6	He	0.607	1, 3, 7
9.33	19	B	0.266	6	HB-40	0.607	1, 3, 7
9.33	19	A	0.309	19	HB-40	0.607	1, 3
9.33	31	B	0.266	6	D_2O	0.607	1, 3, 7
9.33	31	A	0.309	19	D_2O	0.607	1, 2
9.33	31	C	0.372	6	D_2O	0.607	1, 3
9.33	31	D	Depteted UO_2		D_2O	0.607	1, 3
9.33	31	B	0.266	6	He	0.607	1, 3, 7
9.33	31	A	0.309	19	He	0.607	1, 2
9.33	31	C	0.372	6	He	0.607	1, 3
9.33	31	D	Depleted UO_2		He	0.607	1, 3
9.33	31	B	0.266	6	HB-40	0.607	1, 3, 7
9.33	31	A	0.309	19	HB-40	0.607	1, 2
9.33	31	C	0.372	6	HB-40	0.607	1, 3
9.33	31	D	Depleted UO_2		HB-40	0.607	1, 3
12.12	31	B	0.266	6	D_2O	0.607	1, 3, 7
12.12	31	A	0.309	19	D_2O	0.607	1, 2
12.12	31	C	0.372	6	D_2O	0.607	1, 3
12.12	31	D	Depleted UO_2		D_2O	0.607	1, 3
12.12	31	B	0.266	6	He	0.607	1, 3, 7
12.12	31	A	0.309	19	He	0.607	1, 2
12.12	31	C	0.372	6	He	0.607	1, 3
12.12	31	D	Depleted UO_2		He	0.607	1, 3
12.12	31	B	0.266	6	HB-40	0.607	1, 3, 7
12.12	31	A	0.309	19	HB-40	0.607	1, 2
12.12	31	C	0.372	6	HB-40	0.607	1, 3
12.12	31	D	Depleted UO_2		HB-40	0.607	1, 3

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