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SAXTON PLUTONIUM PROJECT
QUARTERLY PROGRESS REPORT
FOR THE PERIOD ENDING
SEPTEMBER 30, 1970

by

W. R. Smalley
Project Engineer

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APPROVED:

R N McDaniel

R. N. McDaniel, Advisory Engineer
NFD Fuel Projects

APPROVED:

R S Miller

R. S. Miller, Manager
NFD Irradiation Technology

Westinghouse Electric Corporation
Nuclear Fuel Division
P. O. Box 355
Pittsburgh, Pennsylvania 15230

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SECTION 1

INTRODUCTION AND SUMMARY

1.1 SCOPE

This quarterly report covers work completed on the Saxton Plutonium Project during the period July through September, 1970.

1.2 OBJECTIVES

The overall purpose of the Saxton Plutonium Project is to develop information concerning the utilization of plutonium-enriched fuel in pressurized water reactor systems. The program includes design, fabrication, operation, and post-irradiation examination of a partial plutonium core. The in-pile performance of the fuel will be evaluated and compared with analytical predictions.

1.3 PROJECT ADMINISTRATION

The quarterly report for the April-June 1970 period was written, reviewed, and released. The Saxton Core III schedule was revised to defer the mid-life shutdown to approximately 3500 effective full power hours (EFPH) and end-of-life to ~6000 to 7000 EFPH. Projected costs and distribution of costs for the Extended Burnup phase of the Saxton Plutonium Project were re-calculated to reflect the schedule changes. Post-irradiation examination of rod RR from the center 3 x 3 subassembly was added to the scope of the project. The Work Program was revised to reflect both of these changes and transmitted to the AEC.

1.4 SUMMARY OF PROGRESS DURING THE PERIOD

The physics section of the final report on Core II fuel evaluation was revised to reflect corrected values of Pu-239/U-238 ratio. After the interim shutdown,

the Saxton reactor operated at power for approximately 22 days during the quarter. As of September 30, the cumulative energy generated in Core III was 2133 megawatt-days, with a total of 184 load follow cycles. The peak burnups in the loose lattice region were:

(1) For peak power rod:	27,600 MWD/MTM
(2) For highest burnup rod:	37,100 MWD/MTM

One of the four rods was removed from the center 3 x 3 subassembly during the interim shutdown. The rod was transferred to the WPIF Hot Laboratory, where it was visually examined and gamma scanned. The examination revealed no evidence of swelling, hydride blisters, cracks, or other defects.

SECTION 2

EVALUATION OF CORE II FUEL

(R. J. Nodvik, W. R. Smalley, R. S. Miller)

Preparation and editing of drafts for the physics and materials sections of the final report on Core II fuel evaluation were continued during the period. Significant revisions were made to the physics section reflecting the corrected values of Pu-239/U-238 ratios which affect the comparison of burnups inferred by heavy element isotopic vs. Nd-148 and also the comparison of predicted and measured Pu-239 depletion.

As shown in Table 2-1, the comparisons of burnup values determined with two independent methods -- the Heavy Element method and the Nd-148 fission product method -- now show agreement to within two percent, (one percent reported previously^[1]), thus verifying the internal consistency of the mass spectrometric data and the validity of the data-reduction methods.

Pellet burnups inferred from Cs-137 activity still show a 4 percent negative bias and indicate the possibility of slight Cs axial migration from the center to the ends of the fuel rods. The evaluation of Cs-137 data from radial microsamples continues to show considerable radial migration of cesium.

With the corrected values of Pu-239/U-238, the comparisons between unit cell calculations and measurements for the main chain U and Pu isotopes still show agreement to within about 3 percent. However, the calculations tend to underpredict the plutonium concentrations by ~2 percent. These results are summarized in Figures 2-1, 2-2, and 2-3.

[1] W. R. Smalley, "Saxton Plutonium Project Quarterly Progress Report for the Period Ending June 30, 1970", WCAP-3385-24, July 1970.

TABLE 21
SUMMARY OF FUEL BURNUP

Assembly	Fuel Rod Lattice Position	Fuel Rod No.	Fuel Type ^(a)	Neutron Spectrum ^(b)	Axial Sample Zone	Axial Location (Inches) ^(c)	Sample I.D. ^(d)	Fuel Burnup (MWD/MTM) ^(e)		Cs Method	Ratio of Burnup by Two Methods		
								Nd Method	HE Method		HE Nd	Cs Nd	Cs HE
C3	E4	RI	P	Asymp.	1	35.6	RI-18	7,240 ± 230	7,360 ± 400	6,910 ± 610	1.016	0.954	0.939
					2	29.3	RI-19	14,550 ± 460	14,920 ± 760	13,960 ± 1,230	1.025	0.959	0.936
					3	24.3	RI-20	16,760 ± 530	17,370 ± 880	16,380 ± 1,440	1.036	0.977	0.943
					4	21.3	RI-21	19,670 ± 620	20,200 ± 1,020	-----	1.027	-----	-----
					6	19.3	RI-3	20,450 ± 640	21,060 ± 1,060	19,480 ± 1,710	1.030	0.952	0.925
					8	17.3	RI-22	20,560 ± 640	21,170 ± 1,070	18,960 ± 1,670	1.030	0.922	0.896
					10	9.3	RI-24	17,600 ± 550	18,240 ± 920	16,680 ± 1,470	1.036	0.948	0.914
					11	2.4	RI-25	9,350 ± 300	9,690 ± 510	9,210 ± 820	1.036	0.985	0.950
C3	E5	JF	P	Asymp.	7	18.3	JF-1	20,110 ± 630	20,640 ± 1,040	-----	1.026	-----	-----
					10	9.3	JF-27	17,620 ± 550	18,040 ± 910	-----	1.024	-----	-----
C3	D5	MY	P	Asymp.	2	29.3	MY-16	14,600 ± 460	14,960 ± 760	-----	1.025	-----	-----
					6	19.3	MY-2	20,230 ± 630	20,740 ± 1,050	-----	1.025	-----	-----
					10	9.3	MY-17	16,700 ± 530	17,880 ± 910	-----	1.071	-----	-----
C3	D1	TE	P	FW/WS	2	29.3	TE-14	20,070 ± 640	20,770 ± 1,050	-----	1.035	-----	-----
					6	19.3	TE-4	27,730 ± 870	28,660 ± 1,450	-----	1.034	-----	-----
					10	9.3	TE-15	24,460 ± 770	24,970 ± 1,260	-----	1.021	-----	-----
C3	A1	QE	P	WS/WS	6	19.3	7405	27,550 ± 860	28,810 ± 1,450	-----	1.046	-----	-----
							640	27,720 ± 870	26,250 ± 1,410	-----	0.947	-----	-----
E2	A1	LA	P	WS/WS	6	19.3	LA-11	24,070 ± 760	24,710 ± 1,250	-----	1.026	-----	-----
D3	A1	TI	P	WS/WS	6	19.3	TI-8	25,980 ± 810	26,560 ± 1,340	-----	1.022	-----	-----
D3	A6	TT	P	FW	6	19.3	TT-10	27,180 ± 860	28,170 ± 1,430	-----	1.036	-----	-----
D3	D1	TP	P	FW/WS	6	19.3	TP-9	26,990 ± 850	27,590 ± 1,390	-----	1.022	-----	-----
D3	D9	CH	P	FW/WS	6	19.0	7403	27,960 ± 880	28,150 ± 1,420	-----	1.007	-----	-----
							680	28,180 ± 880	27,250 ± 1,460	-----	0.967	-----	-----

TABLE 2-1 (Cont)
SUMMARY OF FUEL BURNUP

Assembly	Fuel Rod Lattice Position	Fuel Rod No.	Fuel ^(a) Type	Neutron ^(b) Spectrum	Axial Sample Zone	Axial Location ^(c) (Inches)	Sample ^(d) I.D.	Fuel Burnup (MWS/MTM) ^(e)			Ratio of Burnup by Two Methods		
								Nd Method	HE Method	Cs Method	HE Nd	Cs Nd	Cs HE
D4	D5	S1	V	Asymp	1	35.5	S1-28	7,520 ± 240	7,450 ± 400	-----	0.991	-----	-----
					2	29.3	S1-29	14,820 ± 470	15,000 ± 770	-----	1.016	-----	-----
					6	19.3	S1-7	21,150 ± 660	21,860 ± 1,100	-----	1.034	-----	-----
					10	9.3	S1-30	18,710 ± 590	19,120 ± 970	-----	1.022	-----	-----
					11	2.4	S1-31	9,840 ± 310	10,160 ± 530	-----	1.032	-----	-----
D4	E5	PO	V	Asymp.	2	29.3	PO-32	15,320 ± 480	15,840 ± 810	-----	1.034	-----	-----
					6	19.3	PO-6	20,780 ± 650	21,120 ± 1,070	-----	1.016	-----	-----
					8	17.3	PO-33	21,080 ± 660	21,630 ± 1,090	-----	1.026	-----	-----
					10	9.3	PO-34	18,200 ± 570	18,860 ± 950	-----	1.036	-----	-----
D4	A1	K4	V	WS/WS	6	19.3	K4-5	27,160 ± 850	28,080 ± 1,420	-----	1.034	-----	-----
D4	A2	N3	V	WS	6	19.3	N3-13	25,710 ± 810	26,540 ± 1,340	-----	1.032	-----	-----
D4	A4	N1	V	FW/WS	6	19.3	N1-12	28,900 ± 910	27,620 ± 1,400	-----	0.956	-----	-----
D3	2 x 2	A	P	Pert	6	19.5	7401	21,170 ± 670	20,510 ± 1,040	-----	0.969	-----	-----
D3	2 x 2	B	P	Pert	6	19.5	7402	19,700 ± 620	19,790 ± 1,000	-----	1.004	-----	-----
E3	E1	D	P	FW/WS	6	19.5	7404	13,890 ± 440	13,180 ± 680	-----	0.949	-----	-----
		Average Ratio for Pellet Samples									1.018	0.957	0.929
		Average Ratio for Vipac Samples									1.019	-----	-----
		Average Ratio for all Samples									1.018	-----	-----

Notes: (a) Pelletized and vibratory compacted fuel indicated by P and V, respectively.

(b) Asymp indicates that the fuel rod was located in the asymptotic neutron spectrum in the inner region of the fuel assembly; FW and WS indicate non-asymptotic neutron spectra adjacent to a flux-wire thimble and/or a water slot; and Pert indicates perturbed neutron spectrum in 2 x 2 Overpower Test subassembly.

(c) Distance from bottom fuel rod to mid-point of one-inch sample segment. Subtract 0.75 inches to obtain distance from bottom of fuel column.

(d) All measured data used in burnup determination obtained from WARD, except mass spectrometric data from cross check analyses by GE-Valleitos on samples QE-640 and CH-680.

(e) Units are megawatt-days per 10⁶ grams initial loading of U and Pu metal. Values of MeV/fission used to convert fissions to energy units include kinetic energy of fission fragments and neutrons, energy of prompt and delayed gamma and beta decay, and energy of radiative capture in fuel, cladding, and moderator.

Figure 2-1. Calculated and Measured Uranium Isotopic Abundance versus Burnup in Saxton Core II Mixed-Oxide Fuel

Figure 2-2. Calculated and Measured Plutonium Isotopic Abundance versus Burnup in Saxton Core II Mixed-Oxide Fuel

Figure 2-3. Calculated and Measured Pu/U Mass Ratio versus Burnup in Saxton Core II Mixed Oxide Fuel

The results of measurements for special isotopes (i.e. Pu-236, Pu-238, Np-237, Am-241, Am-243, Cm-242, and Cm-244) are presented in Tables 2-2 through 2-5. The alpha spectrum resolution obtained for the Am-243 samples was not sufficient to detect the Am-243 peak in the presence of the relatively large Am-241 peak; therefore, only maximum values of Am-243 can be reported. As reported previously⁽¹⁾, the measured values of Pu-236 and Am-241 are in good agreement with those predicted by unit cell calculations, while the Np-237 and Pu-238 are about 30 percent above the calculated values. The measurements of Cm-242/Pu-239 and Cm-244/Pu-239, determined by alpha spectrometric analysis of six samples from two asymptotic rods, indicate that unit cell calculations underpredict the Cm-242 and Cm-244 isotopes by approximately 20 and 40 percent, respectively. Table 2-6 summarizes the differences between measurements and unit cell predictions for each of the special isotopes.

(1) Ibid.

TABLE 2-2
SUMMARY OF ALPHA SPECTROMETRIC ANALYSES FOR Pu-236/Pu-239
AND Pu-238/Pu-239 ATOM RATIOS IN SAXTON CORE II FUEL

Fuel Rod	Type of Fuel	Axial Sample Zone	Corresponding Mass. Spec. Sample I.D.	At Time of Analysis ^(a)			At Reference Time ^(b)		
				Date of Analysis	Pu-236/Pu-239 Atom Ratio ($\times 10^9$)	Pu-238/Pu-239 Atom Ratio ($\times 10^3$)	Burnup (MWD/MTM)	Pu-236/Pu-239 Atom Ratio ($\times 10^9$)	Pu-238/Pu-239 Atom Ratio ($\times 10^3$)
Archive	Pellet	Unirrad.	OR-1	10-27-69	1.13 ± 0.26	0.163 ± 0.0010	0	2.87 ± 0.66	0.168 ± 0.001
Archive	Pellet	Unirrad.	9	10-22-69	0.782 ± 0.333	0.162 ± 0.0024	0	1.98 ± 0.84	0.167 ± 0.002
Archive	Pellet	Unirrad.	1394-8409	10-30-69	0.783 ± 0.247	0.156 ± 0.0020	0	1.99 ± 0.63	0.161 ± 0.002
Archive	Vipac	Unirrad.	SX-C	10-29-69	0.676 ± 0.328	0.171 ± 0.0012	0	1.72 ± 0.83	0.176 ± 0.001
Archive	Vipac	Unirrad.	SX-D2	10-28-69	0.746 ± 0.385	0.166 ± 0.0011	0	1.90 ± 0.98	0.171 ± 0.001
Archive	Vipac	Unirrad.	Sx-D3	10-24-69	0.789 ± 0.395	0.163 ± 0.0012	0	2.00 ± 1.00	0.168 ± 0.001
RI	Pellet	2	RI-19	12-2-69	2.11 ± 0.57	1.06 ± 0.0088	14,550	2.77 ± 0.75	0.828 ± 0.026
		6	RI-3	10-20-69	3.02 ± 0.87	1.78 ± 0.0056	20,450	3.86 ± 0.97	1.36 ± 0.04
		10	RI-24	12-1-69	3.77 ± 1.04	1.38 ± 0.0061	17,600	4.95 ± 1.36	0.955 ± 0.044
MY	Pellet	2	MY-16	11-3-69	1.97 ± 0.64	1.02 ± 0.0057	14,600	2.54 ± 0.82	0.808 ± 0.023
		6	MY-2	10-15-69	3.62 ± 0.81	1.75 ± 0.0070	20,230	4.61 ± 1.03	1.33 ± 0.04
		10	MY-17	11-5-69	3.24 ± 0.95	1.32 ± 0.0077	16,700	4.18 ± 1.22	1.01 ± 0.03
JF	Pellet	7	JF-1	10-16-69	2.51 ± 0.52	1.75 ± 0.0072	20,110	3.20 ± 0.66	1.34 ± 0.06
		10	JF-27	12-3-69	2.19 ± 0.69	1.37 ± 0.0080	17,620	2.88 ± 0.91	0.964 ± 0.063
S1	Vipac	2	S1-29	12-4-69	2.43 ± 0.77	1.05 ± 0.0077	14,820	3.20 ± 1.01	0.798 ± 0.040
		6	S1-7	11-4-69	3.33 ± 0.80	1.85 ± 0.012	21,150	4.29 ± 1.03	1.38 ± 0.07
		10	S1-30	12-8-69	2.15 ± 0.65	1.46 ± 0.0074	18,710	2.84 ± 0.86	1.11 ± 0.05
PO	Vipac	2	PO-32	12-15-69	1.31 ± 0.59	1.11 ± 0.0097	15,320	1.74 ± 0.78	0.824 ± 0.045
		6	PO-6	10-21-69	3.95 ± 1.04	1.80 ± 0.0067	20,780	5.05 ± 1.33	1.36 ± 0.07
		10	PO-34	12-22-69	1.60 ± 0.80	1.43 ± 0.022	18,200	2.13 ± 1.06	1.11 ± 0.05

Notes: (a) Alpha spectrometry; errors shown are $\pm$ two standard deviations, based on alpha counts.

(b) Results of alpha spectrometric analyses; unirradiated samples are referenced to Saxton Core II Beginning-of-life on December 28, 1965; irradiated samples are referenced to Core II end-of-life on October 18, 1968.

TABLE 2-3
SUMMARY OF RADIOCHEMICAL ANALYSIS FOR Np-237 IN SAXTON CORE II FUEL

Fuel Rod	Axial Sample Zone	Np-237 ^(a) Activity dpm/gU ($\times 10^{-5}$)	Corresponding Mass Spec. Sample No.	U-238 Weight Fraction in Total U	Np-237/U-238 ^(b) Atom Ratio ($\times 10^4$)
RI	2	1.34	RI-19	0.99362	0.865
	6	1.78	RI-3	0.99398	1.15
	10	1.16	RI-24	0.99375	0.749
MY	2	1.14	MY-16	0.99361	0.736
	6	1.76	MY-2	0.99393	1.14
	10	1.59	MY-17	0.99375	1.03

Notes: (a) Radiochemical analysis; all results $\pm 15\%$, on November 26, 1969.

$$(b) \quad N^{37}/N^{28} = A^{37} W^{28}/\lambda^{37} N_a (wf)^{28}$$

where:

$$A^{37} = \text{Np-237 dpm/gU}$$

$$W^{28} = \text{atomic weight U-238}$$

$$\lambda^{37} = \text{Np-237 decay constant } (6.16 \times 10^{-13} \text{ min}^{-1})$$

$$N_a = \text{Avogadro's Number}$$

$$(wf)^{28} = \text{U-238 weight fraction}$$

TABLE 2-4
SUMMARY OF ANALYSES FOR AM-241 AND AM-243 IN SAXTON CORE II FUEL (e)

Fuel Rod	Axial Sample Zone	Atom Ratio at Time of Analysis ($\times 10^2$)		Corresponding Mass Spectrometric Data			Am-241/Pu-239 ^(d) Atom Ratio ($\times 10^2$) at EOL
		Am-241/Pu-239 ^(a)	Am-243/Pu-239 ^(b)	Sample I.D.	Date of Analysis	Pu-241/Pu-239 ^(c) Atom Ratio ($\times 10^2$)	
RI	2	0.845	<0.10	RI-19	11-10-69	5.48	0.535 $\pm$ 0.127
	6	1.27	<0.80	RI-3	9-3-69	8.19	0.812 $\pm$ 0.191
	10	1.35	<0.15	RI-24	11-17-69	6.80	0.965 $\pm$ 0.203
MY	2	0.840	<0.23	MY-16	10-21-69	5.53	0.528 $\pm$ 0.126
	6	1.23	<0.84	MY-2	9-20-69	8.13	0.774 $\pm$ 0.185
	10	1.04	<0.59	MY-17	11-4-69	6.68	0.663 $\pm$ 0.156

- Notes:
- (a) Alpha spectrometric analysis on November 18, 1969; uncertainties are $\pm 15\%$.
 - (b) Alpha spectrometric analysis on December 18, 1969. The alpha spectrum resolution obtained for this set of samples was not sufficient to detect the Am-243 peak in the presence of the relatively large Am-241 peak; therefore, only "less than" values can be given.
 - (c) At time of mass spectrometric analysis; relative error is approximately ± 0.3 percent.
 - (d) Referenced to Core II end-of-life on October 18, 1968; uncertainty is estimated two-standards deviation, and includes uncertainty in Pu-241 measurement.
 - (e) The atom ratio Am-241/Pu-239 in unirradiated fuel at Core II beginning-of-life on December 28, 1965 is estimated to be 8.34×10^{-4} , and is based on estimated value of Pu-241/Pu-239 atom ratio of 1.05×10^{-2} at time of plutonium separation on or about May 15, 1964.

TABLE 2-5
SUMMARY OF ALPHA SPECTROMETRIC ANALYSIS FOR Cm-242/Pu-239
and Cm-244/Pu-239 ATOM RATIOS IN SAXTON CORE II FUEL

Fuel Rod	Axial Sample Zone	Atom Ratio (x 10 ⁴) at Time of Analysis ^(a)		Corresp. Mass Spec. Sample I.D.	$\frac{N^{49(b)}}{N^{28}}$	$\frac{N^{28(b)}}{No^{28}}$	Atom Ratio (x 10 ⁴) At Core II EOL ^(c)	
		Cm-242/Pu-239	Cm-244/Pu-239		Cm-242/Pu-239	Cm-244/Pu-239		
RI	2	0.556	0.403	RI-19	0.04940	0.99262	2.88	0.420
	6	1.06	1.24	RI-3	0.04410	0.98921	5.48	1.29
	10	1.01	1.21	RI-24	0.04639	0.99091	5.23	1.26
MY	2	0.522	0.366	MY-16	0.04902	0.99292	2.70	0.381
	6	1.05	1.09	MY-2	0.04383	0.98986	5.43	1.14
	10	0.757	0.712	MY-17	0.04642	0.99127	3.92	0.742

- Notes: (a) Alpha spectrometric analysis on November 11, 1969. Relative uncertainties are $\pm 10\%$ for Cm-242 and $\pm 20\%$ for Cm-244.
(b) Pu-239 and U-238 atom ratios are shown here for reference.
(c) Referenced to Core II end-of-life on October 18, 1968.

TABLE 2-6

COMPARISON BETWEEN MEASUREMENT AND LEOPARD-HIC CALCULATION
OF Np, Pu, Am, AND Cm ISOTOPES IN SAXTON CORE II MIXED-OXIDE FUEL

Isotope	Measured Parameter	Percent ^[a] Relative Uncertainty in Measurement	Percent ^[b] Difference Between Calculation and Measurement
Np-237	Np-237 dpm/g U	±15	-34
Pu-236	Pu-236/Pu-239	±24	8
Pu-238	Pu-238/Pu-239	± 4	-28
Am-241	Am-241/Pu-239	±24	-4
Am-243	Am-243/Pu-239	[c]	--
Cm-242	Cm-242/Pu-239	±10	-24
Cm-244	Cm-244/Pu-239	±20	-38

- Notes: (a) Two standard deviations. Referenced to core end-of-life.
- (b) $(\text{Calc}-\text{Meas})/\text{Meas} \times 100$ percent; LEOPARD-HIC axial Zone 6 calculation at about 20,000 MWD/MTM.
- (c) Measured data not resolved.

SECTION 3

CORE III OPERATIONS

(C. E. Palmer, R. L. Stover)

The reactor was shut down from the beginning of the period until August 24, 1970 for the examination of fuel rods from removable assemblies. It was started up on August 24 and operated at 20.8 MWt until August 28. The power was increased to 22.5 MWt on August 28 and continued at this level until September 7, when the reactor was shut down for repair of a flux thimble drive. Following the repair, the reactor was returned to power on September 10 and operated at 23.6 MWt (100% power) until September 18, when it was shut down, as planned, for operator training.

As of the last shutdown, on September 18, the cumulative energy generated in Core III was 2133 megawatt-days, with 448 MWD since August 24. During the period from August 24 to September 18, forty-six additional load follow cycles were achieved, bringing the total to 184 since the beginning of Core III.

A series of flux maps were obtained to determine if radial or axial power transients occurred during load cycling between 100 percent and 40 percent of peak power. With control rod number 2 moving between 17 inches and 14 inches (fully out position is 36.6 inches), radial variations were ± 3 percent and axial variations only ± 1 percent. As a result, it is concluded that no significant power transients occurred during this mode of load cycling.

Flux map data were also analyzed to provide relative assembly and rod power levels during power operation in mid-September at 2800 MWD/MTM average core burnup. Figure 3-1 shows the measured values for all assemblies in the core and compares them with the predicted power levels. Table 3-1 summarizes the operating history of key rods in the loose lattice region of Core III during the past quarter; it includes the best estimate peak linear power and burnup of the lead rods.

- (1) PREDICTED
 (2) MEASURED
 (3) $\frac{\text{MEASURED} - \text{PREDICTED}}{\text{MEASURED}} \times 100$

DATA FROM FLUX MAP NO. 310.3.35 (SEPT. 14, 1970)
 ROD 2 = 17 INCHES (OUT = 36.6 INCHES)
 AVERAGE CORE BURNUP = 2800 MWD/MTU

Figure 3-1. Relative Assembly Power for Saxton Core III

TABLE 3-1

SUMMARY OF SAXTON CORE III OPERATING HISTORY - THIRD QUARTER 1970

	Through June 30	During Aug. & Sept.	Cumulative to Sept. 30.
Energy Generated, MWD	1,685	448	2,133
Number of Load Cycles	138	46	184
Peak Linear Power, kw/ft ^(a)			
1. Peak Power Rod	19.0 ^(c)	18.8	---
2. Peak Burnup Rod (in center 3x3)	15.6 ^(c)	15.3	---
3. Peak Burnup Rod Outside Center 3x3	9.8	9.6	---
Peak Pellet Burnup, MWD/MTM ^(b)			
1. Peak Power Rod	25,300	2,300	27,600
2. Peak Burnup Rod	35,200 ^(c)	1,900	37,100
3. Peak Burnup Rod Outside Center 3x3	32,300	1,200	33,500

(a) Best estimate, thermal basis (thermal = 0.974 of fission)

(b) Best estimate, fission basis

(c) Corrected values based on re-analysis of flux data, using up-dated constants

SECTION 4

EVALUATION OF CORE III FUEL

(J. T. Barnes, E. S. Schwartz, W. R. Smalley, R. S. Miller)

4.1 EVALUATION OF ROD RR

Rod RR was removed from the center 3 x 3 subassembly during the interim shutdown and transferred to the WPIF Hot Laboratory. During the period, the rod was visually examined in detail and gamma scanned.

Visual examination showed that the overall appearance of rod RR was similar to that of the highest power rods removed at the end of Core II. Prior to cleaning, the rod exhibited uniformly light to moderately thick crud over most of its surface. It also showed the usual scratches and score marks, which resulted from removal of the rod from the subassembly and subsequent handling operations. After cleaning, the major surface features were patchy areas of non-uniform color over most of the center 24 inches of the rod. These areas were characterized by alternately dark and light zones, both of irregular shape. Generally, the dark areas were non-lustrous while the lighter ones were somewhat shiny. These conditions are illustrated in Figure 4-1.

Another feature was the transition from the patchy condition to a uniform, semi-lustrous black surface in the areas of the second and third grids, extending approximately 2 inches in each case. A typical area illustrating such a transition is shown in Figure 4-2. The top and bottom 7 inches of the rod appeared to be generally black and uniformly lustrous, except for grid contact marks and handling scratches. The visual examination of rod RR revealed no evidence of swelling, hydride blisters, cracks, or other defects.

After visual examination, the rod was scanned with a sodium iodide scintillation crystal detector to determine gross gamma activity at quarter-inch intervals. The resulting data are being evaluated to help identify the location of samples for subsequent metallographic examination and burnup analysis.

→ TOP OF ROD

MACRO 5326

3.8X

Figure 4-1. Non-Uniform Surface near
Center of Rod RR

→ TOP OF ROD

MACRO 5327

3.8X

Figure 4-2. Transition Area near Grid,
23.8 Inches from Bottom of Rod RR

4.2 MID-LIFE SAMPLING PLAN

At the mid-life shutdown of Core III, seven fuel rods will be removed from two loose lattice assemblies and sent to the WPIF Hot Laboratory for destructive examination. The seven rods selected are listed in Table 4-1.

TABLE 4-1

LOOSE LATTICE FUEL RODS TO BE REMOVED AT MID-LIFE
FOR DESTRUCTIVE EXAMINATION

Assembly Serial Number	Core III Lattice Position Assembly-Rod	Serial Number*	Best Estimate Peak Linear Power, kw/ft
503-17-2	D2 - J1	BO	19-20
503-17-2	D2 - J3	NE	19-20
503-17-2	D2 - H2	NI	17-18
503-17-2	D2 - D8	GL	14-15
503-17-9	E4 - D5	FS	14-15
503-17-9	E4 - G2	MQ	9-10
503-17-9	E4 - J2	FP	9-10

*Identification stamped on horizontal surface of top end plug.