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SALEM NUCLEAR GENERATING STATION

UNIT 1, CYCLE 4

STARTUP TEST REPORT

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PDR ADOCK 05000272
P PDR

PUBLIC SERVICE ELECTRIC and GAS COMPANY

Salem Nuclear Generating Station

Unit 1, Cycle 4

STARTUP TEST REPORT

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INTRODUCTION

The fuel shuffle commenced January 28 by removing 193 fuel assemblies from the core. The core unloading was completed on January 31. During the unloading and until February 9, fuel inspections were performed. After unloading the core fifty-eight (58) Incore Flux thimbles were replaced. Three (3) leaky thimbles were identified and sent off-site for metallurgical evaluation. The lower core plate was then vacuumed and loose objects (3 grid strap pieces and underwater light components) were retrieved.

Westinghouse completed a planned inspection of ten (10) fuel assemblies (the contract for this program was a continuation from Cycle 1 and included a detailed inspection of the two optimized fuel assemblies). Upon discovering a fuel rod failure, an additional fifty-two (52) fuel assemblies were inspected. The failure of pin 9 in assembly C04 was due to pellets becoming wedged in the top several inches of the rod causing excessive rod growth, as diagnosed by Westinghouse. The rod grew most and failed during Cycle 2 and then deteriorated in Cycle 3. Westinghouse contends that rod contact due to bowing, as was noted in the end of Cycle 2 fuel inspection, was not a factor in the failure. The additional fuel inspections were performed to verify the acceptability of these assemblies for use in Cycle 4. Nine (9) of these were replaced with assemblies of comparable burnup with no known damage. Table 2 is a list of observed defects. Additional information is available from the Salem Technical Engineer upon request.

On February 12 the fuel reload for Salem Unit 1, Cycle 4 was completed. A total of fifty-six (56) new assemblies enriched to 3.4 w/o were loaded. The new assemblies are located in the core as indicated on the Core Loading Map, Figure 1. Two secondary source clusters, which were activated during Cycle 3 operation were loaded into locations H-3 and H-13. There are 448 depleted burnable poison rods from Cycle 1 located as shown in Figure 2. Two different burnable poison cluster patterns with 20 and 24 rods were utilized.

The startup physics test program was conducted to ensure the reactor, as loaded, was performing in accordance with design expectations and safety limitations. Hot zero power tests were performed on April 12 and April 13, 1982. Power escalation testing was performed from April 20 thru May 12, 1982.

Appendix A provides a brief description of each test and a summary of test results relative to acceptance criteria.

Table 1 is a sequential listing of all tests that were conducted during the startup.

TABLE 1

STARTUP TESTS

TYPE			
Reactor Startup	1.	Postrefueling Initial Criticality Pull control banks with ICRR Plot Dilute to criticality Reactivity computer checkout	
Zero Power Physics Testing	2.	ARO Boron Endpoint Test	
	3.	ARO Isothermal Temperature Coefficient Measurement	
	4.	ARO Flux Map (#1400)-Flux Map Analysis & Result	
	5.	Rod Swap Reactivity Measurement (Rodworth)	
	6.	SORC Review	
Power Escalation Testing	7.	Heat Balance and NIS Calibration	26% RTP
	8.	Heat Balance and NIS Calibration	50% RTP
	9.	Flux Map #1402	50% RTP
	10.	Flux Maps #1403-1407	47% RTP
	11.	Excore Calibration	47% RTP
	12.	Power Coefficient Measurement	47% RTP
	13.	Heat Balance and NIS Calibration	80% RTP
	14.	Flux Map #1408	84% RTP
	15.	Flux Map #1409-1411	99% RTP
	16.	Excore Calibration	99% RTP
	17.	Power Coefficient Measurement	100% RTP
	18.	RCS Flow Measurement	100% RTP

SALEM UNIT #1 CYCLE 3/4 FDR SUMMARY

FDR #	F/A IDENT	DISPOSITION	DESCRIPTION
PSDF-03	B-16	Reject	Corner grid damage-Grid #2, Faces 1 and 4
PSDF-04	C-52	Voided	Replaced by PSDF-13
PSDF-05	C-04	Reject	Failed fuel rod-Rod #9, between Grids 7 and 8
PSDF-06	C-26	Accept	Several rods exhibited downward growth near the bottom nozzle
PSDF-07	C-41	Voided	Replaced by PSDF-14
PSDF-08	C-27	Reject	Foreign object lodged between bottom of fuel rods and bottom nozzle
PSDF-09	C-13	Voided	Replaced by PSDF-15
PSDF-10	C-37	Reject	Grid damage-Grid #8, Faces 1 and 4
PSDF-11	C-24	Accept	Small chip missing on Grid #8
PSDF-12	Core-IV	Accept	Debris removed from lower coreplate
PSDF-13	C-52	Reject	Obstruction in F/A thimble tubes would not permit complete insertion of an RCCA
PSDF-14	C-41	Reject	Grid damage-Grid #5, Face 1
PSDF-15	C-13	Reject	Corner grid damage-Grid #8, Faces 1 and 4

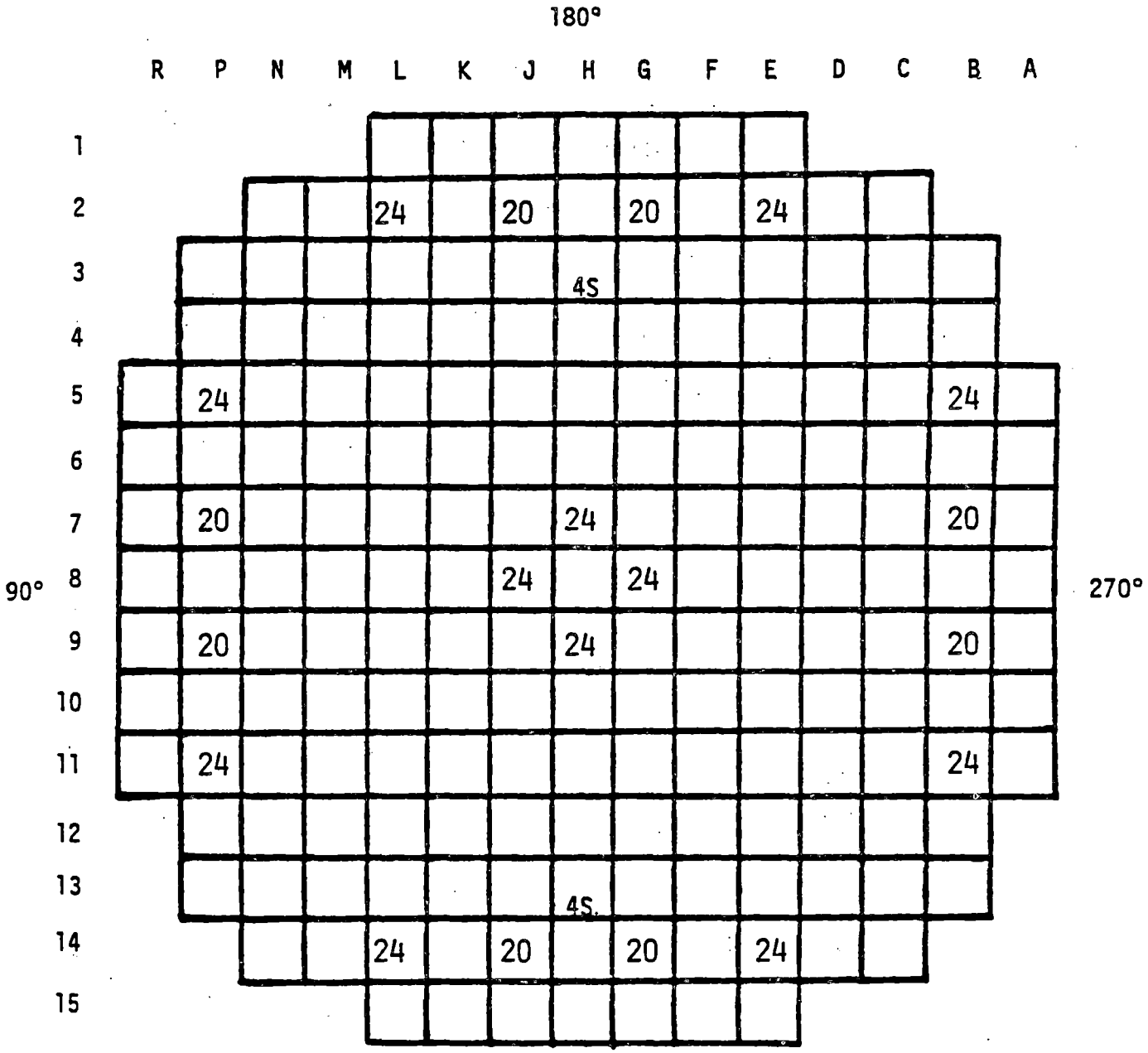
TABLE 2

REACTOR CORE MAP
SALEM UNIT 1
DATE: 2/12/82

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1					F04 PD114	F23 PD94	F26 PD11	D19 PD42	F41 PD28	F43 PD51	F02 PD43				
2			F53 PD32	F11 PD20	F35 24P20	C54 R43	F36 20P8	C40 R39	F31 20P6	C21 R145	F33 24P14	F22 PD5	F25 PD21		
3		F01 PD110	E54 R57	C29 PD27	D20 R115	E09 PD72	C58 R102	E56 SS3	C14 R133	E22 PD68	D29 R32	C44 PD12	E63 R137	F40 PD18	
4		F20 PD37	C49 PD105	E02 R131	E40 PD92	D18 PD36	E06 PD10	E18 R14	E07 PD99	D22 PD47	E31 PD24	E12 R128	C16 PD88	F13 PD106	
5	F48 PD84	F46 24P32	D27 R16	E20 PD139	D31 PD95	E03 PD2	D05 PD90	D40 PDZD5	D04 R50	E38 PD121	D08 PD70	E37 PD55	D03 R36	F38 24P39	F56 PD119
6	F37 PD22	C02 R149	E33 PD122	D28 PD89	E45 PD137	C48 R120	E48 PD34	E08 R112	E13 PD129	C36 R127	E52 PD132	D33 PD124	E10 PD123	C28 R2	F34 PD30
7	F45 PD26	F12 20P11	C39 R58	E41 PD66	D23 R12	E46 PD101	D36 PD65	E60 24P45	D09 PD45	E44 PD118	D38 PD73	E47 PD75	C24 R30	F50 20P13	F10 PD78
8	D17 PD38	C12 R53	E53 PD6	E25 R105	D32 PD113	E01 R52	E57 24P41	C57 R34	E61 24P44	E16 R148	D30 PD79	E29 R7	E64 PD131	C10 R10	D07 PD86
9	F24 PD63	F44 20P12	C34 R35	E11 PD93	D11 PD52	E36 PD80	D24 PD83	E62 24P36	D16 PD61	E43 PD128	D25 R54	E35 PD117	C38 R49	F29 20P9	F47 PD8
10	F49 PD127	C08 R122	E30 PD62	D02 PD100	E27 PD126	C17 R42	E34 PD25	E23 R55	E49 PD112	C63 R41	E51 PD31	D21 PD59	E39 PD64	C64 R51	F55 PD48
11	F05 PD103	F54 24P54	D10 R03	E05 PD23	D12 PD46	E19 PD19	D26 R59	D39 PDZD6	D13 PD104	E15 PD97	D35 PD85	E17 PD111	D37 R27	F06 24P35	F18 PD109
12		F09 PD39	C45 PD108	E04 R4	E26 PD91	D14 PD44	E24 PD102	E50 R143	E21 PD87	D06 PD81	E14 PD1	E28 R38	C06 PD67	F19 PD125	
13		F28 PD50	E55 R61	C26 PD35	D15 R45	E32 PD134	C50 R56	E58 SS4	C43 R26	E42 PD17	D01 R107	C07 PD53	E59 R150	F27 PD69	
14			F14 PD58	F42 PD16	F32 24P2	C25 R60	F51 20P5	C22 R132	F30 20P14	C18 R44	F15 24P30	F21 PD4	F08 PD3		
15					F07 PD57	F16 PD74	F39 PD13	D34 PD76	F52 PD7	F17 PD115	F03 PD107				

NORTH ↑

FIGURE 1



Number indicates number of burnable poison rods 448 Depleted BP Rods
S indicates source rod

Figure 2

Burnable Poison Loading Pattern

Zero Power Test Results

The zero power test schedule for Cycle 4 was abbreviated with respect to previous Cycles. The shorter schedule was due mainly to a change from the traditional boron dilution method for measuring bank rodworth to a rod exchange technique.

The rod exchange method uses a calibrated reference rodbank to measure other rodbanks using a critical exchange procedure at constant RCS boron concentration. The reference rodbank is calibrated using industry standard boron dilution procedures. The total rodworth used for shutdown margin verification is then inferred using analytical procedures. Comparisons of dilution mode rodworths between measurement results and both vendor and PSE&G calculations are shown in Table 3. A comparison of actual to predicted rod exchange positions along with their equivalent reactivity expressed in pcm are shown in Table 4.

A Boron endpoint measurement was conducted with all rods out and was well within the $\pm$50ppm acceptance criteria. The measured value of 1309ppm was 8ppm lower than predicted.

A Isothermal temperature coefficient measurement was performed with all rods out. The value obtained was very close to the predicted value and well within tolerances.

Results of the zero power flux map (#1400) are shown in Table 5. A tilt in the power distribution of 3.9% was discovered in the NE quadrant and the resulting peaking factors FDH and Fxy exceeded the full power Tech Spec limits, but were below the zero power limits. Consultation with the fuel vendor (Westinghouse) confirmed that a HZP Tilt of up to 6% was expected.

TABLE 3

Summary of Zero Power Reactivity Measurements

Boron Endpoint:

Condition	Measured (PPM)	Predicted (PPM)	M-P (PPM)
ARO	1309	1317	8

Isothermal Temperature Coefficient:

Condition	Measured (PCM/OF)	Predicted (PCM/OF)	M-P (PCM/OF
ARO	-3.61	-3.80	0.19

Dilution Mode Rod Worth

	Measurement		Vendor Calculation		PSE&G Calculation	
Bank	(pcm)	method	(pcm)	%	(pcm)	%
D	862	dilution	929	-7.2	847	+1.8
C	804	exchange	808	-0.4	800	+0.5
B	522	↓	592	-11.8	577	-9.5
A	1142	↓	1137	+0.4	1123	+1.7
S	2766	↓	3092	-10.5	2834	-2.4
Total	6096		6558	-7.0	6181	-1.4

Note: All data represent dilution mode conditions; ie, sequential, non-overlap insertion beginning with Bank D.

TABLE 4

Exchange Mode Rod Worth

Bank X	Critical Exchange Positions		Rod Worth		Difference	
	Meas. (steps)	Calc. (steps)	Meas. (pcm)	Calc. (pcm)	(pcm)	%
C	154	155.5	798	794	+4	0.5
B	112	120.5	452	500	-48	-9.6
A	210	210.5	731	719	+12	+1.7
SD	96	105.5	345	413	-68	-16.5
SC	100	99	225	216	+9	+4.2
SB	158	163.5	556	569	-13	-2.3
SA	188	198	1055	1064	-9	-0.9
			$\bar{X}$ = 595	611	-16	-3.3
			S =		30	7.3

Note: All data represent exchange mode conditions; ie, the reference bank moving from initial critical position to final critical position in the presence of bank X.

FLUX MAP RESULTS SUMMARY

MAP #	DATE	% RTP	BANK D	CB	QUADRANT TILTS				N FΔH		FQZ		Fxy Top		Fxy Bottom		Ave Axl Peaking Factor	Ave. Axial OFFSET
					NW	NE	SW	SE	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC		
1400	4/13/82	0	211	1300	1.0135	1.0388	.9611	.9866	1.7070	B5HI	2.7563	B5HI	1.8350	B5HI	1.8380	B5HI	1.5422	+26.536
1402	4/23/82	50.43	224	1112	1.0125	1.0020	.9950	.9905	1.5201	M2MN	2.1157	M2MN	1.6139	M2MN	1.6450	M2MN	1.3206	+12.684
1403	4/23/82	48.0	188	1069	1.0086	.9988	1.0006	.9920	1.5112	M2MN	2.0741	P11JI	1.6034	P11JI	1.6471	P11JI	1.2935	- 2.443
1404	4/23/82	48.0	206	1069	1.0070	.9990	1.0009	.9931	1.5231	P11JI	2.0374	P11JI	1.6291	P11JI	1.6868	P11JI	1.2645	+ 4.565
1405	4/24/82	47.7	216	1006	1.0116	.9971	1.0010	.9903	1.4944	P11JI	2.0521	P11JI	1.5995	P11JI	1.6516	P11JI	1.2889	+ 8.969
1406	4/24/82	47.3	205	950	1.0102	1.0020	.9982	.9896	1.5000	M2MN	2.0206	P11JI	1.5901	P11JI	1.6360	P11JI	1.2731	+ 1.916
1407	4/24/82	47.4	194	986	1.0114	1.0044	.9994	.9848	1.5109	P4MN	2.0782	P4MN	1.6224	P4MN	1.6622	P4MN	1.2862	- 1.508
1408	4/29/82	84.0	228	877	1.0088	1.0031	.9970	.9911	1.4268	M2MN	1.8671	M2MN	1.5066	M2MN	1.5423	P11JI	1.2261	+ 0.283
1409	5/10/82	98.0	228	815	1.0062	1.0032	.9961	.9945	1.4109	M2MN	1.8338	M2MN	1.4931	M2MN	1.5292	P11JI	1.2033	- 1.133
1410	5/10/82	98.8	219	787	1.0063	1.0030	.9967	.9940	1.4088	M2MN	1.8662	M2MN	1.4883	M2MN	1.5258	M2MN	1.2231	- 3.610
1411	5/11/82	100.0	228	787	1.0065	1.0026	.9965	.9943	1.4739	M2MN	1.8325	M2MN	1.4942	M2MN	1.5319	M2MN	1.2102	+ 0.528

TABLE 5

FIGURE 3

EASURED AND PERCENT. DIFF. OF FDHN SALM INCORE MAP1400,2.5% PWR,BK D@211,1300PPM,0MWD/MTU,PT.2,1

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
					.857.	1.050.	1.001.	.600.	.970.	1.032.	.842.				
					1.7.	1.7.	-1.4.	-4.4.	-4.4.	-.0.	.0.				
			.796.	1.150.	1.320.	.931.	1.246.	.876.	1.238.	.915.	1.319.	1.168.	.818.		
			5.2.	1.7.	1.7.	1.6.	-2.3.	-4.3.	-2.9.	-.1.	1.7.	3.3.	8.0.		
		.810.	1.147.	.973.	1.047.	1.046.	.872.	1.149.	.869.	1.029.	1.046.	.955.	1.147.	.844.	
		8.2.	8.0.	5.2.	1.7.	1.7.	-3.3.	-4.9.	-3.6.	.1.	1.7.	3.3.	8.0.	12.7.	
		1.217.	.998.	1.156.	1.169.	.994.	1.010.	1.053.	1.023.	.990.	1.197.	1.205.	1.020.	1.276.	
		8.4.	7.9.	2.6.	-.2.	-.2.	-5.1.	-5.2.	-3.9.	-.6.	2.2.	6.9.	10.3.	13.6.	
	.932.	1.375.	1.085.	1.199.	.978.	1.065.	.871.	.797.	.862.	1.056.	1.011.	1.274.	1.169.	1.479.	.960
4	11.2.	6.4.	6.2.	2.5.	-.2.	-.2.	-2.6.	-3.5.	-3.6.	-1.0.	3.2.	8.8.	14.5.	14.5.	14.5
	1.103.	.937.	1.029.	.996.	1.059.	.841.	.928.	.943.	.911.	.840.	1.103.	1.080.	1.151.	1.028.	1.178
6	7.2.	2.6.	.5.	.2.	-1.0.	-.9.	-.4.	-1.8.	-2.2.	-1.0.	3.1.	8.6.	12.3.	12.5.	14.5
	1.083.	1.311.	.894.	1.044.	.875.	.924.	.871.	.972.	.874.	.921.	.893.	1.110.	.970.	1.399.	1.134
7	7.2.	2.7.	-.4.	-.9.	-2.1.	-1.9.	-1.0.	-.9.	-.7.	-2.2.	.0.	5.4.	8.1.	9.6.	12.3
	.639.	.954.	1.193.	1.048.	.860.	.955.	1.006.	.761.	.981.	.941.	.872.	1.106.	1.282.	1.009.	.668
8	4.5.	2.2.	-.9.	-1.9.	-2.1.	-2.0.	-1.8.	-3.2.	-4.2.	-3.5.	-.7.	3.4.	6.5.	8.1.	9.2
	1.053.	1.304.	.895.	1.019.	.857.	.901.	.840.	.931.	.841.	.908.	.885.	1.073.	.952.	1.380.	1.102
9	4.2.	2.2.	-.3.	-3.3.	-4.1.	-4.3.	-4.6.	-5.1.	-4.4.	-3.6.	-.9.	1.9.	6.0.	8.1.	9.1
	1.059.	.941.	1.035.	.927.	.997.	.790.	.887.	.912.	.894.	.813.	1.045.	.972.	1.083.	.990.	1.115
10	c.0.	3.0.	1.1.	-6.8.	-6.8.	-6.9.	-4.7.	-5.0.	-4.0.	-4.2.	-2.3.	-2.3.	5.8.	8.4.	8.4
	.877.	1.350.	1.066.	1.090.	.903.	.984.	.839.	.782.	.850.	.979.	.958.	1.144.	1.046.	1.324.	.909
11	4.5.	4.5.	4.4.	-6.9.	-7.8.	-7.7.	-6.2.	-5.4.	-4.9.	-8.2.	-2.3.	-2.3.	2.4.	2.5.	8.4
		1.121.	.882.	1.047.	1.066.	.906.	1.001.	1.055.	1.007.	.914.	1.074.	1.085.	.946.	1.149.	
12		-.1.	-4.6.	-7.2.	-9.0.	-9.0.	-6.0.	-5.0.	-5.3.	-8.3.	-8.3.	-3.8.	2.3.	2.4.	
		.714.	1.013.	.862.	.931.	.940.	.827.	1.119.	.840.	.960.	.984.	.890.	1.055.	.766.	
13		-4.6.	-4.6.	-6.8.	-9.5.	-8.5.	-8.2.	-7.4.	-6.7.	-6.6.	-4.4.	-3.8.	-.7.	2.3.	
			.722.	1.062.	1.210.	.856.	1.207.	.867.	1.217.	.870.	1.241.	1.088.	.751.		
14			-4.6.	-6.1.	-6.7.	-6.5.	-5.4.	-5.3.	-4.6.	-5.0.	-4.4.	-3.8.	-.8.		
					.805.	.978.	.961.	.595.	.968.	.981.	.806.				MEAS
15					-4.4.	-5.3.	-5.3.	-5.2.	-4.6.	-5.0.	-4.3.				DIFF

SALM INCORE MAP1400,2.5% PWR,BK D@211,1300PPM,0MWD/MTU,PT.2,1

CALCULATED POWER TILTS (NORMALIZED TO 1.000)

.9994. .9976.		.9985.
1.0276. 1.0799.	1.0135. 1.0388.	1.0072. 1.0516.
.9868. 1.0234.	.9611. .9866.	.9426.
.9354. .9498.		

POSITIVE -Y- VS. NEGATIVE -Y- TILT
1.0261 .9739

POSITIVE -X- VS. NEGATIVE -X- TILT
1.0127 .9873

Power Escalation Testing

Power was increased to approximately 29% on April 21 and held there for eight hours to soak the turbine. On the next day power was increased at 3%/HR to 47% and allowed to stabilize.

On April 23 three incore flux maps were conducted in order to obtain data for an Excore calibration (Maps #1402-1404) however, a defective NIS meter (N41 lower) prevented any usable information from being determined. The defective meter was replaced and Incore flux maps #1405-1407 were conducted the next day to provide the necessary data for the Excore calibration. Peaking factors for the maps conducted at the 47% RTP level were found to meet the full power limits and the quadrant power tilt had diminished to approximately 1.0% in the Nw quadrant. The target ΔI was determined to be +1.9% and this value was set into the instrumentation. The Power Coefficient measurement was conducted and a value of -10.11 pcm/% obtained. The value was compared to the FSAR limiting curves and found to be in the acceptable region.

Preliminary data evaluation at the 47% RTP level was conducted and power escalation was started at 3%/HR on April 25. Power was stabilized at 82% RTP on April 28 and a heat balance was obtained for NIS calibration. Incore flux map #1408 was conducted and results were within the full power limits. The quadrant power tilt was approximately .9% in the Nw quadrant. Power escalation was then continued with several interruptions due to heater drain pump problems, condensate strainer cleaning, and circulators being out of service.

On May 11 the plant reached the 100% RTP level and was stabilized. Incore flux maps #1409-1411 were conducted to obtain data for an Excore calibration. The peaking factors obtained with these maps were within the full power limits. The quadrant power tilt was approximately .6% on these full power maps. The power coefficient measurement was conducted and a value of -11.49 pcm/% was obtained. This value was compared to the FSAR limiting curves and found to be in the acceptable region. A target ΔI value was determined to be -1.0% and set into the instrumentation.

The statepoint data collection and subsequent RCS Flow calculation were completed on May 12 with a measured flow of 385,013 gpm. The measured value exceeds the minimum 100% RTP required flow in the Technical Specifications of 349,200 gpm.

FIGURE 4

SU AND PERCENT. DIFF. OF FDHN SALM INCORE MAP1405,47.67% PWR,BK D@216,1006PPM,34MWD/MTU,PT.6,5

P	N	M	L	K	J	H	G	F	E	D	C	B	A
			.791.	.967.	.939.	.598.	.919.	.899.	.736.				
			3.6.	3.7.	1.4.	-.8.	-.8.	-3.6.	-3.7.				
	.787.	1.142.	1.209.	.899.	1.171.	.856.	1.142.	.835.	1.156.	1.047.	.760.		
	10.9.	11.0.	3.6.	3.8.	-.4.	-2.4.	-2.8.	-3.5.	-.9.	1.7.	7.0.		
.760.	1.078.	.967.	1.040.	1.063.	.895.	1.154.	.879.	.989.	.995.	.910.	1.068.	.790.	
8.1.	8.1.	8.1.	3.4.	3.5.	-1.5.	-3.2.	-3.3.	-3.7.	-1.0.	1.7.	7.0.	12.4.	
1.078.	.942.	1.127.	1.139.	1.002.	1.076.	1.105.	1.067.	.989.	1.161.	1.130.	.954.	1.119.	
5.3.	5.3.	.6.	-4.2.	-4.2.	-4.3.	-5.4.	-5.1.	-5.5.	-2.4.	.9.	6.6.	9.3.	
.872.	1.278.	1.052.	1.193.	.987.	1.093.	.952.	.889.	.945.	1.081.	.992.	1.195.	1.071.	1.248.	.829.
14.6.	10.0.	5.3.	.4.	-5.3.	-5.4.	-4.6.	-5.1.	-5.3.	-6.4.	-4.8.	.5.	7.2.	7.4.	8.9.
1.067.	.991.	1.004.	1.013.	1.107.	.903.	1.005.	1.032.	.989.	.886.	1.078.	1.054.	1.079.	.915.	1.014.
14.7.	14.9.	-1.8.	-3.0.	-4.2.	-5.5.	-5.0.	-5.3.	-6.6.	-7.3.	-6.8.	.9.	5.6.	6.1.	9.0.
1.027.	1.262.	.895.	1.079.	.943.	1.009.	.961.	1.063.	.952.	.996.	.943.	1.119.	.936.	1.233.	.995.
11.4.	7.4.	-1.1.	-3.0.	-5.1.	-5.5.	-4.5.	-3.8.	-5.4.	-6.7.	-5.1.	.5.	3.4.	4.9.	7.9.
.635.	.938.	1.208.	1.091.	.941.	1.047.	1.103.	.853.	1.063.	1.022.	.932.	1.110.	1.213.	.935.	.634.
8.1.	5.2.	1.7.	-3.1.	-4.7.	-5.2.	-4.1.	-5.7.	-7.5.	-7.4.	-5.6.	-1.5.	2.1.	4.9.	7.9.
.997.	1.240.	.939.	1.066.	.934.	1.008.	.954.	1.030.	.933.	.991.	.947.	1.078.	.911.	1.245.	.996.
8.2.	5.5.	3.7.	-4.2.	-6.1.	-5.6.	-5.1.	-6.7.	-7.2.	-7.2.	-4.8.	-3.1.	.6.	6.0.	8.1.
1.028.	.954.	1.105.	.985.	1.091.	.895.	1.002.	1.019.	.991.	.882.	1.088.	.984.	.978.	.938.	1.009.
10.5.	10.6.	8.0.	-5.7.	-5.7.	-6.3.	-5.3.	-6.5.	-6.4.	-7.7.	-5.9.	-5.8.	-4.4.	8.7.	8.4.
.856.	1.306.	1.121.	1.121.	.980.	1.083.	.944.	.889.	.956.	1.090.	.988.	1.129.	.955.	1.250.	.819.
12	12.4.	12.2.	-5.7.	-5.9.	-6.2.	-5.4.	-5.1.	-4.2.	-5.6.	-5.2.	-5.1.	-4.4.	7.6.	7.6.
	1.105.	.928.	1.098.	1.129.	.992.	1.076.	1.121.	1.077.	.988.	1.122.	1.057.	.855.	1.099.	
	7.9.	3.6.	-1.9.	-5.1.	-5.2.	-4.3.	-4.1.	-4.2.	-5.6.	-5.6.	-5.6.	-4.5.	7.3.	
	.731.	1.037.	.910.	.963.	1.003.	.886.	1.162.	.885.	1.007.	1.035.	.934.	1.042.	.754.	
	4.0.	4.0.	1.7.	-4.2.	-2.3.	-2.5.	-2.5.	-2.7.	-1.9.	3.0.	4.4.	4.4.	7.2.	
		.739.	1.060.	1.190.	.886.	1.177.	.876.	1.173.	.882.	1.203.	1.076.	.742.		
		4.0.	3.0.	2.0.	2.4.	.1.	-.2.	-.3.	1.9.	3.1.	4.5.	4.4.		
				.815.	.976.	.942.	.612.	.939.	.949.	.788.				MEAS
				6.7.	4.7.	1.7.	1.6.	1.4.	1.7.	3.2.				DIFF

SALM INCORE MAP1405,47.67% PWR,BK D@216,1006PPM,34MWD/MTU,PT.6,5

CALCULATED POWER TILTS (NORMALIZED TO 1.000)

	.9998. .9727.	
1.0234.		1.0214.
1.0190.		.9963.
	.9831. .9844.	

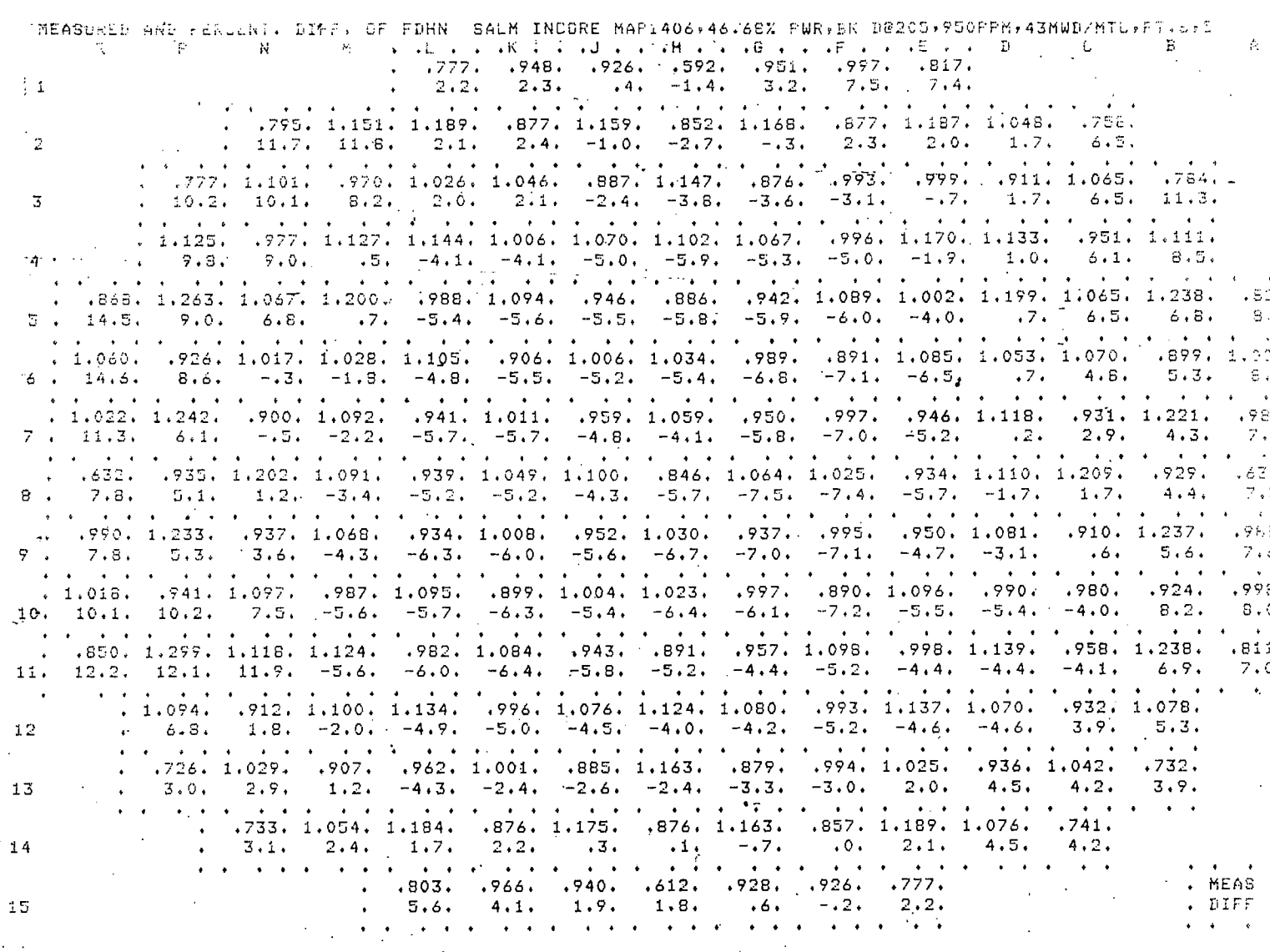
1.0116.		.9971.
1.0010.		.9903.

	.9862.	
1.0212.		1.0088.
	.9837.	

POSITIVE -Y- VS. NEGATIVE -Y- TILT
1.0043 .9957

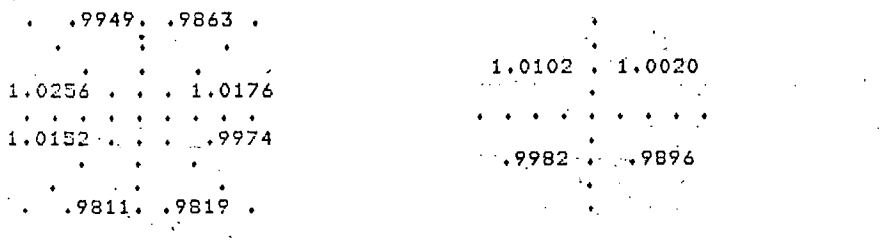
POSITIVE -X- VS. NEGATIVE -X- TILT

FIGURE 5



SALM INCORE MAP1406,46.68% PWR,BK D@205,950PPM,43MWD/MTU,PT.6,5

CALCULATED POWER TILTS (NORMALIZED TO 1.000)



POSITIVE -Y- VS. NEGATIVE -Y- TILT
1.0061 .9939

POSITIVE -X- VS. NEGATIVE -X- TILT
.9958 1.0042

FIGURE 6

MEASURED AND PERCENT. DIFF. OF FDHN SALM INCORE MAP1407,46.36% PWR,BK D@194,986PPM,53MWD/MTU,PT.6,5

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
					.766.	.933.	.915.	.588.	.936.	.973.	.799.				
1					1.3.	1.4.	-.2.	-1.8.	2.1.	5.7.	5.6.				
			.794.	1.147.	1.173.	.858.	1.148.	.848.	1.156.	.857.	1.173.	1.085.	.789.		
2			11.3.	11.4.	1.2.	1.6.	-1.5.	-2.9.	-.9.	1.4.	1.2.	5.3.	10.6.		
		.789.	1.120.	.999.	1.016.	1.035.	.885.	1.148.	.876.	.991.	.974.	.870.	1.108.	.781.	
3		11.8.	11.7.	11.3.	1.1.	1.1.	-2.6.	-3.8.	-3.6.	-3.1.	-3.1.	-3.1.	10.6.	10.8.	
		1.151.	1.008.	1.086.	1.154.	1.015.	1.077.	1.120.	1.083.	1.016.	1.156.	1.134.	.968.	1.106.	
4		12.3.	12.2.	-3.5.	-3.5.	-3.5.	-4.7.	-4.7.	-4.2.	-3.3.	-3.3.	.8.	7.8.	8.0.	
	.834.	1.262.	1.067.	1.182.	.999.	1.107.	.958.	.907.	.966.	1.123.	1.012.	1.205.	1.060.	1.228.	.81
5	13.2.	9.4.	6.8.	-1.1.	-4.8.	-4.9.	-4.8.	-3.9.	-3.9.	-3.5.	-3.5.	.9.	6.1.	6.4.	7.1
	1.045.	.909.	1.016.	1.034.	1.118.	.915.	1.017.	1.057.	1.008.	.905.	1.097.	1.059.	1.066.	.885.	.98
6	13.9.	8.0.	-.3.	-1.5.	-4.1.	-5.0.	-4.6.	-3.6.	-5.4.	-6.0.	-5.9.	.9.	4.6.	5.2.	7.7
	1.009.	1.230.	.901.	1.098.	.952.	1.021.	.968.	1.067.	.961.	1.011.	.957.	1.126.	.931.	1.214.	.97
7	10.5.	5.6.	-.4.	-1.9.	-5.0.	-5.1.	-4.2.	-3.4.	-4.9.	-6.1.	-4.5.	.6.	2.9.	4.2.	6.8
	.625.	.930.	1.204.	1.100.	.950.	1.060.	1.107.	.841.	1.073.	1.037.	.945.	1.119.	1.211.	.926.	.62
8	7.2.	4.7.	1.3.	-2.9.	-4.5.	-4.6.	-3.7.	-5.2.	-6.7.	-6.7.	-5.0.	-1.2.	1.9.	4.3.	6.9
	.979.	1.223.	.936.	1.076.	.944.	1.020.	.962.	1.038.	.947.	1.008.	.959.	1.088.	.909.	1.228.	.97
9	7.2.	5.0.	3.4.	-3.8.	-5.7.	-5.3.	-4.8.	-6.1.	-6.3.	-6.3.	-4.3.	-2.7.	.5.	5.4.	7.1
	.001.	.920.	1.090.	.994.	1.105.	.906.	1.016.	1.034.	1.008.	.898.	1.103.	.994.	.975.	.905.	.98
10	9.1.	9.3.	7.0.	-3.3.	-5.2.	-6.0.	-4.7.	-5.8.	-5.5.	-6.8.	-5.4.	-5.3.	-4.3.	7.5.	7.1
	.835.	1.276.	1.103.	1.132.	.989.	1.093.	.955.	.901.	.968.	1.106.	1.001.	1.141.	.956.	1.220.	.79
11	10.7.	10.6.	10.4.	-5.3.	-5.8.	-6.1.	-5.1.	-4.6.	-3.8.	-5.0.	-4.6.	-4.5.	-4.3.	5.7.	5.8
		1.088.	.916.	1.133.	1.154.	1.011.	1.085.	1.132.	1.088.	.999.	1.140.	1.073.	.920.	1.064.	
12		6.2.	2.1.	.7.	-3.5.	-3.8.	-4.0.	-3.6.	-3.7.	-5.0.	-4.7.	-4.7.	2.5.	3.9.	
		.727.	1.031.	.912.	.972.	1.003.	.885.	1.164.	.878.	.991.	.995.	.920.	1.027.	.724.	
13		2.9.	2.9.	1.6.	-3.4.	-2.0.	-2.6.	-2.4.	-3.3.	-3.1.	-1.1.	2.5.	2.4.	2.4.	
			.735.	1.056.	1.181.	.860.	1.165.	.871.	1.153.	.842.	1.149.	1.019.	.731.		
14			3.0.	2.5.	1.9.	1.8.	-.1.	-.3.	-1.1.	-.4.	-.9.	-1.1.	2.4.		
					.797.	.955.	.930.	.606.	.917.	.914.	.751.				MEAS
15					5.3.	3.8.	1.4.	1.2.	.0.	-.7.	-.8.				DIFF

SALM INCORE MAP1407,46.36% PWR,BK D@194,986PPM,53MWD/MTU,PT.6,5

CALCULATED POWER TILTS (NORMALIZED TO 1.000)

.9954 . .9891		
	1.0114 . 1.0044	.9923
1.0273 . . 1.0197		
		1.0208 . 1.0072
1.0143 . . .9948		
	.9994 . .9848	
		.9797
.9846. .9748		

POSITIVE -Y- VS. NEGATIVE -Y- TILT
1.0079 .9921

FIGURE 7

MEASURED AND PERCENT. DIFF. OF FDHN SALM INCORE MAP1408,84% PWR,BK D@228,877PPM,180MWD/MTU,PT.5,7

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
					.765.	.938.	.917.	.588.	.924.	.951.	.776.				
1					-.5.	-.5.	-1.8.	-3.0.	-1.0.	.9.	.9.				
			.753.	1.095.	1.167.	.876.	1.154.	.850.	1.156.	.871.	1.165.	1.029.	.732.		
2			6.4.	6.4.	-.5.	-.5.	-2.5.	-3.6.	-2.4.	-1.1.	-.7.	.0.	3.4.		
		.739.	1.048.	.932.	1.000.	1.024.	.888.	1.154.	.882.	.997.	.990.	.893.	1.029.	.749.	
3		5.4.	5.4.	4.5.	-.5.	-.5.	-2.5.	-3.1.	-3.1.	-3.2.	-1.6.	.0.	3.4.	6.8.	
		1.075.	.935.	1.121.	1.166.	1.026.	1.085.	1.129.	1.086.	1.017.	1.167.	1.123.	.924.	1.077.	
4		5.1.	4.7.	.6.	-1.5.	-1.5.	-3.1.	-2.9.	-3.0.	-2.4.	-1.5.	.8.	3.5.	5.3.	
	.819.	1.221.	1.036.	1.193.	1.021.	1.132.	.990.	.925.	.984.	1.125.	1.022.	1.198.	1.037.	1.212.	.797
5	6.8.	4.3.	3.7.	.8.	-1.4.	-1.4.	-.1.	-.6.	-.7.	-1.9.	-1.2.	1.2.	3.7.	3.8.	3.9
	1.000.	.913.	1.035.	1.041.	1.139.	.941.	1.058.	1.088.	1.041.	.926.	1.123.	1.049.	1.052.	.902.	.977
6	6.4.	3.9.	1.0.	.1.	-.8.	-.8.	.7.	.4.	-1.0.	-2.4.	-2.2.	.9.	2.6.	2.7.	3.9
	.979.	1.218.	.910.	1.106.	.977.	1.055.	1.009.	1.118.	1.006.	1.051.	.983.	1.115.	.923.	1.210.	.965
7	5.4.	2.9.	.4.	-.2.	-1.1.	-.6.	.6.	1.3.	.3.	-1.0.	-.4.	.6.	1.8.	2.2.	3.8
	.613.	.915.	1.195.	1.112.	.970.	1.093.	1.155.	.910.	1.130.	1.078.	.973.	1.120.	1.203.	.912.	.609
8	3.7.	2.2.	.7.	-.9.	-1.1.	-.4.	.5.	-.8.	-1.7.	-1.8.	-.8.	-.1.	1.4.	1.9.	3.(
	.962.	1.209.	.916.	1.093.	.970.	1.050.	.999.	1.087.	.990.	1.046.	.981.	1.101.	.914.	1.211.	.956
9	3.6.	2.2.	1.1.	-1.4.	-1.8.	-1.1.	-.4.	-1.5.	-1.2.	-1.5.	-.6.	-.7.	.9.	2.3.	2.9
	.975.	.910.	1.054.	1.020.	1.127.	.932.	1.063.	1.082.	1.054.	.923.	1.125.	1.019.	1.008.	.895.	.958
10	3.7.	3.6.	2.8.	-1.9.	-1.9.	-1.7.	1.1.	-.2.	.2.	-2.7.	-2.1.	-2.0.	-1.7.	1.9.	1.9
	.802.	1.222.	1.045.	1.161.	1.008.	1.120.	.988.	.932.	.996.	1.118.	1.016.	1.162.	.982.	1.186.	.778
11	4.5.	4.5.	4.5.	-1.9.	-2.6.	-2.4.	-.3.	.2.	.6.	-2.5.	-1.8.	-1.8.	-1.7.	1.5.	1.(
		1.044.	.889.	1.093.	1.146.	1.008.	1.107.	1.155.	1.109.	1.015.	1.161.	1.093.	.891.	1.030.	
12		2.1.	-.4.	-2.0.	-3.2.	-3.2.	-1.0.	-.7.	-.9.	-2.5.	-2.0.	-2.0.	-.1.	.7.	
		.703.	.997.	.885.	.971.	.997.	.881.	1.156.	.884.	1.001.	.986.	.879.	.987.	.700.	
13		.3.	.2.	-.8.	-3.5.	-3.2.	-3.2.	-3.0.	-2.9.	-2.8.	-2.0.	-1.5.	-.8.	-.1.	
		.710.	1.027.	1.164.	.869.	1.161.	.864.	1.162.	.860.	1.150.	1.014.	.702.			
14		.4.	-.2.	-.8.	-1.4.	-2.0.	-1.9.	-1.9.	-2.5.	-2.0.	-1.5.	-.8.			
				.780.	.938.	.921.	.599.	.922.	.920.	.754.					. MEAS
15				1.5.	-.5.	-1.3.	-1.2.	-1.2.	-2.5.	-2.0.					. DIFF

SALM INCORE MAP1408,84% PWR,BK D@228,877PPM,180MWD/MTU,PT.5,7

CALCULATED POWER TILTS (NORMALIZED TO 1.000)

.9979 .9898		.9938
1.0197 1.0165	1.0088 1.0031	1.0135 1.0072
1.0074 .9980	.9970 .9911	.9854
.9866 .9842		

POSITIVE -Y- VS. NEGATIVE -Y- TILT
1.0060 .9940

POSITIVE -X- VS. NEGATIVE -X- TILT
.9971 1.0029

FIGURE 8

MEASURED AND PERCENT. DIFF. OF FDHN SALM INCORE MAP1409,98.043% PWR,BK D@228,815PPM,510MWD/MTU,PT.5,7

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
					.759.	.931.	.911.	.587.	.918.	.944.	.770.				
1					-1.2.	-1.2.	-2.4.	-3.6.	-1.6.	.3.	.3.				
			.746.	1.083.	1.157.	.872.	1.152.	.850.	1.155.	.869.	1.158.	1.022.	.729.		
2			5.5.	5.5.	-1.2.	-1.2.	-2.9.	-3.7.	-2.6.	-1.4.	-1.1.	-.4.	3.1.		
		.732.	1.037.	.925.	.993.	1.019.	.888.	1.154.	.863.	.998.	.987.	.889.	1.024.	.747.	
3		4.4.	4.4.	3.6.	-1.2.	-1.2.	-2.6.	-3.1.	-3.1.	-3.2.	-1.8.	-.4.	3.1.	6.5.	
		1.062.	.926.	1.119.	1.173.	1.033.	1.088.	1.132.	1.088.	1.018.	1.163.	1.119.	.920.	1.071.	
4		4.0.	3.7.	.5.	-.8.	-.8.	-2.7.	-2.5.	-2.7.	-2.2.	-1.6.	.5.	3.1.	4.9.	
	.808.	1.207.	1.026.	1.188.	1.025.	1.137.	.996.	.931.	.989.	1.126.	1.022.	1.193.	1.034.	1.208.	.790
5	3.6.	3.4.	2.7.	.5.	-.8.	-.8.	.4.	-.1.	-.3.	-1.7.	-1.2.	1.0.	3.5.	3.5.	3.7
	.989.	.905.	1.031.	1.040.	1.142.	.946.	1.065.	1.095.	1.049.	.930.	1.127.	1.049.	1.054.	.903.	.970
6	3.3.	3.0.	.4.	.0.	-.5.	-.3.	1.2.	.9.	-.3.	-2.0.	-1.8.	.9.	2.6.	2.7.	3.7
	.970.	1.211.	.907.	1.103.	.980.	1.061.	1.016.	1.127.	1.014.	1.058.	.989.	1.116.	.926.	1.213.	.966
7	4.4.	2.1.	-.1.	-.5.	-.8.	-.1.	1.2.	1.9.	1.0.	-.4.	.1.	.7.	1.9.	2.3.	3.9
	.608.	.908.	1.186.	1.110.	.973.	1.099.	1.163.	.918.	1.139.	1.086.	.979.	1.122.	1.205.	.915.	.613
8	2.4.	1.1.	-.1.	-.9.	-.9.	.1.	1.1.	-.1.	-1.0.	-1.1.	-.3.	.1.	1.5.	1.9.	2.9
	.950.	1.199.	.908.	1.095.	.975.	1.058.	1.008.	1.098.	.999.	1.054.	.985.	1.102.	.916.	1.211.	.955
9	2.2.	1.1.	-.0.	-1.2.	-1.3.	-.4.	.4.	-.6.	-.5.	-.8.	-.3.	-.6.	.9.	2.2.	2.8
	.959.	.897.	1.037.	1.024.	1.130.	.938.	1.076.	1.094.	1.067.	.930.	1.128.	1.021.	1.009.	.894.	.955
10	2.2.	2.1.	1.0.	-1.5.	-1.5.	-1.2.	2.2.	.9.	1.4.	-2.0.	-1.7.	-1.7.	-1.7.	1.7.	1.7
	.791.	1.205.	1.032.	1.163.	1.011.	1.125.	.997.	.944.	1.008.	1.124.	1.017.	1.162.	.982.	1.184.	.777
11	3.3.	3.3.	3.3.	-1.6.	-2.2.	-1.9.	.6.	1.3.	1.7.	-1.9.	-1.6.	-1.6.	-1.7.	1.5.	1.5
		1.035.	.888.	1.091.	1.147.	1.010.	1.114.	1.164.	1.118.	1.021.	1.163.	1.095.	.894.	1.029.	
12		1.4.	-.6.	-1.9.	-3.0.	-3.0.	-.4.	.2.	-.0.	-1.9.	-1.6.	-1.6.	.2.	.8.	
		.702.	.994.	.884.	.973.	.999.	.884.	1.161.	.889.	1.007.	.988.	.884.	.990.	.702.	
13		.1.	.1.	-.9.	-3.2.	-3.0.	-3.0.	-2.6.	-2.5.	-2.3.	-1.7.	-.9.	-.4.	.2.	
			.709.	1.021.	1.157.	.867.	1.165.	.868.	1.166.	.861.	1.152.	1.017.	.705.		
14			.2.	-.5.	-1.2.	-1.7.	-1.8.	-1.7.	-1.7.	-2.4.	-1.7.	-.9.	-.4.		
					.771.	.932.	.923.	.603.	.924.	.919.	.755.				
15					.4.	-1.0.	-1.2.	-1.0.	-1.1.	-2.4.	-1.7.				MEAS DIFF

SALM INCORE MAP1409,98.043% PWR,BK D@228,815PPM,510MWD/MTU,PT.5,7
CALCULATED POWER TILTS (NORMALIZED TO 1.000)

.9969. .9892		.9931
1.0154 . . 1.0172	1.0062 . 1.0032	1.0094 . . 1.0085
1.0034 9998	.9961 . .9945	.9890
.9888. .9892		

POSITIVE -Y- VS. NEGATIVE -Y- TILT
1.0047 .9953

FIGURE 9

MEASURED AND PERCENT. DIFF. OF FDHN 1410,98.837% PWR,BK D@219,787PPM,534MWD/MTU,PT.6,8,5,7

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
					.753.	.922.	.905.	.584.	.912.	.935.	.763.				
1					-1.3.	-1.2.	-2.4.	-3.6.	-1.7.	.1.	.0.				
			.746.	1.081.	1.150.	.861.	1.145.	.847.	1.149.	.860.	1.153.	1.021.	.726.		
2			5.3.	5.3.	-1.3.	-1.1.	-3.0.	-3.9.	-2.6.	-1.2.	-1.1.	-.5.	2.4.		
		.733.	1.039.	.927.	.990.	1.014.	.886.	1.153.	.883.	.998.	.988.	.889.	1.021.	.741.	
3		4.3.	4.2.	3.7.	-1.5.	-1.4.	-2.8.	-3.2.	-3.1.	-2.9.	-1.7.	-.6.	2.4.	5.4.	
		1.062.	.928.	1.124.	1.175.	1.036.	1.089.	1.136.	1.092.	1.024.	1.167.	1.120.	.917.	1.064.	
4		4.0.	3.7.	.7.	-.9.	-.9.	-2.9.	-2.6.	-2.7.	-2.0.	-1.5.	.3.	2.5.	4.2.	
	.806.	1.203.	1.025.	1.191.	1.029.	1.141.	1.001.	.937.	.996.	1.135.	1.028.	1.195.	1.031.	1.201.	.792.
5	5.9.	3.6.	2.6.	.5.	-.9.	-.9.	.3.	.0.	-.1.	-1.5.	-1.1.	.8.	3.2.	3.4.	4.1.
	.988.	.898.	1.027.	1.041.	1.146.	.952.	1.072.	1.103.	1.057.	.938.	1.134.	1.052.	1.051.	.894.	.970.
6	6.2.	3.5.	.2.	-.2.	-.6.	-.3.	1.4.	1.2.	-.1.	-1.8.	-1.7.	.9.	2.6.	3.0.	4.1.
	.970.	1.207.	.905.	1.105.	.985.	1.069.	1.022.	1.132.	1.019.	1.065.	.994.	1.119.	.925.	1.208.	.961.
7	5.0.	2.3.	-.3.	-.6.	-.9.	.1.	1.5.	2.4.	1.2.	-.3.	.1.	.7.	1.9.	2.5.	4.0.
	.607.	.905.	1.184.	1.113.	.979.	1.108.	1.170.	.916.	1.143.	1.092.	.984.	1.125.	1.205.	.912.	.609.
8	2.5.	1.1.	-.3.	-1.0.	-.9.	.5.	1.6.	.5.	-.7.	-1.0.	-.4.	.0.	-1.4.	1.9.	2.9.
	.946.	1.193.	.905.	1.097.	.980.	1.063.	1.014.	1.102.	1.004.	1.059.	.989.	1.104.	.915.	1.205.	.950.
9	2.4.	1.2.	-.3.	-1.4.	-1.4.	-.4.	.7.	-.3.	-.3.	-.8.	-.4.	-.7.	.8.	2.2.	2.8.
	.953.	.889.	1.033.	1.026.	1.134.	.942.	1.082.	1.101.	1.074.	.935.	1.132.	1.024.	1.007.	.884.	.947.
10.	2.4.	2.5.	.8.	-1.6.	-1.7.	-1.3.	2.3.	1.0.	1.6.	-2.1.	-1.9.	-1.8.	-1.7.	1.9.	1.7.
	.788.	1.203.	1.033.	1.166.	1.016.	1.131.	1.004.	.948.	1.013.	1.128.	1.020.	1.165.	.982.	1.175.	.771.
11.	3.6.	3.6.	3.4.	-1.7.	-2.2.	-1.8.	.7.	1.3.	1.6.	-2.1.	-1.8.	-1.8.	-1.7.	1.2.	1.3.
		1.037.	.892.	1.096.	1.152.	1.015.	1.120.	1.167.	1.121.	1.023.	1.166.	1.098.	.888.	1.023.	
12		1.6.	-.3.	-1.9.	-2.8.	-2.9.	-.2.	.1.	-.1.	-2.1.	-1.7.	-1.7.	-.7.	.2.	
		.703.	.996.	.885.	.974.	.999.	.885.	1.160.	.888.	1.005.	.989.	.885.	.987.	.697.	
13		.0.	-.0.	-1.0.	-3.1.	-2.8.	-2.8.	-2.6.	-2.5.	-2.2.	-1.6.	-1.1.	-.9.	-.7.	
			.709.	1.019.	1.149.	.857.	1.161.	.866.	1.162.	.855.	1.149.	1.016.	.703.		
14			.0.	-.7.	-1.4.	-1.5.	-1.6.	-1.7.	-1.5.	-1.8.	-1.4.	-1.0.	-.9.		
					.764.	.924.	.919.	.601.	.920.	.915.	.753.				
15					.1.	-1.0.	-1.0.	-.9.	-.8.	-1.9.	-1.4.				MEAS
															DIFF

1410,98.837% PWR,BK D@219,787PPM,534MWD/MTU,PT.6,8,5,7

CALCULATED POWER TILTS (NORMALIZED TO 1.000)

.9964. .9895.		.9929.
1.0163. . . 1.0166.	1.0063. 1.0030.	1.0101. . 1.0075.
1.0039. . . .9984.	.9967. .9940.	.9895.
.9894. .9896.		

POSITIVE -Y- VS. NEGATIVE -Y- TILT

1.0047 .9953

FIGURE 10

MEASURED AND PERCENT. DIFF. OF FDHN SALM INCORE MAP1411,100.045% PWR,BK D@228,787PPM,560MWD/MTU,PT.5,7

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1					.756. -1.6.	.927. -1.6.	.912. -2.3.	.591. -3.1.	.920. -1.4.	.942. .1.	.768. .1.				
2				.750. 6.0.	1.088. 6.0.	1.152. -1.6.	.868. -1.6.	1.152. -2.9.	.852. -3.6.	1.158. -2.5.	.870. -1.3.	1.158. -1.1.	1.020. -.6.	.726. 2.7.	
3			.732. 4.4.	1.037. 4.4.	.926. 3.8.	.989. -1.6.	1.014. -1.6.	.888. -2.7.	1.155. -3.0.	.885. -2.9.	1.003. -2.7.	.989. -1.6.	.887. -.6.	1.020. 2.7.	.742. 5.9.
4			1.059. 3.8.	.924. 3.4.	1.117. .4.	1.173. -.7.	1.034. -.7.	1.086. -2.9.	1.131. -2.6.	1.089. -2.6.	1.022. -1.9.	1.166. -1.3.	1.119. .6.	.918. 2.8.	1.067. 4.5.
5		.808. 5.5.	1.206. 3.4.	1.026. 2.7.	1.188. .6.	1.027. -.6.	1.139. -.6.	.995. .4.	.930. -.2.	.989. -.3.	1.129. -1.4.	1.025. -.8.	1.195. 1.2.	1.030. 3.1.	1.202. 3.1.	.789 3.1
6		.989. 5.4.	.907. 3.2.	1.033. .6.	1.041. .1.	1.143. -.4.	.948. -.1.	1.066. 1.3.	1.095. 1.0.	1.049. -.4.	.932. -1.8.	1.129. -1.6.	1.049. 1.0.	1.050. 2.2.	.899. 2.3.	.968 3.1
7		.973. 4.7.	1.215. 2.4.	.909. .1.	1.105. -.3.	.981. -.7.	1.063. .1.	1.017. 1.3.	1.127. 1.9.	1.014. .9.	1.059. -.3.	.990. .2.	1.116. .8.	.924. 1.7.	1.209. 2.0.	.961 3.3
8		.610. 2.6.	.910. 1.4.	1.187. -.0.	1.112. -.8.	.974. -.8.	1.101. .3.	1.165. 1.2.	.921. .1.	1.141. -.8.	1.087. -1.0.	.980. -.3.	1.122. .1.	1.204. 1.4.	.912. 1.6.	.610 2.5
9		.952. 2.4.	1.202. 1.3.	.909. .0.	1.097. -1.0.	.977. -1.2.	1.059. -.3.	1.010. .5.	1.101. -.4.	1.002. -.2.	1.055. -.7.	.987. -.1.	1.103. -.4.	.917. 1.0.	1.208. 1.9.	.952 2.4
10		.960. 2.2.	.898. 2.1.	1.035. .8.	1.025. -1.4.	1.132. -1.4.	.940. -1.0.	1.077. 2.3.	1.097. 1.1.	1.069. 1.6.	.931. -1.9.	1.129. -1.6.	1.023. -1.6.	1.013. -1.3.	.890. 1.3.	.951 1.3
11		.792. 3.6.	1.208. 3.6.	1.035. 3.6.	1.164. -1.4.	1.012. -2.1.	1.126. -1.7.	.999. .7.	.945. 1.4.	1.010. 1.8.	1.126. -1.7.	1.019. -1.4.	1.165. -1.4.	.986. -1.3.	1.180. 1.2.	.774 1.2
12			1.034. 1.3.	.884. -1.0.	1.091. -2.0.	1.148. -2.8.	1.011. -2.9.	1.114. -.3.	1.165. .2.	1.119. .1.	1.023. -1.7.	1.165. -1.4.	1.097. -1.4.	.893. .0.	1.027. .6.	
13			.698. -.4.	.990. -.4.	.881. -1.2.	.973. -3.2.	1.000. -3.0.	.885. -3.0.	1.161. -2.5.	.889. -2.5.	1.007. -2.3.	.985. -1.9.	.880. -1.4.	.987. -.6.	.701. .0.	
14				.705. -.3.	1.018. -.8.	1.156. -1.3.	.867. -1.7.	1.166. -1.8.	.868. -1.7.	1.166. -1.8.	.860. -2.5.	1.148. -1.9.	1.012. -1.4.	.703. -.7.		
15					.770. .3.	.932. -1.0.	.923. -1.1.	.604. -1.0.	.923. -1.1.	.918. -2.5.	.753. -1.9.				MEAS DIFF

SALM INCORE MAP1411,100.045% PWR,BK D@228,787PPM,560MWD/MTU,PT.5,7

CALCULATED POWER TILTS (NORMALIZED TO 1.000)

.9966. .9899. 1.0164 . . 1.0154 1.0041 . . .9996 .9889. .9891.	1.0065 . 1.0026 .9965 . .9943	.9933 1.0103 . 1.0075 .9890

POSITIVE -Y- VS. NEGATIVE -Y- TILT
1.0046 .9954

POSITIVE -X- VS. NEGATIVE -X- TILT
.9985 1.0015

APPENDIX A

STARTUP TEST PROGRAM DESCRIPTION
SALEM UNIT 1 CYCLE 4

The startup program is written such that there is a mandatory hold point at the zero, 50, and 100% testing plateaus. The Station Operating Review Committee reviews the data and makes a decision as to continued escalation of power. Deviations between measurement and design beyond established tolerances could call for a review of test data, a repeat of the measurement or a review of the safety analysis. Operation is always within FSAR and Technical Specification limits.

STARTUP TEST PROGRAM DESCRIPTION
SALEM UNIT 1 CYCLE 4

Test: Initial Criticality

Initial Conditions:

Mode 3, Tave = 547°F, C_B = 2000 ppm

Shutdown Banks Withdrawn

Control Banks Inserted

Test Description:

Pull control banks to D at 160 steps.

Dilute to criticality.

Checkout reactivity computer.

Acceptance Criteria:

Design:

Reactivity computer readings are within 4% of doubling time measurements.

FSAR/T.S.:

Reactor must achieve criticality with the control banks above the zero power insertion limits.

STARTUP TEST PROGRAM DESCRIPTION
SALEM UNIT 1 CYCLE 4

Test: Flux Mapping

Initial Conditions:

HZP, ARO

Test Description:

Operate Flux Mapping System in accordance with Part 13 of the Reactor Engineering Manual "Incore Flux Mapping System Operation".

Acceptance Criteria:

Design: Assembly Power

Design $\pm$ 10% for assembly Power $\geq$ 0.9

Design $\pm$ 15% for assembly Power $\leq$ 0.9

FSAR/T.S.:

Not applicable below 5% power.

STARTUP TEST PROGRAM DESCRIPTION

SALEM UNIT 1 CYCLE 4

Rod Worth Measurements

Initial Conditions:

HZP

The rod exchange method is scheduled to measure all control bank worths. Based on the results of these measurements, additional measurements using the boron dilution method may be necessary.

Test Description:

Determine the worth of the reference rod bank by using the boron dilution method. Exchange this reference bank with another bank while keeping the reactor critical and constant RCS boron concentration. Using the heights of the rod banks with respect to the reference bank, infer the equivalent boron dilution rod worths using analytical techniques and compare results to acceptance criteria.

Acceptance Criteria:

Design: Design value $\pm$ 10% on total banks worth
Design value $\pm$ 15% on any individual bank
Design values are listed on attached Table.

FSAR/T.S.:

Worth of all rods less most reactive stuck rod must be 1.6% $\Delta k/k$.

STARTUP TEST PROGRAM DESCRIPTION

SALEM UNIT 1 CYCLE 4

Test: Boron Endpoint

Initial Conditions:

HZP

Endpoint is run for the ARO configuration.

Test Description:

Adjust RCS boron to near the just critical endpoint configuration. Move rods to endpoint while measuring additional worth on the reactivity computer.

Acceptance Criteria:

Design:

Design* $\pm$ 50 ppm

FSAR/T.S.:

Design* $\pm$ 100 ppm

*Design values on attached Table.

STARTUP TEST PROGRAM DESCRIPTION

SALEM UNIT 1 CYCLE 4

Test: Isothermal Temperature Coefficient

Initial Conditions:

HZP

The coefficient is measured at the ARO rod configuration.

Test Description:

Starting with Tave = 547°F, cooldown the primary system approx. 5°F.

Heat the primary system back up to 547°F.

The X-Y recorder will plot reactivity vs. Tave.

Acceptance Criteria:

Design:

ARO: -3.3 ± 3 pcm/°

FSAR/T.S.:

-2.9×10^{-4} $(\Delta\kappa/\kappa/)/°F \leq MTC^* \leq 0$

*The design value of Doppler coefficient is subtracted from the measured isothermal measurement to derive the measured moderator temperature coefficient (MTC).

STARTUP TEST PROGRAM DESCRIPTION

SALEM UNIT 1 CYCLE 4

Test: Power Coefficient

Initial Conditions:

Reactor power is not changing. The Xenon concentration is within 3% of its equilibrium value. This test is run twice during the startup program. First at 47% power, then at 100%.

Test Description:

Take a heat balance. Change turbine power between 2% and 4% with the control rods in manual. The Tave and ΔT recorders will monitor changes in these parameters as a function of time.

Acceptance Criteria:

Design:

Design value* $\pm$ 30%

FSAR/T.S.:

Must fall between upper and lower curve assumed in FSAR accident analysis.

*See attached curve (Figure A-1)

SALEM I, CYCLE IV
ACCEPTANCE CRITERIA
SHEET 1
PHYSICS RESULTS

Parameter Measured	Test Conditions	Measured Value	Required Value	Requirement Reference	Comments
Isothermal Temperature Coefficient	Critical HZP ARO	-3.61	$<0 \times 10^{-4}$ AND $> -2.9 \times 10^{-4} \Delta k/k/^{0}F$ -3.8 ± 3	T.S.3.1.1.4 Ref. 2.3	Good RHS
	Critical, HZP C/B D inserted	NA	$<0 \times 10^{-4}$ AND $> -2.9 \times 10^{-4} \Delta k/k/^{0}F$ -4.5 ± 3	T.S.3.1.1.4 Ref. 2.3	NA
Critical Boron Concentration	Critical HZP, ARO	1309	1317 ± 50 ppm	Ref. 2.3	Good ?
	Critical, HZP C/B D inserted	N/A	(Cal. from ARO Boron) ($\pm$)ppm	PART 15 Ref. 2.2	
	Critical, HZP C/B C inserted	N/A	N.A.	N.A.	
	Critical, HZP C/B B inserted	N/A	N.A.	N.A.	
	Critical, HZP C/B A inserted	N/A	N.A.	N.A.	
Power Coefficient	47% RTP	10.11	Figure 1 $\pm$ 30%	Ref. 2.3 12.6	1
			Limits of Figure 2.	Ref. 2.4 8.5	
	~~95%~~ 100% RTP	11.49	Figure 1 $\pm$ 30%	Ref. 2.3	100%
			Limits of Figure 2.	Ref. 2.4	
Reactivity Computer Check	Critical HZP, controlling on C/B D	27 42 64	(Double Time Reactivity $\pm$ 4%) 26.5 $\pm$ 1.06 42 $\pm$ 1.68 63 $\pm$ 2.52	Ref. 2.3	Acceptable

Reviewed By Jeff Jackson / JRH
(Reactor Engineer)

APR 8 1982
RX ENGR DEPT

SALEM I, CYCLE IV
ACCEPTANCE CRITERIA
SHEET 2
ROD WORTH RESULTS

ROD SWAP RESULTS

ROD BANK	TEST CONDITIONS.	MEASURED INTEGRAL WORTH	DESIGN VALUE REF. 2.3 AND TOLERANCE	COMMENTS
SUM OF CONTROL BANKS AND SHUTDOWN BANKS	ROD SWAP TEST ONLY	~~6085~~ 6096 pcm 4-15-82	6561 ± 656	-465 pcm 4-15-82 ~~-476 pcm~~ * ~~-7.3%~~ 7.09% 4-15-82 Acceptable

* IF THE ACCEPTANCE CRITERIA IS NOT MET PERFORM ROD WORTH MEASUREMENTS USING DILUTION OF CONTROL BANKS D,C,B,AND A.

CONTROL BANK ROD WORTH RESULTS (DILUTION)

Rod Bank	Test Conditions	Measured Integral Worth	Design Value Ref. 2.3 and Tolerance	comments
Control D	ARO,	N/A	929 ± 139	***
Control C	CB D IN,	N/A	808 ± 121	***
Control B	CB D,C IN,	N/A	592 ± 89	***
Control A	CB D,C,B IN,	N/A	1137 ± 171	***
Control Banks Sum	N/A	N/A	3466 ± 347	**

** IF THE ACCEPTANCE CRITERIA IS NOT MET CONTINUE ROD WORTH MEASUREMENTS IN ACCORDANCE WITH APPENDIX A.

*** IF THE ACCEPTANCE CRITERIA FOR ANY ONE BANK IS NOT WITHIN THE 15% TOLERANCE, EVALUATE SAFETY IMPLICATIONS.

Reviewed By J. J. Jackson Jr. (Reactor Engineer)

APR 8 1982 RX ENGR DEPT

SALEM I, CYCLE IV
ACCEPTANCE CRITERIA
SHEET 3
FLUX MAP RESULTS

Parameter Measured	Test Conditions	Measured value	Required value		Requirement Reference
$F_{\Delta}^{N}{}_{H}$ Nuclear Enthalpy Hot Channel Factor	Critical, HZP, ARO Map 1400	____ (Max) 1.7069 (Max) (Attached Code Map)	±10% for F/A pwr≥.9 1.8623 ±15% for F/A pwr<.9 (for measures Thimbles)		Ref. 2.3
	∿ 47% Map 1402	1.5201	≤1.55[1.0+0.2(1-P)] 1.6815		T.S. 3.2.3
	∿ 95% Map 1411	1.4739	≤1.55[1.0+0.2(1-P)] 1.5366		T.S. 3.2.3
$F_Q(Z)$ Heat Flux Hot Channel Factor	Critical, HZP, ARO Map 1400	2.7563	≤[4.64][K(z)] 4.462		T.S. 3.2.2 (INFO)
	∿ 47% Map 1402	2.1157	≤[4.64][K(z)] 4.4853		T.S. 3.2.2
	∿ 95% Map 1411	1.8325	≤[2.32/P][K(z)] 2.3190		T.S. 3.2.2
F_{XY}^{C} Computed Radial Peaking Factor	Critical, HZP, ARO Map 1400	TOP 1.8350 BOT 1.8380	$\leq F_{xy}^{RTP}$ 1.65 1.67	$\leq F_{xy}^{L}$ 1.98 2.004	T.S. 3.2.2 (INFO)
	∿ 47% Map 1402	TOP 1.6139 BOT 1.6450	1.65 1.67	1.8954 1.9183	T.S. 3.2.2
	∿ 95% Map 1411	TOP 1.4942 BOT 1.5319	1.65 1.67	1.65 1.67	T.S. 3.2.2

Reviewed By Jeff Jackson/JRH
Reactor Engineer

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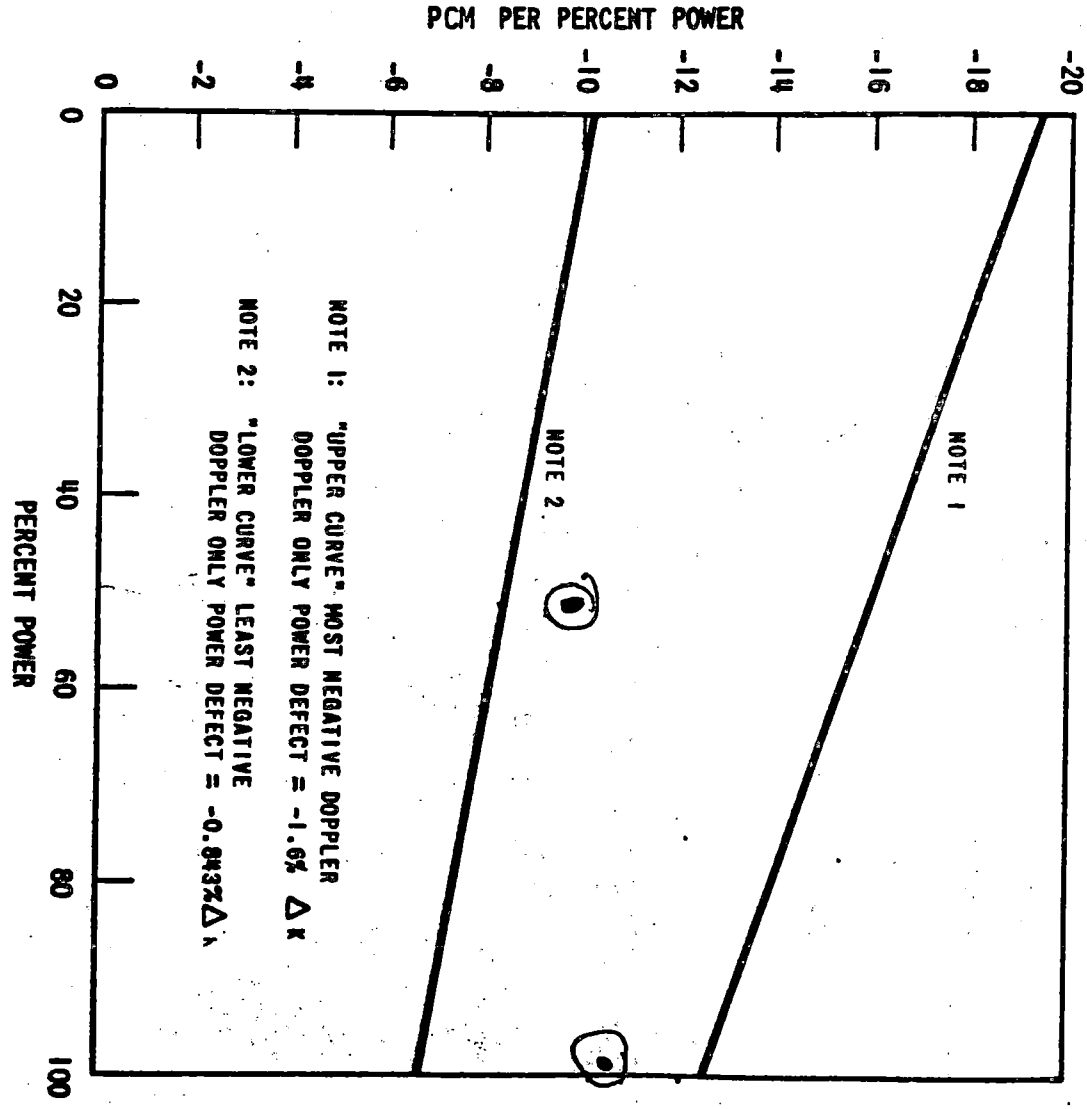
FIGURE A-1

(FSAR Fig 14.0-5)



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