ALABAMA POWER COMPANY

JOSEPH M. FARLEY NUCLEAR PLANT

UNIT NUMBER 2, CYCLE 2

STARTUP TEST REPORT

PREPARED BY PLANT REACTOR ENGINEERING GROUP

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2-28-83

DISK: CYCLE 2

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1.0 INTRODUCTION

The Joseph M. Farley Unit 2 Cycle 2 Startup Test Report addresses the tests performed as required by plant procedures following core refueling. The report provides a brief synopsis of each test and gives a comparison of measured parameters with design predictions, Technical Specifications, or values assumed in the FSAR safety analysis.

Unit 2 of the Joseph M. Farley Nuclear Plant is a Three Loop Westinghouse pressurized water reactor rated at 2652 MWth. The Cycle 2 core loading consists of 157 17 x 17 fuel assemblies.

The Unit began commercial operations on July 30, 1981, and completed Cycle 1 on October 22, 1982 with an average core burnup of 15350.5 MWD/MTU.

2.0 UNIT 2 CYCLE 2 CORE REFUELING

REFERENCES

1. Westinghouse Refueling Procedure FP-APR-R1

2. Westinghouse WCAP 10187 (The Nuclear Design and Core Management of the Joseph M. Farley Unit 2 Power Plant Cycle 2)

The refueling commenced on 11/6/82 and was completed in 10 days on 11/16/82. The as-loaded Cycle 2 core is depicted in Figures 2.1 and 2.2, which give the location of each fuel assembly and insert, and the assembly enrichments. The Cycle 2 core consists of 1 Region-1 fuel assembly, 52 Region-2 assemblies, 52 Region-3 assemblies, and 52 Region-4 assemblies. Fuel assembly inserts consist of 48 full length rod cluster control assemblies, 107 thimble plug inserts, and 2 secondary sources.

Figure 2.1

APR Unit 2, Cycle 2 Reference Loading Pattern

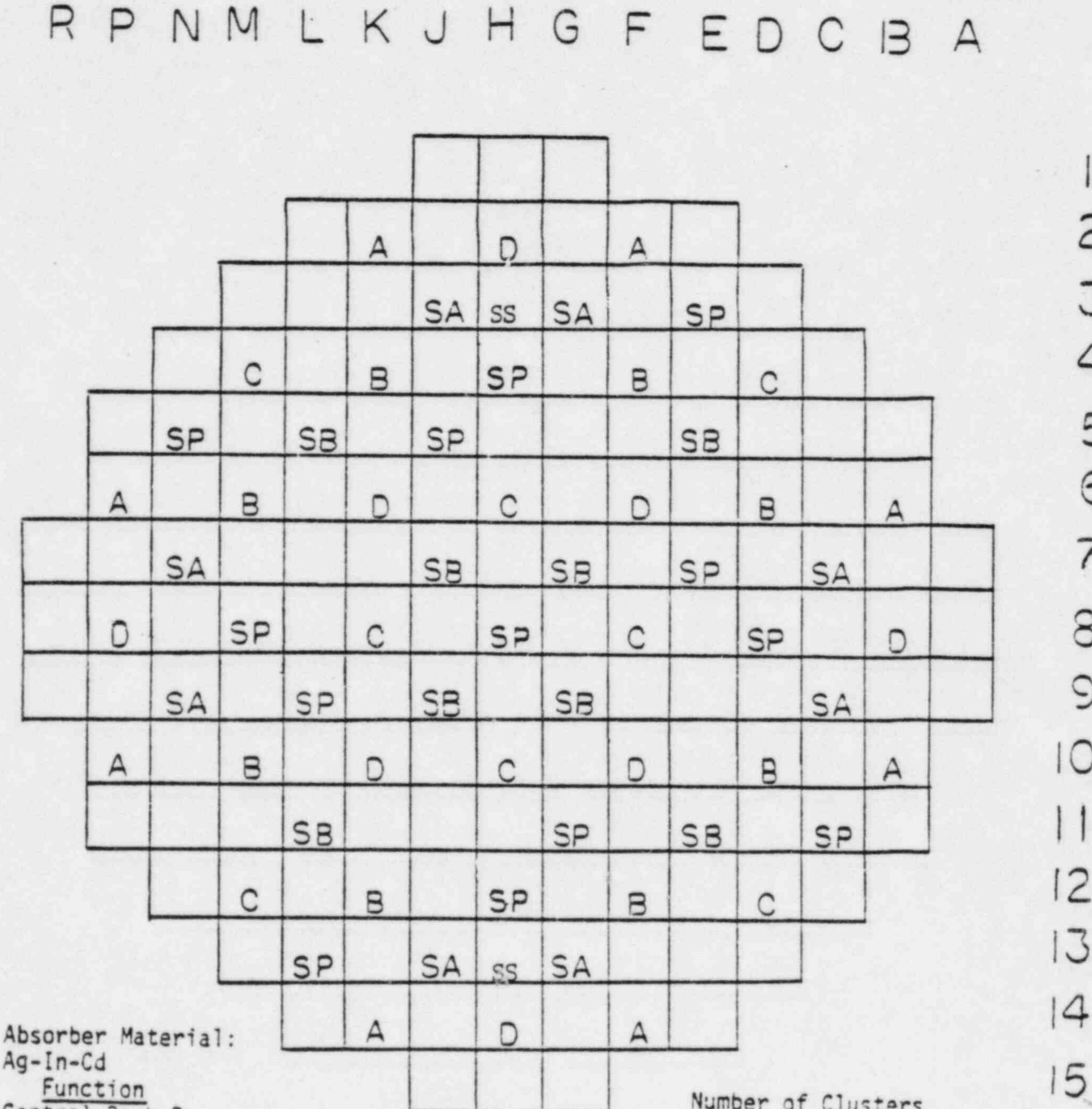
	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							P-03 F	P-21 F	P-24 F						
2					P-38 F	P-40 F	P-02 F	M-43 H-7	P-49 F	P-10 F	P-33 F				
3				P-34 F	P-29 F	M-51 J-4	M-16 K-5	N-30 SS M-3	M-18 F-5	M-33 G-4	P-31 F	P-20 F			
4			P-23 F	N-12 B-11	M-09 J-6	N-25 G-15	N-15 L-3	M-24 H-3	N-47 E-3	N-02 J-15	M-31 G-6	N-44 L-14	P-01 F		
5		P-37 F	P-18 F	M-06 K-7	N-13 L-2	M-17 K-3	N-06 B-7	M-38 H-5	N-04 P-7	M-50 F-3	N-51 B-5	M-47 F-7	P-12 F	P-45 F	
6		P-43 F	M-05 M-7	N-49 A-9	M-45 N-6	N-20 N-4	M-15 L-4	N-36 K-2	M-37 E-4	N-23 D-3	M-02 C-6	N-14 R-9	M-12 D-7	P-36 F	
7	P-52 F	P-35 F	M-22 L-6	N-09 N-5	N-46 J-14	M-07 M-5	N-45 P-6	N-22 H-1	N-07 F-2	M-39 D-5	N-33 G-14	N-18 C-5	M-23 E-6	P-32 F	P-42 F
8	P-11 F	M-35 J-8	N-37 N-12	M-27 N-8	M-41 L-8	N-21 P-10	N-52 R-8	L-11 D-12	N-41 A-8	N-17 B-6	M-03 E-8	M-08 C-8	N-38 C-4	M-14 G-8	P-47 F
9	P-09 F	P-22 F	M-52 L-10	N-16 N-11	N-40 J-2	M-48 M-11	N-08 K-14	N-31 H-15	N-03 B-10	M-42 D-11	N-39 G-2	N-34 C-11	M-04 E-10	P-41 F	P-27 F
10		P-44 F	M-36 M-9	N-28 A-7	M-20 N-10	N-29 M-13	M-40 L-12	N-19 F-14	M-29 E-12	N-24 C-12	M-28 C-10	N-43 R-7	M-32 D-9	P-46 F	
11		P-51 F	P-04 F	M-21 K-9	N-42 P-11	M-46 K-13	N-50 B-9	M-25 H-11	N-26 P-9	M-19 F-13	N-10 E-14	M-49 F-9	P-50 F	P-05 F	
12			P-16 F	N-48 E-2	M-11 J-10	N-05 G-1	N-35 L-13	M-44 H-13	N-01 E-13	N-32 J-1	M-34 G-10	N-27 P-5	P-08 F		
13				P-17 F	P-26 F	M-13 J-12	M-10 K-11	N-11 SS D-13	M-01 F-11	M-26 G-12	P-25 F	P-13 F			
14					P-39 F	P-30 F	P-48 F	M-30 H-9	P-28 F	P-14 F	P-19 F				
15							P-07 F	P-06 F	P-15 F						

COLOR CODE	ID XX	ID XX	ID XX	ID
REGION	1	2	3	4
FROM CYCLE	1	1	1	FEED
W/O U_{235}	2.120	2.601	3.100	3.10

LEGEND:

ID: ASSEMBLY IDENTIFICATION

XX: PREVIOUS CYCLE LOCATION



Absorber Material:
Ag-In-Cd

Function	Number of Clusters
Control Bank D	8
Control Bank C	8
Control Bank B	8
Control Bank A	8
Shutdown Bank S_B	8
Shutdown Bank S_A	8
SP (Spare Rod Locations)	13

SS (Secondary Source)

Figure 2.2 CONTROL ROD LOCATIONS

3.0 CONTROL ROD DROP TIME MEASUREMENT (FNP-2-STP-112)

PURPOSE

The purpose of this test was to measure the drop time of all full length control rods under hot-full flow conditions in the reactor coolant system to insure compliance with Technical Specification requirements.

SUMMARY OF RESULTS

For the Hot-full flow condition ($T_{avg} \geq 541°F$ and all reactor coolant pumps operating) Technical Specification 3.1.3.4 requires that the rod drop time from the fully withdrawn position shall be < 2.2 seconds from the beginning of stationary gripper coil voltage decay until dashpot entry. All full length rod drop times were measured to be less than 2.2 seconds. The longest drop time recorded was 1.45 seconds for rod B-6. The rod drop time results for both dashpot entry and dashpot bottom are presented in Figure 3.1. Mean drop times are summarized below:

TEST CONDITIONS	MEAN TIME TO DASHPOT ENTRY	MEAN TIME TO DASHPOT BOTTOM
Hot-full Flow	1.362 sec	1.863 sec

To confirm normal rod mechanism operation prior to conducting the rod drops, a Control Rod Drive Test (FNP-0-IMP-230.3) was performed. In the test, the stepping waveforms of the stationary, lift and moveable gripper coils were examined and rod stepping speed measurements were conducted. All results were satisfactory.

NORTH

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
R								90°							
P						1.33 1.86		1.37 1.86		1.40 1.94					
N							1.36 1.86		1.35 1.86						
M				1.35 1.85		1.36 1.86				1.35 1.85		1.39 1.90			
L					1.36 1.85						1.35 1.84				
K		1.43 1.95		1.36 1.88		1.32 1.80		1.33 1.82		1.35 1.88		1.35 1.86		1.39 1.90	
J			1.37 1.86				1.33 1.83		1.32 1.79				1.36 1.83		
H	0°	1.38 1.88				1.35 1.84				1.37 1.85				1.35 1.83	180°
G			1.35 1.86				1.32 1.80		1.34 1.87				1.39 1.90		
F		1.37 1.88		1.37 1.86		1.35 1.83		1.33 1.82		1.37 1.87		1.37 1.85		1.35 1.85	
E					1.36 1.87						1.37 1.88				
D				1.38 1.87		1.35 1.83				1.33 1.85		1.36 1.86			
C							1.38 1.87		1.37 1.87						
B						1.40 1.92		1.40 1.92		1.45 1.98					
A								270°							

DRIVE LINE "DROP TIME" TABULATION

TEMPERATURE - 547°F PRESSURE - 2235 psig % FLOW - 100%

X.XX	BREAKER "OPENING" TO DASHPOT ENTRY - IN SECONDS
X.XX	BREAKER "OPENING" TO DASHPOT BOTTOM - IN SECONDS

DATE - 11-28-82

FIGURE 3.1

4.0 INITIAL CRITICALITY (FNP-2-ETP-3601)

PURPOSE

The purpose of this procedure was to achieve initial reactor criticality under carefully controlled conditions, establish the upper flux limit for the conduct of zero power physics test, and operationally verify the calibration of the reactivity computer.

SUMMARY OF RESULTS

Initial Reactor Criticality for Cycle 2 was achieved during dilution mixing at 1136 hours on November 30, 1982. The reactor was allowed to stabilize at the following critical conditions: RCS pressure- 2240 psig, RCS temperature 547°F, intermediate range power 1.1×10^{-8} amp, RCS boron concentration 1361 ppm, and Control Bank D position- 188.5 steps. Following stabilization, the point of adding nuclear heat was determined and a checkout of the reactivity computer using both positive and negative flux periods was successfully accomplished. In addition, source and intermediate range neutron channel overlap data were taken during the flux increase preceding and immediately following initial criticality to demonstrate that adequate overlap existed.

5.0 CONTROL ROD AND BORON WORTH MEASUREMENTS (FNP-2-ETP-3601)

PURPOSE

The objectives of Control Rod and Boron Worth Measurements were: (1) to measure the differential and integral reactivity worth of each control rod bank, both individually and when moving in overlap, (2) to determine the differential boron worth over the range of control bank movement, and (3) compare results with the design calculations.

SUMMARY OF RESULTS

The results of the control bank worth measurements both for banks moving individually and in overlap mode, together with boron worth determinations are summarized in Table 5.1. All measurements satisfied their respective review criteria.

TABLE 5.1

SUMMARY OF CONTROL ROD AND BORON WORTH MEASUREMENTS

Rod Configuration	Avg. Boron Conc. (ppm)	Predicted Bank Worth & Review Criteria (pcm)	Measured Bank Worth (pcm)	Percent Difference	Design Boron Worth (pcm/ppm)	Measured Boron Worth (pcm/ppm)
D	1330	1085 ± 163	1048	-3.41	-9.35	-9.29
D + C	1218	1107 ± 166	1075.5	-2.85	-9.46	-9.86
D + C + B	1072	1614 ± 242	1505.8	-6.70	-----	-8.27
D + C + B + A	898	1675 ± 251	1552.5	-7.31	-----	-9.30
Cumulative Data from Control Banks moving individually during dilution		5481 ± 548	5181.8	-5.46	-----	-9.07
Cumulative Data from Control Banks moving in overlap during boration		5481 ± 548	5250.5	-4.21	-----	-9.17

Conditions of Measurement: Hot Zero Power (547°F; 2235 psig)

6.0 ARO HZP FLUX DISTRIBUTION, MODERATOR TEMPERATURE COEFFICIENT, AND BORON ENDPOINTS (FNP-2-ETP-3601)

PURPOSE

The objectives of these measurements were to: (1) determine the core flux distribution for the HZP all-rods-out configuration; (2) determine the hot zero power isothermal and moderator temperature coefficients for the all-rods-out configuration; and (3) measure the boron end point concentrations for the ARO, D-in, D + C-in, D + C + B-in and the D + C + B + A-in rod configurations.

SUMMARY OF RESULTS

Table 6.1 gives a tabulation of the measured boron end point concentrations compared with the design values for each rod configuration considered. The design acceptance criterion for the all-rods-out critical boron concentration was satisfactorily met.

Table 6.2 is a tabulation of measured isothermal and moderator temperature coefficients for the all-rods-out configuration. The design acceptance criterion for the ARO isothermal temperature coefficient was met.

TABLE 6.1

HZP BORON ENDPOINT CONCENTRATIONS

Rod Configuration	Measured C_B (ppm)	Design-Predicted C_B (ppm)
ARO	1387.0	1381 ± 50 ppm*
D in	1273.0	1265
D+C in	1163.0	1148
D+C+B in	981.0	979
D+C+B+A in	815.5	803

*Design Acceptance Criterion.

TABLE 6.2

HZP ISOTHERMAL AND MODERATOR TEMPERATURE COEFFICIENT

Rod Configuration	Boron Concentration ppm	Measured α_T pcm/°F	Calculated α_{mod} pcm/°F	α_T Design Acceptance Criterion pcm/°F
All Rods Out	1387.5	-2.03	-0.13	-2.3 ± 3

α_T - Isothermal temperature coefficient, includes -1.9 pcm/°F doppler coefficient

α_{mod} - Moderator only temperature coefficient

7.0 POWER ASCENSION PROCEDURE (FNP-2-ETP-3605)

PURPOSE

The purpose of this procedure was to provide controlling instructions for:

1. Ramp rate and control rod movement limitations
2. Incore movable detector system final alignment
3. Flux map at less than 50% power
4. Adhering to the delta flux band during ascension to 75% power
5. Incore/Excore calibration at 75% power.

SUMMARY OF RESULTS

In compliance with Westinghouse recommendations and fuel warranty provisions, the power ramp rate was limited to 3% of full power per hour between 20% and 100% power until full power was achieved for 72 cumulative hours out of any seven-day operation period. Control rod motion during the initial return to power was minimized, and the startup was conducted with the rods withdrawn as far as possible. The rod withdrawal rate was limited to 3 steps per hour above 50% power.

Final alignment of the incore movable detector system was completed during power ascension (at power levels above 5%) prior to performing the flux max at 49% power.

Full core flux maps were taken at 49% and 80% power. The results were within Technical Specification Limits and are summarized in Table 7.1.

An incore/excore calibration check was performed at 49% power. A full recalibration of the excore AFD channels was performed at approximately 75% power to comply with Technical Specification requirements. The incore/excore recalibration is described in section 8.0.

TABLE 7.1

SUMMARY OF POWER ASCENSION FLUX MAP DATA

Parameter	Map 34	Map 35
Date	12/06/82	12/08/82
Time	18:34	15:52
Avg. % Power	49.54	80.375
Max. F_Q (Z)	1.9654	1.8646
Max. FΔH	1.5025	1.4629
Max. Power Tilt*	+1.0111	+1.0080
Avg. Core % A.O.	+4.168	+5.009

*Calculated power tilts based on assembly FΔHN from all assemblies.

8.0 INCORE-EXCORE DETECTOR CALIBRATION (FNP-2-STP-121)

PURPOSE

The objective of this procedure was to determine the relationship between power range upper and lower excore detector currents and incore axial offset for the purpose of calibrating the delta flux penalty to the overtemperature ΔT protection system, and for calibrating the control board and plant computer axial flux difference (AFD) channels.

SUMMARY OF RESULTS

A preliminary verification of excore AFD channel calibration was performed at 49% power to insure AFD could be kept within the target band during the ascension to 80% power. Flux maps for incore-excore recalibration were run at 75% - 80% power at average percent core axial offsets of + 17.909, +5.009, -9.806, and -17.873, as determined from the incore printouts.

The measured detector currents were normalized to 100% power, and a least squares fit was performed to obtain the linear equation for each top and bottom detector current versus core axial offset.

Using these equations, detector current data was generated and utilized to recalibrate the AFD channels and the delta flux penalty to the overtemperature ΔT setpoint. (See Figure 8.1)

FIGURE 8.1

DETECTOR CURRENT VERSUS AXIAL OFFSET EQUATIONS
OBTAINED FROM INCORE-EXCORE CALIBRATION TEST

<u>CHANNEL N41:</u>

I-Top	=	1.5357*AO + 292.2089 μa
I-Bottom	=	-1.7647*AO + 302.1177 μa

<u>CHANNEL 42:</u>

I-Top	=	1.5517*AO + 287.7846 μa
I-Bottom	=	-1.8000*AO + 298.4756 μa

<u>CHANNEL N43:</u>

I-Top	=	1.5793*AO + 299.2300 μa
I-Bottom	=	-1.8412*AO + 301.0934 μa

<u>CHANNEL N44:</u>

I-Top	=	1.5736*AO + 279.0687 μa
I-Bottom	=	-1.8654*AO + 300.3199 μa

9.0 REACTOR COOLANT SYSTEM FLOW MEASUREMENT (FNP-2-STP-115.1)

PURPOSE

The purpose of this procedure was to measure the flow rate in each reactor coolant loop in order to confirm that the total core flow met the minimum flow requirement given in the Unit 2 Technical Specifications.

SUMMARY OF RESULTS

To comply with the Unit 2 Technical Specifications, the total reactor coolant system flow rate measured at normal operating temperature and pressure must equal or exceed 265,500 gpm for three loop operation. From the average of six calorimetric heat balance measurements, the total core flow was determined to be 286,607.7 gpm, which meets the above criterion.