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March 19, 1991

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20555

Subject: McGuire Nuclear Station, Unit 2
Docket Number 50-369
Cycle 7 Startup Report

Attached is the startup report for McGuire Nuclear Station Unit 2 Cycle 7. This report is submitted pursuant to Technical Specification 6.9.1.1, which requires that a report be submitted if a modification is made which may have significantly altered the nuclear, thermal, or hydraulic performance of the plant. During the recently completed outage, a modification was performed to permanently resolve the baffle-jetting problem that has been experienced at McGuire.

If there are any questions, please call Scott Gewehr at (704) 373-7581.

Very truly yours,

M. S. Tuckman

M. S. Tuckman

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DUKE POWER COMPANY

McGUIRE NUCLEAR STATION

UNIT 2
CYCLE 7

STARTUP REPORT

February 28, 1991

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1.0 Introduction

Core loading for McGuire Unit 2 Cycle 7 was started on October 13, 1990 and was completed October 16. The core for McGuire 2 Cycle 7 consists of 193 Westinghouse optimized fuel assemblies. To control power peaking and maximize cycle length, 64 Westinghouse Wet Annular Burnable Absorber (WABA) inserts are utilized. Figure 1 gives the Unit 2 Cycle 7 core loading pattern.

Criticality, Zero Power Physics Testing (ZPPT) and Power Escalation Testing (PET) began December 25, 1990. During performance of the Zero Power Physics Test, PT/0/A/4150/11A, Control Rod Worth Measurement: Rod Swap, a manual trip occurred on December 27, 1990 at 0142 hours due to Shutdown Bank E falling into the core. After more than 30 hours of troubleshooting on the Rod Control System to determine the root cause of Shutdown Bank E falling to its fully inserted position, criticality was achieved again on December 28, 1990. ZPPT and PET were then successfully completed. The unit reached 100% power on January 4, 1991.

Figure 1

Core Loading Pattern

McGuire Nuclear Station

Unit 2 Cycle 7

ASM #
INS #

QUADRANT

1	2
4	3

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
A					T10 315KT	U59 59	T46 56	U38 227KT	T24 69	U19 207KT	T14 68					A
B			T57 225KT	T25 R136	U47 4P159K	T51 R143	U07 8P221K	S34 R135	U67 8P226K	T52 R145	U73 4P157K	T13 R108	T28 67			B
C		T60 312KT	T18 124	U28 4P155K	T29 R120	U32 12P114K	S05 R106	T07 216KT	S16 R110	U09 12P120K	T69 R131	U45 4P160K	T55 120	T36 58		C
D		T26 R118	U41 4P161K	S52 R124	U51 12P115K	S24 98	U75 12P125K	T08 R137	U44 12P130K	S03 60	U27 12P110K	S60 R129	U61 4P163K	T44 R155		D
E	T27 126	U71 4P150K	T16 R102	U54 12P134K	S30 228KT	U12 12P139K	S53 125	U23 12P113K	S64 201KT	U10 12P118K	S21 20[illegible]T	U49 12P144K	T62 R151	U42 4P158K	T65 75	E
F	U36 91	T34 R127	U50 12P132K	S18 204KT	U76 12P121K	T71 R105	T35 44	S13 R132	T21 211KT	T54 R17	U02 12P142K	S01 43	U05 12P112K	T5[illegible] R148	U25 139	F
G	T09 147KT	U03 8P227K	S33 R61	U01 12P109K	S50 133	T12 71	S02 270KT	U11 12P133K	S35 55	T19 53	S57 119	U24 12P126K	S37 R154	U21 8P224K	T63 57	G
H	U31 81	S20 R60	T33 DS58	T15 R113	U52 12P140K	S19 R119	U65 12P119K	S40 R126	U56 12P143K	S04 R140	U04 12P116K	T20 R142	T30 DS59	S44 R157	U58 94	H
J	T64 205KT	U57 8P225K	S41 R128	U33 12P105K	S68 73	T50 220KT	S36 122	U22 12P108K	S11 229KT	T42 80	S49 221KT	U26 12P124K	S42 R115	U34 8P222K	T72 45	J
K	U06 103	T53 R116	U48 12P138K	S47 226KT	U62 12P128K	T31 R103	T06 212KT	S25 R123	T41 114	T11 R141	U20 12P111K	S39 83	U18 12P135K	T67 R146	U70 51	K
L	T61 84	U55 4P158K	T23 R152	U30 12P127K	S45 215KT	U66 12P129K	S54 50	U08 12P1[illegible]3K	S58 52	U29 12P137K	S06 121	U72 12P1[illegible]0K	T56 R134	U43 4P162K	T04 208KT	L
M		T68 R104	U13 4P149K	S61 R112	U64 12P106K	S12 127	U63 12P117K	T70 R159	U16 12P107K	S17 218KT	U68 12P131K	S55 R138	U35 4P151K	T01 R153		M
N		T38 331KT	T05 222KT	U46 4P153K	T32 R111	U14 12P141K	S46 R63	T22 219KT	S27 R107	U17 12P122K	T66 R125	U69 4P164K	T03 108	T37 334KT		N
P			T45 46	T43 R121	U15 4P152K	T02 R139	U39 8P223K	S26 R109	U37 8P228K	T59 R144	U53 4P154K	T40 R150	T17 85			P
R					T39 72	U60 88	T48 100	U74 105	T47 206KT	U40 95	T49 313KT					R
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	

1.1 Prestartup NIS Realignment Following Refueling - PT/0/A/4600/78

This procedure was performed on October 10, 1990.

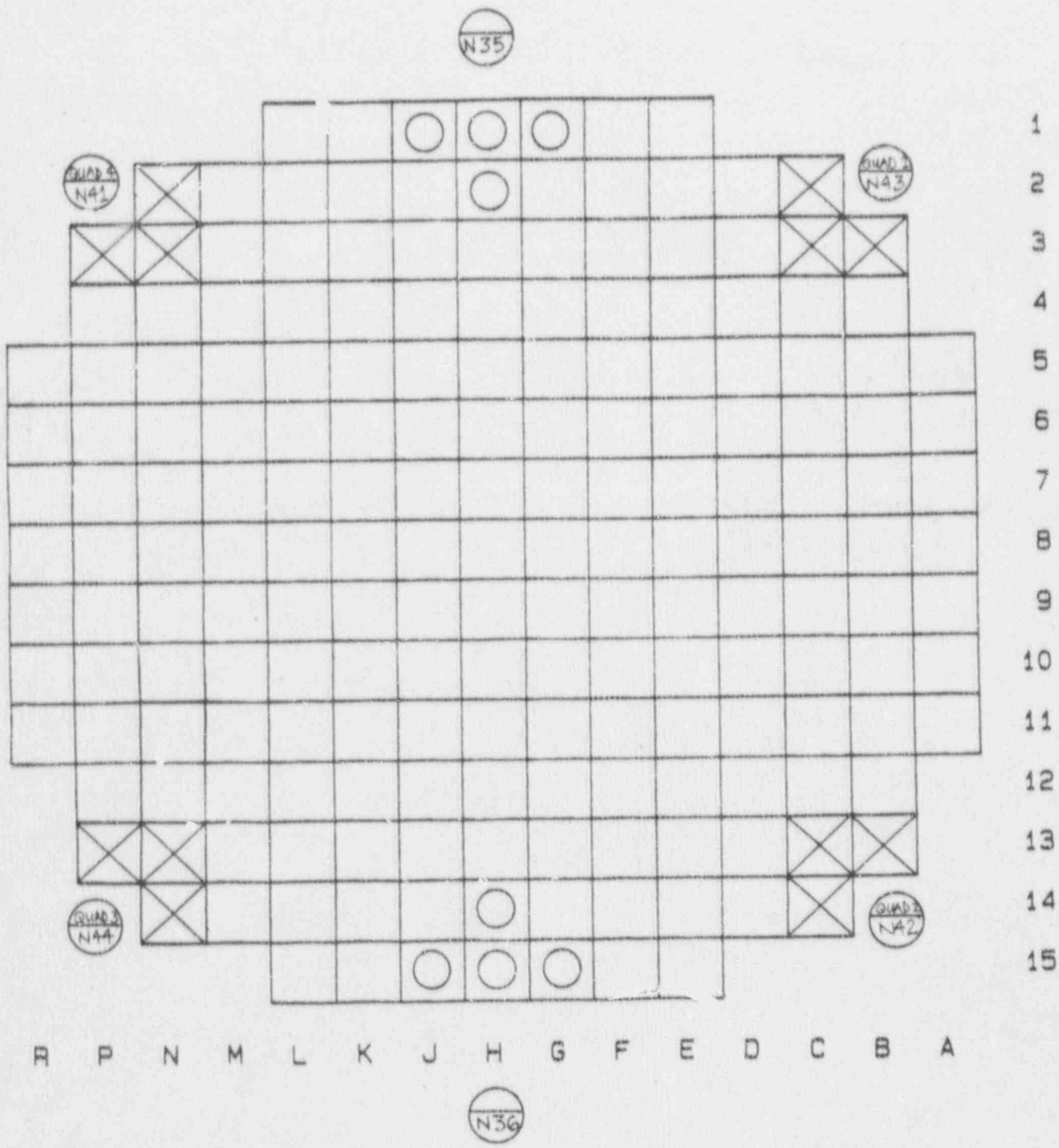
This test was used to calculate preliminary calibration data for the intermediate range (IR) and power range (PR) detectors following refueling.

The set of Cycle 7 preliminary calibration data was determined by taking the End of Cycle 6 (EOC6) calibration data and adjusting it by a weighted average of the ratio of the sum of the predicted assembly powers for the Cycle 7 loading to the sum of the measured assembly powers from the last Cycle 6 Incore/Excore calibration. The core locations used to calculate the ratio of the predicted Beginning of Cycle 7 (BOC7) assembly powers to the measured EOC6 values are shown in Figure 2.

The predicted BOC7-to-EOC6 IR ratio was ~0.87; the predicted BOC7-to-EOC6 PR ratio was ~0.92. Based on these results, the IR and PR currents were adjusted prior to Cycle 7 Initial Criticality.

Figure 2

Assemblies to Use for Calculating
IR and PR Calibration Setpoints



Core locations used for
PR calibration

Core locations used for
IR calibration

2.0 Criticality Following a Change in Core Nuclear Characteristics - PT/0/A/4150/28

On December 25, 1990, boron samples were taken in preparation for the approach to criticality. These samples indicated reactor coolant boron to be 1925 ppm. Since it was desired to achieve criticality with ~500 pcm of Control Bank D inserted, a target value of 1533 ppm was chosen for reactor coolant boron concentration. This represented the predicted BOC, ARO, HZP, No Xenon, equilibrium Samarium critical boron concentration of 1583 ppm less 50 ppm. Calculations using the unit Data Book (OP/2/A/6100/22) indicated a volume of 13,899 gallons of demineralized water should be added to the system to dilute from 1925 ppm to 1533 ppm. On December 25, 1990, this dilution of the Reactor Coolant System was started. The dilution was secured after 13,899 gallons of demineralized water had been added to the system. After adequate system mixing, Chemistry samples indicated Reactor Coolant System boron was 1485 ppm.

Since this boron concentration was not within 30 ppm of the desired target reactor coolant boron concentration, four hundred twenty-five (425) gallons of boric acid was added. After system mixing, Chemistry samples then indicated Reactor Coolant System boron was 1521 ppm.

On December 25, 1990, rod withdrawal commenced starting with Shutdown Bank A. As rods were withdrawn, both source range detectors were observed and rod motion was stopped each time either flux level doubled or any control rod bank was fully withdrawn. At these points a set of counts were taken on each source range detector and Inverse Count Rate Ratio (ICRR) was plotted to monitor the approach to criticality. The unit achieved criticality at 1555 hours on December 25, 1990, with Control Bank D at 49 steps withdrawn. The predicted critical position per OP/0/A/6100/06, Reactivity Balance Calculation was 76 steps withdrawn on Control Bank D. This represented a reactivity difference of 184 pcm.

Due to the manual reactor trip on December 27, 1990, PT/0/A/4150/28 was performed again to achieve criticality on December 28, 1990. Chemistry samples indicated Reactor Coolant System boron was 1520 ppm. Rod withdrawal commenced on December 28, 1990, and the source range counts were monitored as previously described. The unit achieved criticality at 1234 hours on December 28, 1990, with Control Bank D at 42 steps withdrawn. The predicted critical position per OP/0/A/6100/06, Reactivity Balance Calculation was 74 steps withdrawn on Control Bank D. This represented a reactivity difference of 219 pcm.

3.0 Zero Power Physics Testing- (ZPPT)

Zero Power Physics Testing for McGuire 2 Cycle 7 started December 25, 1990, and was completed December 29, 1990. The output of Power Range Detector N42 was used as input to the reactivity computer for Zero Power Physics Testing. All acceptance criteria for ZPPT were met.

A minimum of one decade of overlap between the source range and the intermediate range detectors was verified on both December 25 and 28, 1990 via the Control Board indication, the NIS panel, and the Operator Aid Computer (OAC). The results shown on Table 1 reflect the data from the OAC.

The point of adding nuclear heat was determined December 26, 1990. This was done by establishing a slow positive startup rate and observing a change in plant parameters such as an increase in Reactor Coolant System average temperatures (Tave) with a change in the reactivity trace and an increase in pressurizer level. The test was performed three times to establish repeatability of the data. Table 2 gives the results of the second two trials which were used to determine an average nuclear heat reading.

Nuclear heat was determined to be at an average flux level of 2.73×10^{-6} amps on the reactivity computer picoammeter (N42) and 1.84×10^{-6} amps on Intermediate Range Detector N35 and 2.29×10^{-6} amps on Intermediate Range Detector N36. From these results the test band for ZPPT was determined to be 10^{-8} to 10^{-7} amps on the reactivity computer.

On both December 26 and 28, 1990, an on line checkout of the reactivity computer was performed. This was done by withdrawing Control Bank D until a positive reactivity insertion of ~+25 pcm was indicated on the reactivity computer. The time for the flux level to double was measured and from this doubling time (DT), the reactor period was calculated (period = DT/0.693). Using the reactor period, the amount of reactivity was determined using the predicted data. This reactivity was compared to the reactivity computer indication. The test was repeated for a reactivity insertion of ~+40 pcm. An on-line negative reactivity checkout on the reactivity computer was also performed. This was done by inserting Control bank D until a negative reactivity change of ~-40 pcm was indicated on the reactivity computer. The time for the flux level to halve was measured and from this halving time (HT), the reactor period was calculated (period = HT/0.693). Using the reactor period, the amount of reactivity was determined using predicted data. This reactivity was compared to the reactivity computer indication. The test was repeated for a reactivity change of ~-25 pcm. The final results met all acceptance criteria and are given in Table 3.

An electronics only negative reactivity insertion test was also completed satisfactorily as part of PT/0/B/4600/55, Reactivity Computer Periodic Test.

TABLE 1

Overlap Data
on December 25, 1990

	Source Range cps		Intermediate Range amps	
	N31	N32	N35	N36
	1.4×10^{3}	1.4×10^{3}	1.5×10^{-11}	1.8×10^{-11}
	1.8×10^{4}	1.9×10^{4}	1.6×10^{-10}	1.9×10^{-10}
When SR blocked	2.0×10^{4}	2.1×10^{4}	1.8×10^{-10}	2.1×10^{-10}

Overlap Data
on December 28, 1990

	Source Range cps		Intermediate Range amps	
	N31	N32	N35	N36
	0.6×10^{3}	0.7×10^{3}	1.1×10^{-11}	1.2×10^{-11}
	1.2×10^{4}	1.4×10^{4}	1.1×10^{-10}	1.2×10^{-10}
When SR blocked	1.9×10^{4}	2.0×10^{4}	1.7×10^{-10}	2.0×10^{-10}

TABLE 2

Nuclear Heat

	Reactivity Computer	Intermediate Range	
	N42	N35	N36
	2.38×10^{-6}	1.64×10^{-6}	2.10×10^{-6}
	3.08×10^{-6}	2.04×10^{-6}	2.48×10^{-6}
AVERAGE	2.73×10^{-6} amps	1.84×10^{-6} amps	2.29×10^{-6} amps

Test Band: 10^{-8} to 10^{-7} amps on N42.

TABLE 3
Reactivity Computer Checkout

Results on December 26, 1990

Initial Flux Level (Amps) Reactivity Computer	Period (Seconds)	Doubling or Halving Time (Seconds)	Reactivity Computer($\Delta\rho_c$) (pcm)	Reactivity DT($\Delta\rho_{DT}$) or HT($\Delta\rho_{HT}$) (pcm)	% Error+
1.44×10^{-8}	199	138	32.5	32.6	0.3
4.40×10^{-8}	97	67	59.3	58.7	1.0
8.89×10^{-8}	-372	257	-23.0	-22.7	1.3
8.73×10^{-8}	-248	172	-37.3	-36.2	2.9

Results on December 28, 1990

Initial Flux Level (Amps) Reactivity Computer	Period (Seconds)	Doubling or Halving Time (Seconds)	Reactivity Computer($\Delta\rho_c$) (pcm)	Reactivity DT($\Delta\rho_{DT}$) or HT($\Delta\rho_{HT}$) (pcm)	% Error+
2.91×10^{-8}	231	160	28	28.8	2.[illegible]
3.36×10^{-8}	137	95	44	44.9	2.0
6.70×10^{-8}	-244	169	-37.5	-36.9	1.6
$7.3[illegible] \times 10^{-8}$	-364	25[illegible]	-23	-23.2	0.9

$$+ \left| \frac{\Delta\rho_{DT} - \Delta\rho_c}{\Delta\rho_c} \right| \times 100 \ \underline{OR} \ \left| \frac{\Delta\rho_{HT} - \Delta\rho_c}{\Delta\rho_c} \right| \times 100$$

3.1 Boron Endpoint Measurement - PT/0/A/4150/10

This test was performed December 26, 1990. Two sets of data were obtained. In the first set, Control Bank D was initially at 215 steps withdrawn, the Reactor Coolant System boron concentration was 1601 ppm and the Pressurizer boron concentration was 1586 ppm.

Control Bank D was pulled to the All Rods Out (ARO) Configuration and the resulting reactivity change was converted to equivalent boron using the predicted Differential Boron Worth. Control Bank D was then reinserted to the just critical condition and the test was repeated three times. After these four test trials, an additional two trials were performed. The initial conditions for these additional two trials were: Control Bank D at 201 steps withdrawn, the Reactor Coolant System boron concentration was 1594 ppm and the Pressurizer boron concentration was 1586 ppm.

The results of these reactivity changes were each added to the initial Reactor Coolant System boron concentration to give two values for the ARO Boron Endpoint. All of the values were averaged to give the final result of 1600 ppm. This value met the acceptance criterion for the Hot Zero Power (HZP) ARO Critical Boron concentration of 1583 ±50 ppm.

3.2 Isothermal Temperature Coefficient Measurement - PT/0/A/4150/12

This test was performed on December 26, 1990. The test measures Isothermal Temperature Coefficient (ITC) by plotting Reactivity versus Average Reactor Coolant System Temperature. The Moderator Temperature Coefficient (MTC) is found using the relationship as follows:

$$MTC\ (pcm/^{\circ}F) = ITC - \text{Doppler Temperature Coefficient}$$

The acceptance criterion on the ARO ITC was 1.90 ±2.0 pcm/°F. The predicted Doppler Temperature Coefficient was -1.41 pcm/°F.

The Reactor Coolant System boron concentration was 1598 ppm at the start of the test. A heatup/cooldown was performed while keeping rod position and boron constant to determine reactivity change versus temperature. The heatup/cooldown was performed a second time to establish repeatability of the data. The results are shown in Figures 3 and 4. The average ARO ITC was found to be +1.70 pcm/°F. This fell within the acceptance criterion band. This gave an ARO MTC of +3.11 pcm/°F which was within acceptable Technical Specification limits.

Following the completion of this test, PT/0/A/4150/31, Determination of Rod Withdrawal Limits to Ensure Moderator Temperature Coefficient Within Limits of Technical Specifications was performed. The results of this test indicated there were no rod withdrawal limits needed for Unit 2 Cycle 7.

Figure 3

ITC Heatup and Cooldown Data: First Run

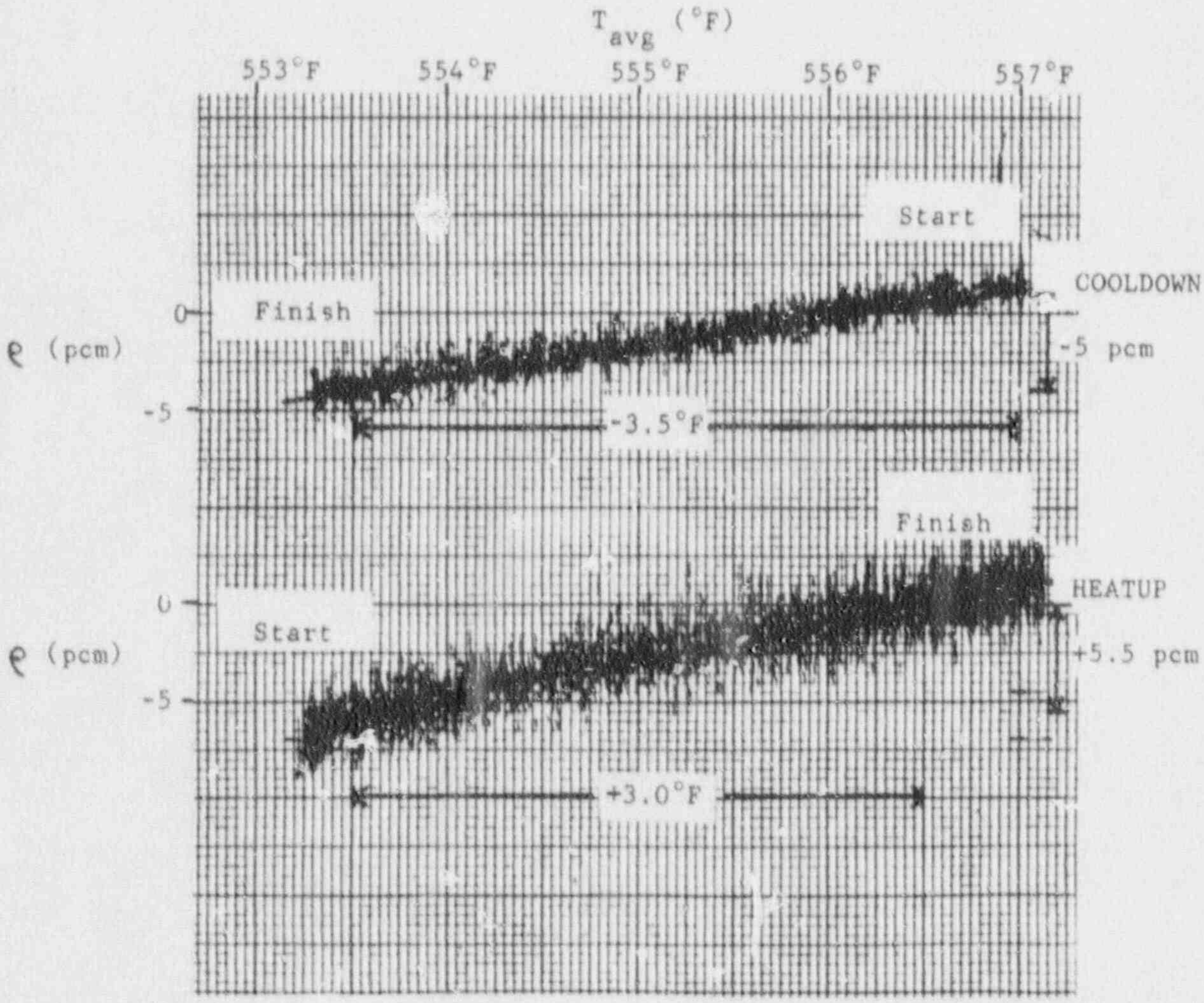
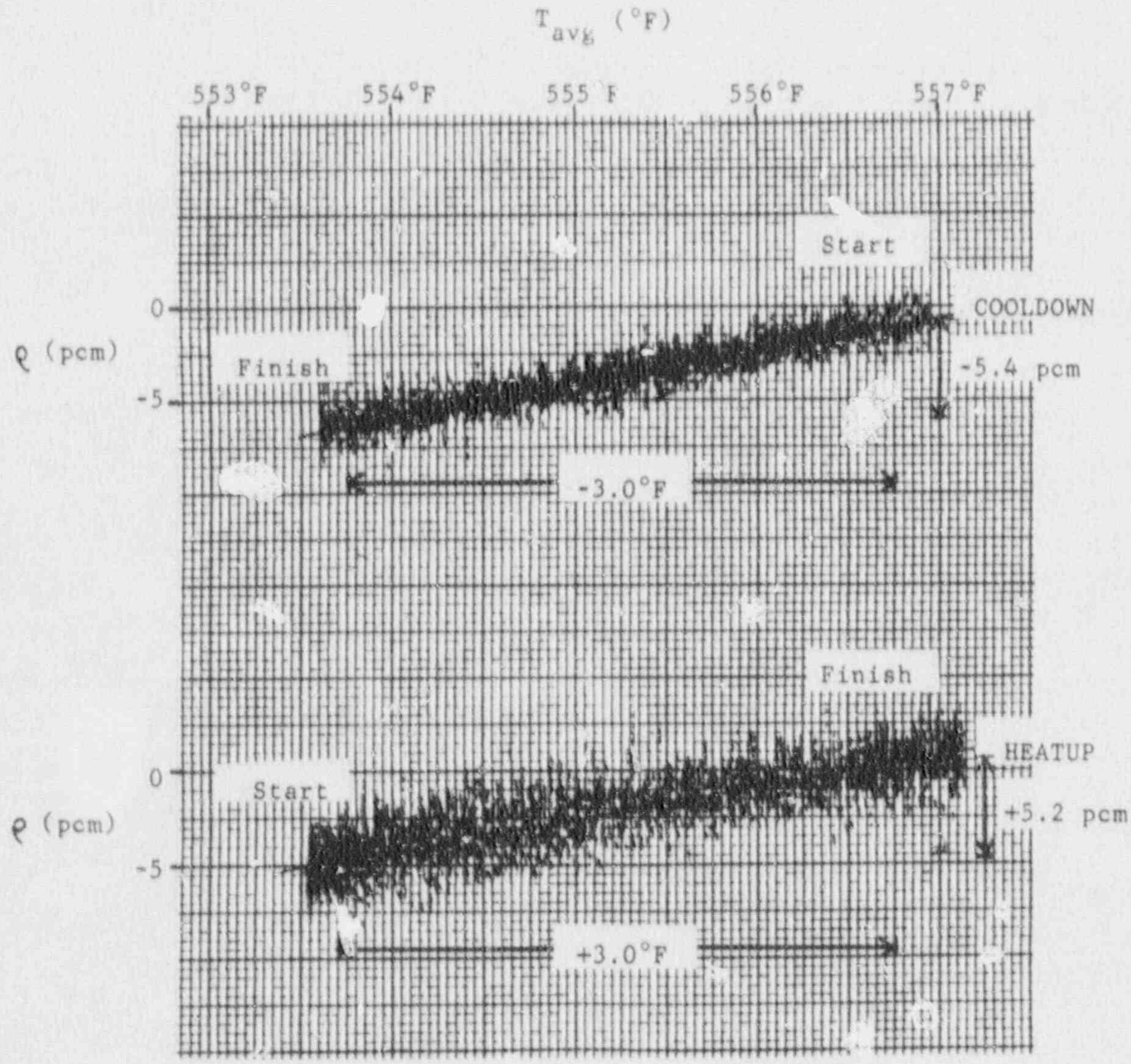


Figure 4

ITC Heatup and Cooldown Data: Second Run

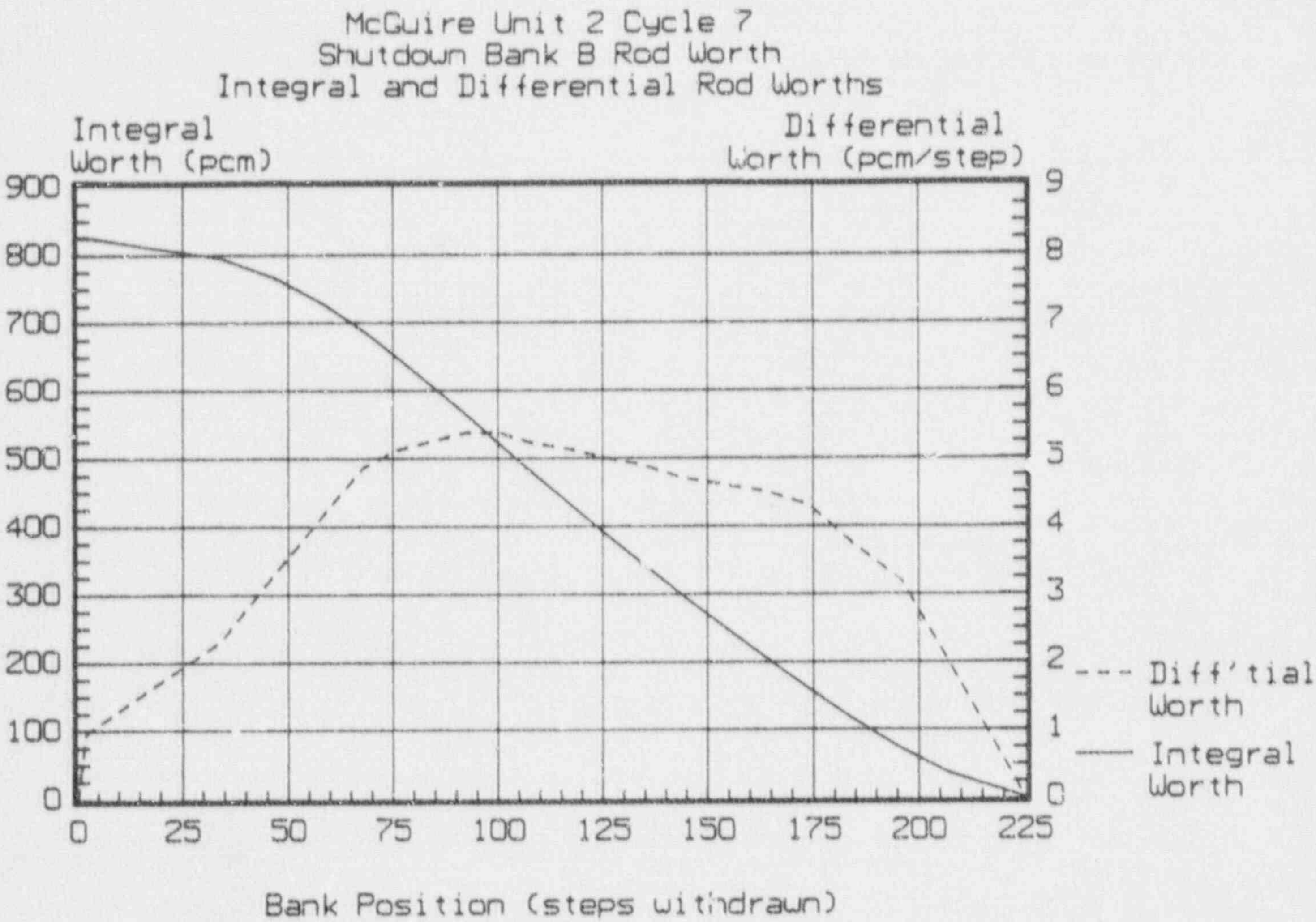


3.3 Control Rod Worth Measurement - PT/0/A/4150/11

On December 26, 1990, Shutdown Bank B rod worth was measured using the established boration/dilution method. There were no other rods in the core at the time. Shutdown Bank B was predicted to be the highest worth bank and was measured using this method so as to serve as the reference bank for Control Rod Worth Measurements by Rod Swap.

The measured worth of Shutdown Bank B was 826 pcm. The predicted worth was 860 pcm ± 29 pcm. This represented an error of 4.0% and was within the acceptance criterion of ±15%. Figure 5 shows the measured integral and differential rod worths for Shutdown Bank B.

Figure 5



McGuire Unit 2 Cycle 7
Shutdown Bank B Rod Worth
Integral and Differential Rod Worths
Integral Worth (pcm)
Differential Worth (pcm/step)
900
800
700
600
500
400
300
200
100
0
9
8
7
6
5
4
3
2
1
0
0
25
50
75
100
125
150
175
200
225
Bank Position (steps withdrawn)
Diff'tial Worth
Integral Worth

3.4 Control Rod Worth Measurement: Rod Swap - PT/0/A/4150/11A

On December 27, 1990, the rod swap method of control rod worth measurement was begun. Shutdown Bank B was used as the reference bank and its worth was measured by the boration/dilution method (see Section 3.3).

With the reference bank essentially all the way in and the reactor just critical, each control and shutdown bank was exchanged with the reference bank. The integral worth of the bank being measured (i.e., the test bank) was determined from the difference in the critical rod position of the reference bank with and without the test bank in the core. The following banks were first measured: Control Bank A and Shutdown Banks A, C, D and E. While attempting to measure the rod worth of Control Bank D, Shutdown Bank E was withdrawn to the demand position of 225 steps. The Reactor Operator (RO) noticed that the Digital Rod Position Indication (DRPI) System indicated 228 steps withdrawn. While the RO began to manually insert Shutdown Bank E to 225 steps withdrawn, Shutdown Bank E fell into the core to its fully inserted position. The reactor was then manually tripped. Extensive investigation and troubleshooting was then performed by station personnel to determine the root cause of Shutdown Bank E falling into the core. No abnormalities were discovered. Criticality was again achieved on December 28, 1990. At this time, the remaining control rod banks were measured and PT/0/A/4150/11A was completed.

The measured bank worths were compared with predicted worths and all banks were within the acceptance criteria of ±30% or ±200 pcm whichever was greater. The measured total rod worth was >90% of the predicted worth which met the acceptance criteria. In addition, all review criteria were met.

The results of the rod exchange test are given on Table 4.

TABLE 4

Control Rod Worth Measurement: Rod Swap

Bank Identification	Predicted Worth pcm	Measured Worth pcm++	Percent+ Difference
Shutdown Bank B (reference)	860	826*	4.1
Control Bank A	295	289	2.1
Control Bank B	773	739	4.6
Control Bank C	830	774	7.2
Control Bank D	494	468	5.6
Shutdown Bank A	309	313	1.3
Shutdown Bank C	455	419	8.6
Shutdown Bank D	455	430	5.8
Shutdown Bank E	482	462	4.3
TOTAL ROD WORTH	4953	4720	4.9

*Measured by boration/dilution method

+ $\left|\frac{\text{Predicted - Measured}}{\text{Measured}}\right| \times 100$

++ Rounded to nearest pcm

4.0 Power Escalation Testing

McGuire Unit 2 Cycle 7 Power Escalation testing started December 29, 1990, at the conclusion of ZPPT and was completed January 7, 1991.

The unit went on line December 29 at 1230 hours. The unit experienced some holds during power escalation which were scheduled to allow testing per PT/0/A/4150/21, Post Refueling Controlling Procedure for Criticality, Zero Power Physics, and Power Escalation Testing, and to allow a secondary side boron soak per Primary Chemistry.

During a hold for turbine testing at ~30% power on December 31, PT/0/A/4150/02A, Core Power Distribution, was performed. The results from the test indicated that Core Power Distribution Technical Specification Limits for operation to 94.8% power would not be violated, and all test acceptance criteria were met. Table 5 shows the test results.

Following completion of the secondary side boron soak at 30%, power was increased to ~50% at ~2.5%/hr. From 50% to 80%, PT/0/A/4600/02E, Incore and NIS Recalibration: Post Outage, was performed (see Section 4.1).

At ~76% power on January 3, 1991, PT/0/A/4150/02A, Core Power Distribution, was performed. The test results are given in Table 6. All test acceptance criteria were met. The results from the full core flux map taken were used to project a "limiting" power at which F_Q or $F_{\Delta H}$ Tech Spec peaking factor margin would be maintained. This projection indicated that $F_{\Delta H}$ Tech Spec peaking factor margin would be maintained for all power levels up to 100% power and that the F_Q Tech Spec peaking factor margin would be maintained for all power levels up to 99.14% power. At ~90% power, Tech Spec RAOC Axial Flux Difference (AFD) wings were reduced by 1% based on Design Engineering recommendations to increase power beyond 99.14% and up to 100% power.

The excore detectors were calibrated at ~76% power on January 2-3, 1991, and power escalation then resumed at a rate of ~2.5%. Upon achieving ~90%, PT/0/A/4150/03, Thermal Power Output Measurement, was performed (see Section 4.2).

The remaining tests designated for Hot Full Power Equilibrium Conditions were performed on January 7, 1991. The tests and their results are described in Sections 4.3 - 4.5.

TABLE 5

Core Power Distribution Results
30% Full Power

NOTE: Axial location 1 is the bottom of the core.
Axial location 61 is the top of the core.

Unit 2 Cycle 7	Map FCM/2/07/001
Date/Time Map Taken	12/30/90 2130 hours
Power Level	30.46%
Cycle Burnup	0.32 EFPD 13.3 MWD/MTU
Boron Concentration	1488 ppm
Control Rod Position	Control Bank D at 205/206 steps withdrawn
Maximum F_Q^T:	2.0420 at Axial Loc. 42, Horiz. Loc D-13
Maximum F_Z:	1.2981 at Axial Loc. 42
Maximum pin $F_{\Delta H}^N$	1.4637 at Horiz. Loc. D-13
Maximum error $F_{\Delta H}^N$ (from predicted)	6.44% at Horiz. Loc. J-01
Maximum $F_Q^T/K(Z)$	2.2126 at Axial Loc. 42
Maximum % Reduction in Axial Flux Difference (AFD) Wings	None
Minimum % Margin to AFD Wings	-44.8004% at Axial Loc. 40
R_{max} (Tech Spec 3/4.2.3)	0.8128
Total Reactor Coolant Flowrate (Process Computer)	391,328 gallons/minute
Total Incore Axial Offset	12.881%
Incore Tilts %:	

Upper Core		Lower Core	
Quadrant 1:	-1.317%	Quadrant 1:	-0.779%
Quadrant 2:	0.974%	Quadrant 2:	1.262%
Quadrant 3:	-0.01 %	Quadrant 3:	-0.332%
Quadrant 4:	0.352%	Quadrant 4:	-0.151%

TABLE 6

Core Power Distribution Results
76% Full Power

<u>NOTE</u>: Axial location 1 is the bottom of the core.
Axial location 61 is the top of the core.

Unit 2 Cycle 7	Map FCM/2/07/016
Date/Time Map Taken	1/3/91 0817 hours
Power Level	76.25%
Cycle Burnup	2.25 E+0 94 MWD/MTU
Boron Concentration	1237 ppm
Control Rod Position	Control Bank D at 196 steps withdrawn
Maximum F_Q^T:	1.8776 at Axial Loc. 35, Horiz. Loc D-13
Maximum F_Z:	1.2[illegible]23 at Axial Loc. 34
Maximum pin $F_{\Delta H}^N$	1.3939 at Horiz. Loc. D-13
Maximum error $F_{\Delta H}^N$ (from predicted)	6.20% at Horiz. Loc. J-01
Maximum $F_Q^T/K(Z)$	2.0102 at Axial Loc. 40
Maximum % Reduction in Axial Flux Difference (AFD) Wings	None
Minimum % Margin to AFD Wings	-22.8938% at Axial Loc. 36
R_{max} (Tech Spec 3/4.2.3)	0.8734
Total Reactor Coolant Flowrate (Process Computer)	389,924 gallons/minute
Total Incore Axial Offset	3.521%
Incore Tilts %:	

Upper Core		Lower Core	
Quadrant 1:	-1.361%	Quadrant 1:	-0.132%
Quadrant 2:	1.628%	Quadrant 2:	0.328%
Quadrant 3:	-0.227%	Quadrant 3	-0.149%
Quadrant 4:	-0.040%	Quadrant 4:	-0.047%

4.1 Incore and NIS Recalibration: Post Outage - PT/0/A/4600/02E

This test was started on January 1, 1991, and was run during the power escalation from 50% to 80% Full Power. The data obtained from this test were used to set the nuclear instrumentation system amplifier gains and the axial flux difference function of the overpower ΔT setpoints and to determine the correlation between incore and excore axial offsets.

Data collection was accomplished by taking quarter core flux maps and associated excore detector currents at eleven different axial offsets as indicated in Table 7. (The quarter core flux map pattern had previously been verified as an accurate representation of axial offset through PT/0/A/4150/23, Quarter Core Flux Map Qualification Test). These data were input into a benchmarked off-line computer program which generated the output shown in Figure 6. The appropriate factors were then put into the plant instrumentation systems and all acceptance criteria were met.

TABLE 7
Quarter Core Flux Map Data for
PT/0/A/4600/02E, Incore and NIS Recalibration: Post Outage

	Map	Average Thermal Power (%)	Incore Axial Offset (%)
1)	QCM/2/07/003	52.6	13.[illegible]8
2)	QCM/2/07/004	55.0	11.198
3)	QCM/2/07/005	57.4	8.815
4)	QCM/2/07/006	59.8	5.754
5)	QCM/2/07/007	62.5	3.681
6)	QCM/2/07/008	64.9	1.565
7)	QCM/2/07/009	67.6	0.60
8)	QCM/2/07/010	69.9	-1.297
9)	QCM/2/07/011	72.7	-2.700
10)	QCM/2/07/012	75.6	-4.911
11)	QCM/2/07/013	76.5	-5.792

Figure 6

Incore and NIS Recalibration Results

Excore Currents and Voltages
Correlated to 100% Full Power
at Various Axial Offsets

Unit 2 Cycle 7

FULL POWER DETECTOR CURRENTS (MICROAMPS) CORRESPONDING TO VARIOUS INCORE AXIAL OFFSETS

INCORE AXIAL OFFSET	DETECTOR N-41		DETECTOR N-42		DETECTOR N-43		DETECTOR N-44	
	T	B	T	B	T	B	T	B
30.0	260.3	190.0	337.9	237.2	291.6	209.0	283.9	201.3
20.0	248.8	213.6	323.9	266.1	280.0	235.0	272.8	225.3
10.0	237.2	237.2	309.8	295.0	268.3	261.0	261.7	249.4
0.0	225.7	260.7	295.8	324.0	256.7	287.0	250.[illegible]	273.4
-10.0	214.2	284.3	281.8	352.9	245.1	313.0	239.5	297.4
-20.0	202.6	307.8	267.8	381.8	233.4	339.0	228.4	321.5
-30.0	191.1	331.4	253.8	410.8	221.8	365.1	217.3	345.5
r*	0.9799	-0.[illegible]964	0.9773	-0.9960	0.9741	-0.9967	0.9735	-0.9961

NORMALIZED DETECTOR VOLTAGES (VOLTS) AT VARIOUS AXIAL OFFSETS

INCORE AXIAL OFFSET	DETECTOR N-41			DETECTOR N-42			DETECTOR N-43			DETECTOR N-44		
	T	B	T-B	T	B	T-B	T	B	T-B	T	B	T-B
30.0	9.608	6.071	3.537	9.515	6.098	3.416	9.463	6.066	3.397	9.438	6.133	3.305
20.0	9.182	6.824	2.358	9.120	6.842	2.277	9.085	6.820	2.265	9.069	6.865	2.203
10.0	8.756	7.577	1.179	8.725	7.586	1.139	8.708	7.575	1.132	8.699	7.598	1.102
0.0	8.330	8.330	0.000	8.330	8.[illegible]	0.000	8.330	8.330	0.000	8.330	8.330	-0.000
-10.0	7.904	9.083	-1.179	7.935	9.074	-1.139	7.952	9.085	-1.132	7.961	9.062	-1.102
-20.0	7.478	9.636	-2.358	7.540	9.818	-2.277	7.575	9.840	-2.265	7.591	9.795	-2.203
-30.0	7.052	10.589	-3.537	7.145	10.562	-3.416	7.197	10.594	-3.397	7.222	10.527	-3.305

AFD INCORE/EXCORE RATIOS FOR QUADRANTS 1 - 4

QUAD 4 N-41	QUAD 2 N-42	QUAD 1 N-43	QUAD 3 N-44
M = 1.413	M = 1.463	M = 1.471	M = 1.512

4.2 Thermal Power Output Measurement - PT/0/A/4150/03

This test was used to verify that the primary and secondary heat balances on the plant computer were consistent with primary and secondary heat balances on a benchmarked offline computer. The test was run on January 3, 1991, at ~90% F.P. The results are shown in Table 8.

The acceptance criterion of 1% difference between the offline computer and the plant computer was met.

TABLE 8

Thermal Power Output Measurement Results

	Plant Computer		Off-Line Computer	
	%	MW_t	%	MWt
Primary Heat Balance	89.43	3050.58	89.64	3057.62
Secondary Heat Balance	89.92	3067.09	89.99	3069.56

4.3 Reactivity Anomalies Calculation - PT/0/A/4150/04

This test compared the actual core reactivity to the predicted core reactivity by taking into account the actual Reactor Coolant System boron concentration, Xenon and Samarium worths, rod positions and power level and adjusting these to the ARO, Hot Full Power (HFP), equilibrium Xenon and Samarium condition. Theoretical and actual Reactor Coolant System boron concentration for this conditions were then compared.

The test, performed at ~100% on January 7, 1991, indicated that the actual ARO, HFP, equilibrium Xenon and Samarium condition boron concentration was 1131.5 ppm. This compares to a predicted value of 1138 ppm. The 6.5 ppm difference translated into a 56.6 pcm error between actual and predicted reactivity worths. This was within the acceptance criterion for the test of ±1000 pcm.

4.4 Incore and Nuclear Instrumentation System Correlation Check - PT/0/A/4600/02A

This test was used to compare the incore axial flux difference as indicated by a full core flux map to the axial flux difference indicated on the plant computer by the excore detectors. This test also verifies the incore/excore calibration data that had been implemented during PT/0/A/4600/02E, Incore and NIS Recalibation: Post Outage.

The test was performed at ~100% on January 7, 1991. The indicated incore axial flux difference from flux map FCM/2/07/017 was 2.436%. The core average axial flux difference from the excore detectors was 3.950%. These results gave an absolute difference of 1.514% and was within the acceptance criterion of ±3% difference.

4.5 Core Power Distribution - PT/0/A/4150/02A

On January 7, 1991, PT/0/A/4150/02A, Core Power Distribution, was performed to verify the Core Power Distribution Technical Specification Limits for operation would not be violated. The reactor was at ~100% Full Power and equilibrium conditions. One result of this test indicated a 0.8918% margin to the F_Q Tech Spec peaking factor limit. The Tech Spec RAOC AFD wings were then restored to their 100% power operation value.

All acceptance criteria for this test were met. Table 9 gives the test results.

TABLE 9

Core Power Distribution Results
~100% Full Power

<u>NOTE</u>: Axial location 1 is the bottom of the core.
Axial location 61 is the top of the core.

Unit 2 Cycle 7	Map FCM/2/07/017
Date/Time Map Taken	1/7/91 0935 hours
Power Level	~100%
Cycle Burnup	16.1 EFPD 253 MWD/MTU
Boron Concentration	1139 ppm
Control Rod Position	Control Bank D at 209 steps withdrawn
Maximum F_Q^T:	1.8495 at Axial Loc. 34, Horiz. Loc. C-12
Maximum F_Z:	1.2217 at Axial Loc. 34
Maximum pin $F_{\Delta H}^N$	1.3862 at Horiz. Loc. C-12
Maximum error $F_{\Delta H}^N$ (from predicted)	5.3% at Horiz. Loc. E-09
Maximum $F_Q^T/K(Z)$	1.9634 at Axial Loc. 39
Maximum % Reduction in Axial Flux Difference (AFD) Wings	None
Minimum % Margin to AFD Wings	-0.8918% at Axial Loc. 39
R (Tech Spec 3/4.2.3)	0.9296
Total Reactor Coolant Flowrate (Process Computer)	391,117 gallons/minute
Total Incore Axial Offset	+2.436%
Incore Tilts %:	

Upper Core		Lower Core	
Quadrant 1:	-0.624%	Quadrant 1:	-0.516%
Quadrant 2:	0.322%	Quadrant 2:	0.786%
Quadrant 3:	0.319%	Quadrant 3:	0.082%
Quadrant 4:	-0.017%	Quadrant 4:	-0.351%