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Vepco

NORTH ANNA UNIT 2, CYCLE 3 STARTUP PHYSICS TEST REPORT

NUCLEAR OPERATIONS DEPARTMENT

Virginia Electric and Power Company

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VEP-NOS-4

NORTH ANNA UNIT 2, CYCLE 3
STARTUP PHYSICS TEST REPORT

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PREFACE

The purpose of this report is to present the analysis and evaluation of the physics tests which were performed to verify that the North Anna 2, Cycle 3 core could be operated safely, and to make an initial evaluation of the performance of the core. It is not the intent of this report to discuss the particular methods of testing or to present the detailed data taken. Standard test techniques and methods of data analysis were used. The test data, results, and evaluations, together with the detailed startup procedures, are on file at the North Anna Power Station. Therefore, only a cursory discussion of these items is included in this report. The analyses presented includes a brief summary of each test, a comparison of the test results with design predictions, and an evaluation of the results.

The North Anna 2, Cycle 3 Startup Physics Tests Results and Evaluation Sheets have been included as an appendix to provide additional information on the startup test results. Each data sheet provides the following information: 1) test identification, 2) test conditions (design), 3) test conditions (actual), 4) test results, 5) acceptance criteria, and 6) comments concerning the test. These sheets provide a compact summary of the startup test results in a consistent format. The design test conditions and design values of the measured parameters were completed prior to startup physics testing. The entries for the design values were based on the calculations performed by Vepco's Nuclear Fuel Engineering Group[1]. During the tests, the data sheets were used as guidelines both to verify that the proper test conditions were met and to facilitate the preliminary comparison between measured and predicted test results, thus enabling a quick identification of possible problems occuring during the tests. The Appendix to this report contains the final completed and approved version of the Startup Physics Tests Results and Evaluation Sheets.

Section 1

INTRODUCTION AND SUMMARY

On April 2, 1983, Unit No. 2 of the North Anna Power Station was shut down for its second refueling. During this shutdown, 56 of the 157 fuel assemblies in the core were replaced with fresh fuel assemblies. The core loading pattern and the design parameters for each batch are shown in Figure 1.1. Fuel assembly burnups are given in Figure 1.2. The incore instrumentation locations are identified in Figure 1.3. Figure 1.4 identifies the the location and number of burnable poison rods in the Cycle 3 core. Figure 1.5 identifies the location and number of control rods in the Cycle 3 core.

On May 27, 1983, at 0629, the third cycle core achieved initial criticality. Following criticality, startup physics tests were performed as outlined in Table 1.1. A summary of the results of these tests follows:

1. The drop time of each control rod was confirmed to be within the 2.2 second limit of the North Anna Technical Specifications[2].
2. Individual control rod bank worths for all control rod banks were measured using the rod swap technique[3] and were found to be within 13.6% of the design predictions. The sum of the individual control rod bank worths was measured to be within 2.6% of the design prediction. These results are within the design tolerance of ±15% for individual bank worths (±10% for the rod swap reference bank worth) and the design tolerance of ±10% for the sum of the individual control rod bank worths.
3. Critical boron concentrations for two control bank configurations were measured to be within 29 ppm of the

design predictions. These results were within the design tolerances and also met the accident analysis acceptance criterion.

4. The boron worth coefficient was measured to be within 1.1% of the design prediction, which is well within the design tolerance of ±10% and met the accident analysis criterion.
5. The isothermal temperature coefficient was measured to be within 0.05 pcm/°F of design prediction. This result is within the design tolerance of ±3 pcm/°F and also met the accident analysis acceptance criterion.
6. Core power distributions for various HZP and at power conditions were generally within 5% of the predicted power distributions. For all maps, the hot channel factors were measured to be within the limits of the Technical Specifications. However, at power levels less than 79%, there were violations of the Radial Peaking Factor, Fxy(RTP), surveillance limit, and at 4% power, a quadrant power tilt ratio of 2.76% was measured. Generally, all measurement parameters met their respective design value tolerances. All measurement parameters met their respective accident analysis acceptance criteria.

In summary, all startup physics test results were acceptable. Detailed results, together with specific design tolerances and acceptance criteria for each measurement, are presented in the appropriate sections of this report.

Table 1.1

NORTH ANNA 2 - BOL CYCLE 3 PHYSICS TESTS

CHRONOLOGY OF TESTS

Test	Date	Time	Power	Reference Procedure
Hot Rod Drop-Hot Full Flow	5/26/83	1243	HSD	2-PT-17.2
Reactivity Computer Checkout	5/27/83	1338	HZP	2-PT-94.2
Boron Endpoint-ARO	5/28/83	0640	HZP	2-PT-94.3
Temperature Coefficient-ARO	5/28/83	0746	HZP	2-PT-94.4
Bank B Worth	5/28/83	1139	HZP	2-PT-94.5
Boron Endpoint-B In	5/28/83	1655	HZP	2-PT-94.3
Bank D Worth - Rod Swap	5/28/83	1737	HZP	2-PT-94.7
Bank C Worth - Rod Swap	5/28/83	1837	HZP	2-PT-94.7
Bank A Worth - Rod Swap	5/28/83	1927	HZP	2-PT-94.7
Bank SB Worth - Rod Swap	5/28/83	2011	HZP	2-PT-94.7
Bank SA Worth - Rod Swap	5/28/83	2056	HZP	2-PT-94.7
Flux Map - ARO	5/29/83	0512	4%	2-PT-21.1
Flux Map - Verify Fxy	5/29/83	1840	31%	2-PT-21.1
Flux Map - I/E Calibration	6/06/83	0823	50%	2-PT-21.1
Flux Map - I/E Calibration	6/07/83	0606	79%	2-PT-21.1
Flux Map - Delta I Target	6/08/83	0806	97%	2-PT-21.1
Flux Map - Delta I Target	6/08/83	1632	99%	2-PT-21.1
Flux Map - I/E Calibration	6/09/83	1057	100%	2-PT-21.1
Flux Map - HZP, Eq. Xenon	6/10/83	0749	100%	2-PT-21.1

Figure 1.1

NORTH ANNA UNIT 2 - CYCLE 3

CORE LOADING MAP

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							3A2 P16	4A R07	3A2 P34						
2					4A R02	5A S22	5A S34	3A2 P30	5A S36	5A S07	4A R03				
3				4A R15	4A R50	5A S54	3A2 P17	4A R49	3A2 P45	5A S46	4A R17	4A R24			
4			4A R33	4A R37	5A S27	4A R34	5A S33	3A2 P23	5A S19	4A R22	5A S32	4A R28	4A R05		
5		4A R11	4A R47	5A S20	3A2 P06	5A S25	3A2 P51	4A R27	3A2 P27	5A S30	3A2 P33	5A S05	4A R10	4A R38	
6		5A S44	5A S04	4A R45	5A S16	3A2 P31	5A S53	3A2 P05	5A S21	3A2 P10	5A S23	4A R39	5A S10	5A S09	
7	3A2 P47	5A S24	3A2 P08	5A S12	3A2 P44	5A S45	3A2 P32	4A R19	3A2 P28	5A S11	3A2 P52	5A S47	3A2 P19	5A S31	3A2 P15
8	4A R26	3A2 P37	4A R51	3A2 P20	4A R13	3A2 P43	4A R40	3A2 P50	4A R30	3A2 P49	4A R23	3A2 P24	4A R04	3A2 P38	4A R14
9	3A2 P01	5A S41	3A2 P36	5A S42	3A2 P13	5A S03	3A2 P14	4A R36	3A2 P25	5A S14	3A2 P48	5A S29	3A2 P07	5A S02	3A2 P35
10		5A S13	5A S49	4A R35	5A S17	3A2 P41	5A S40	3A2 P02	5A S38	3A2 P22	5A S55	4A R06	5A S52	5A S48	
11		4A R46	4A R48	5A S43	3A2 P40	5A S18	3A2 P12	4A R18	3A2 P42	5A S26	3A2 P26	5A S08	4A R08	4A R44	
12			4A R16	4A R25	5A S28	4A R42	5A S39	3A2 P29	5A S50	4A R41	5A S51	4A R20	4A R29		
13				4A R01	4A R43	5A S37	3A2 P03	4A R31	3A2 P21	5A S35	4A R12	4A R21			
14					4A R52	5A S01	5A S56	3A2 P11	5A S06	5A S15	4A R32				
15							3A2 P09	4A R09	3A2 P18						

--> BATCH
--> ASSEMBLY ID

FUEL ASSEMBLY DESIGN PARAMETERS

	3A2	4A	5A
Initial Enrichment (w/o U235)	3.10	3.41	3.59
Burnup at BOC-3 (MWD/MTU)	20,319	7,763	0
Assembly Type	17x17	17x17	17x17
Number of Assemblies	49	52	56
Fuel Rods Per Assembly	264	264	264

Figure 1.2

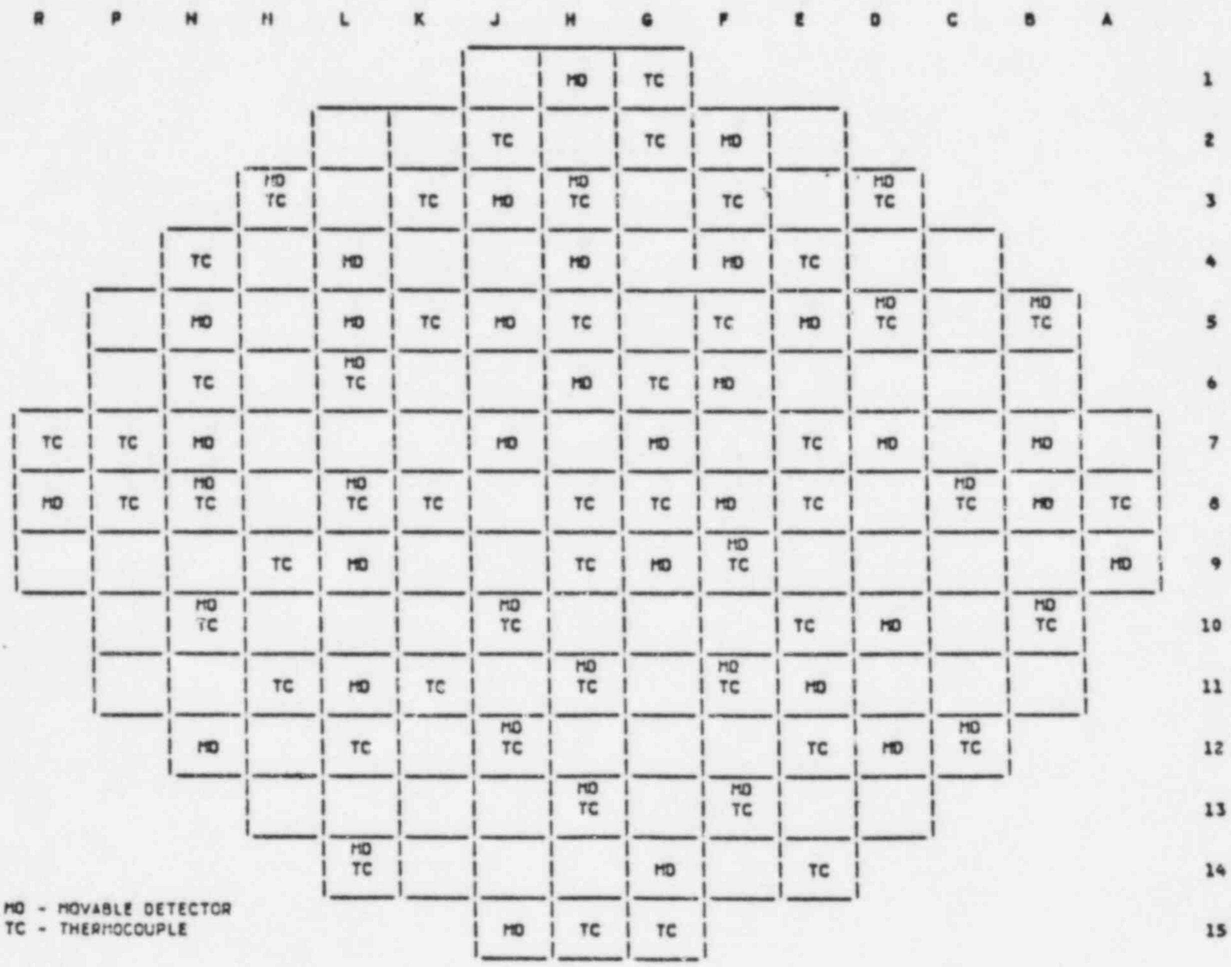
NORTH ANNA UNIT 2 - CYCLE 3
BEGINNING OF CYCLE FUEL ASSEMBLY BURNUPS

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							P16 23504	R07 6088	P34 23629						
2					R02 9238	S22 0	S34 0	P30 18354	S36 0	307 0	R03 9198				
3				R15 6517	R50 8534	S54 0	P17 21962	R49 7569	P45 21742	S46 0	R17 8520	R24 6705			
4			R33 6457	R37 6255	S27 0	R34 9675	S33 0	P23 18527	S19 0	R22 9977	S32 0	R28 6201	R05 6625		
5		R11 9019	R47 8428	S20 0	P06 23277	S25 0	P51 18789	R27 6184	P27 18319	S30 0	P33 23210	S05 0	R10 8603	R38 9306	
6		S44 0	S04 0	R45 9698	S16 0	P31 20255	S53 0	P05 17930	S21 0	P10 18586	S23 0	R39 9662	S10 0	S09 0	
7	P47 23458	S24 0	P08 22083	S12 0	P44 18546	S45 0	P32 17000	R19 6412	P28 16686	S.1 0	P52 20096	S47 0	P19 21792	S31 0	P15 23403
8	R26 6118	P37 18467	R51 7591	P20 18277	R13 5984	P43 17899	R40 6264	P50 23614	R30 6134	P49 17920	R23 6214	P24 18450	R04 7503	P38 18497	R14 6054
9	P01 23481	S41 0	P36 21663	S42 0	P13 18546	S03 0	P14 16863	R36 6050	P25 16962	S14 0	P48 18484	S29 0	P07 21716	S02 0	P35 23688
10		S13 0	S49 0	R35 9753	S17 0	P41 19931	S40 0	P02 18127	S38 0	P22 20113	S55 0	R06 9926	S52 0	S48 0	
11		R46 9332	R48 8636	S43 0	P40 23325	S18 0	P12 18637	R18 6411	P42 18543	S26 0	P26 23476	S08 0	R08 8822	R44 9296	
12			R16 6639	R25 6198	S28 0	R42 9569	S39 0	P29 18509	S50 0	R41 9720	S51 0	R20 6163	R29 6662		
13				R01 6728	R43 9088	S37 0	P03 21976	R31 7450	P21 21770	S35 0	R12 8725	R21 6625			
14					R52 9711	S01 0	S56 0	P11 18615	S06 0	S15 0	R32 9360				
15							P09 23164	R09 6031	P18 23782						

Legend: box top line --> ASSEMBLY ID; box second line --> ASSEMBLY BURNUP

Figure 1.3

NORTH ANNA UNIT 2 - CYCLE 3
INCORE INSTRUMENTATION LOCATIONS



MD - MOVABLE DETECTOR
TC - THERMOCOUPLE

Figure 1.4

NORTH ANNA UNIT 2 - CYCLE 3

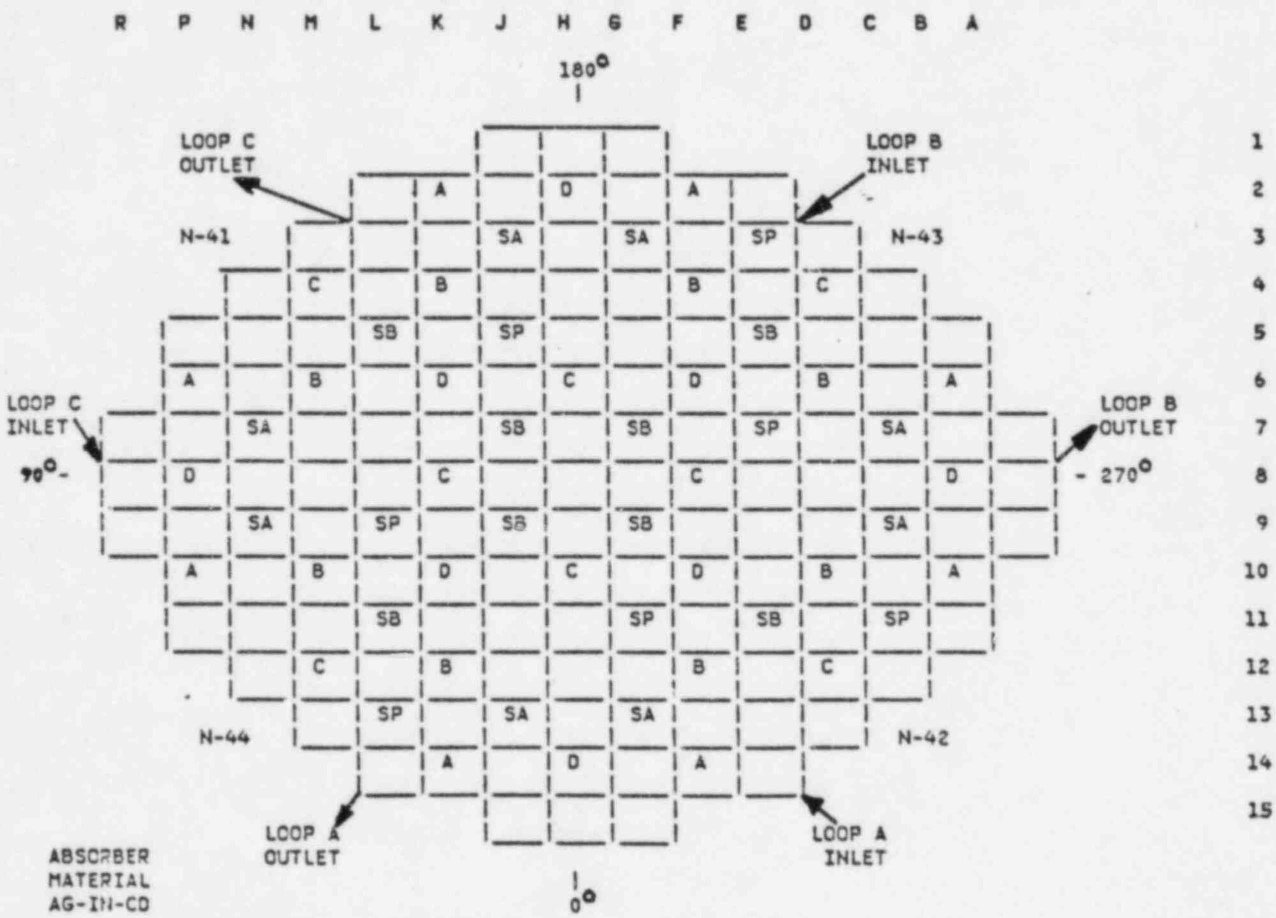
BURNABLE POISON AND SOURCE ASSEMBLY LOCATIONS

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1															
2							4P		4P						
3						20P		SS11		20P					
4					20P		20P		20P		20P				
5				20P		20P		8P		20P		20P			
6			20P		20P		20P		20P		20P		20P		
7		4P		20P		20P		8P		20P		20P		4P	
8					8P		8P		8P		8P				
9		4P		20P		20P		8P		20P		20P		4P	
10			20P		20P		20P		20P		20P		20P		
11				20P		20P		8P		20P		20P			
12					20P		20P		20P		20P				
13						20P		SS12		20P					
14							4P		4P						
15															

896 FRESH BURNABLE POISON RODS
SS - SECONDARY SOURCE

Figure 1.5

NORTH ANNA UNIT 2 - CYCLE 3
CONTROL ROD LOCATIONS



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 SB	8
SHUTDOWN BANK SA	8
SP (SPARE ROD LOCATIONS)	8

Section 2

CONTROL ROD DROP TIME MEASUREMENTS

The drop time of each control rod was measured at hot RCS conditions in order to confirm satisfactory operation and to verify that the rod drop times were less than the maximum allowed by the Technical Specifications. The hot control rod drop time measurements were run with the RCS at hot, full flow conditions (547 °F, 2235 psig) and are described below.

The rod drop time measurements were performed by first withdrawing a rod bank to its fully withdrawn position, and then removing the movable gripper coil fuse and stationary gripper coil fuse for the test rod. This allows the rod to drop into the core as it would in a normal plant trip. The data recorded during this test are, the stationary gripper coil voltage, the LVDT (Linear Variable Differential Transformer) primary coil voltage and a 60Hz timing trace which are recorded via a visicorder. The rod drop time to the dashpot entry and to the bottom of the dashpot are determined from this data. Figure 2.1 provides an example of the data that is recorded during a rod drop time measurement.

As shown in Figure 2.1, the initiation of the rod drop is indicated by the decay of the stationary gripper coil voltage when the stationary coil fuse is removed. A voltage is then induced in the LVDT primary coil as the rod drops. The magnitude of this voltage is a function of the rod velocity. When the rod enters the dashpot section of its guide tube, the velocity slows causing a voltage decrease in the LVDT coil. The LVDT voltage then reaches a minimum as the rod reaches the bottom of the dashpot. Subsequent variations in the trace are caused by the rod

bouncing. This procedure was repeated for each control rod.

The measured drop times for each control rod are recorded on Figure 2.2. The slowest, fastest, and average drop times are summarized in Table 2.1. Technical Specification 3.1.3.4 specifies a maximum rod drop time from loss of stationary gripper coil voltage to dashpot entry of 2.2 seconds with the RCS at hot, full flow conditions. All test results met this limit.

Table 2.1

NORTH ANNA UNIT 2 - CYCLE 3 BOL PHYSICS TEST
HOT ROD DROP TIME SUMMARY

ROD DROP TIME TO DASHPOT ENTRY

SLOWEST ROD	FASTEST ROD	AVERAGE TIME
B-10, 1.82 Sec.	M-4, 1.43 Sec.	1.61 Sec.

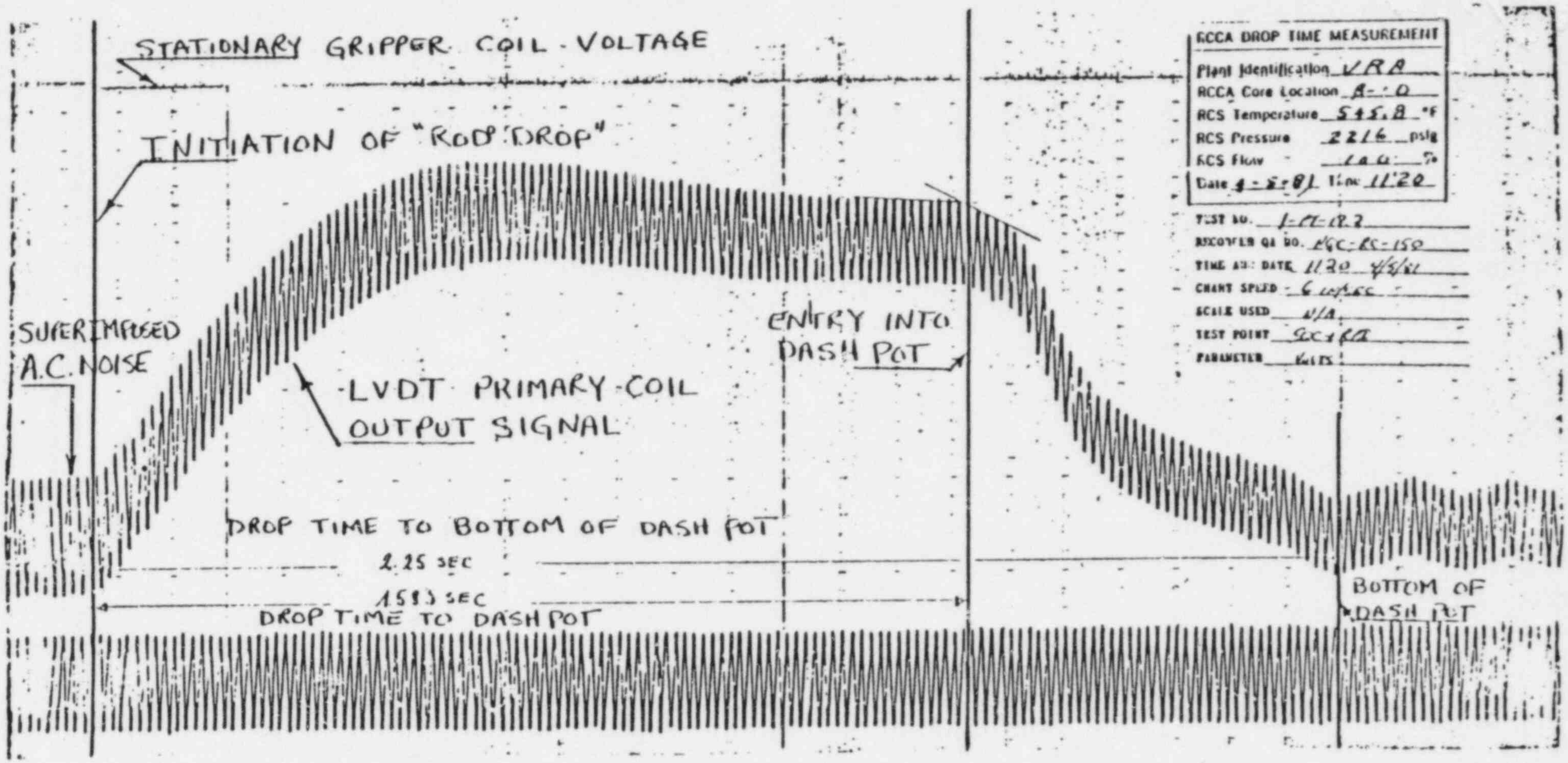
ROD DROP TIME TO BOTTOM OF DASHPOT

SLOWEST ROD	FASTEST ROD	AVERAGE TIME
B-6, 2.49 Sec.	M-4, 2.06 Sec.	2.29 Sec.

Figure 2.1

NORTH ANNA UNIT 2 - CYCLE 3 BOL PHYSICS TEST

TYPICAL ROD DROP TRACE



TIMING TRACE - STATION BUS FREQUENCY

Figure 2.2

NORTH ANNA UNIT 2 - CYCLE 3 BOL PHYSICS TEST
ROD DROP TIMES - HOT FULL FLOW CONDITIONS

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1															
2						1.66 2.35		1.64 2.31		1.60 2.26					
3							1.59 2.23		1.50 2.25						
4				1.43 2.06		1.68 2.42				1.55 2.24		1.68 2.35			
5					1.56 2.27						1.58 2.24				
6		1.60 2.28		1.63 2.33		1.64 2.31		1.58 2.28		1.64 2.29		1.58 2.25		1.80 2.49	
7			1.52 2.19				1.52 2.18		1.58 2.25				1.59 2.32		
8		1.68 2.35				1.60 2.31				1.57 2.24				1.71 2.36	
9			1.60 2.27				1.54 2.20		1.60 2.25				1.46 2.10		
10		1.67 2.31		1.55 2.20		1.63 2.28		1.59 2.31		1.63 2.30		1.56 2.24		1.82 2.32	
11					1.61 2.30						1.58 2.27				
12				1.63 2.35		1.55 2.25				1.54 2.19		1.67 2.35			
13							1.57 2.30		1.64 2.30						
14						1.77 2.48		1.70 2.42		1.71 2.36					
15															

Legend (each box): upper value --ROD DROP TIME TO DASHPOT ENTRY(SEC.); lower value --ROD DROP TIME TO BOTTOM OF DASHPOT(SEC.)

Section 3

CONTROL ROD BANK WORTH MEASUREMENTS

Control rod bank worth measurements were obtained for all control and shutdown banks using the rod swap technique. The first step in the rod swap procedure was to dilute the most reactive control rod bank (hereafter referred to as the reference bank) into the core and measure its reactivity worth using conventional test techniques. The reactivity changes resulting from the reference bank movements were recorded continuously by the reactivity computer[5] and were used to determine the differential and integral worth of the reference bank (Control Bank B). At the completion of the reference bank reactivity worth measurement, the reactor coolant system temperature and boron concentration were stabilized such that the reactor was critical with the reference bank near full insertion. Initial statepoint data for the rod swap maneuver were obtained by moving the reference bank to its fully inserted position and recording the core reactivity and moderator temperature. At this point, a rod swap maneuver was performed by withdrawing the reference bank while one of the other control rod banks (i.e., a test bank) was inserted. The core was kept nominally critical throughout this rod swap and the maneuver was continued until the test bank was fully inserted and the reference bank was at the position at which the core was just critical. This measured critical position (MCP) of the reference bank with the test bank fully inserted is the major parameter of interest and was used to determine the integral reactivity worth of the test bank. Statepoint data (core reactivity, moderator temperature, and the differential worth of the reference bank) were recorded with the reference bank at the MCP. The rod swap maneuver was then performed in reverse order such that the reference bank once again was near full insertion and the test bank was

once again fully withdrawn from the core. The rod swap process was then repeated for all of the other control rod banks (control and shutdown).

A summary of the results for these tests is given in Table 3.1. As shown by this table and the Startup Physics Tests Results and Evaluation Sheets given in the Appendix, the individual measured bank worths for all of the control and shutdown banks were within the design tolerance (±10% for the reference bank and ±15% for the test banks). The sum of the individual rod bank worths was measured to be within 2.6% of the design prediction. This is well within the design tolerance of ±10% for the sum of the individual control rod bank worths.

The integral and differential reactivity worths of the reference bank (Control Bank B) are shown in Figures 3.1 and 3.2, respectively. The design predictions and the measured data are plotted together in order to illustrate their agreement. In summary, all measured rod worth values were satisfactory.

Table 3.1

NORTH ANNA UNIT 2 - CYCLE 3 BOL PHYSICS TEST

CONTROL ROD BANK WORTH SUMMARY

BANK	MEASURED WORTH (PCM)	PREDICTED WORTH (PCM)	PERCENT DIFFERENCE (M-P)/P X 100
B-Reference Bank	1569	1544	1.6
D	859	850	1.1
C	896	903	-0.8
A	758	667	13.6
SB	806	827	-2.5
SA	995	945	5.3
Total Worth	5883	5736	2.6

Figure 3.1

NORTH ANNA UNIT 2 - CYCLE 3 BOL PHYSICS TEST
BANK B INTEGRAL ROD WORTH - HZP
BANK B WITH ALL OTHER RODS OUT

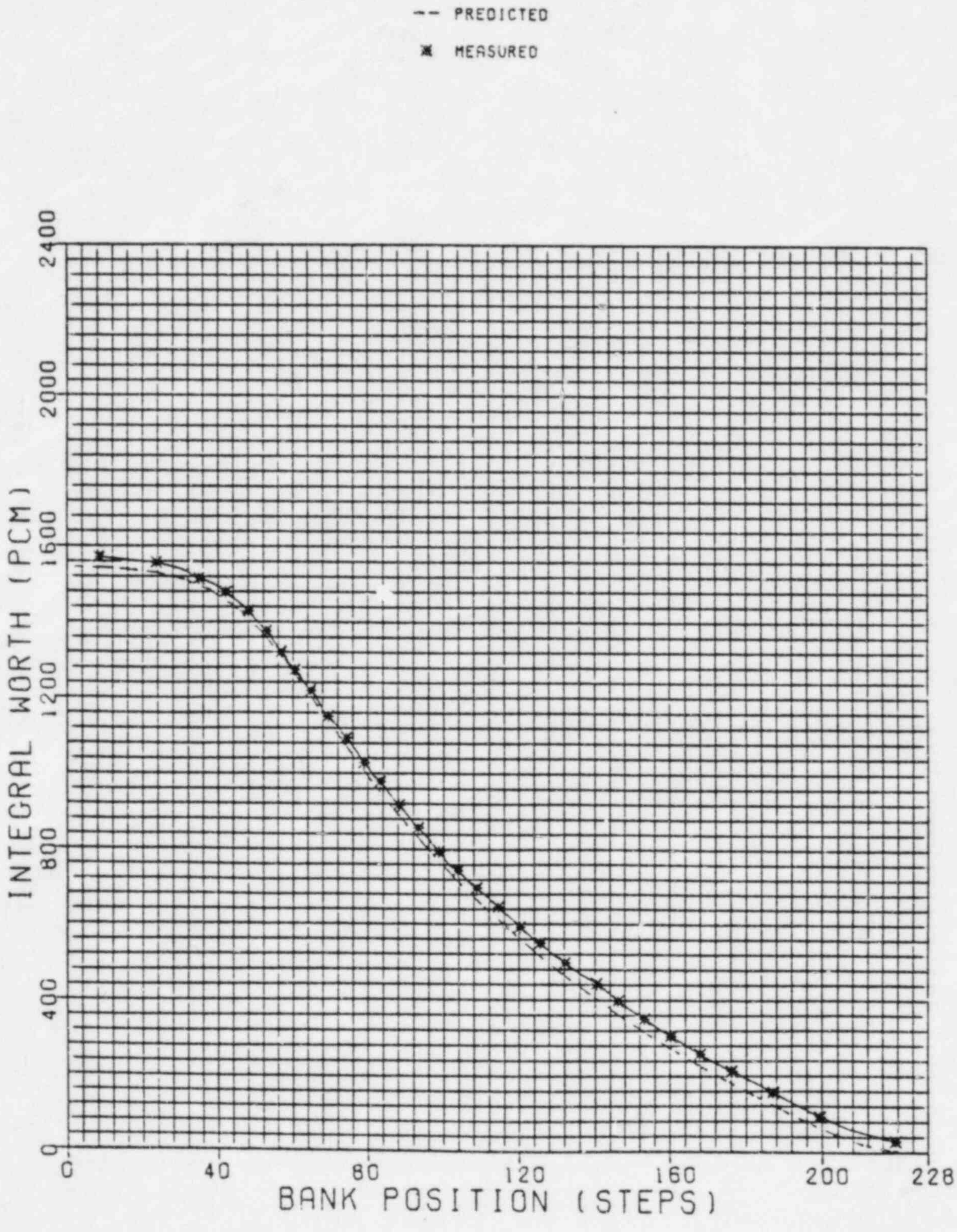
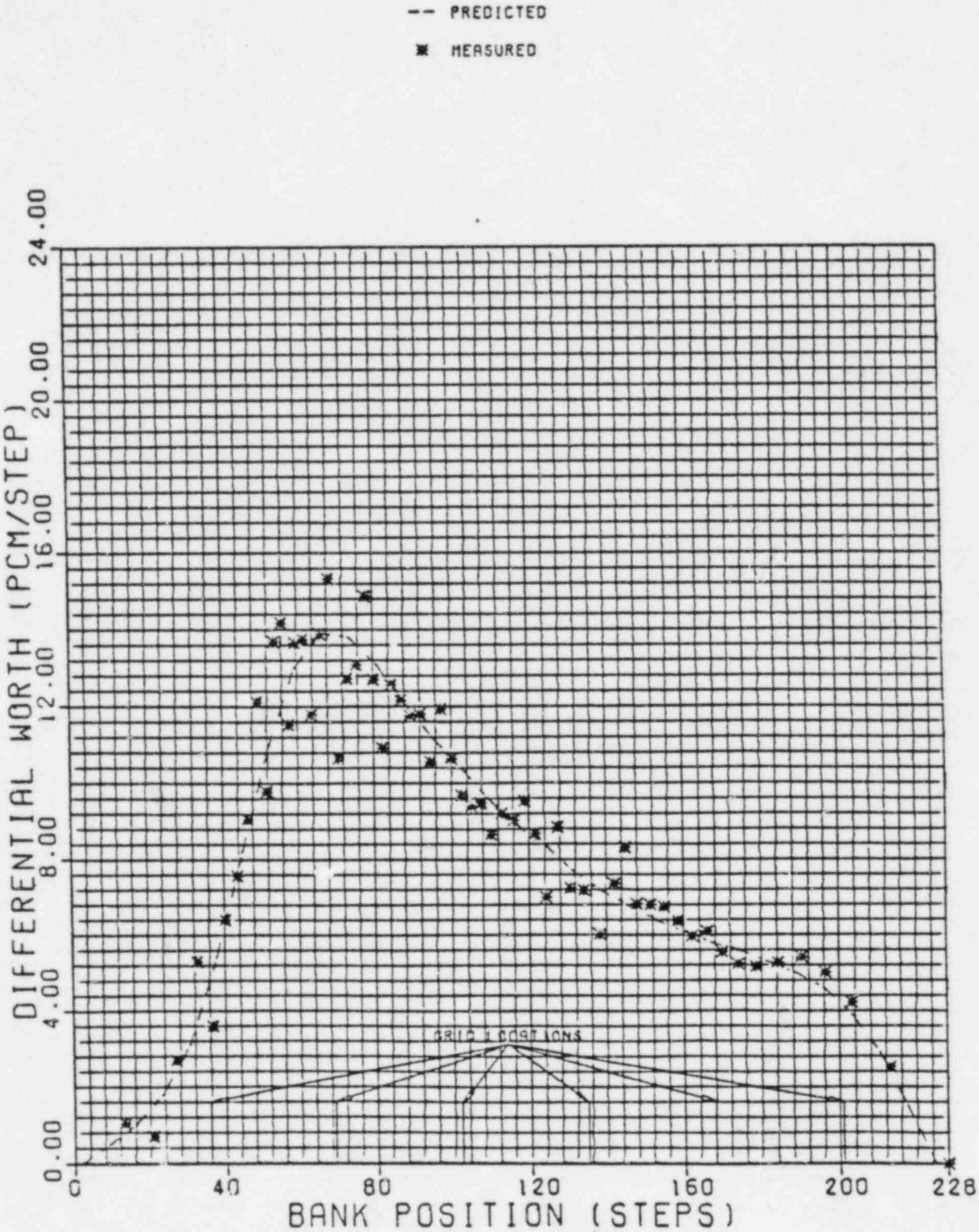


Figure 3.2

NORTH ANNA UNIT 2 - CYCLE 3 BOL PHYSICS TEST
BANK B DIFFERENTIAL ROD WORTH - HZP
BANK B WITH ALL OTHER RODS OUT



Section 4

BORON ENDPOINT AND WORTH MEASUREMENTS

Boron Endpoint

With the reactor critical at hot zero power, reactor coolant system boron concentrations were measured at selected rod bank configurations to enable a direct comparison of measured boron endpoints with design predictions. For each measurement, the RCS conditions were stabilized with the control banks at or very near a selected endpoint position. The critical boron concentration was then measured. If necessary, an adjustment to the measured critical boron concentration was made to account for off-nominal core conditions, such as rod position and moderator temperature.

The results of these measurements are given in Table 4.1. As shown in this table and in the Startup Physics Test Results and Evaluation Sheets given in the Appendix, all measured critical boron endpoint values were within their respective design tolerances. All measured values met the accident analysis acceptance criterion. In summary, all results were satisfactory.

Boron Worth Coefficient

The measured boron endpoint values provide stable statepoint data from which the boron worth coefficient was determined. A plot of the boron concentration as a function of integrated reactivity can be constructed by relating each endpoint concentration to the integrated rod worth present in the core at the time of the endpoint measurement. The value of the boron coefficient, over the range of boron endpoint concentrations, is

obtained directly from this plot.

The boron worth plot is shown in Figure 4.1. As indicated in this figure and in the Appendix, the boron worth coefficient of reactivity was measured to be -7.85 pcm/ppm. The measured boron worth coefficient is within -1.1% of the predicted value of -7.94 pcm/ppm and is well within the design tolerance of ±10%. The measurement result also met the accident analysis acceptance criterion. In summary, this result was satisfactory.

Table 4.1

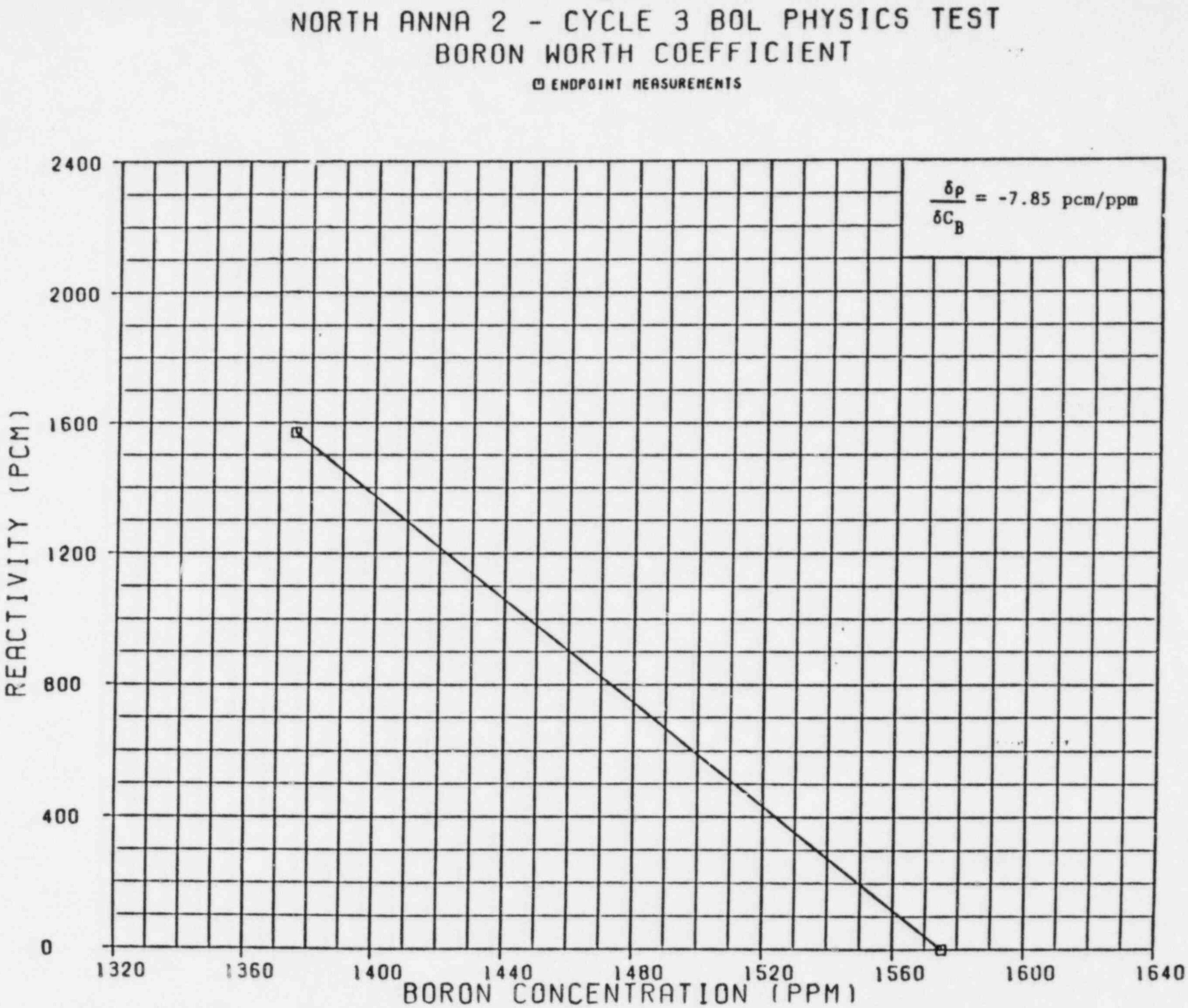
NORTH ANNA UNIT 2 - CYCLE 3 BOL PHYSICS TEST

BORON ENDPOINTS SUMMARY

Control Rod Configuration	Measured Endpoint (ppm)	Predicted Endpoint (ppm)	Difference M-P (ppm)
ARO	1575	1546	29
B Bank In	1375	1387*	-12

*The predicted endpoint for the B Bank in configuration has been adjusted for the difference between the measured and predicted values of the endpoint taken at the ARO configuration as shown in the boron endpoint Startup Physics Test Results and Evaluation Sheets in the Appendix.

Figure 4.1


NORTH ANNA 2 - CYCLE 3 BOL PHYSICS TEST
BORON WORTH COEFFICIENT
ENDPOINT MEASUREMENTS
δρ/δC_B = -7.85 pcm/ppm
REACTIVITY (PCM)
2400
2000
1600
1200
800
400
0
1320
1360
1400
1440
1480
1520
1560
1600
1640
BORON CONCENTRATION (PPM)

Section 5

TEMPERATURE COEFFICIENT MEASUREMENTS

The isothermal temperature coefficient measurements were accomplished by controlling the RCS heat gains/losses with the steam dump valves to the condenser, establishing a constant and uniform heatup/cooldown rate, and then monitoring the resulting reactivity changes on the reactivity computer. These measurements were performed at very low power levels in order to minimize the effects of non-uniform nuclear heating, thus, the moderator and fuel were approximately at the same temperature (between 544 and 548 °F) during these measurements. To eliminate the boron reactivity effect of outflow from the pressurizer, the pressurizer level was maintained constant or slightly increasing during these measurements.

Reactivity measurements were taken during both RCS heatup and cooldown ramps during which the RCS temperature varied approximately 4°F. Reactivity was determined using the reactivity stripchart recorder and temperature was recorded on the average RCS temperature stripchart. The temperature coefficient was then determined from the change in these parameters. The change in reactivity divided by the change in temperature yields the isothermal temperature coefficent.

The predicted and measured isothermal temperature coefficient values are compared in Table 5.1. As can be seen from this summary and from the Startup Physics Test Results and Evaluation Sheet given in the Appendix, the measured isothermal temperature coefficient value was within the design tolerance of ±3 pcm/°F and met the accident analysis acceptance criterion. In summary, the measured result was satisfactory.

Table 5.1

NORTH ANNA UNIT 2 - CYCLE 3 BOL PHYSICS TESTS

ISOTHERMAL TEMPERATURE COEFFICIENT SUMMARY

BANK POSITION	TEMPERATURE RANGE (°F)	BORON CONCENTRATION (PPM)	ISOTHERMAL TEMPERATURE COEFFICIENT (PCM/°F)				
			HEATUP	COOL DOWN	AVER.	PRED.	DIFFER (M-P)
All Rods Out	544.3 to 548.1	1575	-3.73	-3.56	-3.65	-3.70	0.05

Section 6

POWER DISTRIBUTION MEASUREMENTS

The core power distributions were measured using the incore movable detector flux mapping system. This system consists of five fission detectors which traverse fuel assembly instrumentation thimbles in 50 core locations (see Figure 1.3). For each traverse, the detector output is continuously monitored on a strip chart recorder. The output is also scanned for 61 discrete axial points by the PRODAC P-250 process computer. Full core, three-dimensional power distributions are then determined by analyzing this data using the Westinghouse computer program, INCORE[6]. INCORE couples the measured flux map data with predetermined analytic power-to-flux ratios in order to determine the power distribution for the whole core.

A list of all the flux maps taken during the test program together with a list of the measured values of the important power distribution parameters is given in Table 6.1. The measured power distribution parameter values are compared with their Technical Specifications limits in Table 6.2. Flux map 1 was taken at 4% power. This flux map served as the base case design check. Figure 6.1 shows the resulting radial power distribution associated with the flux map. Map 1 indicated the presence of a small quadrant power tilt violation (measured 2.76%) and violations of the rated thermal power limit for the radial peaking factor (Fxy(RTP)).

Several additional flux maps were taken during power escalation for Fxy monitoring. A typical power distribution for one of these maps is shown in Figure 6.2. The measured values for Fxy continued to exceed Fxy(RTP) during the power escalation, until a map was taken at 79% power. No further violations of Fxy(RTP) were measured at higher power levels, and at no time was Fxy(L) exceeded.

Flux maps 3 through 10 were taken over a wide range of power levels and control rod configurations. These flux maps were taken to check the at-power design predictions and hot channel factors, establish a target delta flux for operation, and to measure core power distributions at various operating conditions. These maps also provide incore/excore detector calibration data for the nuclear instrumentation system. The radial power distributions for these maps are given in Figures 6.3 through 6.8. These figures show that the measured relative assembly power values are generally within 5% of the predicted values. Although the assemblywise relative power for Map 3, taken at 50% power, was slightly higher than the design prediction, the measured F-Q(T) and F-ΔH(N) peaking factor values for the at-power flux maps were within the Technical Specifications limits.

In conclusion, all power distribution measurement results were considered to be acceptable with respect to the design tolerances, the accident analysis acceptance criteria, and the Technical Specification limits. It is therefore anticipated that the core will continue to operate safely throughout Cycle 3.

Table 6.1

NORTH ANNA UNIT 2 - CYCLE 3 BOL PHYSICS TESTS

INCORE FLUX MAP SUMMARY

MAP DESCRIPTION	MAP NO.	DATE	BURNUP MWD/MTU	PWR (%)	BANK D STEPS	F-Q(T) HOT CHANNEL FACTOR [1] ASSY	PIN	AXIAL POINT	F-Q(T)	F-DH(N) HOT CHNL.FACTOR [2] ASSY	PIN	F-DH(N)	CORE F(Z) MAX AXIAL POINT	F(Z)	F(XY) MAX [3]	QPTR [4] MAX	LOC	AXIAL OFF SET (%)	NO. OF THIMBLES
ARO	1	5-29-83	0	4	211	M10	ED	20	2.479	M10	ED	1.574	21	1.514	1.662	1.028	NW	22.96	41
VERIFY FXY (5)	2	5-29-83	0	31	177	K14	MN	29	2.279	K14	MN	1.570	29	1.386	1.646	1.016	SW	0.60	41
VERIFY FXY	3	6- 6-83	85	50	179	K14	MN	29	2.139	K14	MN	1.545	29	1.320	1.620	1.015	SW	-1.82	45
VERIFY FXY (6)	6	6- 7-83	112	79	192	K14	MN	28	1.980	K14	MN	1.480	29	1.270	1.555	1.011	SW	-0.30	50
DELTA I TARGET	7	6- 8-83	140	97	228	K14	MN	37	1.915	K14	MN	1.474	37	1.241	1.557	1.008	SW	-3.85	46
DELTA I TARGET	8	6- 8-83	155	99	228	K14	MN	37	1.940	K14	MN	1.475	37	1.255	1.558	1.009	SW	-5.94	50
I/E CAL.	9	6- 8-83	185	100	210	K14	MN	38	1.976	K14	MN	1.476	37	1.275	1.555	1.010	SW	-7.36	49
HFP, EQ. XENON	10	6-10-83	215	100	228	K14	MN	29	1.906	K14	MN	1.473	37	1.229	1.558	1.009	SW	-2.10	49

NOTES: HOT SPOT LOCATIONS ARE SPECIFIED BY GIVING ASSEMBLY LOCATIONS (E.G. H-8 IS THE CENTER-OF-CORE ASSEMBLY), FOLLOWED BY THE PIN LOCATION (DENOTED BY THE "Y" COORDINATE WITH THE SEVENTEEN ROWS OF FUEL RODS LETTERED A THROUGH R AND THE "X" COORDINATE DESIGNATED IN A SIMILAR MANNER).
IN THE "Z" DIRECTION THE CORE IS DIVIDED INTO 61 AXIALPOINTS STARTING FROM THE TOP OF THE CORE.

1. F-Q(T) INCLUDES A TOTAL UNCERTAINTY OF 1.05 X 1.03

2. F-DH(N) INCLUDES A MEASUREMENT UNCERTAINTY OF 1.04

3. F(XY) INCLUDES A TOTAL UNCERTAINTY OF 1.05 X 1.03.

4. QPTR - QUADRANT POWER TILT RATIO.

5. FLUX MAPS 2, 3, AND 6 WERE TAKEN TO EXAMINE F-XY WITH RESPECT TO THE F-XY(RTP) SURVEILLANCE LIMIT.

6. FLUX MAPS 4 AND 5 WERE QUARTER-CORE MAPS TAKEN FOR PRELIMINARY EXCORE DETECTOR CALIBRATION.

Table 6.2

NORTH ANNA UNIT 2 - CYCLE 3 BOL PHYSICS TESTS
COMPARISION OF MEASURED POWER DISTRIBUTION PARAMETERS
WITH THEIR TECHNICAL SPECIFICATION LIMITS

MAP NO.	F-Q(T) HOT CHANNEL FACTOR[1]			F-DH(N) HOT CHANNEL FACTOR[2]			F(XY) MAX[3]			
	MEAS	LIMIT	MARGIN (%)	MEAS	LIMIT	MARGIN (%)	MEAS	AXIAL POINT	LIMIT	MARGIN (%)
2	2.28	4.38	47.9	1.57	1.87	16.0	1.65	35	1.82	9.3
3	2.14	4.38	51.1	1.55	1.78	12.9	1.62	29	1.76	8.0
6	1.98	2.77	28.5	1.48	1.65	10.3	1.56	29	1.67	6.6
7	1.92	2.27	15.4	1.47	1.56	5.8	1.56	29	1.61	3.1
8	1.94	2.22	12.6	1.48	1.55	4.5	1.56	29	1.60	2.5
9	1.98	2.20	10.0	1.48	1.55	4.5	1.56	29	1.60	2.5
10	1.91	2.19	12.8	1.47	1.55	5.2	1.56	29	1.60	2.5

1 The Technical Specification's limit for the heat flux hot channel factor, F-Q(T) is a function of core height. The value for F-Q(T) listed above is the maximum of F-Q(T) in the core. The Technical Specification's limit listed above is evaluated at the plane of maximum F-Q(T). The minimum margin values listed above are the minimum percent difference between the measured values of F-Q(T) and the Technical Specification's limit for each map. All measured F-Q(T) hot channel factors include 5% measurement uncertainty and 3% engineering uncertainty.

2 The measured values for the enthalpy rise hot channel factor, F-ΔH(N) includes 4% measurement uncertainty.

3 All measured F(XY) MAX values include 5% measurement uncertainty and 3% engineering uncertainty.

FIGURE 6.1
NORTH ANNA UNIT 2, CYCLE 3
ASSEMBLYWISE POWER DISTRIBUTION
ARO, 4% POWER

PREDICTED / MEASURED / PCT DIFFERENCE

Row	R	P	N	M	L	K	J	H	G	F	E	D		B	A
1							0.31 0.33 7.4	0.47 0.51 7.3	0.31 0.32 4.7						
2					0.56 0.61 8.3	1.03 1.06 3.0	1.11 1.14 2.9	0.80 0.82 2.7	1.11 1.14 2.5	1.03 1.05 1.7	0.56 0.57 1.7				
3				0.64 0.69 8.2	1.09 1.18 8.3	1.25 1.29 3.0	0.98 0.99 0.2	1.24 1.24 -0.1	0.98 0.98 -0.4	1.25 1.27 1.7	1.09 1.11 1.7	0.64 0.63 -1.2			
4			0.64 0.69 7.2	1.16 1.23 6.3	1.29 1.37 6.3	1.37 1.39 1.3	1.26 1.25 -0.8	1.05 1.04 -0.9	1.26 1.24 -1.4	1.37 1.35 -1.8	1.29 1.27 -1.5	1.16 1.14 -1.5	0.64 0.65 0.7		
5		0.56 0.59 6.2	1.09 1.15 6.2	1.28 1.33 3.4	1.00 1.02 2.1	1.22 1.22 0.1	1.01 0.98 -3.0	1.16 1.13 -2.9	1.01 0.98 -2.5	1.22 1.19 -2.2	1.00 0.98 -1.8	1.28 1.26 -1.5	1.09 1.09 0.8	0.56 0.57 2.7	
6		1.02 1.10 7.8	1.25 1.33 7.0	1.37 1.43 4.4	1.22 1.24 1.7	0.92 0.91 -1.0	1.09 1.05 -3.9	0.92 0.89 -3.8	1.09 1.05 -3.4	0.92 0.90 -2.7	1.22 1.20 -1.8	1.37 1.35 -1.5	1.25 1.25 0.5	1.02 1.04 1.3	
7	0.31 0.33 7.8	1.11 1.18 6.4	0.98 1.04 6.5	1.26 1.29 2.8	1.01 1.00 -1.1	1.10 1.07 -2.1	0.92 0.88 -3.9	1.03 0.99 -3.8	0.92 0.88 -3.9	1.10 1.05 -3.9	1.01 0.97 -4.1	1.26 1.18 -5.7	0.98 0.96 -2.3	1.11 1.08 -2.1	0.31 0.30 -0.6
8	0.47 0.49 4.9	0.80 0.85 6.2	1.23 1.31 6.3	1.05 1.08 3.0	1.17 1.16 -0.5	0.92 0.91 -1.6	1.03 0.99 -3.9	0.82 0.79 -3.8	1.03 0.98 -5.0	0.92 0.88 -5.1	1.17 1.09 -6.2	1.05 0.99 -5.7	1.23 1.20 -2.5	0.80 0.79 -0.9	0.47 0.47 0.8
9	0.31 0.32 4.8	1.11 1.16 4.9	0.98 1.03 4.9	1.26 1.28 2.2	1.01 1.00 -0.3	1.10 1.08 -0.9	0.92 0.90 -2.0	1.03 1.00 -3.1	0.92 0.87 -5.5	1.10 1.03 -5.6	1.01 0.94 -6.4	1.26 1.18 -6.3	0.98 0.94 -4.6	1.11 1.10 -0.9	0.31 0.31 1.6
10		1.02 1.07 4.8	1.25 1.31 4.8	1.37 1.41 3.5	1.22 1.25 2.9	0.92 0.93 1.2	1.09 1.06 -2.7	0.92 0.89 -3.2	1.09 1.04 -4.8	0.92 0.88 -4.9	1.22 1.15 -5.5	1.37 1.30 -5.1	1.25 1.16 -6.8	1.02 1.06 3.8	
11		0.56 0.60 7.3	1.09 1.17 7.3	1.28 1.36 6.5	1.00 1.05 5.0	1.22 1.24 1.6	1.01 0.99 -1.3	1.16 1.15 -1.4	1.01 0.97 -3.5	1.22 1.18 -3.0	1.00 0.96 -4.4	1.28 1.24 -3.0	1.09 1.06 -2.8	0.56 0.57 2.0	
12			0.64 0.70 9.9	1.16 1.24 7.3	1.29 1.35 5.0	1.37 1.42 3.3	1.26 1.26 -0.1	1.05 1.05 -0.2	1.26 1.23 -2.1	1.37 1.32 -3.4	1.29 1.24 -3.5	1.16 1.14 -1.7	0.64 0.64 -0.7		
13				0.64 0.70 9.9	1.09 1.14 5.0	1.25 1.27 1.8	0.98 1.00 1.4	1.24 1.26 1.6	0.98 0.98 -0.3	1.25 1.23 -1.3	1.09 1.05 -3.8	0.64 0.63 -1.0			
14					0.56 0.62 9.9	1.03 1.04 1.1	1.11 1.12 1.1	0.80 0.81 1.4	1.11 1.11 -0.1	1.03 1.02 -1.0	0.56 0.54 -3.9				
15							0.31 0.31 1.1	0.47 0.48 2.0	0.31 0.31 2.0						

STANDARD DEVIATION =2.337

AVERAGE PCT DIFFERENCE = 3.4

SUMMARY

MAP NO: N2-3- 1 DATE: 5/29/83 POWER: 4%

CONTROL ROD POSITIONS: F-Q(T) = 2.479 QPTR:

D BANK AT 211 STEPS F-DH(N) = 1.574

NW 1.028	NE 0.980
SW 1.025	SE 0.967

F(Z) = 1.514

F(XY) = 1.662

BURNUP = 0 MWD/MTU A.O = 22.96(%)

FIGURE 6.2
NORTH ANNA UNIT 2, CYCLE 3
ASSEMBLYWISE POWER DISTRIBUTION
31% POWER

Legend (each cell): PREDICTED / MEASURED / PCT DIFFERENCE

Row		R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1	Predicted							0.30	0.46	0.30						
	Measured							0.32	0.49	0.32						
	Pct Difference							6.7	6.5	5.6						
2	Predicted					0.57	1.04	1.10	0.76	1.10	1.04	0.57				
	Measured					0.61	1.06	1.12	0.77	1.13	1.08	0.59				
	Pct Difference					6.6	2.0	1.7	1.5	2.5	4.3	4.2				
3	Predicted				0.65	1.11	1.26	0.98	1.23	0.98	1.26	1.11	0.65			
	Measured				0.70	1.18	1.29	0.97	1.21	0.98	1.32	1.15	0.63			
	Pct Difference				6.5	6.5	2.0	-1.2	-1.5	-0.7	4.2	4.2	-3.2			
4	Predicted			0.65	1.18	1.30	1.38	1.26	1.05	1.26	1.38	1.30	1.18	0.65		
	Measured			0.69	1.22	1.34	1.38	1.24	1.03	1.22	1.35	1.27	1.15	0.66		
	Pct Difference			5.3	3.6	3.1	-0.2	-1.6	-1.7	-3.1	-2.2	-2.7	-2.8	0.6		
5	Predicted		0.57	1.10	1.30	1.00	1.21	1.00	1.16	1.00	1.21	1.00	1.30	1.10	0.57	
	Measured		0.59	1.15	1.31	0.99	1.19	0.98	1.14	0.99	1.21	0.99	1.26	1.11	0.59	
	Pct Difference		4.2	4.2	0.6	-1.1	-1.6	-2.3	-2.3	-1.2	-0.7	-1.5	-2.8	0.6	4.5	
6	Predicted		1.03	1.26	1.38	1.21	0.88	1.08	0.92	1.08	4.88	1.21	1.38	1.26	1.03	
	Measured		1.08	1.72	1.40	1.20	0.86	1.05	0.90	1.07	0.87	1.19	1.34	1.27	1.07	
	Pct Difference		5.0	4.9	1.8	-1.3	-1.9	-2.2	-1.8	-0.7	-1.1	-1.4	-2.7	1.1	3.2	
7	Predicted	0.30	1.10	0.98	1.26	1.00	1.08	0.91	1.03	0.91	1.08	1.00	1.26	0.98	1.10	0.30
	Measured	0.32	1.14	1.02	1.27	0.99	1.06	0.89	1.01	0.90	1.07	1.00	1.22	0.98	1.09	0.31
	Pct Difference	5.7	3.5	3.7	1.0	-1.7	-1.9	-2.1	-1.6	-1.0	-0.8	-0.5	-2.9	-0.5	-0.2	2.1
8	Predicted	0.46	0.76	1.22	1.05	1.17	0.92	1.02	0.82	1.02	0.92	1.17	1.05	1.22	0.76	0.46
	Measured	0.46	0.78	1.26	1.07	1.16	0.91	1.00	0.80	1.01	0.90	1.14	1.02	1.21	0.78	0.48
	Pct Difference	1.1	3.3	3.3	1.6	-0.3	-0.9	-2.1	-1.5	-1.7	-1.8	-2.3	-2.9	-0.7	2.3	5.1
9	Predicted	0.30	1.10	0.98	1.26	1.00	1.08	0.91	1.03	0.91	1.08	1.00	1.26	0.98	1.10	0.30
	Measured	0.30	1.11	0.99	1.27	1.00	1.07	0.90	1.01	0.89	1.06	0.97	1.20	0.94	1.13	0.32
	Pct Difference	0.7	0.9	1.0	0.4	-0.2	-0.7	-1.5	-1.4	-2.1	-2.2	-3.5	-4.4	-4.3	2.6	7.8
10	Predicted		1.03	1.26	1.38	1.21	0.88	1.08	0.92	1.08	0.88	1.21	1.38	1.26	1.03	
	Measured		1.04	1.27	1.39	1.22	0.88	1.05	0.90	1.05	0.85	1.17	1.31	1.18	1.11	
	Pct Difference		0.6	0.6	0.8	0.9	-0.1	-2.4	-2.1	-2.6	-2.8	-3.9	-4.6	-5.8	7.9	
11	Predicted		0.57	1.10	1.30	1.00	1.21	1.00	1.16	1.00	1.21	1.00	1.30	1.10	0.57	
	Measured		0.59	1.15	1.34	1.02	1.21	0.98	1.14	0.97	1.18	0.97	1.26	1.08	0.58	
	Pct Difference		4.0	4.0	3.1	1.3	-0.6	-2.1	-2.2	-3.4	-3.1	-3.9	-2.6	-2.3	1.5	
12	Predicted			0.65	1.18	1.30	1.38	1.26	1.05	1.26	1.38	1.30	1.18	0.65		
	Measured			0.70	1.23	1.32	1.38	1.23	1.03	1.23	1.34	1.27	1.16	0.65		
	Pct Difference			7.4	4.5	1.3	-0.2	-2.2	-2.3	-2.6	-2.9	-2.9	-1.6	-0.5		
13	Predicted				0.65	1.11	1.26	0.98	1.23	0.98	1.26	1.11	0.65			
	Measured				0.71	1.20	1.31	0.97	1.22	0.98	1.26	1.07	0.65			
	Pct Difference				7.9	8.4	3.4	-1.8	-0.5	-0.7	-0.4	-2.8	-0.8			
14	Predicted					0.57	1.04	1.10	6.76	1.10	1.04	0.57				
	Measured					0.62	1.12	1.08	0.76	3.10	1.03	0.55				
	Pct Difference					8.4	8.5	-2.0	0.2	-0.4	-0.1	-2.7				
15	Predicted							0.30	0.46	0.30						
	Measured							0.33	0.47	0.31						
	Pct Difference							8.6	2.6	2.5						

STANDARD DEVIATION =1.998

AVERAGE PCT DIFFERENCE = 2.6

SUMMARY

MAP NO: N2-3- 2 DATE: 5/29/83 POWER: 31%

CONTROL ROD POSITIONS: F-Q(T) = 2.279 QPTR:

D BANK AT 177 STEPS F-DH(N) = 1.570

NW 1.010	NE 0.994
SW 1.016	SE 0.980

F(Z) = 1.386

F(XY) = 1.646

BURNUP = 0 MWD/MTU A.O = 0.60(%)

FIGURE 6.3
NORTH ANNA UNIT 2, CYCLE 3
ASSEMBLYWISE POWER DISTRIBUTION
50% POWER

PREDICTED
MEASURED
PCT DIFFERENCE

Row	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							0.31	0.47	0.31						
							0.32	0.45	0.33						
							2.3	-3.8	3.7						
2					0.55	1.00	1.09	0.78	1.09	1.00	0.55				
					0.60	1.03	1.08	0.77	1.09	1.04	0.58				
					7.9	2.4	-0.6	-0.9	0.1	3.5	5.2				
3				0.63	1.06	1.22	0.99	1.22	0.99	1.22	1.06	0.63			
				0.66	1.10	1.23	0.99	1.21	0.99	1.22	1.09	0.67			
				4.4	4.0	1.4	-0.4	-0.9	-0.8	0.6	2.8	7.1			
4			0.63	1.12	1.25	1.34	1.26	1.08	1.26	1.34	1.25	1.12	0.63		
			0.66	1.16	1.28	1.34	1.24	1.07	1.22	1.32	1.26	1.14	0.66		
			7.6	3.2	2.8	0.0	-1.6	-1.7	-2.9	-1.7	0.7	1.8	4.3		
5		0.55	1.05	1.25	1.01	1.21	1.05	1.20	1.05	1.21	1.01	1.25	1.05	0.55	
		0.57	1.09	1.25	1.00	1.20	1.01	1.15	1.02	1.20	1.00	1.24	1.08	0.59	
		3.6	3.6	0.0	-0.6	-1.5	-3.7	-3.7	-2.3	-1.3	-1.1	-0.8	3.0	6.8	
6		1.00	1.21	1.33	1.21	0.93	1.13	0.99	1.13	0.93	1.21	1.33	1.21	1.00	
		1.04	1.26	1.35	1.20	0.90	1.08	0.95	1.10	0.91	1.19	1.30	1.22	1.04	
		4.1	4.1	1.4	-1.4	-2.9	-4.0	-3.6	-2.5	-1.7	-1.8	-2.3	0.7	4.5	
7	0.31	1.08	0.99	1.26	1.05	1.13	0.99	1.10	0.99	1.13	1.05	1.26	0.99	1.08	0.31
	0.35	1.13	1.01	1.25	1.01	1.09	0.95	1.06	0.96	1.11	1.01	1.21	0.99	1.09	0.32
	10.3	4.8	2.2	-0.7	-3.6	-3.9	-4.2	-3.6	-2.7	-2.4	-3.1	-4.1	-0.7	1.0	2.7
8	0.47	0.78	1.22	1.08	1.20	0.99	1.10	0.90	1.10	0.99	1.20	1.08	1.22	0.78	0.47
	0.51	0.81	1.24	1.08	1.16	0.96	1.05	0.87	1.06	0.95	1.14	1.04	1.21	0.79	0.48
	10.1	4.5	1.8	-0.5	-2.9	-3.4	-4.5	-3.5	-3.7	-3.7	-4.6	-4.0	-0.7	1.1	2.7
9	0.31	1.08	0.99	1.26	1.05	1.13	0.99	1.10	0.99	1.13	1.05	1.26	0.99	1.08	0.31
	0.35	1.12	1.00	1.24	1.02	1.09	0.94	1.05	0.95	1.08	1.00	1.22	1.00	1.10	0.32
	10.3	3.8	0.5	-1.2	-2.8	-3.6	-5.0	-4.2	-4.2	-4.3	-4.5	-2.9	1.0	1.2	3.2
10		1.00	1.21	1.33	1.21	0.93	1.13	0.99	1.13	0.93	1.21	1.33	1.21	1.00	
		1.02	1.23	1.34	1.21	0.91	1.07	0.95	1.07	0.89	1.17	1.33	1.25	1.03	
		1.6	1.6	0.4	-0.3	-2.0	-5.1	-4.2	-4.9	-4.0	-3.8	-0.5	2.9	3.0	
11		0.55	1.05	1.25	1.01	1.21	1.05	1.20	1.05	1.21	1.01	1.25	1.05	0.55	
		0.58	1.11	1.29	1.02	1.19	1.00	1.15	0.99	1.17	0.99	1.27	1.08	0.57	
		5.1	5.1	3.9	1.5	-2.0	-3.9	-3.9	-5.5	-3.1	-1.7	1.6	2.9	3.9	
12			0.63	1.12	1.25	1.34	1.26	1.08	1.26	1.34	1.25	1.12	0.63		
			0.65	1.18	1.27	1.33	1.23	1.06	1.22	1.31	1.23	1.14	0.65		
			8.7	5.2	1.5	-0.7	-2.4	-2.4	-2.8	-2.4	-1.5	1.7	2.9		
13				0.63	1.06	1.22	0.99	1.22	0.99	1.22	1.06	0.63			
				0.69	1.16	1.26	0.97	1.21	0.99	1.22	1.05	0.65			
				9.1	9.6	3.4	-2.4	-1.2	-0.5	0.1	-0.2	2.7			
14					0.55	1.00	1.09	0.78	1.09	1.00	0.55				
					0.61	1.11	1.14	0.81	1.08	1.00	0.55				
					9.6	11.1	5.4	3.8	-0.3	0.2	-1.1				
15							0.31	0.47	0.31						
							0.35	0.50	0.32						
							12.4	7.2	1.6						

STANDARD DEVIATION =2.373

AVERAGE PCT DIFFERENCE = 3.1

SUMMARY

MAP NO: N2-3- 3

DATE: 6/ 6/83

POWER: 50%

CONTROL ROD POSITIONS:

D BANK AT 179 STEPS

F-Q(T) = 2.139

F-DH(N) = 1.545

F(Z) = 1.320

F(XY) = 1.620

BURNUP = 85 MWD/MTU

A.O = -1.82(%)

QPTR:

NW 1.008	NE 0.994
SW 1.015	SE 0.983

FIGURE 6.4
NORTH ANNA UNIT 2, CYCLE 3
ASSEMBLYWISE POWER DISTRIBUTION
79% POWER

Legend (each cell): PREDICTED / MEASURED / PCT DIFFERENCE

Row	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							0.34 0.34 2.5	0.51 0.52 2.3	0.34 0.35 3.8						
2					0.56 0.60 7.3	0.99 1.01 1.5	1.10 1.09 -0.2	0.83 0.82 -0.6	1.10 1.11 1.0	0.99 1.04 5.0	0.56 0.59 5.9				
3				0.63 0.66 4.9	1.04 1.09 4.7	1.18 1.20 1.8	1.00 0.98 -2.0	1.23 1.20 -2.3	1.00 0.99 -1.0	1.18 1.21 2.1	1.04 1.08 3.8	0.63 0.68 6.9			
4			0.63 0.67 5.5	1.10 1.14 3.5	1.21 1.25 3.2	1.30 1.30 0.2	1.24 1.20 -2.5	1.09 1.06 -2.6	1.24 1.20 -2.9	1.30 1.30 -0.2	1.21 1.23 1.9	1.10 1.13 2.9	0.63 0.66 4.5		
5		0.54 0.58 3.8	1.04 1.08 3.7	1.21 1.22 1.3	0.99 1.00 0.4	1.19 1.19 -0.6	1.05 1.01 -3.7	1.20 1.16 -3.7	1.05 1.03 -2.0	1.19 1.19 -0.0	0.99 1.00 0.3	1.21 1.22 0.8	1.04 1.07 3.3	0.56 0.59 5.5	
6		0.99 1.03 3.9	1.18 1.23 3.8	1.30 1.32 1.7	1.19 1.19 -0.5	0.96 0.93 -2.6	1.14 1.09 -4.4	1.02 0.97 -4.1	1.14 1.11 -2.5	0.96 0.94 -1.1	1.19 1.19 -0.3	1.30 1.29 -0.6	1.18 1.20 1.3	0.99 1.03 3.8	
7	0.34 0.35 4.9	1.10 1.12 2.5	1.00 1.01 1.4	1.24 1.23 -0.7	1.05 1.02 -2.7	1.15 1.10 -3.7	1.02 0.97 -4.8	1.14 1.09 -4.3	1.02 1.00 -2.9	1.15 1.12 -2.4	1.05 1.03 -2.[illegible]	1.24 1.19 -3.4	1.00 0.99 -0.7	1.10 1.10 0.4	0.34 0.34 2.1
8	0.51 0.53 4.8	0.82 0.84 2.2	1.23 1.24 1.0	1.09 1.08 -0.8	1.20 1.17 -2.7	1.01 0.98 -3.5	1.13 1.07 -5.2	0.95 0.91 -4.2	1.13 1.09 -3.9	1.01 0.97 -3.9	1.20 1.16 -3.9	1.09 1.05 -3.4	1.23 1.22 -0.8	0.82 0.83 1.2	0.51 0.52 2.9
9	0.34 0.35 4.9	1.10 1.12 2.2	1.00 1.01 0.7	1.24 1.22 -0.9	1.05 1.03 -2.5	1.15 1.11 -2.9	1.02 0.99 -3.4	1.14 1.09 -3.7	1.02 0.98 -4.2	1.15 1.10 -4.2	1.05 1.01 -3.8	1.24 1.20 -3.2	1.00 1.00 -0.2	1.10 1.12 1.8	0.34 0.35 3.5
10		0.99 1.02 3.0	1.18 1.22 2.9	1.30 1.31 1.0	1.19 1.19 0.0	0.96 0.94 -1.3	1.14 1.09 -4.8	1.02 0.97 -4.6	1.14 1.09 -4.6	0.96 0.92 -3.3	1.19 1.16 -2.8	1.30 1.27 -1.9	1.18 1.19 0.2	0.99 1.03 4.0	
11		0.56 0.59 5.0	1.04 1.09 5.0	1.21 1.25 3.7	0.99 1.01 1.3	1.19 1.19 -0.7	1.05 1.02 -3.3	1.20 1.16 -3.5	1.05 1.00 -5.0	1.19 1.17 -2.2	0.99 0.98 -1.5	1.21 1.21 0.5	1.04 1.05 1.6	0.56 0.58 4.2	
12			0.63 0.68 7.1	1.10 1.15 4.3	1.21 1.22 1.2	1.30 1.31 0.5	1.24 1.20 -3.2	1.09 1.05 -3.4	1.24 1.20 -3.2	1.30 1.29 -1.1	1.21 1.20 -0.6	1.10 1.12 1.7	0.63 0.65 3.1		
13				0.63 0.68 7.0	1.04 1.11 7.0	1.18 1.22 3.4	1.00 0.98 -1.9	1.23 1.22 -1.0	1.00 1.00 -0.4	1.18 1.20 1.2	1.04 1.05 0.9	0.63 0.65 2.9			
14					0.56 0.60 7.0	0.99 1.08 8.3	1.10 1.13 3.1	0.83 0.84 2.2	1.10 1.09 -0.2	0.99 1.00 1.2	0.56 0.56 0.9				
15							0.34 0.37 9.5	0.51 0.54 5.6	0.34 0.34 1.6						

STANDARD DEVIATION =1.862

AVERAGE PCT DIFFERENCE = 2.8

SUMMARY

MAP NO: N2-3- 6

DATE: 6/ 7/83

POWER: 79%

CONTROL ROD POSITIONS:

D BANK AT 192 STEPS

F-Q(T) = 1.980

F-DH(N) = 1.480

F(Z) = 1.270

F(XY) = 1.555

BURNUP = 112 MWD/MTU A.O = -0.30(%)

QPTR:

NW 1.004	NE 0.998
SW 1.011	SE 0.987

FIGURE 6.5
NORTH ANNA UNIT 2, CYCLE 3
ASSEMBLYWISE POWER DISTRIBUTION
97% POWER

Legend (each cell): PREDICTED / MEASURED / PCT DIFFERENCE

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							0.35 0.36 3.3	0.52 0.54 3.3	0.35 0.35 1.7						
2					0.55 0.57 2.6	0.99 1.00 1.2	1.11 1.11 -0.1	0.86 0.86 -0.1	1.11 1.10 -0.5	0.99 0.99 0.0	0.55 0.57 3.5				
3				0.63 0.64 2.0	1.02 1.04 1.9	1.17 1.18 1.2	1.00 0.98 -1.9	1.24 1.21 -2.2	1.00 0.98 -2.4	1.17 1.16 -1.1	1.02 1.04 1.8	0.63 0.67 7.3			
4			0.63 0.65 3.5	1.08 1.10 2.1	1.19 1.20 1.3	1.29 1.30 0.9	1.23 1.20 -2.0	1.09 1.06 -2.2	1.23 1.19 -3.2	1.29 1.27 -1.2	1.19 1.21 1.6	1.08 1.11 3.0	0.63 0.66 4.7		
5		0.55 0.58 4.3	1.02 1.07 4.3	1.19 1.20 0.9	0.99 0.99 -0.3	1.19 1.19 -0.3	1.05 1.02 -3.4	1.20 1.16 -3.4	1.05 1.04 -1.8	1.19 1.19 -0.2	0.99 0.99 0.3	1.19 1.20 0.9	1.02 1.06 3.5	0.55 0.58 5.2	
6		0.99 1.03 4.3	1.17 1.22 4.3	1.28 1.29 0.6	1.19 1.18 -1.2	0.99 0.97 -2.5	1.16 1.10 -4.8	1.02 0.98 -4.6	1.16 1.13 -2.3	0.99 0.99 -0.7	1.19 1.19 -0.1	1.28 1.27 -0.8	1.17 1.18 1.1	0.99 1.02 3.3	
7	0.34 0.36 4.6	1.11 1.12 1.2	1.00 0.98 -2.1	1.23 1.20 -2.6	1.06 1.03 -2.8	1.16 1.12 -3.7	1.04 0.99 -4.8	1.15 1.09 -4.6	1.04 1.01 -2.7	1.16 1.13 -2.0	1.06 1.04 -1.9	1.23 1.19 -2.8	1.00 0.99 -1.3	1.11 1.11 0.1	0.34 0.35 1.4
8	0.52 0.55 4.6	0.86 0.87 1.2	1.24 1.21 -2.1	1.09 1.06 -2.1	1.20 1.18 -2.1	1.02 0.99 -3.1	1.14 1.08 -5.3	0.96 0.91 -4.5	1.14 1.10 -3.7	1.02 0.98 -3.7	1.20 1.16 -3.5	1.09 1.06 -2.7	1.24 1.22 -1.3	0.86 0.88 2.1	0.52 0.55 4.2
9	0.34 0.36 4.6	1.11 1.12 1.5	1.00 1.00 -0.1	1.23 1.21 -1.1	1.06 1.04 -1.9	1.16 1.13 -2.4	1.04 1.00 -3.3	1.15 1.10 -3.6	1.04 1.00 -3.6	1.16 1.12 -3.5	1.06 1.02 -3.6	1.23 1.19 -2.9	1.00 0.99 -1.1	1.11 1.14 2.7	0.34 0.36 4.8
10		0.99 1.01 1.9	1.17 1.19 1.9	1.28 1.29 0.2	1.19 1.19 -0.7	0.99 0.98 -1.6	1.16 1.12 -3.3	1.02 0.99 -3.6	1.16 1.11 -3.5	0.99 0.96 -3.0	1.19 1.16 -3.0	1.28 1.25 -2.9	1.17 1.16 -0.8	0.99 1.03 4.4	
11		0.55 0.58 4.4	1.02 1.07 4.4	1.19 1.22 2.7	0.99 0.98 -0.6	1.19 1.18 -1.4	1.05 1.03 -1.9	1.20 1.18 -1.9	1.05 1.02 -3.4	1.19 1.16 -2.5	0.99 0.97 -2.0	1.19 1.19 0.3	1.02 1.04 1.5	0.55 0.58 4.3	
12			0.63 0.67 6.8	1.08 1.12 3.3	1.19 1.18 -0.6	1.29 1.28 -0.5	1.23 1.20 -2.2	1.09 1.06 -2.4	1.23 1.21 -1.0	1.29 1.29 -0.1	1.19 1.19 0.2	1.08 1.10 2.0	0.63 0.65 3.8		
13				0.63 0.67 7.0	1.02 1.10 7.3	1.17 1.21 3.4	1.00 0.98 -2.4	1.24 1.22 -1.6	1.00 1.00 0.3	1.17 1.20 2.8	1.02 1.05 2.8	0.63 0.65 3.5			
14					0.55 0.59 7.3	0.99 1.07 8.6	1.11 1.14 3.1	0.86 0.88 2.0	1.11 1.11 0.3	0.99 1.01 2.6	0.55 0.58 4.5				
15							0.35 0.38 10.1	0.52 0.55 5.5	0.35 0.35 0.7						

STANDARD DEVIATION =1.788

AVERAGE PCT DIFFERENCE = 2.6

SUMMARY

MAP NO: N2-3- 7 DATE: 6/ 8/83 POWER: 97%

CONTROL ROD POSITIONS: F-Q(T) = 1.915 QPTR:

D BANK AT 228 STEPS F-DH(N) = 1.474

F(Z) = 1.241

F(XY) = 1.557

QPTR	
NW 1.004	NE 0.998
SW 1.008	SE 0.990

BURNUP = 140 MWD/MTU A.O = -3.85(%)

FIGURE 6.6
NORTH ANNA UNIT 2, CYCLE 3
ASSEMBLYWISE POWER DISTRIBUTION
99% POWER

PREDICTED / MEASURED / PCT DIFFERENCE	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
							0.35	0.52	0.35							
							0.36	0.54	0.36							1
							3.5	3.5	3.9							
					0.55	0.99	1.11	0.86	1.11	0.99	0.55					
					0.59	0.99	1.11	0.86	1.12	1.03	0.59					2
					5.8	0.8	-0.1	-0.1	1.1	4.2	5.6					
				0.63	1.02	1.17	1.00	1.24	1.00	1.17	1.02	0.63				
				0.65	1.06	1.18	0.98	1.21	0.99	1.18	1.06	0.67				3
				3.8	3.5	1.0	-2.0	-2.3	-1.3	1.2	3.2	7.1				
			0.63	1.08	1.19	1.29	1.23	1.09	1.23	1.29	1.19	1.08	0.63			
			0.66	1.11	1.22	1.29	1.20	1.06	1.19	1.27	1.21	1.11	0.66			4
			4.7	2.9	2.5	0.1	-2.3	-2.4	-3.1	-1.2	1.5	2.9	4.8			
		0.55	1.02	1.19	0.99	1.19	1.05	1.20	1.05	1.19	0.99	1.19	1.02	0.55		
		0.57	1.06	1.20	0.99	1.19	1.02	1.17	1.03	1.18	0.99	1.20	1.06	0.58		5
		3.6	3.6	1.0	0.1	-0.6	-3.0	-3.0	-2.0	-0.8	-0.1	0.8	3.7	5.7		
		0.99	1.17	1.28	1.19	0.99	1.16	1.02	1.16	0.99	1.19	1.28	1.17	0.99		
		1.03	1.22	1.30	1.19	0.97	1.11	0.99	1.13	0.98	1.18	1.27	1.18	1.02		6
		4.1	4.1	1.7	-0.7	-2.1	-3.6	-3.5	-2.2	-1.1	-0.8	-1.1	1.1	3.7		
	0.34	1.11	1.00	1.23	1.06	1.16	1.04	1.15	1.04	1.16	1.06	1.23	1.00	1.11	0.34	
	0.36	1.13	1.01	1.22	1.02	1.12	0.99	1.10	1.01	1.13	1.03	1.18	0.99	1.11	0.35	7
	4.4	2.2	1.3	-0.9	-3.0	-3.6	-4.1	-3.8	-2.7	-2.4	-2.9	-3.9	-0.8	0.6	2.3	
	0.52	0.86	1.24	1.09	1.20	1.02	1.14	0.96	1.14	1.02	1.20	1.09	1.24	0.86	0.52	
	0.55	0.88	1.25	1.08	1.17	0.99	1.09	0.92	1.10	0.99	1.15	1.05	1.23	0.88	0.55	8
	4.4	2.1	0.7	-0.7	-2.4	-3.1	-4.7	-3.6	-3.5	-3.6	-4.2	-3.9	-0.9	2.1	4.0	
	0.34	1.11	1.00	1.23	1.06	1.16	1.04	1.15	1.04	1.16	1.06	1.23	1.00	1.11	0.34	
	0.36	1.12	0.99	1.21	1.03	1.13	1.00	1.11	1.00	1.12	1.02	1.19	1.00	1.13	0.36	9
	4.4	1.1	-0.6	-1.4	-2.1	-2.5	-3.1	-3.1	-3.6	-3.7	-3.5	-2.8	-0.2	2.4	4.3	
		0.99	1.17	1.28	1.19	0.99	1.16	1.02	1.16	0.99	1.19	1.28	1.17	0.99		
		1.00	1.18	1.29	1.20	0.99	1.11	0.99	1.11	0.97	1.16	1.26	1.17	1.03		10
		1.3	1.3	0.9	0.6	-0.7	-3.8	-3.6	-3.7	-2.7	-2.4	-1.4	-0.2	4.4		
		0.55	1.02	1.19	0.99	1.19	1.05	1.20	1.05	1.19	0.99	1.19	1.02	0.55		
		0.57	1.06	1.22	1.01	1.19	1.03	1.17	1.01	1.17	0.98	1.20	1.04	0.58		11
		3.7	3.7	3.0	1.6	-0.6	-2.7	-2.9	-4.0	-1.9	-1.3	0.9	1.5	3.9		
			0.63	1.08	1.19	1.29	1.23	1.09	1.23	1.29	1.19	1.08	0.63			
			0.67	1.12	1.21	1.29	1.19	1.05	1.19	1.27	1.18	1.10	0.65			12
			6.2	4.0	1.6	0.5	-2.8	-3.0	-3.0	-1.2	-0.8	2.0	3.3			
				0.63	1.02	1.17	1.00	1.24	1.00	1.17	1.02	0.63				
				0.67	1.10	1.21	0.98	1.22	0.99	1.17	1.03	0.65				13
				6.8	7.5	3.5	-2.2	-1.8	-1.5	-0.3	0.1	3.1				
					0.55	0.99	1.11	0.86	1.11	0.99	0.55					
					0.60	1.07	1.14	0.88	1.09	0.98	0.55					14
					7.5	8.8	3.3	1.8	-1.4	-0.3	-0.2					
							0.35	0.52	0.35							
							0.38	0.55	0.34							15
							10.1	5.1	-0.3							

STANDARD DEVIATION =1.787

AVERAGE PCT DIFFERENCE = 2.6

SUMMARY

MAP NO: N2-3- 8

DATE: 6/ 8/83

POWER: 99%

CONTROL ROD POSITIONS:

D BANK AT 228 STEPS

F-Q(T) = 1.940

F-DH(N) = 1.475

F(Z) = 1.255

F(XY) = 1.558

BURNUP = 155 MWD/MTU

QPTR:

NW 0.997	NE 1.001
SW 1.009	SE 0.993

A.O = -5.94(%)

FIGURE 6.7
NORTH ANNA UNIT 2, CYCLE 3
ASSEMBLYWISE POWER DISTRIBUTION
100% POWER

Key (upper left and upper right corners): PREDICTED / MEASURED / PCT DIFFERENCE

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
						0.34	0.52	0.34							
						0.36	0.54	0.36							1
						3.7	3.6	3.6							
				0.56	0.99	1.10	0.85	1.10	0.99	0.56					
				0.59	1.00	1.10	0.85	1.11	1.02	0.58					2
				6.3	0.9	0.0	-0.1	0.9	3.4	5.1					
			0.63	1.03	1.17	1.00	1.24	1.00	1.17	1.03	0.63				
			0.65	1.07	1.18	0.98	1.21	0.99	1.18	1.06	0.67				3
			4.0	3.7	1.0	-2.0	-2.3	-1.5	0.7	2.9	7.0				
		0.63	1.08	1.19	1.29	1.23	1.09	1.23	1.29	1.19	1.08	0.63			
		0.66	1.12	1.22	1.29	1.20	1.06	1.19	1.28	1.21	1.11	0.66			4
		5.0	3.1	2.7	0.2	-2.1	-2.2	-3.1	-1.0	1.4	2.7	4.5			
	0.56	1.03	1.19	0.99	1.19	1.05	1.20	1.05	1.19	0.99	1.19	1.03	0.56		
	0.58	1.06	1.20	0.99	1.19	1.02	1.17	1.03	1.19	0.99	1.19	1.06	0.59		5
	3.7	3.7	1.0	0.1	-0.5	-2.9	-2.9	-2.1	-0.6	-0.2	0.4	3.3	5.9		
	0.99	1.17	1.29	1.19	0.98	1.15	1.02	1.15	0.98	1.19	1.29	1.17	0.99		
	1.02	1.21	1.30	1.19	0.96	1.11	0.99	1.13	0.97	1.18	1.27	1.18	1.02		6
	3.5	3.5	1.5	-0.5	-2.0	-3.6	-3.3	-2.1	-0.9	-0.8	-1.1	0.8	3.3		
0.34	1.10	1.00	1.23	1.06	1.16	1.04	1.15	1.04	1.16	1.06	1.23	1.00	1.10	0.34	
0.36	1.12	1.00	1.21	1.02	1.11	0.99	1.11	1.01	1.13	1.03	1.19	0.99	1.10	0.35	7
5.1	1.9	0.5	-1.3	-3.1	-3.6	-4.3	-3.6	-2.5	-2.0	-2.6	-3.5	-1.1	0.1	1.4	
0.52	0.85	1.24	1.09	1.20	1.02	1.14	0.96	1.14	1.02	1.20	1.09	1.24	0.85	0.52	
0.55	0.86	1.24	1.07	1.17	0.99	1.09	0.92	1.11	0.99	1.16	1.05	1.22	0.87	0.55	8
5.0	1.8	0.1	-1.4	-3.0	-3.5	-4.6	-3.4	-3.3	-3.4	-3.9	-3.4	-1.1	2.7	4.9	
0.34	1.10	1.00	1.23	1.06	1.16	1.04	1.15	1.04	1.16	1.06	1.23	1.00	1.10	0.34	
0.36	1.12	0.99	1.21	1.03	1.12	1.00	1.11	1.00	1.11	1.02	1.20	1.00	1.14	0.36	9
5.1	1.4	-0.4	-1.7	-2.9	-3.1	-3.4	-3.3	-3.6	-3.7	-3.4	-2.6	-0.3	3.4	5.8	
	0.99	1.17	1.29	1.19	0.98	1.15	1.02	1.15	0.98	1.19	1.29	1.17	0.99		
	1.00	1.19	1.29	1.19	0.97	1.10	0.98	1.10	0.96	1.17	1.27	1.17	1.05		10
	1.7	1.7	0.5	-0.1	-1.3	-4.3	-4.0	-4.2	-2.6	-2.1	-1.3	-0.1	6.5		
	0.56	1.03	1.19	0.99	1.19	1.05	1.20	1.05	1.19	0.99	1.19	1.03	0.56		
	0.58	1.07	1.23	1.01	1.18	1.02	1.16	1.00	1.20	0.99	1.20	1.04	0.58		11
	4.3	4.3	3.3	1.6	-0.9	-3.2	-3.4	-5.3	0.2	-0.4	1.1	1.7	4.1		
		0.63	1.08	1.19	1.29	1.23	1.09	1.23	1.29	1.19	1.08	0.63			
		0.67	1.13	1.21	1.29	1.19	1.05	1.19	1.29	1.19	1.11	0.65			12
		6.9	4.3	1.6	0.2	-3.3	-3.4	-3.3	-0.2	0.1	2.4	3.7			
			0.63	1.03	1.17	1.00	1.24	1.00	1.17	1.03	0.63				
			0.67	1.11	1.21	0.98	1.21	0.99	1.17	1.03	0.65				13
			7.3	7.8	3.4	-2.5	-1.8	-1.5	-0.3	0.1	3.4				
				0.56	0.99	1.10	0.85	1.10	0.99	0.56					
				0.60	1.07	1.14	0.87	1.09	0.99	0.55					14
				7.8	8.8	3.1	1.8	-1.4	-0.3	-0.5					
						0.34	0.52	0.34							
						0.38	0.55	0.34							15
						9.8	5.1	0.1							

STANDARD DEVIATION =1.922

AVERAGE PCT DIFFERENCE = 2.7

SUMMARY

MAP NO: N2-3- 9   DATE: 6/ 8/83   POWER: 100%

CONTROL ROD POSITIONS: F-Q(T) = 1.976   QPTR:

D BANK AT 210 STEPS   F-DH(N) = 1.476

NW 1.003	NE 0.996
SW 1.010	SE 0.991

F(Z) = 1.275

F(XY) = 1.555

BURNUP = 185 MWD/MTU   A.O = -7.36(%)

FIGURE 6.8
NORTH ANNA UNIT 2, CYCLE 3
ASSEMBLYWISE POWER DISTRIBUTION
HFP, EQUILIBRIUM XENON

PREDICTED
MEASURED
PCT DIFFERENCE

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							0.34	0.52	0.34						
							0.36	0.54	0.36						
							3.3	3.3	3.3						
2					0.55	0.99	1.11	0.86	1.11	0.99	0.55				
					0.59	1.00	1.11	0.86	1.11	1.02	0.58				
					6.6	1.9	0.2	0.2	0.8	3.4	5.0				
3				0.63	1.02	1.17	1.00	1.24	1.00	1.17	1.02	0.63			
				0.65	1.06	1.19	0.98	1.21	0.98	1.18	1.05	0.67			
				4.2	3.9	1.5	-1.8	-2.1	-1.7	0.6	-2.7	6.7			
4			0.63	1.08	1.19	1.29	1.23	1.09	1.23	1.29	1.19	1.08	0.63		
			0.66	1.11	1.22	1.30	1.20	1.06	1.19	1.27	1.20	1.11	0.65		
			4.9	3.0	2.6	1.2	-2.0	-2.2	-3.0	-1.4	1.2	2.5	4.5		
5		0.55	1.02	1.19	0.99	1.20	1.05	1.20	1.05	1.20	0.99	1.19	1.02	0.55	
		0.57	1.06	1.20	0.99	1.20	1.02	1.16	1.03	1.19	0.99	1.19	1.06	0.59	
		3.4	3.4	0.9	0.1	0.0	-3.7	-3.7	-2.3	-0.7	-0.3	0.3	3.4	6.0	
6		0.98	1.17	1.28	1.20	0.99	1.16	1.03	1.16	0.99	1.20	1.28	1.17	0.98	
		1.02	1.21	1.30	1.19	0.97	1.11	0.99	1.13	0.99	1.19	1.27	1.18	1.02	
		3.3	3.3	1.3	-0.7	-1.9	-4.3	-3.8	-2.1	-0.8	-0.8	-1.2	0.9	3.5	
7	0.34	1.10	1.00	1.23	1.06	1.16	1.04	1.15	1.04	1.16	1.06	1.23	1.00	1.10	0.34
	0.36	1.12	1.00	1.21	1.03	1.12	0.99	1.10	1.01	1.14	1.03	1.18	0.99	1.11	0.35
	5.0	1.9	0.5	-1.1	-2.6	-3.3	-4.3	-3.8	-2.4	-1.8	-2.4	-3.6	-0.9	0.4	1.8
8	0.52	0.86	1.24	1.09	1.20	1.02	1.14	0.96	1.14	1.02	1.20	1.09	1.24	0.86	0.52
	0.55	0.88	1.24	1.07	1.17	0.99	1.09	0.92	1.11	0.99	1.16	1.05	1.23	0.88	0.54
	5.0	1.8	3.1	-1.1	-2.4	-3.1	-4.6	-3.6	-3.4	-3.4	-3.8	-3.5	-0.9	1.9	3.6
9	0.34	1.10	1.00	1.23	1.06	1.16	1.04	1.15	1.04	1.16	1.06	1.23	1.00	1.10	0.34
	0.36	1.12	0.99	1.21	1.03	1.13	1.01	1.11	1.00	1.12	1.02	1.19	1.00	1.13	0.36
	5.0	1.4	-0.4	-1.4	-2.2	-2.4	-2.8	-3.1	-3.6	-3.6	-3.3	-2.7	-0.2	2.2	4.1
10		0.98	1.17	1.28	1.20	0.99	1.16	1.03	1.16	0.99	1.20	1.28	1.17	0.98	
		1.00	1.19	1.29	1.20	0.98	1.11	0.98	1.11	0.96	1.16	1.26	1.16	1.03	
		1.8	1.8	0.7	0.1	-0.9	-4.0	-4.0	-4.2	-2.9	-2.6	-1.4	-0.3	4.2	
11		0.55	1.02	1.19	0.99	1.20	1.05	1.20	1.05	1.20	0.99	1.19	1.02	0.55	
		0.58	1.06	1.22	1.00	1.19	1.02	1.16	1.01	1.17	0.98	1.20	1.04	0.57	
		4.1	4.1	3.2	1.4	-0.9	-3.3	-3.4	-4.7	-2.0	-1.4	1.0	1.6	3.9	
12			0.63	1.08	1.19	1.29	1.23	1.09	1.23	1.29	1.19	1.08	0.63		
			0.67	1.12	1.21	1.29	1.18	1.05	1.19	1.27	1.18	1.10	0.65		
			6.5	4.1	1.4	-0.0	-3.5	-3.7	-3.2	-1.1	-0.6	2.2	3.6		
13				0.63	1.02	1.17	1.00	1.24	1.00	1.17	1.02	0.63			
				0.67	1.10	1.21	0.97	1.21	0.99	1.17	1.03	0.65			
				7.2	7.9	3.3	-2.7	-2.0	-1.2	0.1	0.5	3.3			
14					0.55	0.99	1.11	0.86	1.11	0.99	0.55				
					0.60	1.07	1.14	0.85	1.09	0.99	0.56				
					7.9	8.0	3.1	1.7	-1.2	0.1	0.6				
15							0.34	0.52	0.34						
							0.38	0.55	0.34						
							9.7	4.9	-0.2						

STANDARD DEVIATION =1.831

AVERAGE PCT DIFFERENCE = 2.6

SUMMARY

MAP NO: N2-3-10 DATE: 6/10/83 POWER: 100%

CONTROL ROD POSITIONS: F-Q(T) = 1.906 QPTR:

D BANK AT 228 STEPS F-DH(N) = 1.473

NW 1.007	NE 0.999
SW 1.009	SE 0.985

F(Z) = 1.229

F(XY) = 1.558

BURNUP = 215 MWD/MTU A.O = -2.10(%)

Section 7

REFERENCES

1. A. Abbasi, R. A. Hall, "North Anna Unit 2, Cycle 3, Design Report," NFE Technical Report No. 288, Vepco, April, 1983.

2. North Anna Unit 2 Technical Specifications, Sections 3.1.3.4, 3/4.2.

3. T. K. Ross, W. C. Beck, "Control Rod Reactivity Worth Determination By The Rod Swap Technique," VEP-FRD-36A, December 1980.

4. T. J. Kunsitis, "RXFLOW, A Computer Program to Calculate Reactor Flow and Thermal Output," NFO-CCR-8, Vepco, March, 1983.

5. "Technical Manual for Westinghouse Solid State Reactivity Computer," Westinghouse Electric Corporation.

6. W. Leggett and L. Eisenhart, "The INCORE Code," WCAP-7149, December, 1967

APPENDIX

STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEETS

NORTH ANNA POWER STATION UNIT 2 CYCLE 3
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Reactivity Computer Checkout Proc No /Section: 2-PT-94.2 Sequence Step No: 3	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB: 228 CC: 228 CD: *	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating *At the just crit. position
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB: 228 CC: 228 CD: 101	RCS Temperature (°F): 548.1 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 5/27/83 1338	
IV	Measured Parameter (Description)	ρ_c = Meas. Reactivty using ρ-computer ρ_t = Inferred React from react period
Test Results	Measured Value	ρ_c = +27pcm -18.5 +44 -27 ρ_t = +26.3pcm -18.3 +44 -27.3 %D = 2.7% 1.1% 0.0% -1.1%
	Design Value (Actual Conditions)	$\%D = [(\rho_c - \rho_t)/\rho_t] \times 100\% \leq 4.0\%$
	Design Value (Design Conditions)	$\%D = [(\rho_c - \rho_t)/\rho_t] \times 100\% \leq 4.0\%$
	Reference	WCAP 7905, Rev. 1, Table 3.6
V Acceptance Criteria	FSAR/Tech Spec	Not Applicable
	Reference	Not Applicable
VI Comments	Design Tolerance is met : X YES __NO Acceptance Criteria is met : X YES __NO	
	Allowable Range = ± 27 pcm	

Completed By: RS Thomas
Test Engineer

Evaluated By: C.A. Ford

Recommended for Approval By : C.J. Snow
NFO Engineer

NORTH ANNA POWER STATION UNIT 2 CYCLE 3
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Critical Boron Concentration - ARO Proc No /Section: 2-PT-94.3 Sequence Step No: 4		
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB: 228 CC: 228 CD: 228		RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB: 228 CC: 228 CD: 228		RCS Temperature (°F): 542.1 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 5/28/83 0640		
IV Test Results	Meas Parameter (Description)	$(C_B)^M_{ARO}$; Critical Boron Conc - ARO	
	Measured Value	$(C_B)^M_{ARO}$ = 1575 ppm	
	Design Value (Actual Cond)	C_B = 1546 ± 50 ppm	
	Design Value (Design Cond)	C_B = 1546 ± 50 ppm	
	Reference	VEP-PSE-NFE-288	
V Acceptance Criteria	FSAR/Tech Spec	$\alpha_{C_B} \times C_B \leq 24{,}000$ pcm	
	Reference	UFSAR Section 15.2.4	
VI Comments	Design Tolerance is met : ✓ YES __NO Acceptance Criteria is met : ✓ YES __NO		
	α_{C_B} = -7.94 pcm/ppm for preliminary analysis α_{C_B} = -7.85 pcm/ppm for final analysis.		

Completed By: R S Thomas
Test Engineer

Evaluated By: B. D. Mann

Recommended for Approval By : C. T. Snow
NFO Engineer

NORTH ANNA POWER STATION UNIT 2 CYCLE 3
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Isothermal Temperature Coefficient - ARO Proc No /Section: 2-PT-94.4 Sequence Step No: 5		
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB: 228 CC: 228 CD: 228		RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB: 228 CC: 228 CD: 212		RCS Temperature (°F): 543.6 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 5/28/83 0746		
IV Test Results	Meas Parameter (Description)	$(\alpha_T^{ISO})_{ARO}$ Isothermal Temp Coeff - ARO	
	Measured Value	$(\alpha_T^{ISO})_{ARO}$ = −3.65 pcm/°F (C_B = 1575 ppm)	
	Design Value (Actual Cond)	$(\alpha_T^{ISO})_{ARO}$ = −3.70±3.0 pcm/°F (C_B = 1575 ppm)	
	Design Value (Design Cond)	$(\alpha_T^{ISO})_{ARO}$ = -4.04 ± 3.0 pcm/°F (C_B = 1549 ppm)	
	Reference	VEP-PSE-NFE-288	
V Acceptance Criteria	FSAR/Tech Spec	α_T^{ISO} ≤ -2.11 pcm/°F α_T^{Dop} = -2.11 pcm/°F	
	Reference	TS 3.1.1.4, VEP-PSE-NFE-288	
VI Comments	Design Tolerance is met : ✓ YES __NO Acceptance Criteria is met : ✓ YES __NO		

Completed By: R. S. Thomas
Test Engineer

Evaluated By: B. D. Mann

Recommended for Approval By: C. T. Snow
NFO Engineer

NORTH ANNA POWER STATION UNIT 2 CYCLE 3
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Cntl Bank B Worth Meas., Rod Swap Ref. Bank Proc No /Section: 2-PT-94.5 Sequence Step No: 7		
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB: Moving CC: 228 CD: 228		RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB: Moving CC: 228 CD: 228		RCS Temperature (°F): 543.9 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 5/28/83 1139		
IV Test Results	Measured Parameter (Description)	I_B^{REF}; Integral Worth of Cntl Bank B, All Other Rods Out	
	Measured Value	I_B^{REF} = 1569 pcm	
	Design Value (Actual Conditions)	I_B^{REF} = 1544 ± 154 pcm	
	Design Value (Design Conditions)	I_B^{REF} = 1544 ± 154 pcm	
	Reference	VEP-PSE-NFE-288	
V Acceptance Criteria	FSAR/Tech Spec	If Design Tolerance is exceeded, SNSOC shall evaluate impact of test result on safety analysis. SNSOC may specify that additional testing be performed.	
	Reference	VEP-FRD-36A	
VI Comments	Design Tolerance is met : ✓ YES ___ NO Acceptance Criteria is met : ✓ YES ___ NO		

Completed By: [signature] Test Engineer

Evaluated By: [signature]

Recommended for Approval By: C. J. Snow NFO Engineer

NORTH ANNA POWER STATION UNIT 2 CYCLE 3
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Critical Boron Concentration - B Bank In Proc No /Section: 2-PT-94.3 Sequence Step No: 8	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB: 0 CC: 228 CD: 228	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB: 0 CC: 228 CD: 228	RCS Temperature (°F): 543.8 Power Level (% F.P.); 0 Other (Specify): -- Below Nuclear Heating
	Date/Time Test Performed: 5/28/83 1655	
IV Test Results	Meas Parameter (Description)	$(C_B)^M_B$; Critical Boron Conc - B Bank In
	Measured Value	$(C_B)^M_B$ = 1375 ppm
	Design Value (Actual Cond)	C_B = 1387 ± 30 ppm
	Design Value (Design Cond)	$C_B = 1358 + \Delta C_B^{Prev} \pm (10 + 154.4/\lvert\alpha_{C_B}\rvert)$ppm
	Reference	VEP-PSE-NFE-288
V Acceptance Criteria	FSAR/Tech Spec	$\alpha_{C_B} \times C_B \leq 24,000$ pcm
	Reference	UFSAR Section 15.2.4
VI Comments	Design Tolerance is met : ✓ YES ___NO Acceptance Criteria is met : ✓ YES ___NO	
	α_{C_B} = -7.94 pcm/ppm for preliminary analysis $\Delta C_B^{Prev} = (C_B)^M_{ARO}$ -1546 α_{C_B} = -7.85 pcm/ppm for final analysis.	

Completed By: R.S. Thomas
Test Engineer

Evaluated By: B. O. Mann

Recommended for Approval By: C. J. Snow
NFO Engineer

NORTH ANNA POWER STATION UNIT 2 CYCLE 3
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: HZP Boron Worth Coefficent Measurement Proc No /Section: 2-PT-94.5 Sequence Step No: 7		
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB:Moving CC: 228 CD: 228		RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB:Moving CC: 228 CD: 228		RCS Temperature (°F): 542.1 Power Level (% F.P.): 0 Other (Specify): -- Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 5/28/83 0640		
	Measured Parameter (Description)	α_{C_B}, Boron Worth Coefficient	
	Measured Value	α_{C_B} = -7.85 pcm/ppm	
	Design Value (Actual Conditions)	α_{C_B} = -7.94 ± 0.79 pcm/ppm	
	Design Value (Design Conditions)	α_{C_B} = -7.94 ± 0.79 pcm/ppm	
	Reference	VEP-PSE-NFE-288	
V Acceptance Criteria	FSAR/Tech Spec	$\alpha_{C_B} \times C_B \leq 24{,}000$ pcm	
	Reference	UFSAR Section 15.2.4	
VI Comments	Design Tolerance is met : ✓ YES __ NO Acceptance Criteria is met : ✓ YES __ NO		

Completed By: R S Thomas
Test Engineer

Evaluated By: B. D. Mann

Recommended for Approval By: C. J. Snow
NFO Engineer

NORTH ANNA POWER STATION UNIT 2 CYCLE 3
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Cntl Bank D Worth Measurement-Rod Swap Proc No /Section: 2-PT-94.7 Sequence Step No: 10		
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB:Moving CC: 228 CD:Moving		RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB:Moving CC: 228 CD:Moving		RCS Temperature (°F): 543.7 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 5/28/83 1737		
	Meas Parameter (Description)	I_D^{RS}; Int Worth of Cntl Bank D-Rod Swap	
	Measured Value	I_D^{RS}= 859 pcm (Adj. Meas. Crit. Ref Bank Position = 106 steps)	
	Design Value (Actual Cond)	I_D^{RS}= 850 ± 128 pcm (Adj. Meas. Crit. Ref Bank Position = 106 steps)	
	Design Value (Design Cond)	I_D^{RS}= 851 ± 128 pcm (Critical Ref Bank Position = 106 steps)	
	Reference	VEP-PSE-NFE-288, VEP-FRD-36A, NFO-TI-2.2A	
V Acceptance Criteria	FSAR/Tech Spec	If Design Tolerance is exceeded, SNSOC shall evaluate impact of test result on safety analysis. SNSOC may specify that additional testing be performed.	
	Reference	VEP-FRD-36A	
VI Comments	Design Tolerance is met : ✓ YES ___ NO Acceptance Criteria is met : ✓ YES ___ NO		

Completed By: R.S. Thomas
Test Engineer

Evaluated By: Paul A. Reed

Recommended for Approval By : C. T. Snow
NFO Engineer

NORTH ANNA POWER STATION UNIT 2 CYCLE 3
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Cntl Bank C Worth Measurement-Rod Swap Proc No /Section: 2-PT-94.7 Sequence Step No: 11	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB:Moving CC:Moving CD: 228	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB:Moving CC:Moving CD: 228	RCS Temperature (°F): 543.4 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 5/28/83 1837	
	Meas Parameter (Description)	I_C^{RS};Int Worth of Cntl Bank C-Rod Swap
	Measured Value	I_C^{RS}= 890 pcm (Adj. Meas. Crit. Ref Bank Position = 110 steps)
	Design Value (Actual Cond)	I_C^{RS}= 903 ± 135 pcm (Adj. Meas. Crit. Ref Bank Position = 110 steps)
	Design Value (Design Cond)	I_C^{RS}= 900 ± 135 pcm (Critical Ref Bank Position = 111 steps)
	Reference	VEP-PSÉ-NFE-288, VEP-FRD-36A, NFO-TI-2.2A
V Acceptance Criteria	FSAR/Tech Spec	If Design Tolerance is exceeded, SNSOC shall evaluate impact of test result on safety analysis. SNSOC may specify that additional testing be performed.
	Reference	VEP-FRD-36A
VI Comments	Design Tolerance is met : ✓YES __NO Acceptance Criteria is met : ✓YES __NO	

Completed By: R.G. Thomas
Test Engineer

Evaluated By: Paul J. Rod

Recommended for Approval By : C. T. Snow
NFO Engineer

NORTH ANNA POWER STATION UNIT 2 CYCLE 3
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Cntl Bank A Worth Measurement-Rod Swap Proc No /Section: 2-PT-94.7 Sequence Step No: 12	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA:Moving CB:Moving CC: 228 CD: 228	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA:Moving CB:Moving CC: 228 CD: 228	RCS Temperature (°F): 544 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 5/28/83 1927	
IV Test Results	Meas Parameter (Description)	I_A^{RS}; Int Worth of Cntl Bank A - Rod Swap
	Measured Value	I_A^{RS} = 758 pcm (Adj. Meas. Crit. Ref Bank Position = 96 steps)
	Design Value (Actual Cond)	I_A^{RS} = 667 ± 100 pcm (Adj. Meas. Crit. Ref Bank Position = 96 steps)
	Design Value (Design Cond)	I_A^{RS} = 665 ± 100 pcm (Critical Ref Bank Position = 89 steps)
	Reference	VEP-PSÉ-NFE-288, VEP-FRD-36A, NFO-TI-2.2A
V Acceptance Criteria	FSAR/Tech Spec	If Design Tolerance is exceeded, SNSOC shall evaluate impact of test result on safety analysis. SNSOC may specify that additional testing be performed.
	Reference	VEP-FRD-36A
VI Comments	Design Tolerance is met : ✓ YES ___ NO Acceptance Criteria is met : ✓ YES ___ NO	

Completed By: [signature] Test Engineer

Evaluated By: [signature]

Recommended for Approval By: C. J. Snow, NFO Engineer

NORTH ANNA POWER STATION UNIT 2 CYCLE 3
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Shutdown Bank B Worth Meas. - Rod Swap Proc No /Section: 2-PT-94.7 Sequence Step No: 13		
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB:Moving CA: 228 CB:Moving CC: 228 CD: 228	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating	
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB:Moving CA: 228 CB:Moving CC: 228 CD: 228	RCS Temperature (°F): 543.9 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating	
IV Test Results	Date/Time Test Performed: 5/28/83 2011		
	Meas Parameter (Description)	I_{SB}^{RS}; Int Worth of Shutdown Bank B-Rod Swap	
	Measured Value	I_{SB}^{RS}= 806 pcm (Adj. Meas. Crit. Ref Bank Position = 101 steps)	
	Design Value (Actual Cond)	I_{SB}^{RS}= 827 ± 124 pcm (Adj. Meas. Crit. Ref Bank Position = 101 steps)	
	Design Value (Design Cond)	I_{SB}^{RS}= 831 ± 125 pcm (Critical Ref Bank Position = 104 steps)	
	Reference	VEP-PSÉ-NFE-288, VEP-FRD-36A, NFO-TI-2.2A	
V Acceptance Criteria	FSAR/Tech Spec	If Design Tolerance is exceeded, SNSOC shall evaluate impact of test result on safety analysis. SNSOC may specify that additional testing be performed.	
	Reference	VEP-FRD-36A	
VI Comments	Design Tolerance is met : ✓ YES __ NO Acceptance Criteria is met : ✓ YES __ NO		

Completed By: *[signature]* Test Engineer

Evaluated By: *[signature]*

Recommended for Approval By: C. J. Snow NFO Engineer

NORTH ANNA POWER STATION UNIT 2 CYCLE 3
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Shutdown Bank A Worth Meas. - Rod Swap Proc No /Section: 2-PT-94.7 Sequence Step No: 14	
II Test Conditions (Design)	Bank Positions (Steps) SDA:Moving SDB: 228 CA: 228 CB:Moving CC: 228 CD: 228	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA:Moving SDB: 228 CA: 228 CB:Moving CC: 228 CD: 228	RCS Temperature (°F): 542.9 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 5/28/83 2056	
	Meas Parameter (Description)	I_{SA}^{RS}; Int Worth of Shutdown Bank A-Rod Swap
	Measured Value	I_{SA}^{RS}= 995 pcm (Adj. Meas. Crit. Ref Bank Position = 121 steps)
	Design Value (Actual Cond)	I_{SA}^{RS}= 945±142 pcm (Adj. Meas. Crit. Ref Bank Position = 121 steps)
	Design Value (Design Cond)	I_{SA}^{RS}= 947 ± 142 pcm (Critical Ref Bank Position = 116 steps)
	Reference	VEP-PSE-NFE-288, VEP-FRD-36A, NFO-TI-2.2A
V Acceptance Criteria	FSAR/Tech Spec	If Design Tolerance is exceeded, SNSOC shall evaluate impact of test result on safety analysis. SNSOC may specify that additional testing be performed.
	Reference	VEP-FRD-36A
VI Comments	Design Tolerance is met : ✓ YES ___ NO Acceptance Criteria is met : ✓ YES ___ NO	

Completed By: [signature] Test Engineer

Evaluated By: [signature]

Recommended for Approval By : C. J. Snow NFO Engineer

NORTH ANNA POWER STATION UNIT 2 CYCLE 3
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Total Rod Worth - Rod Swap Proc No /Section: 2-PT-94.7	Sequence Step No: 16
II Test Conditions (Design)	Bank Positions (Steps) SDA:Moving SDB:Moving CA:Moving CB:Moving CC:Moving CD:Moving	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA:Moving SDB:Moving CA:Moving CB:Moving CC:Moving CD:Moving	RCS Temperature (°F): 543.9 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 5/28/83 1737	

IV Test Results	Meas Parameter (Description)	I_{Total}; Int Worth of All Banks - Rod Swap
	Measured Value	I_{Total} = 5883 pcm
	Design Value (Actual Cond)	I_{Total} = 5736 ± 574 pcm
	Design Value (Design Cond)	I_{Total} = 5738 ± 574 pcm
	Reference	VEP-PSE-NFE-288, VEP-FRD-36A, NFO-TI-2.2A
V Acceptance Criteria	FSAR/Tech Spec	If Design Tolerance is exceeded, SNSOC shall evaluate impact of test result on safety analysis. SNSOC may specify that additional testing be performed.
	Reference	VEP-FRD-36A
VI Comments	Design Tolerance is met : ✓ YES ___ NO Acceptance Criteria is met : ✓ YES ___ NO	

Completed By: R S Thomas
Test Engineer

Evaluated By: Paul J. R[illegible]

Recommended for Approval By: C. T. Snow
NFO Engineer

NORTH ANNA POWER STATION UNIT 2 CYCLE 3
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

Section		
I Reference	Test Description : M/D Flux Map - HZP, ARO Proc No / Section: 2-PT-21.1	Sequence Step No: 6
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB : 228 CC : 228 CD: 228	RCS Temperature (°F): T_{REF} ±1 Power Level (% F.P.): ~ 3 Other (specify) Must have ≥ 38 thimbles
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB : 228 CC : 228 CD: 211 Date/Time Test Performed: 5/29/83 0512	RCS Temperature (°F): T_{REF} Power Level (% F.P.): 4 Other (Specify): 41 Thimbles

		MAX. REL ASSY PWR % DIFF (M-P)/P	NUC ENTHAL RISE HOT CHAN FACT F-dH(N)	TOTAL HEAT FLUX HOT CH... FACT F-Q(T)	QUADRANT POWER TILT RATIO QPTR
IV Test Results	Meas Parameter (Description)				
	Measured Value	8.3% for P_{13} = 1.18 9.9% for P_{U4} = 0.62	1.574	2.479	1.028#
	Design Value (Design Conds)	≤ 10% for P_i ≥ 0.9 ≤ 15% for P_i < 0.9 (P_i = Assy. Pwr.)	$F^N_{\Delta H} \le 1.55[1+.3(1-P)]$ [1+RBP(BU)]	$F^T_Q(Z) \le 4.40 \times K(Z)$	≤ 1.02
	Reference	WCAP-7905 REV.1	NONE	NONE	WCAP-7905 REV.1
V Acceptance Criteria	FSAR/Tech Spec	NONE	NA	NA	NA
	Reference	NONE	TS 3.2.3	TS 3.2.2	TS 3.2.4

VI Comments

Design Tolerance is met : __YES ✓ NO
Acceptance Criteria is met : ✓ YES __NO

Design tolerance not met but test results are acceptable per North Anna Power Station Deviation Report 83-477.

Completed By: B. Thomas
Test Engineer

Evaluated By: N. S. Pierce

Recommended for Approval By : C. T. Snow
NFO Engineer

NORTH ANNA POWER STATION UNIT 2 CYCLE 3
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference

Test Description : M/D Flux Map-At Power, NI Calibration
Proc No / Section: 2-PT-22.2 Sequence Step No: 43

II Test Conditions (Design)

Bank Positions (Steps)	RCS Temperature (°F): T_{REF} ±1
SDA: 228 SDB: 228 CA: 228 CB : 228 CC : 228 CD: *	Power Level (% F.P.): ~ AR Other (specify) Must have ≥ 38 thimbles

III Test Conditions (Actual)

Bank Positions (Steps)	RCS Temperature(°F): T_{REF}
SDA: 228 SDB: 228 CA: 228 CB : 228 CC : 228 CD: 179	Power Level (% F.P.): 47.7% Other (Specify): 45 thimbles
Date/Time Test: Performed: 6/06/83 0823	

IV Test Results

	Meas Parameter (Description)	MAX. REL ASSY PWR % DIFF (M-P)/P	NUC ENTHAL RISE HOT CHAN FACT F-dH(N)	TOTAL HEAT FLUX HOT CHAN FACT F-Q(T)	QUADRANT POWER TILT RATIO QPTR
IV Test Results	Measured Value	11.1% for P_{H-11} = 1.11 12.4% for P_{J-15} = 0.35	1.545	2.139	1.015
	Design Value (Design Conds)	± 10% for $P_i \ge 0.9$ ± 15% for $P_i < 0.9$ (P_i = Assy. Pwr.)	NA	NA	≤ 1.02
	Reference	WCAP-7905 REV.1	NONE	NONE	WCAP-7905 REV.1
V Acceptance Criteria	FSAR/Tech Spec	NONE	$F^N_{\Delta H} \le 1.55(1+.2(1-P))$ [1-RBP(BU)]	$F_Q^T(Z) \le 4.40 \times K(Z)$ for $P \le 0.5$ $F_Q^T(Z) \le 2.20/P \times K(Z)$ for $P > 0.5$	NA
	Reference	NONE	TS 3.2.3	TS 3.2.2	TS 3.2.4

VI Comments

Design Tolerance is met : ___YES ✓ NO
Acceptance Criteria is met : ✓ YES ___NO

* As Required
A violation of the Fxy Technical Specifications limit occured, but was deemed acceptable as per North Anna Power Station Deviation Report #83-519.

Completed By: [signature]
Test Engineer

Evaluated By: [signature]

Recommended for Approval By : C. J. Snow
NFO Engineer

1. This deviation is deemed acceptable as per North Anna Power Station Deviation Report #83-551.

NORTH ANNA POWER STATION UNIT 2 CYCLE 3
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description : M/D Flux Map-At Power, NI Calibration Proc No / Section: 2-PT-22.2 Sequence Step No: 44	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB : 228 CC : 228 CD: *	RCS Temperature (°F): T_{REF} ±1 Power Level (% F.P.): ~ AR Other (specify)
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB : 228 CC : 228 CD: 161	RCS Temperature(°F): T_{REF} Power Level (% F.P.): 49.8% Other (Specify): 21 thimbles Quarter-Core Flux Map
	Date/Time Test Performed: 6/06/83 1600	

IV	Meas Parameter (Description)	MAX. REL ASSY PWR % DIFF (M-P)/P	NUC ENTHAL RISE HOT CHAN FACT F-dH(N)	TOTAL HEAT FLUX HOT CHAN FACT F-Q(T)	QUADRANT POWER TILT RATIO QPTR
Test Results	Measured Value	5.7% for P = 1.06 (K2) 12.1% for P = 0.52 (M-5)	NA[1]	NA[1]	NA[1]
	Design Value (Design Conds)	≤ 10% for P_i ≥ 0.9 ≤ 15% for P_i < 0.9 (P_i = Assy. Pwr.)	NA	NA	≤ 1.02
	Reference	WCAP-7905 REV.1	NONE	NONE	WCAP-7905 REV.1
V Acceptance Criteria	FSAR/Tech Spec	NONE	$F^N_{\Delta H} \le 1.55[1+.3(1-P)]$ / (1-RBP(BU))	$F_Q^T(Z) \le$ [illegible]/P × K(Z)	NA
	Reference	NONE	TS 3.2.3	TS 3.2.2	TS 3.2.4

VI Comments

Design Tolerance is met : ✓ YES ___NO
Acceptance Criteria is met : ✓ YES ___NO

Must have at least 38 thimbles for a full-core flux map or, at least 16 thimbles for a quarter-core flux map.

* As Required

Completed By: B S Thomas
Test Engineer

Evaluated By: B D Mann

Recommended for Approval By : C. J. Snow
NFO Engineer

1. These parameters are not verified using a partial-core map obtained for NI calibration.

NORTH ANNA POWER STATION UNIT 2 CYCLE 3
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description : M/D Flux Map-At Power, NI Calibration Proc No / Section: 2-PT-22.2 Sequence Step No: 45	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB : 228 CC : 228 CD: *	RCS Temperature (°F): T_{REF} ±1 Power Level (% F.P.): ~ AR Other (specify)
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB : 228 CC : 228 CD: 192	RCS Temperature(°F): T_{REF} Power Level (% F.P.): 77.2% Other (Specify): 50 thimbles
	Date/Time Test: Performed: 6/07/83 0606	

IV	Meas Parameter (Description)	MAX. REL ASSY PWR % DIFF (M-P)/P	NUC ENTHAL RISE HOT CHAN FACT F-dH(N)	TOTAL HEAT FLUX HOT CHAN FACT F-Q(T)	QUADRANT POWER TILT RATIO QPTR
Test Results	Measured Value	8.3% for P_{R-N} = 1.08 9.5% for P_{J-05} = 0.37	1.480	1.980	1.011
	Design Value (Design Conds)	± 10% for $P_i \ge 0.9$ ± 15% for $P_i < 0.9$ (P_i = Assy. Pwr.)	NA	NA	≤ 1.02
	Reference	WCAP-7905 REV.1	NONE	NONE	WCAP-7905 REV.1
V Acceptance Criteria	FSAR/Tech Spec	NONE	$F^N_{\Delta H} \le 1.55[1+.3(1-P)]$ [1-RBP(BU)]	$F^T_Q(Z) \le 2.20/P \times K(Z)$	NA
	Reference	NONE	TS 3.2.3	TS 3.2.2	TS 3.2.4

VI Comments	Design Tolerance is met : ✓ YES __ NO Acceptance Criteria is met : ✓ YES __ NO
	Must have at least 38 thimbles for a full-core flux map, or at least 16 thimbles for a quarter-core flux map. * As Required

Completed By: *RS Thomas*
Test Engineer

Evaluated By: *BD Mann*

Recommended for Approval By : *C. J. Snow*
NFO Engineer

NORTH ANNA POWER STATION UNIT 2 CYCLE 3
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description : M/D Flux Map - HFP, ARO, Eq. Xe Proc No / Section: 2-PT-21.1 Sequence Step No: 46	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB : 228 CC : 228 CD: *	RCS Temperature (°F): T_{REF} ±1 Power Level (% F.P.): 95 ± 5 Other (specify): Eq. Xe. Must have ≥ 38 thimbles
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB : 228 CC : 228 CD: 228	RCS Temperature(°F): T_{REF} Power Level (% F.P.): 100% Other (Specify): 49 thimbles
	Date/Time Test Performed: 6/10/83 0749	

	Meas Parameter (Description)	MAX. REL ASSY PWR % DIFF (M-P)/P	NUC ENTHAL RISE HOT CHAN FACT F-dH(N)	TOTAL HEAT FLUX HOT CHAN FACT F-Q(T)	QUADRANT POWER TILT RATIO QPTR
IV Test Results	Measured Value	8.8% for P_{K-14} = 1.07 7.7% for P_{J-15} = 0.38	1.473	1.906	1.01
	Design Value (Design Conds)	≤ 10% for P_i ≥ 0.9 ≤ 15% for P_i < 0.9 (P_i = Assy. Pwr.)	NA	NA	≤ 1.02
	Reference	WCAP-7905 REV.1	NONE	NONE	WCAP-7905 REV.1
V Acceptance Criteria	FSAR/Tech Spec	NONE	$F_{\Delta H}^N \le 1.55(1+.3(1-P))$ / (1-RBP(BU))	$F_Q^T(Z) \le 2.20/P \times K(Z)$	NA
	Reference	NONE	TS 3.2.3	TS 3.2.2	TS 3.2.4

VI Comments	Design Tolerance is met : ✓ YES ___ NO Acceptance Criteria is met : ✓ YES ___ NO
	* As Required

Completed By: [signature] Test Engineer

Evaluated By: [signature]

Recommended for Approval By : C. J. Snow NFO Engineer

VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

W. L. STEWART
VICE PRESIDENT
NUCLEAR OPERATIONS

July 19, 1983

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
ATTN: Mr. Robert A. Clark, Chief
Operating Reactors Branch No. 3
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Serial No. 410
NOD:BDM:hca

Docket No. 50-339
License No. NPF-7

Gentlemen:

NORTH ANNA POWER STATION
UNIT 2, CYCLE 3 STARTUP PHYSICS TEST REPORT

For your information, enclosed are five copies of the Vepco Topical Report VEP-NOS-4, "North Anna Unit 2, Cycle 3 Startup Physics Test Report".

Should you have any questions, please contact us.

Very truly yours

W. L. Stewart

W. L. Stewart

Enclosures

cc: Mr. James P. O'Reilly
Regional Administrator
Region II

Mr. M. B. Shymlock
NRC Resident Inspector
North Anna Power Station

IE26
1/5