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North Anna Unit 2, Cycle 6 Startup Physics Tests Report

Nuclear Operations Department

VIRGINIA POWER

VP-NOS-38

NORTH ANNA UNIT 2, CYCLE 6

STARTUP PHYSICS TESTS 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 6 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 include 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 6 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 the startup physics testing. The entries for the design values were based on the calculations performed by Virginia Electric and Power Company's Nuclear 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 August 24, 1987 Unit No. 2 of the North Anna Power Station was shutdown for its fifth refueling. During this shutdown, 64 of the 157 fuel assemblies in the core were replaced with fresh fuel assemblies. The sixth cycle core consists of 8 sub-batches of fuel: three once-burned batches, two from Cycle 5 (batches 7A and 7B) and one from North Anna Unit 1, Cycle 4 (batch N1/6); two twice burned batches, one from Cycles 4 and 5 (batch 6), and one from North Anna 1, Cycles 3 and 4 (batch N1/5); one thrice-burned batch from Cycles 3, 4, and 5 (batch 5A), and two fresh batches (batches 8A and 8B). 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 location and number of burnable poison rods and source assemblies for Cycle 6, and Figure 1.5 identifies the location and number of control rods in the Cycle 6 core.

On November 3, 1987 at 0245, the sixth 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 the control rod banks were measured using the rod swap technique[3] and were found to be within 8.5% of the design predictions. The sum of the individual control rod bank worths was measured to be within 5.1% 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 12 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 6.2% of the design prediction, which is within the design tolerance of ±10% and met the accident analysis criterion.

5. The isothermal temperature coefficient for the all-rods-out configuration was measured to be within 0.4 pcm/°F of the design prediction. This result is within the design tolerance of ±3 pcm/°F and also meets the accident analysis acceptance criterion.

6. Core power distributions for at-power conditions were within established design tolerances. Generally, the measured core power distribution was within 5.6% of the predicted power distribution. The measured parameters were within the limits of the Technical Specifications and met their respective accident analysis acceptance criteria.

In summary, the 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 - CYCLE 6 STARTUP PHYSICS TESTS

CHRONOLOGY OF TESTS

Test	Date	Time	Power	Reference Procedure
Hot Rod Drop - Hot Full Flow	11/01/87	1530	HSD	2-PT-17.2
Zero Power Testing Range	11/03/87	0335	HZP	2-PT-94.0
Reactivity Computer Checkout	11/03/87	0348	HZP	2-PT-94.0
Boron Endpoint-ARO	11/03/87	1000	HZP	2-PT-94.0
Temperature Coefficient-ARO	11/03/87	1131	HZP	2-PT-94.0
Bank B Worth	11/03/87	1257	HZP	2-PT-94.0
Boron Endpoint-B In	11/03/87	1832	HZP	2-PT-94.0
Bank D Worth - Rod Swap	11/03/87	2125	HZP	2-PT-94.0
Bank C Worth - Rod Swap	11/03/87	2204	HZP	2-PT-94.0
Bank A Worth - Rod Swap	11/03/87	2300	HZP	2-PT-94.0
Bank SB Worth - Rod Swap	11/03/87	2333	HZP	2-PT-94.0
Bank SA Worth - Rod Swap	11/04/87	0010	HZP	2-PT-94.0
Flux Map - 30% Power	11/06/87	0713	28%	2-PT-21.1
Flux Map - Delta I Target	11/11/87	2300	50%	2-PT-21.1
Flux Map - QPTR Verification	11/12/87	0900	47%	2-PT-21.1
Flux Map - HFP	11/16/87	0950	100%	2-PT-21.1
Flux Map - HFP	11/23/87	1300	100%	2-PT-21.1
Flux Map - I/E Calibration	11/24/87	0637	100%	2-PT-22.2
Flux Map - I/E Calibration	11/24/87	1743	100%	2-PT-22.2
Flux Map - I/E Calibration	11/25/87	0854	100%	2-PT-22.2

Figure 1.1

NORTH ANNA UNIT 2 - CYCLE 6

CORE LOADING MAP

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
							5A S16	*5A E23	5A S23							1
					6A T50	7A V36	8B W34	7B V64	8B W43	7A V10	6A T39					2
				5A S50	8A W22	8B W56	7B V49	8B W63	7B V51	8B W29	8A W07	5A S39				3
			5A S29	7B V45	8B W45	7B V54	8B W46	7A V03	8B W54	7B V42	8B W36	7B V41	5A S42			4
		6A T13	8A W27	8B W30	7A V04	8A W19	7A V15	7B V63	7A V06	8A W20	7A V02	8B W41	8A W25	6A T29		5
		7A V32	8B W42	7B V61	8A W09	7A V31	8A W04	7A V08	8A W[illegible]	7A V14	8A W21	7B V62	8B W57	7A V27		6
	5A S25	8B W64	7B V43	8B W39	7A V34	8A W23	7A V17	8A W10	7A V13	8A W18	7A V29	8B W59	7B V39	8B W31	5A S30	7
	*5A E11	*6A F41	8B W37	7A V12	7B V58	7A V33	8A W24	*6A F01	8A W12	7A V28	7B V48	7A V24	8B W52	7B V55	*5A E04	8
	5A S18	8B W44	7B V38	8B W60	7A V18	8A W11	7A V11	8A W03	7A V25	8A W14	7A V09	8B W51	7B V40	8B W38	5A S26	9
		7A V35	8B W33	7B V46	8A W02	7A V16	8A W13	7A V19	8A W17	7A V23	8A W05	7B V56	8B W32	7A V26		10
		6A T12	8A W26	8B W53	7A V30	8A W08	7A V07	7B V50	7A V05	8A W28	7A V20	8B W58	8A W01	6A T09		11
			5A S47	7B V52	8B W61	7B V59	8B W47	7A V21	8B W49	7B V60	8B W48	7B V44	5A S12			12
				5A S19	8A W06	8B W40	7B V53	8B W35	7B V47	8B W55	8A W15	5A S33				13
					6A T53	7A V01	8B W50	7B V37	8B W62	7A V22	6A T16					14
							5A S17	*5A E02	5A S55							15

--> BATCH
--> ASSEMBLY ID

FUEL ASSEMBLY DESIGN PARAMETERS

	SUB-BATCH							
	N1/5A	N1/6A	5A	6A	7A	7B	8A	8B
INITIAL ENRICHMENT (W/O U-235)	3.40	3.59	3.59	3.60	3.60	3.79	3.79	4.00
BURNUP AT BOC 6 (MWD/MTU)	22512	15658	33400	31707	22291	19541	0	0
ASSEMBLY TYPE	17X17	17X17	17X17	17X17	17X17	17X17	17X17	17X17
NUMBER OF ASSEMBLIES	4	2	16	8	36	27	28	36
FUEL RODS PER ASSEMBLY	264	264	264	264	264	264	264	264

Figure 1.2

NORTH ANNA UNIT 2 - CYCLE 6

BEGINNING OF CYCLE FUEL ASSEMBLY BURUNUPS

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
						S16 32889	E23 22772	S23 32626							1
				T50 31173	V36 20643	W34 0	V64 17915	W43 0	V10 21087	T39 31555					2
			S50 34340	W22 0	W56 0	V49 19000	W63 0	V51 18917	W29 0	W07 0	S39 34203				3
		S29 33940	V45 21484	W45 0	V54 20424	W46 0	V03 23042	W54 0	V42 20838	W36 0	V41 21753	S42 34534			4
	T13 32049	W27 0	W30 0	V04 22814	W19 0	V15 22354	V63 18026	V06 22229	W20 0	V02 22877	W41 0	W25 0	T29 31376		5
	V32 21296	W42 0	V61 20596	W09 0	V31 23117	W04 0	V08 22719	W16 0	V14 23057	W21 0	V62 20502	W57 0	V27 21139		6
S25 32418	W64 0	V43 18525	W39 0	V34 22380	W23 0	V17 23030	W10 0	V13 23094	W18 0	V29 21788	W59 0	V39 18961	W31 0	S30 33063	7
E11 22298	F41 15701	W37 0	V12 23065	V58 17964	V33 22793	W24 0	F01 15614	W12 0	V28 23019	V48 18074	V24 22764	W52 0	V55 17841	T04 22453	8
S18 32513	W44 0	V38 19036	W60 0	V18 22209	W11 0	V11 22793	W03 0	V25 22767	W14 0	V09 22146	W51 0	V40 19064	W38 0	S26 32516	9
	V35 20690	W33 0	V46 20256	W02 0	V16 22950	W13 0	V19 22745	W17 0	V23 22741	W05 0	V56 20933	W32 0	V26 20499		10
	T12 32237	W26 0	W53 0	V30 23158	W08 0	V07 21957	V50 17667	V05 21949	W28 0	V20 22683	W58 0	W01 0	T09 31445		11
		S47 33667	V52 21534	W61 0	V59 20606	W47 0	V21 22891	W49 0	V60 20181	W48 0	V44 21799	S12 34253			12
			S19 34183	W06 0	W40 0	V53 19183	W35 0	V47 18525	W55 0	W15 0	S33 33715				13
				T53 31929	V01 20953	W50 0	V37 18042	W62 0	V22 21049	T16 31893					14
						S17 33010	E02 22524	S55 32530							15

--> ASSEMBLY ID
--> ASSEMBLY BURNUP

Figure 1.3

NORTH ANNA UNIT 2 - CYCLE 6
INCORE INSTRUMENTATION LOCATIONS

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

MD - Movable Detector
TC - Thermocouple

Figure 1.4

NORTH ANNA UNIT 2 - CYCLE 6

BURNABLE POISON AND SOURCE ASSEMBLY LOCATIONS

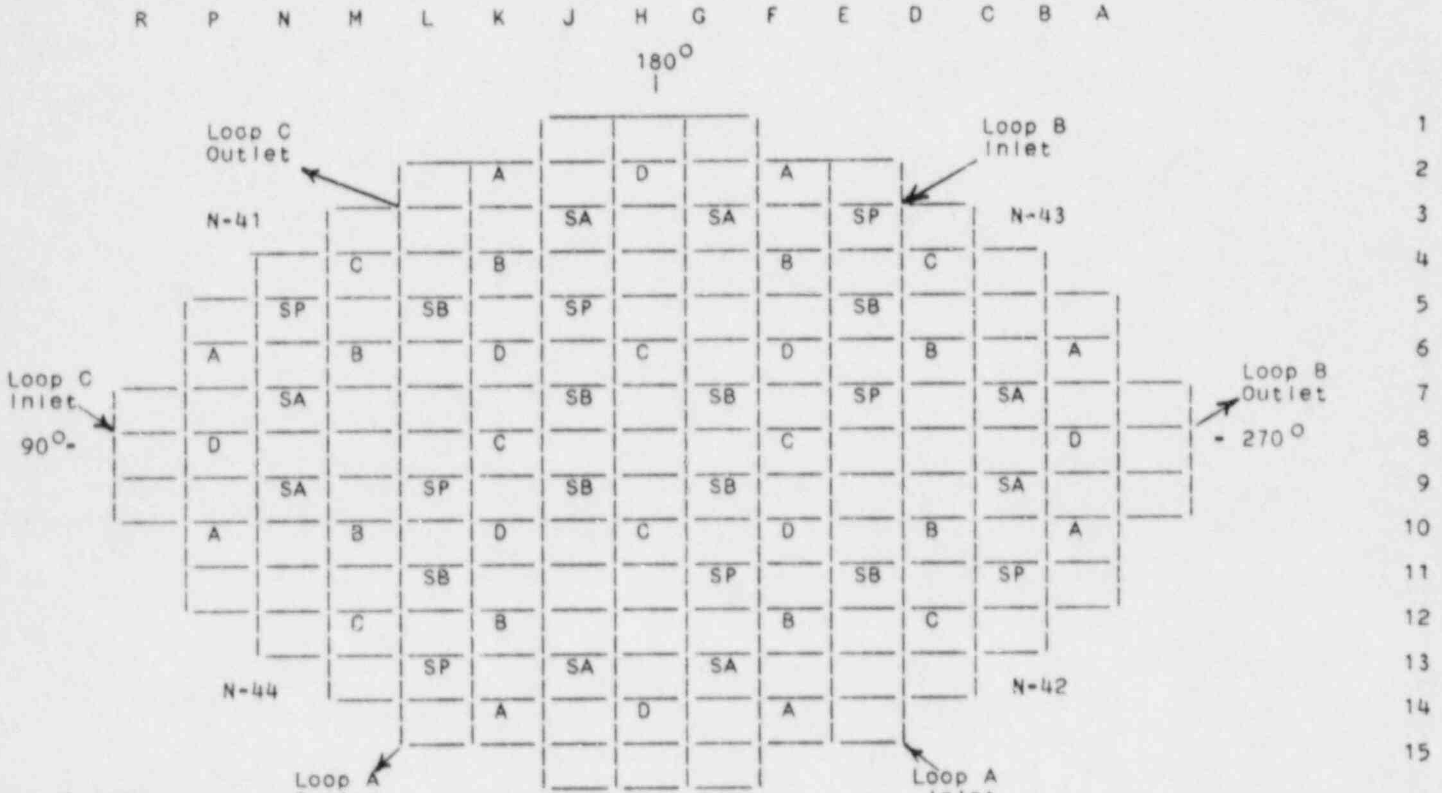
R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
															1
						SS11									2
				4P*	12P		16P		12P	4P*					3
				12P		16P		16P		12P					4
		4P*	12P		16P				16P		12P	4P*			5
		12P		16P		12P		12P		16P		12P			6
			16P		12P		20P		12P		16P				7
		16P				20P		20P			SS16	16P			8
			16P		12P		20P		12P		16P				9
		12P		16P		12P		12P		16P		12P			10
		4P*	12P		16P				16P		12P	4P*			11
				12P		16P		16P		12P					12
				4P*	12P		16P		12P	4P*					13
															14
															15

12P -- 12 BURNABLE POISON ROD CLUSTER
16P -- 16 BURNABLE POISON ROD CLUSTER
20P -- 20 BURNABLE POISON ROD CLUSTER
4P* -- 4 DEPLETED BURNABLE POISON ROD CLUSTER
SSXX -- SECONDARY SOURCE

Figure 1.5

NORTH ANNA UNIT 2 - CYCLE 6

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 full-flow 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 above 500°F and 2235 psig.

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 and the LVDT (Linear Variable Differential Transformer) primary coil voltage. 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. The test results met this limit.

Table 2.1

NORTH ANNA UNIT 2 - CYCLE 6 STARTUP PHYSICS TESTS
HOT ROD DROP TIME SUMMARY

ROD DROP TIME TO DASHPOT ENTRY

SLOWEST ROD	FASTEST ROD	AVERAGE TIME
B-06 1.86 sec.	M-04 1.42 sec.	1.60 sec.

ROD DROP TIME TO BOTTOM OF DASHPOT

SLOWEST ROD	FASTEST ROD	AVERAGE TIME
B-06 2.54 sec.	M-04 2.02 sec.	2.24 sec.

FIGURE 2.1

TYPICAL ROD DROP TRACE

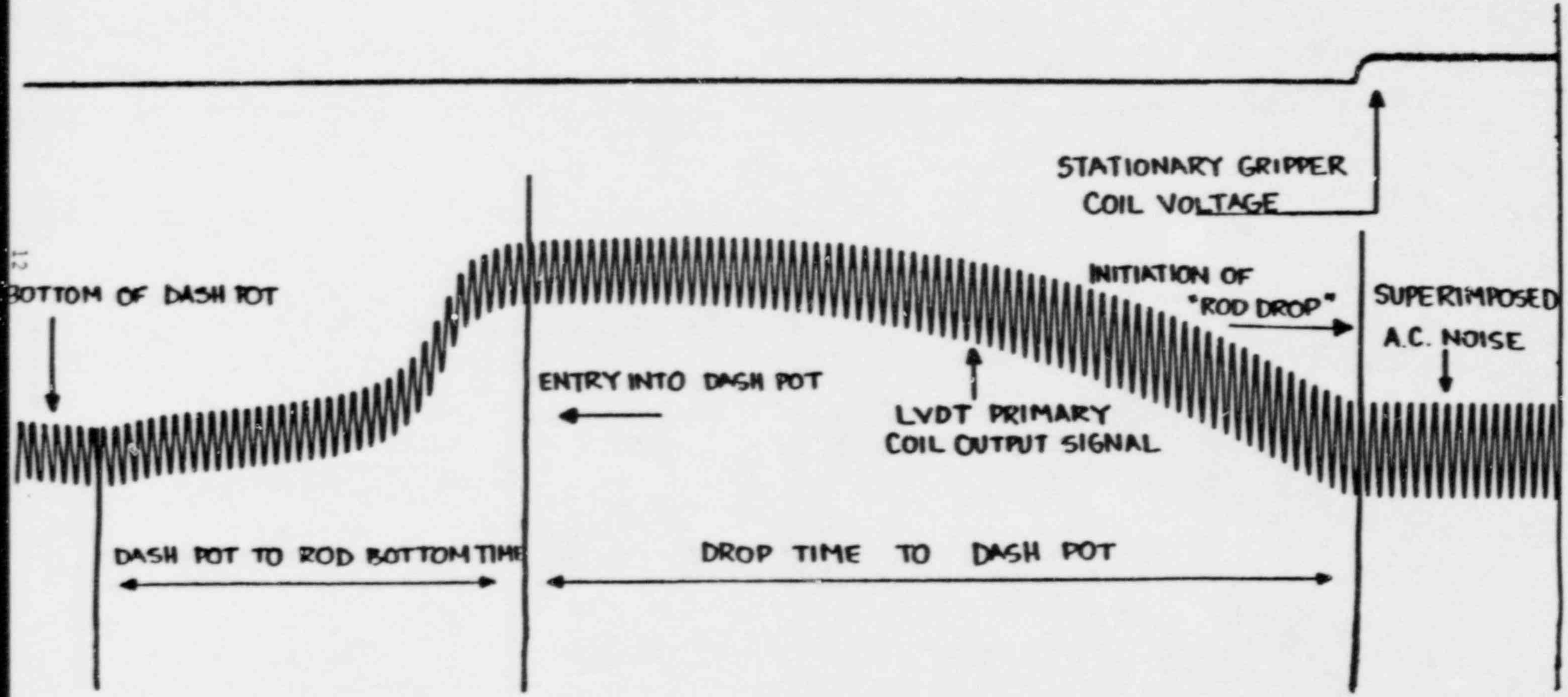
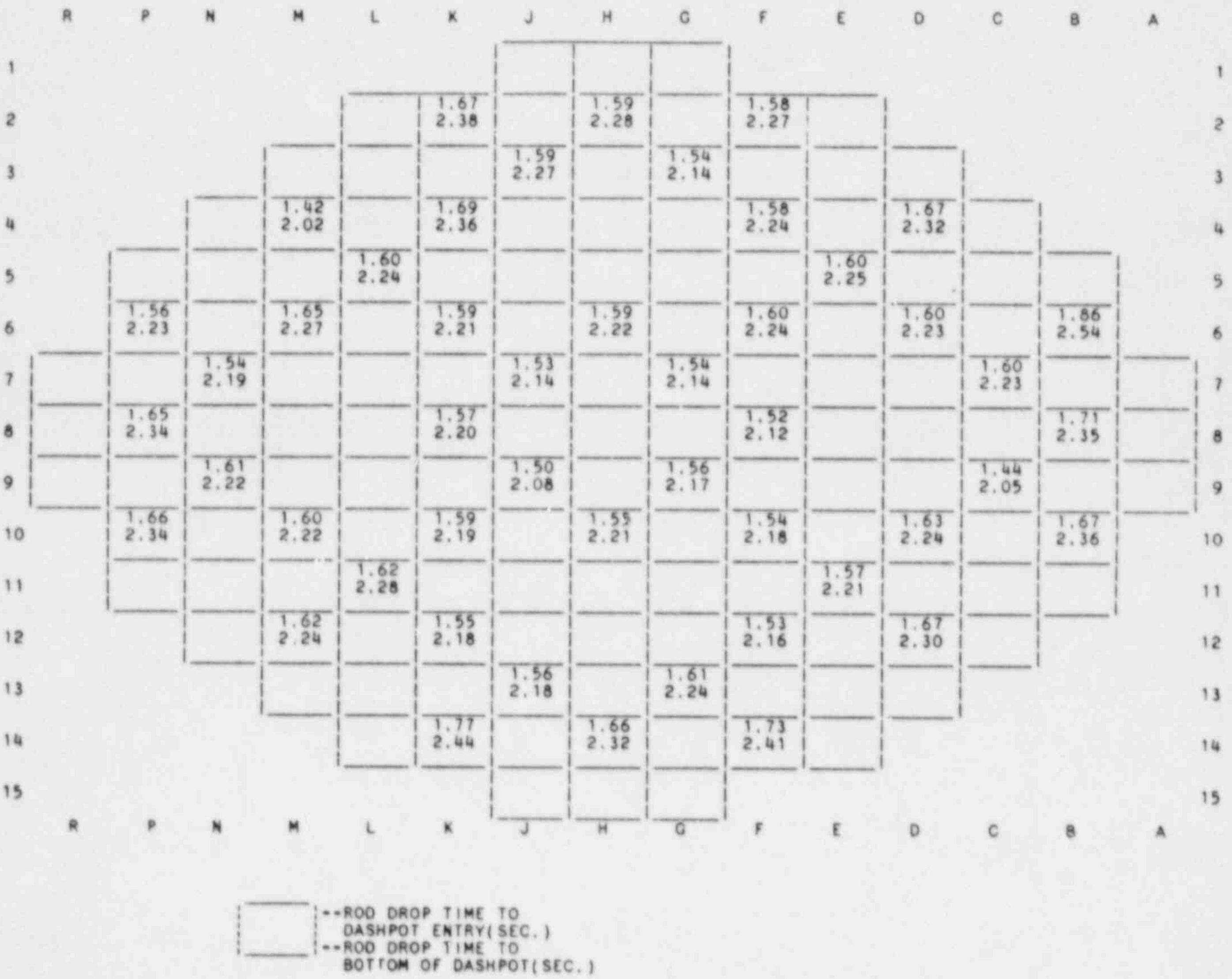


Figure 2.2

NORTH ANNA UNIT 2 - CYCLE 6 STARTUP PHYSICS TESTS

ROD DROP TIME - HOT FULL FLOW CONDITIONS



	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1															
2						1.67 2.38		1.59 2.28		1.58 2.27					
3							1.59 2.27		1.54 2.14						
4				1.42 2.02		1.69 2.36				1.58 2.24		1.67 2.32			
5					1.60 2.24						1.60 2.25				
6		1.56 2.23		1.65 2.27		1.59 2.21		1.59 2.22		1.60 2.24		1.60 2.23		1.86 2.54	
7			1.54 2.19				1.53 2.14		1.54 2.14				1.60 2.23		
8		1.65 2.34				1.57 2.20				1.52 2.12				1.71 2.35	
9			1.61 2.22				1.50 2.08		1.56 2.17				1.44 2.05		
10		1.66 2.34		1.60 2.22		1.59 2.19		1.55 2.21		1.54 2.18		1.63 2.24		1.67 2.36	
11					1.62 2.28						1.57 2.21				
12				1.62 2.24		1.55 2.18				1.53 2.16		1.67 2.30			
13							1.56 2.18		1.61 2.24						
14						1.77 2.44		1.66 2.32		1.73 2.41					
15															

--ROD DROP TIME TO DASHPOT ENTRY(SEC.)

--ROD DROP TIME TO BOTTOM OF DASHPOT(SEC.)

SECTION 3

CONTROL ROD BANK WORTH MEASUREMENTS

Control rod bank worth measurements were obtained for the 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[4] 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 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 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 5.1% 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, the measured rod worth values were satisfactory.

Table 3.1

NORTH ANNA UNIT 2 - CYCLE 6 STARTUP PHYSICS TESTS
CONTROL ROD BANK WORTH SUMMARY

BANK	MEASURED WORTH (PCM)	PREDICTED WORTH (PCM)	PERCENT DIFFERENCE (%) (M-P)/P X 100
B-Reference Bank	1282	1367	-6.2
D	944	994	-5.0
C	715	732	-2.4
A	327	332	-1.5 <100 pcm
SB	921	953	-3.3
SA	955	1045	-8.6
Total Worth	5144	5423	-5.1

FIGURE 3.1

NORTH ANNA UNIT 2 - CYCLE 6 BOL PHYSICS TEST
BANK B INTEGRAL ROD WORTH - HZP
BANK B WITH ALL OTHER RODS OUT

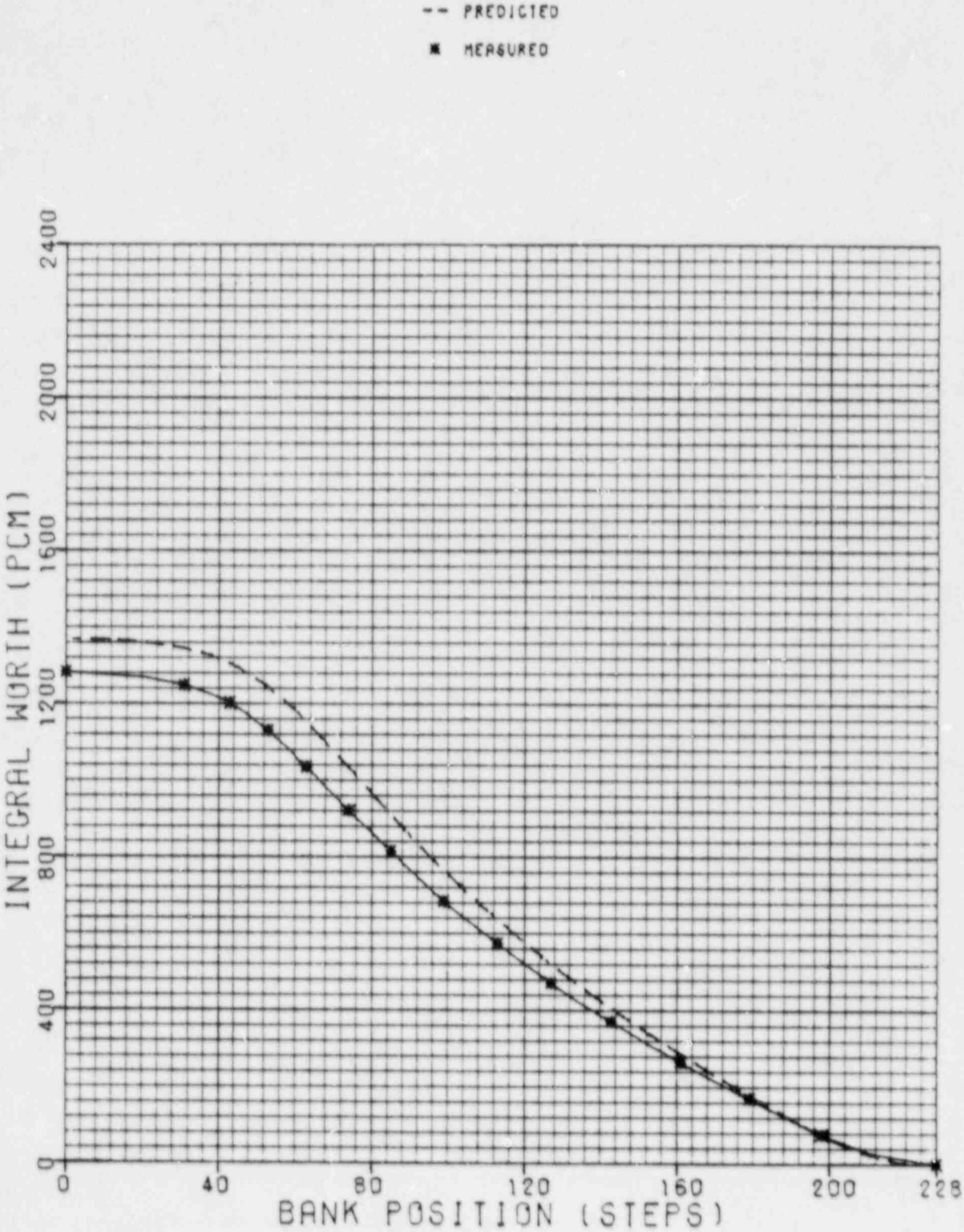
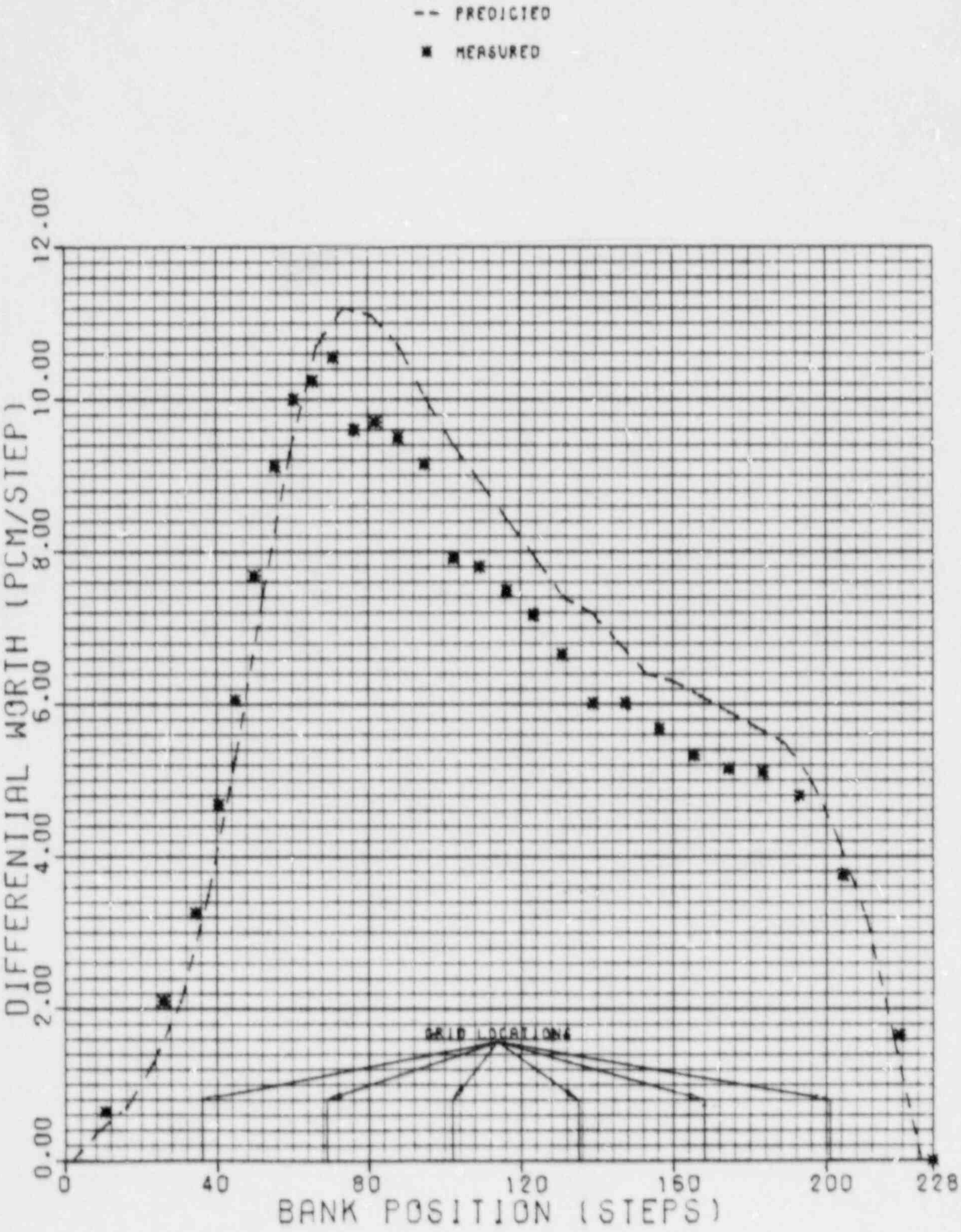


FIGURE 3.2
NORTH ANNA UNIT 2 - CYCLE 6 BOL PHYSICS TEST
BANK B DIFFERENTIAL ROD WORTH - HZP
BANK B WITH ALL OTHER RODS OUT



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 (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 Tests Results and Evaluation Sheets given in the Appendix, the measured critical boron endpoint values were within their respective design tolerances. The measured values met the accident analysis acceptance criterion. In summary, the boron endpoint 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 -6.82 pcm/ppm. The measured boron worth coefficient is within 6.2% of the predicted value of -7.27 pcm/ppm and is well within the design tolerance of ±10%. The measurement result also met the accident analysis acceptance criterion. In summary, the measured boron worth was satisfactory.

Table 4.1

NORTH ANNA UNIT 2 - CYCLE 6 STARTUP PHYSICS TESTS
BORON ENDPOINTS SUMMARY

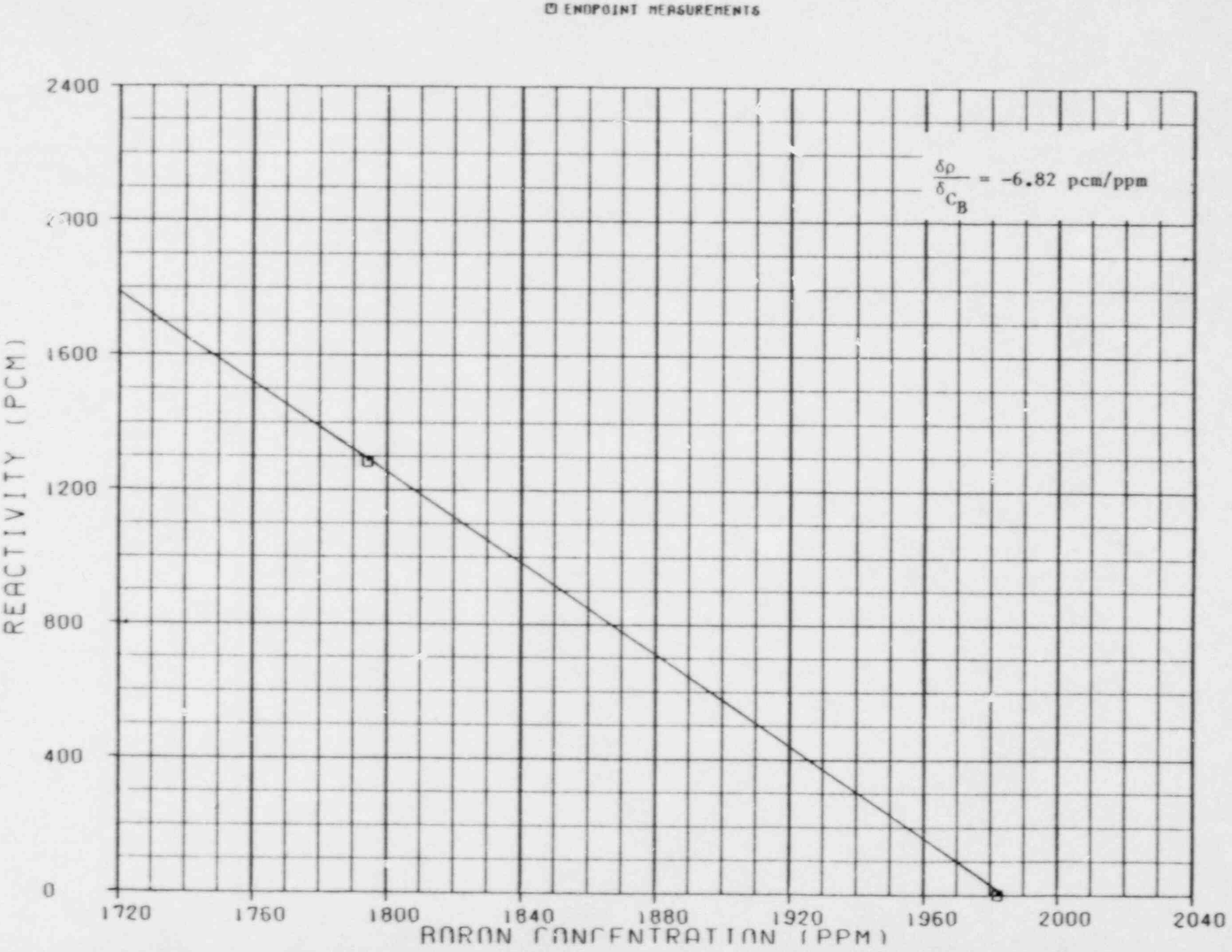
Control Rod Configuration	Measured Endpoint (ppm)	Predicted Endpoint (ppm)	Difference M-P (ppm)
ARO	1982	1994	-12
B Bank In	1794	1794*	0

* 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 UNIT 2 - CYCLE 6 BOL PHYSICS TEST

BORON WORTH COEFFICIENT



SECTION 5

TEMPERATURE COEFFICIENT MEASUREMENT

The isothermal temperature coefficient measurement at the all-rods-out condition was 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. This measurement was performed at a very low power level in order to minimize the effects of non-uniform nuclear heating, thus, the moderator and fuel were approximately at the same temperature (between 542 and 546 °F) during these measurements.

Reactivity measurements were taken during both RCS heatup and cooldown ramps during which the RCS temperature varied approximately 3.0°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 6 STARTUP 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)
D/212	542.8 to 545.8	1979	-1.00	-0.20	-0.60	-0.94	0.34

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 47 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[5]. 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 the full-core 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 28% power. This flux map served as the base case design check. Figure 6.1 shows the resulting radial power distribution associated with this flux map.

Flux maps 2 through 5 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 to measure core power distributions at various operating conditions. The radial power distributions for these maps are given in Figures 6.2 thru 6.5. These figures show that the measured relative assembly power values are generally within 5.6% of the predicted values. Further, the measured F-Q(T) and F-ΔH(M) peaking

In conclusion, the 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 6.

TABLE 6.1

NORTH ANNA 2 - CYCLE 6 STARTUP 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]				F-DH(M) HOT CHNL. FACTOR			CORE F(Z) MAX		QPTR[2]		AXIAL OFF SET (%)	NO. OF THIMBLES
						ASSY	PIN	AXIAL POINT	F-Q(T)	ASSY	PIN	F-DH(M)	AXIAL POINT	F(Z)	MAX	LOC		
LOW POWER	1	11-06-87	15	28	129	K13	IP	36	2.265	L13	DM	1.549	37	1.386	1.016	NW	-11.48	39
DELTA I TARGET	2	11-11-87	75	50	152	L03	MC	29	2.181	L03	MC	1.486	30	1.380	1.019	NW	-5.30	39
QPTR VERIFICATION	3	11-12-87	94	47	160	L03	MC	28	2.126	C11	AQ	1.476	29	1.349	1.016	NW	-2.37	39
HFP	4	11-16-87	222	100	228	L03	MC	36	1.857	L03	MC	1.396	37	1.223	1.009	NW	-2.56	47
HFP (3)	5	11-23-87	502	100	228	D11	IP	37	1.843	C10	BI	1.398	37	1.214	1.010	NW	-2.53	47

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 AXIAL POINTS STARTING FROM THE TOP OF THE CORE.

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

2. QPTR - QUADRANT POWER TILT RATIO.

3. MAPS 6, 7 AND 8 WERE QUARTER-CORE FLUX MAPS TAKEN FOR INCORE/EXCORE DETECTOR CALIBRATION.

Table 6.2

NORTH ANNA UNIT 2 - CYCLE 6 STARTUP PHYSICS TESTS
COMPARISICN OF MEASURED POWER DISTRIBUTION PARAMETERS
WITH THEIR TECHNICAL SPECIFICATION LIMITS

MAP NO.	F-Q(T) HOT CHANNEL FACTOR*			F-DH(M) HOT CHANNEL FACTOR		
	MEAS	LIMIT	MARGIN (%)	MEAS	LIMIT	MARGIN (%)
1	2.27	4.30	47.3	1.55	1.81	14.4
2	2.18	4.28	49.1	1.49	1.71	12.9
3	2.13	4.27	50.1	1.48	1.73	14.5
4	1.86	2.15	13.3	1.40	1.49	6.0
5	1.84	2.15	14.4	1.40	1.49	6.0

* 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 value 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. The measured F-Q(T) hot channel factors include 8% total uncertainty.

Figure 6.1

NORTH ANNA UNIT 2 - CYCLE 6 STARTUP PHYSICS TESTS

ASSEMBLYWISE POWER DISTRIBUTION

28% POWER

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
	PREDICTED MEASURED PCT DIFFERENCE					0.25 0.25 0.9	0.30 0.29 -3.8	0.25 0.26 2.3				PREDICTED MEASURED PCT DIFFERENCE			1
				0.34 0.37 7.9	0.64 0.65 0.9	1.09 1.08 -1.3	0.81 0.79 -1.5	1.09 1.09 -0.6	0.64 0.66 2.3	0.34 0.35 3.3					2
			0.36 0.37 3.3	1.17 1.20 2.8	1.34 1.33 -0.6	1.22 1.21 -1.0	1.30 1.28 -1.3	1.22 1.21 -0.6	1.34 1.35 1.0	1.17 1.19 2.2	0.36 0.37 4.3				3
		0.36 0.37 4.3	0.83 0.84 2.2	1.35 1.39 2.3	1.30 1.30 0.6	1.39 1.39 0.0	1.17 1.17 -0.1	1.39 1.37 -1.4	1.30 1.30 0.0	1.35 1.35 0.0	0.83 0.83 0.1	0.36 0.36 0.1			4
	0.34 0.34 1.0	1.17 1.18 0.9	1.36 1.35 -0.6	1.16 1.14 -1.4	1.27 1.28 0.2	1.12 1.14 2.4	1.13 1.16 2.4	1.12 1.13 1.2	1.27 1.28 0.4	1.16 1.15 -0.7	1.36 1.33 -2.2	1.17 1.12 -4.2	0.34 0.33 -2.5		5
	0.64 0.65 1.0	1.34 1.35 1.0	1.30 1.30 0.2	1.27 1.27 -0.6	0.98 0.98 1.0	1.22 1.26 3.7	1.04 1.08 3.9	1.22 1.25 2.6	0.98 0.98 0.7	1.27 1.25 -1.8	1.30 1.26 -3.0	1.34 1.29 -3.9	0.64 0.62 -2.6		6
0.25 0.27 6.9	1.09 1.11 1.9	1.22 1.18 -3.5	1.39 1.38 -0.8	1.12 1.12 0.5	1.22 1.23 0.5	1.04 1.08 4.4	1.11 1.16 4.5	1.04 1.07 2.7	1.22 1.24 1.8	1.12 1.11 -0.4	1.39 1.32 -5.2	1.22 1.18 -3.5	1.09 1.06 -2.0	0.25 0.25 -1.7	7
0.30 0.32 6.5	0.81 0.82 1.4	1.30 1.25 -3.4	1.17 1.16 -0.9	1.13 1.15 1.6	1.04 1.06 1.6	1.11 1.12 1.6	1.11 1.15 3.0	1.11 1.12 1.3	1.04 1.06 1.4	1.13 1.13 -0.6	1.17 1.11 -5.2	1.30 1.25 -3.5	0.81 0.80 -0.5	0.30 0.31 1.5	8
0.25 0.27 6.9	1.09 1.09 -0.0	1.22 1.18 -3.7	1.39 1.36 -1.9	1.12 1.13 1.6	1.22 1.22 0.3	1.04 1.03 -0.9	1.11 1.10 -0.8	1.04 1.05 1.2	1.22 1.23 1.0	1.12 1.13 0.8	1.39 1.35 -2.8	1.22 1.21 -1.2	1.09 1.11 1.1	0.25 0.26 3.5	9
	0.64 0.62 -4.0	1.34 1.28 -4.1	1.30 1.27 -2.5	1.27 1.27 -0.7	0.98 0.97 -0.9	1.22 1.22 0.1	1.04 1.05 0.3	1.22 1.21 -0.6	0.98 0.97 -1.1	1.27 1.27 -0.7	1.30 1.30 -0.1	1.34 1.35 0.8	0.64 0.67 4.9		10
	0.34 0.33 -4.1	1.17 1.12 -4.1	1.36 1.32 -2.4	1.16 1.15 -0.7	1.27 1.26 -0.8	1.12 1.12 0.3	1.13 1.14 0.5	1.12 1.11 -0.5	1.27 1.26 -1.2	1.16 1.15 -0.8	1.36 1.38 1.8	1.17 1.20 2.5	0.34 0.35 3.8		11
		0.36 0.34 -4.2	0.83 0.82 -0.8	1.35 1.34 -0.8	1.30 1.29 -0.8	1.39 1.36 -2.1	1.17 1.14 -2.1	1.39 1.35 -2.5	1.30 1.27 -2.0	1.35 1.33 -1.9	0.83 0.85 3.1	0.36 0.38 5.9			12
			0.36 0.37 3.6	1.17 1.21 3.7	1.34 1.38 3.7	1.22 1.15 -5.7	1.30 1.24 -4.1	1.22 1.17 -3.8	1.34 1.29 -3.0	1.17 1.13 -3.7	0.36 0.38 5.9				13
				0.34 0.35 3.7	0.64 0.67 4.5	1.09 1.09 -0.1	0.81 0.80 -1.1	1.09 1.05 -3.6	0.64 0.62 -2.9	0.34 0.33 -3.7					14
	STANDARD DEVIATION =1.676					0.25 0.27 5.0	0.30 0.31 1.5	0.25 0.25 -2.2				AVERAGE PCT DIFFERENCE = 2.2			

SUMMARY

MAP NO: N2-6-01

DATE: 11/06/87

POWER: 28%

CONTROL ROD POSITIONS:

F-Q(T) = 2.265

QPTR:

D BANK AT 129 STEPS

F-DH(M) = 1.549

NW	1.016	NE	0.998
SW	0.993	SE	0.993

F(Z) = 1.386

BURNUP = 15 MWD/MTU A.O = -11.48(%)

Figure 6.2

NORTH ANNA UNIT 2 - CYCLE 6 STARTUP PHYSICS TESTS

ASSEMBLYWISE POWER DISTRIBUTION

50% POWER

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
	PREDICTED MEASURED PCT DIFFERENCE					0.27 0.27 1.0	0.32 0.11 -3.2	0.27 0.27 1.7				PREDICTED MEASURED PCT DIFFERENCE			1
				0.34 0.36 5.9	0.64 0.65 1.0	1.11 1.10 -0.9	0.85 0.84 -1.2	1.11 1.10 -0.6	0.64 0.66 1.6	0.34 0.35 2.6					2
			0.36 0.37 2.7	1.15 1.17 2.3	1.31 1.31 -0.0	1.21 1.20 -0.4	1.29 1.29 -0.6	1.21 1.21 0.0	1.31 1.32 1.3	1.15 1.17 2.0	0.36 0.37 3.5				3
		0.36 0.37 3.3	0.82 0.83 1.9	1.32 1.35 2.0	1.27 1.28 1.1	1.36 1.37 0.6	1.16 1.17 0.5	1.36 1.36 -0.4	1.27 1.28 0.9	1.32 1.33 0.4	0.82 0.82 0.2	0.36 0.36 -0.2			4
	0.34 0.35 0.9	1.15 1.16 0.9	1.32 1.31 -0.8	1.14 1.12 -1.8	1.27 1.27 0.0	1.12 1.15 2.9	1.14 1.17 2.9	1.12 1.14 2.0	1.27 1.29 1.3	1.14 1.14 0.0	1.32 1.30 -1.6	1.15 1.10 -3.8	0.34 0.33 -3.3		5
	0.65 0.65 1.0	1.31 1.32 1.0	1.27 1.26 -0.7	1.27 1.24 -2.6	1.03 1.02 -0.3	1.24 1.29 3.9	1.06 1.10 4.1	1.24 1.28 3.0	1.03 1.04 1.5	1.27 1.26 -1.0	1.27 1.24 -2.2	1.31 1.26 -3.3	0.65 0.63 -3.2		6
0.27 0.28 3.7	1.11 1.11 0.3	1.21 1.17 -3.4	1.36 1.35 -1.2	1.12 1.12 -0.2	1.24 1.24 -0.3	1.06 1.11 4.5	1.13 1.18 4.5	1.06 1.09 3.0	1.24 1.27 2.3	1.12 1.13 0.3	1.36 1.31 -4.0	1.21 1.18 -2.9	1.11 1.08 -2.7	0.27 0.26 -1.8	7
0.32 0.34 3.3	0.85 .85 0.0	1.30 1.25 -3.3	1.16 1.16 -0.6	1.14 1.16 2.1	1.06 1.08 2.1	1.13 1.15 2.1	1.14 1.17 3.1	1.13 1.15 1.9	1.06 1.08 1.9	1.14 1.14 0.1	1.16 1.12 -4.0	1.30 1.26 -2.9	0.85 0.85 -0.7	0.32 0.33 0.7	8
0.27 0.28 3.7	1.11 1.10 -1.1	1.21 1.17 -3.7	1.36 1.34 -1.7	1.12 1.14 2.1	1.24 1.25 0.9	1.06 1.06 -0.1	1.13 1.13 -0.1	1.06 1.08 1.7	1.24 1.26 1.6	1.12 1.14 1.6	1.36 1.34 -1.7	1.21 1.20 -0.6	1.11 1.11 0.7	0.27 0.27 2.6	9
	0.65 0.62 -4.0	1.31 1.26 -4.0	1.27 1.25 -2.1	1.27 1.27 0.1	1.03 1.02 -0.1	1.24 1.25 0.5	1.06 1.07 0.6	1.24 1.24 0.1	1.03 1.02 -0.2	1.27 1.28 0.2	1.27 1.28 0.8	1.31 1.33 1.4	0.65 0.67 3.5		10
	0.34 0.33 -4.1	1.15 1.10 -4.1	1.32 1.30 -2.0	1.14 1.14 0.0	1.27 1.27 -0.0	1.12 1.13 0.6	1.14 1.15 0.7	1.12 1.12 -0.1	1.27 1.27 -0.4	1.14 1.15 0.1	1.32 1.35 1.7	1.15 1.17 2.2	0.34 0.35 2.7		11
		0.36 0.35 -4.1	0.82 0.82 -0.0	1.32 1.32 -0.0	1.27 1.27 0.0	1.36 1.34 -1.7	1.16 1.14 -1.7	1.36 1.34 -2.0	1.27 1.25 -1.3	1.32 1.31 -1.3	0.82 0.83 2.1	0.36 0.37 3.7			12
			0.36 0.36 0.8	1.15 1.15 0.8	1.31 1.32 0.5	1.21 1.15 -4.8	1.29 1.24 -4.1	1.21 1.17 -3.6	1.31 1.27 -3.2	1.15 1.11 -3.0	0.36 0.37 3.7				13
				0.34 0.35 2.9	0.64 0.66 1.8	1.11 1.10 -0.9	0.85 0.84 -1.8	1.11 1.07 -3.5	0.64 0.62 -3.1	0.34 0.33 -3.0					14
	STANDARD DEVIATION =1.359					0.27 0.27 2.5	0.32 0.32 -0.3	0.27 0.26 -3.2				AVERAGE PCT DIFFERENCE = 1.8			

SUMMARY

MAP NO: N2-6-02

DATE: 11/11/87

POWER: 50%

CONTROL ROD POSITIONS:

F-Q(T) = 2.181

QPTR:

D BANK AT 152 STEPS

F-DH(M) = 1.486

NW	1.019	NE	0.999
SW	0.986	SE	0.996

F(Z) = 1.380

BURNUP = 75 MWD/MTU

A.O = -5.30(%)

Figure 6.3

NORTH ANNA UNIT 2 - CYCLE 6 STARTUP PHYSICS TESTS

ASSEMBLYWISE POWER DISTRIBUTION

47% POWER

```
    R       P       N       M       L       K       J       H       G       F       E       D       C       B       A

        .  PREDICTED   .                        .  0.27 .  0.33 .  0.27 .                       .  PREDICTED   .
        .  MEASURED    .                        .  0.27 .  0.32 .  0.27 .                       .  MEASURED    .            1
        .PCT DIFFERENCE.                        .   0.8 .  -3.0 .   1.1 .                       .PCT DIFFERENCE.

                                .  0.34 .  0.65 .  1.11 .  0.86 .  1.11 .  0.65 .  0.34 .
                                .  0.36 .  0.65 .  1.10 .  0.85 .  1.10 .  0.65 .  0.35 .                                   2
                                .   5.1 .   0.7 .  -1.0 .  -1.2 .  -0.9 .   1.0 .   2.1 .

                        .  0.36 .  1.14 .  1.30 .  1.21 .  1.29 .  1.21 .  1.30 .  1.14 .  0.36 .
                        .  0.37 .  1.16 .  1.30 .  1.20 .  1.28 .  1.21 .  1.31 .  1.16 .  0.37 .                           3
                        .   2.0 .   1.7 .  -0.5 .  -0.6 .  -0.8 .  -0.2 .   1.0 .   1.7 .   3.2 .

                .  0.36 .  0.81 .  1.32 .  1.27 .  1.36 .  1.16 .  1.36 .  1.27 .  1.32 .  0.81 .  0.36 .
                .  0.37 .  0.82 .  1.33 .  1.28 .  1.36 .  1.16 .  1.35 .  1.28 .  1.32 .  0.81 .  0.36 .                   4
                .   2.7 .   1.3 .   1.3 .   0.8 .   0.4 .   0.3 .  -0.6 .   0.7 .   0.3 .   0.0 .  -0.2 .

        .  0.34 .  1.14 .  1.32 .  1.14 .  1.27 .  1.12 .  1.14 .  1.12 .  1.27 .  1.14 .  1.32 .  1.14 .  0.34 .
        .  0.34 .  1.15 .  1.31 .  1.13 .  1.28 .  1.15 .  1.17 .  1.14 .  1.29 .  1.14 .  1.30 .  1.10 .  0.33 .           5
        .   0.4 .   0.4 .  -0.4 .  -0.8 .   0.6 .   2.6 .   2.6 .   1.8 .   1.1 .  -0.1 .  -1.7 .  -3.6 .  -2.7 .

        .  0.65 .  1.30 .  1.27 .  1.27 .  1.04 .  1.25 .  1.06 .  1.25 .  1.04 .  1.27 .  1.27 .  1.30 .  0.65 .
        .  0.65 .  1.31 .  1.27 .  1.27 .  1.05 .  1.29 .  1.10 .  1.28 .  1.05 .  1.26 .  1.24 .  1.26 .  0.63 .           6
        .   0.5 .   3.4 .   0.2 .  -0.1 .   1.2 .   3.7 .   3.9 .   2.9 .   1.3 .  -1.2 .  -2.4 .  -3.5 .  -2.7 .

.  0.27 .  1.11 .  1.21 .  1.36 .  1.12 .  1.25 .  1.06 .  1.13 .  1.06 .  1.25 .  1.12 .  1.36 .  1.21 .  1.11 .  0.27 .
.  0.28 .  1.11 .  1.17 .  1.35 .  1.13 .  1.26 .  1.11 .  1.18 .  1.09 .  1.27 .  1.12 .  1.30 .  1.17 .  1.08 .  0.27 .   7
.   3.7 .   0.3 .  -3.3 .  -0.5 .   0.9 .   0.8 .   4.2 .   4.3 .   2.8 .   2.0 .  -0.0 .  -4.4 .  -3.1 .  -2.7 .  -1.8 .

.  0.33 .  0.86 .  1.30 .  1.16 .  1.14 .  1.06 .  1.13 .  1.14 .  1.13 .  1.06 .  1.14 .  1.16 .  1.30 .  0.86 .  0.33 .
.  0.34 .  0.86 .  1.25 .  1.15 .  1.16 .  1.08 .  1.15 .  1.17 .  1.14 .  1.08 .  1.13 .  1.11 .  1.26 .  0.86 .  0.33 .   8
.   3.3 .  -0.1 .  -3.3 .  -0.7 .   1.9 .   1.8 .   1.9 .   2.5 .   1.3 .   1.3 .  -0.5 .  -4.4 .  -3.1 .  -0.9 .   0.6 .

.  0.27 .  1.11 .  1.21 .  1.36 .  1.12 .  1.25 .  1.06 .  1.13 .  1.06 .  1.25 .  1.12 .  1.35 .  1.21 .  1.11 .  0.27 .
.  0.28 .  1.10 .  1.17 .  1.34 .  1.14 .  1.25 .  1.06 .  1.12 .  1.08 .  1.26 .  1.13 .  1.33 .  1.20 .  1.12 .  0.28 .   9
.   3.7 .  -1.1 .  -3.6 .  -1.8 .   1.9 .   0.5 .  -0.7 .  -0.6 .   1.1 .   1.0 .   1.0 .  -2.0 .  -0.8 .   0.5 .   2.3 .

        .  0.65 .  1.30 .  1.27 .  1.27 .  1.04 .  1.25 .  1.06 .  1.25 .  1.04 .  1.27 .  1.27 .  1.30 .  0.65 .
        .  0.62 .  1.25 .  1.24 .  1.27 .  1.03 .  1.25 .  1.07 .  1.24 .  1.03 .  1.27 .  1.28 .  1.32 .  0.67 .          10
        .  -4.0 .  -4.0 .  -2.1 .  -0.1 .  -0.5 .   0.4 .   0.6 .  -0.1 .  -0.4 .   0.0 .   0.7 .   1.1 .   3.3 .

        .  0.34 .  1.14 .  1.32 .  1.14 .  1.27 .  1.12 .  1.14 .  1.12 .  1.27 .  1.14 .  1.32 .  1.14 .  0.34 .
        .  0.33 .  1.10 .  1.29 .  1.14 .  1.27 .  1.13 .  1.15 .  1.12 .  1.27 .  1.14 .  1.34 .  1.17 .  0.35 .          11
        .  -4.1 .  -4.1 .  -2.0 .  -0.1 .  -0.4 .   0.6 .   0.7 .   0.0 .  -0.4 .  -0.0 .   1.7 .   2.0 .   2.7 .

                .  0.36 .  0.81 .  1.32 .  1.27 .  1.36 .  1.16 .  1.36 .  1.27 .  1.32 .  0.81 .  0.36 .
                .  0.35 .  0.81 .  1.31 .  1.26 .  1.34 .  1.14 .  1.33 .  1.25 .  1.30 .  0.83 .  0.37 .                  12
                .  -4.1 .  -0.2 .  -0.1 .  -0.1 .  -1.5 .  -1.5 .  -2.1 .  -1.5 .  -1.4 .   2.4 .   3.8 .

                        .  0.36 .  1.14 .  1.30 .  1.21 .  1.29 .  1.21 .  1.30 .  1.14 .  0.36 .
                        .  0.36 .  1.15 .  1.31 .  1.15 .  1.24 .  1.16 .  1.26 .  1.10 .  0.37 .                          13
                        .   0.9 .   0.9 .   1.0 .  -4.8 .  -4.1 .  -3.9 .  -3.5 .  -3.6 .   3.8 .

                                .  0.34 .  0.65 .  1.11 .  0.86 .  1.11 .  0.65 .  0.34 .
                                .  0.35 .  0.66 .  1.10 .  0.85 .  1.07 .  0.62 .  0.33 .                                  14
                                .   0.9 .   1.9 .  -0.9 .  -1.8 .  -3.7 .  -3.4 .  -3.6 .

        .   STANDARD   .                        .  0.27 .  0.33 .  0.27 .                       .    AVERAGE     .
        .  DEVIATION   .                        .  0.28 .  0.33 .  0.26 .                       .PCT DIFFERENCE.
        .   =1.345     .                        .   2.6 .  -0.3 .  -3.2 .                       .     = 1.7      .
```

SUMMARY

```
MAP NO: N2-6-03              DATE: 11/12/87                  POWER:   47%

CONTROL ROD POSITIONS:       F-Q(T)  = 2.126                 QPTR:

D BANK AT 160 STEPS          F-DH(M) = 1.476                 NW    1.016 | NE    1.000
                                                             ------------|------------
                             F(Z)    = 1.349                 SW    0.991 | SE    0.993

                             BURNUP  =     94 MWD/MTU     A.O =  -2.37(%)
```

Figure 6.4

NORTH ANNA UNIT 2 - CYCLE 6 STARTUP PHYSICS TESTS

ASSEMBLYWISE POWER DISTRIBUTION

HFP

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
		PREDICTED MEASURED PCT DIFFERENCE				0.30 0.30 1.0	0.37 0.38 1.0	0.30 0.30 0.9				PREDICTED MEASURED PCT DIFFERENCE			1
				0.35 0.37 5.5	0.65 0.65 0.0	1.13 1.13 -0.7	0.96 0.95 -0.3	1.13 1.13 -0.5	0.65 0.66 0.7	0.35 0.36 2.2					2
			0.36 0.37 2.2	1.10 1.12 1.8	1.25 1.24 -0.9	1.19 1.18 -1.1	1.29 1.27 -1.2	1.19 1.19 -0.4	1.25 1.26 0.9	1.10 1.12 1.9	0.36 0.38 3.8				3
		0.36 0.37 2.6	0.80 0.81 1.5	1.26 1.28 1.8	1.22 1.23 0.8	1.32 1.32 -0.1	1.15 1.14 -0.2	1.32 1.31 -0.7	1.22 1.24 1.1	1.26 1.27 0.6	0.80 0.80 0.5	0.36 0.37 0.7			4
	0.35 0.35 -0.1	1.10 1.10 -0.1	1.26 1.26 0.1	1.13 1.13 0.3	1.27 1.28 0.8	1.13 1.16 2.2	1.15 1.17 2.2	1.13 1.15 1.8	1.27 1.29 1.5	1.13 1.13 0.2	1.26 1.24 -1.4	1.10 1.09 -0.9	0.35 0.35 1.6		5
	0.65 0.66 0.6	1.25 1.26 0.6	1.22 1.24 0.9	1.27 1.29 1.0	1.14 1.16 1.6	1.28 1.32 3.4	1.09 1.13 3.4	1.28 1.32 3.2	1.14 1.16 1.7	1.27 1.26 -0.8	1.22 1.20 -1.9	1.25 1.22 -2.2	0.65 0.65 -1.0		6
0.30 0.31 3.1	1.13 1.14 0.3	1.19 1.18 -1.0	1.32 1.32 -0.3	1.13 1.14 0.6	1.28 1.29 0.6	1.10 1.14 4.1	1.15 1.20 4.1	1.10 1.13 2.9	1.28 1.31 2.3	1.13 1.14 0.4	1.32 1.27 -3.7	1.19 1.16 -2.9	1.13 1.10 -2.8	0.30 0.29 -2.0	7
0.38 0.39 3.1	0.96 0.96 0.2	1.29 1.27 -1.4	1.15 1.15 0.2	1.15 1.17 1.6	1.09 1.11 1.6	1.15 1.17 1.5	1.16 1.19 2.4	1.15 1.16 1.2	1.09 1.10 1.2	1.15 1.14 -0.3	1.15 1.10 -3.8	1.29 1.25 -2.9	0.96 0.95 -1.2	0.38 0.37 -0.0	8
0.30 0.31 3.1	1.13 1.12 -1.5	1.19 1.15 -3.8	1.32 1.31 -1.0	1.13 1.15 1.6	1.28 1.29 0.7	1.10 1.09 -1.1	1.15 1.14 -1.1	1.10 1.11 1.1	1.28 1.29 1.0	1.13 1.14 0.9	1.32 1.30 -1.8	1.19 1.19 -0.6	1.13 1.14 0.3	0.30 0.30 2.0	9
	0.65 0.63 -3.8	1.25 1.20 -3.8	1.22 1.22 -0.7	1.27 1.29 1.0	1.14 1.14 0.3	1.28 1.28 0.0	1.09 1.09 0.1	1.28 1.28 0.2	1.14 1.14 -0.1	1.27 1.27 0.2	1.22 1.23 0.7	1.25 1.27 1.4	0.65 0.67 2.9		10
	0.35 0.35 -0.7	1.10 1.09 -0.7	1.26 1.25 -0.4	1.13 1.13 0.3	1.27 1.26 -1.1	1.13 1.12 -0.8	1.15 1.14 -0.6	1.13 1.13 0.4	1.27 1.27 -0.0	1.13 1.13 0.5	1.26 1.28 1.7	1.10 1.12 2.1	0.35 0.36 3.1		11
		0.36 0.37 2.3	0.80 0.81 1.3	1.26 1.26 0.3	1.22 1.21 -1.2	1.32 1.29 -2.0	1.15 1.12 -1.9	1.32 1.30 -1.9	1.22 1.21 -1.2	1.26 1.25 -0.5	0.80 0.81 2.1	0.36 0.37 2.8			12
			0.36 0.37 1.7	1.10 1.11 1.0	1.25 1.24 -0.8	1.19 1.15 -3.6	1.29 1.24 -3.6	1.19 1.15 -3.8	1.25 1.21 -3.5	1.10 1.08 -1.2	0.36 0.37 2.7				13
				0.35 0.35 1.0	0.65 0.66 1.4	1.13 1.12 -1.2	0.96 0.94 -2.1	1.13 1.09 -3.8	0.65 0.63 -3.5	0.35 0.33 -3.7					14
		STANDARD DEVIATION =1.165				0.30 0.30 1.9	0.37 0.37 -0.6	0.30 0.29 -3.4				AVERAGE PCT DIFFERENCE = 1.5			

SUMMARY

MAP NO: N2-6-04

DATE: 11/16/87

POWER: 100%

CONTROL ROD POSITIONS:

D BANK AT 228 STEPS

F-Q(T) = 1.857

F-DH(M) = 1.396

F(Z) = 1.223

BURNUP = 222 MWD/MTU

QPTR:

NW 1.009	NE 1.003
SW 0.995	SE 0.993

A.O = -2.56(%)

Figure 6.5

NORTH ANNA UNIT 2 - CYCLE 6 STARTUP PHYSICS TESTS

ASSEMBLYWISE POWER DISTRIBUTION

HFP

PREDICTED
MEASURED
PCT DIFFERENCE

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
						0.30 0.30 1.3	0.37 0.38 1.3	0.30 0.30 1.6							1
				0.35 0.37 5.7	0.65 0.65 0.2	1.13 1.12 -0.5	0.9[illegible] 0.95 -0.6	1.13 1.13 0.0	0.65 0.66 1.9	0.35 0.36 3.0					2
			0.36 0.37 2.1	1.09 1.11 1.7	1.25 1.24 -1.0	1.19 1.17 -1.0	1.29 1.27 -1.2	1.19 1.18 -0.1	1.25 1.27 1.6	1.09 1.12 2.5	0.36 0.38 4.1				3
		0.36 0.37 2.6	0.80 0.81 1.3	1.26 1.28 1.5	1.22 1.23 0.5	1.32 1.32 -0.2	1.14 1.14 -0.3	1.32 1.31 -0.7	1.22 1.24 1.1	1.26 1.27 0.8	0.80 0.80 0.6	0.36 0.37 0.9			4
	0.35 0.35 -0.2	1.09 1.09 -0.2	1.26 1.26 -0.3	1.13 1.12 -0.2	1.28 1.28 0.4	1.13 1.15 1.8	1.15 1.17 1.7	1.13 1.15 1.6	1.28 1.30 1.5	1.13 1.13 0.3	1.26 1.24 -1.3	1.09 1.09 -0.7	0.35 0.35 1.9		5
	0.65 0.65 0.4	1.25 1.25 0.4	1.22 1.23 0.5	1.28 1.29 0.6	1.14 1.16 1.2	1.29 1.32 2.7	1.09 1.12 2.8	1.29 1.32 2.7	1.14 1.16 1.6	1.28 1.27 -0.9	1.22 1.20 -2.1	1.25 1.22 -2.2	0.55 0.64 -0.8		6
0.30 0.31 4.3	1.13 1.13 0.6	1.19 1.17 -1.0	1.32 1.32 -0.4	1.13 1.14 0.3	1.29 1.29 0.3	1.11 1.14 3.2	1.16 1.20 3.2	1.11 1.13 2.5	1.29 1.32 2.2	1.13 1.13 0.1	1.32 1.27 -4.1	1.19 1.15 -3.1	1.13 1.09 -2.8	0.30 0.29 -2.0	7
0.37 0.39 4.3	0.95 0.96 0.6	1.29 1.27 -1.4	1.14 1.14 -0.1	1.15 1.16 1.2	1.09 1.11 1.1	1.16 1.18 1.3	1.17 1.20 2.2	1.16 1.17 0.9	1.09 1.10 1.0	1.15 1.14 -0.6	1.14 1.10 -4.1	1.29 1.25 -3.1	0.95 0.94 -1.0	0.37 0.37 0.3	8
0.30 0.31 4.3	1.13 1.12 -0.9	1.19 1.14 -3.5	1.32 1.31 -1.2	1.13 1.15 1.1	1.29 1.29 0.2	1.11 1.09 -1.7	1.16 1.14 -1.7	1.11 1.11 0.9	1.29 1.30 0.8	1.13 1.14 0.8	1.32 1.30 -1.8	1.19 1.18 -0.4	1.13 1.13 0.7	0.30 0.30 2.5	9
	0.65 0.63 -3.6	1.25 1.20 -3.6	1.22 1.21 -0.7	1.28 1.29 0.8	1.14 1.14 -0.0	1.29 1.28 -0.4	1.09 1.09 -0.3	1.29 1.29 -0.2	1.14 1.14 -0.2	1.28 1.28 0.1	1.22 1.23 1.0	1.25 1.27 1.7	0.65 0.67 3.5		10
	0.35 0.35 -0.5	1.09 1.09 -0.5	1.26 1.26 -0.1	1.13 1.13 0.7	1.28 1.26 -1.3	1.13 1.12 -1.2	1.15 1.14 -1.1	1.13 1.13 -0.1	1.28 1.28 -0.1	1.13 1.13 0.4	1.26 1.28 1.9	1.09 1.12 2.3	0.35 0.36 3.7		11
		0.36 0.37 2.6	0.80 0.81 1.7	1.26 1.27 0.7	1.22 1.21 -1.3	1.32 1.29 -2.3	1.14 1.12 -2.2	1.32 1.30 -2.1	1.22 1.21 -1.3	1.26 1.25 -0.7	0.80 0.82 2.3	0.36 0.37 3.0			12
			0.36 0.37 2.2	1.09 1.11 1.9	1.25 1.24 -0.6	1.19 1.14 -3.8	1.29 1.24 -3.7	1.19 1.14 -3.8	1.25 1.20 -3.5	1.09 1.08 -1.5	0.36 0.37 2.8				13
				0.35 0.35 1.9	0.65 0.66 2.4	1.13 1.12 -0.7	0.95 0.94 -1.7	1.13 1.08 -3.8	0.65 0.63 -3.4	0.35 0.33 -3.7					14
						0.30 0.31 2.9	0.37 0.37 -0.0	0.30 0.29 -3.1							

STANDARD
DEVIATION
=1.214

AVERAGE
PCT DIFFERENCE
= 1.6

SUMMARY

MAP NO: N2-6-05

DATE: 11/23/87

POWER: 100%

CONTROL ROD POSITIONS:

D BANK AT 228 STEPS

F-Q(T) = 1.843

F-DH(M) = 1.398

F(Z) = 1.214

BURNUP = 502 MWD/MTU

QPTR:

NW	1.010	NE	1.003
SW	0.995	SE	0.992

A.O = -2.53(%)

SECTION 7

REFERENCES

1. D. A. Trace, "North Anna Unit 2, Cycle 6 Design Report," NE Technical Report No. 599, Virginia Electric and Power Company, September, 1987.

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

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

APPENDIX

STARTUP PHYSICS TESTS RESULTS AND EVALUATION SHEETS

NORTH ANNA POWER STATION UNIT 2 CYCLE 6
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Reactivity Computer Checkout Proc No /Section: 2-PT-94.0 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
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB: 228 CC: 228 CD: 115	RCS Temperature (°F): 546.9 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 11/03/87 0348	
	Measured Parameter (Description)	ρ_c = Meas. Reactivty using ρ-computer ρ_t = Inferred React from react period
	Measured Value	ρ_c = -44.5 pcm +44.0 pcm ρ_t = -46.0 pcm +44.0 pcm %D = -3.26% 0.0%
	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	
	* At The Just Critical Position Allowable Range = ± 44 pcm	

Completed By: Nolan W James II
Test Engineer

Evaluated By: C. O. Ford

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

NORTH ANNA POWER STATION UNIT 2 CYCLE 6
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Critical Boron Concentration - ARO Proc No /Section: 2-PT-94.0 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): 545.8 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 11/3/87 1000	
IV Test Results	Meas Parameter (Description)	$(C_B)^{M}_{ARO}$; Critical Boron Conc - ARO
	Measured Value	$(C_B)^{M}_{ARO}$ = 1982 ppm
	Design Value (Actual Cond)	C_B = 1994 ± 50 ppm
	Design Value (Design Cond)	C_B =1994 ± 50 ppm
	Reference	NE Technical Report No. 599
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 : x YES __NO Acceptance Criteria is met : x YES __NO	
	α_{C_B} = -7.27 pcm/ppm for preliminary analysis α_{C_B} = -6.82 pcm/ppm for final analysis	

Completed By:
Test Engineer

Evaluated By:

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

NORTH ANNA POWER STATION UNIT 2 CYCLE 6
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Isothermal Temperature Coefficient - ARO Proc No /Section: 2-PT-94.0	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 D: 212	RCS Temperature (°F): 544.3 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 11/3/87 1131	
IV Test Results	Meas Parameter (Description)	$(\alpha_T^{ISO})_{ARO}$ Isothermal Temp Coeff - ARO
	Measured Value	$(\alpha_T^{ISO})_{ARO} = -0.6$ pcm/°F (C_B = 1979 ppm)
	Design Value (Actual Cond)	$(\alpha_T^{ISO})_{ARO} = -0.94 \pm 3.0$ pcm/°F (C_B = 1979 ppm)
	Design Value (Design Cond)	$(\alpha_T^{ISO})_{ARO} = -0.79 \pm 3.0$ pcm/°F (C_B = 1994 ppm)
	Reference	NE Technical Report No. 599
V Acceptance Criteria	FSAR/Tech Spec	$\alpha_T^{ISO} \le 3.77^*$ pcm/°F $\alpha_T^{Dop} = -1.73$ pcm/°F
	Reference	TS 3.1.1.4, NE Technical Report No. 599
VI Comments	Design Tolerance is met : x YES __NO Acceptance Criteria is met : x YES __NO	
	Uncertainty on $\alpha_{T_{MOD}}$ = 0.5 pcm/°F (Reference memorandum from C.T. Snow to E.J. Lozito, June 27, 1980)	

Completed By: __________
Test Engineer

Evaluated By: __________

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

NORTH ANNA POWER STATION UNIT 2 CYCLE 6
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-94.0 Sequence Step No: 6	
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): 545.5 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 11/3/87 1257	
IV Test Results	Measured Parameter (Description)	I_B^{REF}; Integral Worth of Cntl Bank B, All Other Rods Out
	Measured Value	I_B^{REF} = 1281.7 pcm
	Design Value (Actual Conditions)	I_B^{REF} = 1367 ± 137 pcm
	Design Value (Design Conditions)	I_B^{REF} = 1367 ± 137 pcm
	Reference	NE Technical Report No. 599
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 : x YES __NO Acceptance Criteria is met : x YES __NO	

Completed By: __________
Test Engineer

Evaluated By: H. S. Pierce

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

NORTH ANNA POWER STATION UNIT 2 CYCLE 6
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Critical Boron Concentration - B Bank In Proc No /Section: 2-PT-94.0 Sequence Step No: 7	
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): 546.7 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 11/3/87 1832	
	Meas Parameter (Description)	$(C_B)^M_D$; Critical Boron Conc - B Bank In
	Measured Value	$(C_B)^M_D$ = 1794 ppm
	Design Value (Actual Cond)	C_B = 1794 ± 30 ppm
	Design Value (Design Cond)	$C_B = 1806 + \Delta C_B^{Prev} \pm (10 + 136.7/\lvert\alpha_{C_B}\rvert)$ppm
	Reference	NE Technical Report No. 599
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 : x YES __NO Acceptance Criteria is met : x YES __NO	
	α_{C_B} = -7.27 pcm/ppm for preliminary analysis $\Delta C_B^{Prev} = (C_B)^M_{ARO} - 1994 = (1982-1994) = -12$ ppm	

Completed By: __________
Test Engineer

Evaluated By: __________

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

NORTH ANNA POWER STATION UNIT 2 CYCLE 6
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: HZP Boron Worth Coefficent Measurement Proc No /Section: 2-PT-94.0 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): 545.8 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 11/3/87 1000	
IV Test Results	Measured Parameter (Description)	α_{C_B} , Boron Worth Coefficient
	Measured Value	α_{C_B} = -6.82 pcm/ppm
	Design Value (Actual Conditions)	α_{C_B} = -7.27 ± 0.73 pcm/ppm
	Design Value (Design Conditions)	α_{C_B} = -7.27 ± 0.73 pcm/ppm
	Reference	NE Technical Report No. 599
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 : X YES ___NO Acceptance Criteria is met : X YES ___NO	

Completed By: ____________
Test Engineer

Evaluated By: ____________

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

NORTH ANNA POWER STATION UNIT 2 CYCLE 6
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Cntl Bank D Worth Measurement-Rod Swap Proc No /Section: 2-PT-94.0 Sequence Step No: 9	
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): 546.8 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 11/3/87 2125	
IV Test Results	Meas Parameter (Description)	I_D^{RS};Int Worth of Cntl Bank D-Rod Swap
	Measured Value	I_D^{RS}= 944.4 pcm (Adj. Meas. Crit. Ref Bank Position = 149 steps)
	Design Value (Actual Cond)	I_D^{RS}= 994.2± 149 pcm (Adj. Meas. Crit. Ref Bank Position = 149 steps)
	Design Value (Design Cond)	I_D^{RS}= 997 ± 150 pcm (Critical Ref Bank Position = 148 steps)
	Reference	NE Technical Report No. 599, 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 : x YES ___NO Acceptance Criteria is met : x YES ___NO	

Completed By: ______________
Test Engineer

Evaluated By: ______________

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

NORTH ANNA POWER STATION UNIT 2 CYCLE 6
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Cntl Bank C Worth Measurement-Rod Swap Proc No /Section: 2-PT-94.0 Sequence Step No: 10	
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): 546.8 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 11/3/87 2204	
	Meas Parameter (Description)	I_C^{RS};Int Worth of Cntl Bank C-Rod Swap
	Measured Value	$I_C^{RS}=$ 714.9 pcm (Adj. Meas. Crit. Ref Bank Position = 114 steps)
	Design Value (Actual Cond)	$I_C^{RS}=$ 732.2±110 pcm (Adj. Meas. Crit. Ref Bank Position = 114 steps)
	Design Value (Design Cond)	$I_C^{RS}=$ 731 ± 110 pcm (Critical Ref Bank Position = 113 steps)
	Reference	NE Technical Report No. 599, 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 : x YES __NO Acceptance Criteria is met : x YES __NO	

Completed By: __________
Test Engineer

Evaluated By: __________

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

NORTH ANNA POWER STATION UNIT 2 CYCLE 6
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Cntl Bank A Worth Measurement-Rod Swap Proc No /Section: 2-PT-94.0	Sequence Step No: 11
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): 546.6 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 11/3/87 2300	
IV Test Results	Meas Parameter (Description)	I_A^{RS};Int Worth of Cntl Bank A - Rod Swap
	Measured Value	I_A^{RS}= 327.2 pcm (Adj. Meas. Crit. Ref Bank Position = 71 steps)
	Design Value (Actual Cond)	I_A^{RS}= 332.3$\pm$100 pcm (Adj. Meas. Crit. Ref Bank Position = 71 steps)
	Design Value (Design Cond)	I_A^{RS}= 335 ± 100 pcm (Critical Ref Bank Position = 74 steps)
	Reference	NE Technical Report No. 599, VEP-FRD-36A, NFO-TI-2.2A
V Acceptance Criteria	FSAR/Tech Spec	If Design Tolerance is exceeded, SNSCC 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 : x YES ___NO Acceptance Criteria is met : x YES ___NO	

Completed By: ______________
Test Engineer

Evaluated By: K L Pierce

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

NORTH ANNA POWER STATION UNIT 2 CYCLE 6
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Shutdown Bank B Worth Meas. - Rod Swap Proc No /Section: 2-PT-94.0 Sequence Step No: 12		
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): 546.6 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 11/3/87 2333		
IV Test Results	Meas Parameter (Description)	I_{SB}^{RS};Int Worth of Shutdown Bank B-Rod Swap	
	Measured Value	I_{SB}^{RS}= 920.9 pcm	(Adj. Meas. Crit. Ref Bank Position = 145 steps)
	Design Value (Actual Cond)	I_{SB}^{RS}= 952.6± 143 pcm	(Adj. Meas. Crit. Ref Bank Position = 145 steps)
	Design Value (Design Cond)	I_{SB}^{RS}= 955 ± 143 pcm	(Critical Ref Bank Position = 142 steps)
	Reference	NE Technical Report No. 599, 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 : x YES __NO Acceptance Criteria is met : x YES __NO		

Completed By: Test Engineer

Evaluated By: K. L. Pierce

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

NORTH ANNA POWER STATION UNIT 2 CYCLE 6
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Shutdown Bank A Worth Meas. - Rod Swap Proc No /Section: 2-PT-94.0 Sequence Step No: 13	
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): 546.7 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 11/4/87 0010	
IV Test Results	Meas Parameter (Description)	I_{SA}^{RS}; Int Worth of Shutdown Bank A-Rod Swap
	Measured Value	I_{SA}^{RS} = 955.2 pcm (Adj. Meas. Crit. Ref Bank Position = 150 steps)
	Design Value (Actual Cond)	I_{SA}^{RS}=1044.5±157 pcm (Adj. Meas. Crit. Ref Bank Position = 150 steps)
	Design Value (Design Cond)	I_{SA}^{RS} = 1049 ± 157 pcm (Critical Ref Bank Position = 156 steps)
	Reference	NE Technical Report No. 599, 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 : X YES __ NO Acceptance Criteria is met : X YES __ NO	

Completed By: __________
Test Engineer

Evaluated By: K. L. Pierce

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

NORTH ANNA POWER STATION UNIT 2 CYCLE 6
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Total Rod Worth - Rod Swap Proc No /Section: 2-PT-94.0 Sequence Step No: 14	
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): 545.5 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 11/3/87 1257	
	Meas Parameter (Description)	I_{Total}, Int Worth of All Banks - Rod Swap
	Measured Value	I_{Total} = 5144.3 pcm
	Design Value (Actual Cond)	I_{Total} = 5422.8 ± 542 pcm
	Design Value (Design Cond)	I_{Total} = 5434 ± 543 pcm
	Reference	NE Technical Report No. 599, 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 : x YES __NO Acceptance Criteria is met : x YES __NO	

Completed By: __________
Test Engineer

Evaluated By: N. L. Pierce

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

NORTH ANNA POWER STATION UNIT 2 CYCLE 6
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference

Test Description : M/D Flux Map - At power
Proc No / Section: 2-PT-21.1 Sequence Step No: 40

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.): <30%
Other (specify)
Must have ≥ 38 thimbles

III Test Conditions (Actual)

Bank Positions (Steps)
SDA: 228 SDB: 228 CA: 228
CB : 228 CC : 228 CD: 129

RCS Temperature(°F): Tref
Power Level (% F.P.): 28.2%
Other (Specify):
39 Thimbles

Date/Time Test Performed: 11/6/87 0713

	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	-5.7% for $P_i \geq 0.90$ at J13 7.1% for $P_i < 0.90$ at L2	1.549	2.265	1.0156
	Design Value (Design Conds)	± 10% for $P_i \geq 0.9$ ± 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	$F^N_{\Delta H} \leq 1.49[1+.3(1-P)]$	$F^T_Q(Z) \leq 4.30 \times K(Z)$	NA
	Reference	NONE	TS 3.2.3	TS 3.2.2	TS 3.2.4

VI Comments

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

* As Required

Completed By: ______________ Test Engineer

Evaluated By: K. L. Pierce

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

NORTH ANNA POWER STATION UNIT 2 CYCLE 6
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description : M/D Flux Map - At power Proc No / Section: 2-PT-21.1 Sequence Step No: 42	
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.): <75% Other (specify) Must have ≥ 38 thimbles
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB : 228 CC : 228 CD: 160	RCS Temperature(°F): T_{ref} Power Level (% F.P.): 47% Other (Specify): 39 thimbles
	Date/Time Test Performed: 11/12/87 0854	

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	-7.8% for $P_i \ge 0.90$ at J13 5.1% for $P_i < 0.90$ at L2	1.476	2.126	1.0164
	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	$F^N_{\Delta H} \le 1.49[1+.3(1-P)]$	$F^T_Q(Z) \le 2.18/P \times K(Z)$	NA
	Reference	NONE	TS 3.2.3	TS 3.2.2	TS 3.2.4

VI
Comments

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

* As Required

Completed By: Test Engineer

Evaluated By:

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

NORTH ANNA POWER STATION UNIT 2 CYCLE 6
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference

Test Description : M/D Flux Map - HFP, ARO, Eq. Xenon
Proc No / Section: 2-PT-21.1
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.): 95 ± 5
Other (specify)
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):
47 Thimbles

Date/Time Test Performed: 11/16/87 0950

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	+1% for $P_i \geq 0.9$ i=H7 3.5% for $P_i < 0.9$ i=L2	1.396	1.857	1.0094
	Design Value (Design Conds)	± 10% for $P_i \geq 0.9$ ± 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	$F^N_{\Delta H} \leq 1.49[1+.3(1-P)]$	$F^T_Q(Z) \leq 2.19/P \times K(Z)$	NA
	Reference	NONE	TS 3.2.3	TS 3.2.2	TS 3.2.4

VI Comments

Design Tolerance is met : X YES __NO
Acceptance Criteria is met : X YES __NO

* As Required

Completed By: Robert W. Jones
Test Engineer

Evaluated By: D. L. Pierce

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

NORTH ANNA POWER STATION UNIT 2 CYCLE 6
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference

Test Description : M/D Flux Map - 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.): 95±5
Other (specify) **

III Test Conditions (Actual)

Bank Positions (Steps)
SDA: 228 SDB: 228 CA: 228
CB : 228 CC : 228 CD: 205

RCS Temperature(°F): T_{ref}
Power Level (% F.P.): 100%
Other (Specify):
21 Thimbles
quarter core flux map

Date/Time Test Performed: 11/24/87 0637

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
	Measured Value	-7.8% for $P_i \geq 0.9$ i = H8 -4.7% for $P_i < 0.9$ i = H15	NA	NA	NA
	Design Value (Design Conds)	± 10% for $P_i \geq 0.9$ ± 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	$F^N_{\Delta H} \leq 1.49(1+.3(1-P))$	$F^T_Q(Z) \leq 2.19/P \times K(Z)$	NA
	Reference	NONE	TS 3.2.3	TS 3.2.2	TS 3.2.4

VI Comments

Design Tolerance is met : X YES __NO
Acceptance Criteria is met : x YES __NO

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

Completed By: Robert M Farmer II
Test Engineer

Evaluated By: C. C. Ford

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

NORTH ANNA POWER STATION UNIT 2 CYCLE 6
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description : M/D Flux Map - NI Calibration Proc No / Section: 2-PT 22.2	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) **
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB : 228 CC : 228 CD: 228	RCS Temperature(°F): Tref Power Level (% F.P.): 100% Other (Specify): 25 Thimbles quarter core flux map
	Date/Time Test Performed: 11/24/87 1743	

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	3.8% for $P_i \geq 0.9$ i = H8 3.3% for $P_i < 0.9$ i = H15	NA	NA	NA
	Design Value (Design Conds)	± 10% for $P_i \geq 0.9$ ± 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	$F^N_{\Delta H} \leq 1.49[1+.3(1-P)]$	$F^T_Q(Z) \leq 2.18/P \times K(Z)$	NA
	Reference	NONE	TS 3.2.3	TS 3.2.2	TS 3.2.4

VI Comments	Design Tolerance is met : X YES __NO Acceptance Criteria is met : X YES __NO
	* As Required ** Must have at least 38 thimbles for a full core flux map, or at least 16 thimbles for a quarter-core flux map.

Completed By: ________
Test Engineer

Evaluated By: K. L. Pierce

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

NORTH ANNA POWER STATION UNIT 2 CYCLE 6
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description : M/D Flux Map - NI Calibration Proc No / Section: 2-PT-22.2	Sequence Step No: 48
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) **
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB : 228 CC : 228 CD: 228	RCS Temperature(°F): Tref Power Level (% F.P.): 100% Other (Specify):
	Date/Time Test Performed: 11/25/87 0854	26 Thimbles quarter core flux map

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
	Measured Value	-3.0% for $P_i \geq 0.9$ i = H3 3.0% for $P_i < 0.9$ i = H15	NA	NA	NA
	Design Value (Design Conds)	± 10% for $P_i \geq 0.9$ ± 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	$F^N_{\Delta H} \leq 1.49[1+.3(1-P)]$	$F^T_Q(Z) \leq 2.19/P \times K(Z)$	NA
	Reference	NONE	TS 3.2.3	TS 3.2.2	TS 3.2.4

VI Comments

Design Tolerance is met : X YES __NO
Acceptance Criteria is met : X YES __NO

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

Completed By: __________
Test Engineer

Evaluated By: Pierce

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