North Anna Unit 1 Cycle 9 Startup Physics Report

Nuclear Analysis and Fuel
Nuclear Engineering Services

May, 1991

VIRGINIA POWER

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TECHNICAL REPORT NE-840 - Rev. 0

NORTH ANNA UNIT 1, CYCLE 9

STARTUP PHYSICS TESTS REPORT

NUCLEAR ANALYSIS AND FUEL
NUCLEAR ENGINEERING SERVICES
VIRGINIA POWER
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PREFACE

This report presents the analysis and evaluation of the physics tests which were performed to verify that the North Anna 1, Cycle 9 core could be operated safely, and makes 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 testing 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 1, Cycle 9 startup physics tests results and evaluation sheets are 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 Analysis and Fuel 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.

SECTION 1

INTRODUCTION AND SUMMARY

On January 12, 1991 Unit No. 1 of the North Anna Power Station shutdown for its eighth refueling. During this shutdown, 93 of the 157 fuel assemblies in the core were replaced with 68 fresh fuel assemblies, one once-burned fuel assembly, and 24 twice-burned fuel assemblies. The ninth cycle core consists of 11 sub-batches of fuel: five once-burned batches, four from Cycle 8 (batches 10A, 10B, 10C, and N2/9B) and one from Cycle 7 (batch 9B); four twice-burned batches, one from North Anna 1 Cycles 5 and 6 (batch 7A), two from North Anna 1 Cycles 6 and 7 (batches 8A and 8B), and one from North Anna 2 Cycles 4 and 5 (batch N2/6); and two fresh batches (batches 11A and 11B). The two fresh batches of fuel assemblies have top and bottom grids of Inconel-718 while the inner six grids are made of Zircaloy-4 (all reload batches have eight grids made of Inconel-718). Cycle 9 incorporates a new burnable poison rod design made of B_4C in Alumina, which is available in various enrichments of B_4C. Six core locations occupied by neither control rod banks nor burnable poison assemblies will have demonstration thimble plugging devices inserted. Twenty-four peripheral assemblies will have baffle clips mounted on them to help protect against baffle jetting degradation. The center assembly, 4M2 of batch 9B, is a test assembly which is part of the demonstration corrosion program. It contains several rods clad in Zirconium-based advanced alloys instead of the standard Zircaloy-4 cladding as well as 18 replacement 1.9 w/o U-235 fresh fuel rods. Reference 1 provides a more detailed description of the Cycle 9 core.

The core loading pattern and the design parameters for each sub-batch are shown in Figure 1.1. Fuel assembly burnups are given in Figure 1.2. The available incore moveable detector locations used for the BOC flux map analysis are identified in Figure 1.3. Figure 1.4 identifies the location and number of burnable poison rods and source assemblies for Cycle 9, and Figure 1.5 identifies the location and number of control rods in the Cycle 9 core.

On March 7, 1991 at 2301, the ninth 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 measured drop time of each control rod was within the 2.7 second limit of Technical Specification 3.1.3.4.

2. Individual control rod bank worths were measured using the rod swap technique[2] and the results were within 3.4% of the design predictions. The sum of the individual measured control rod bank worths was within 0.2% 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. Measured critical boron concentrations for two control bank configurations were within 32 ppm of the design predictions.

These results were within the design tolerances and also met the Technical Specification 4.1.1.1.2 criterion that the overall core reactivity balance shall be within ±1% Δk/k of the design prediction.

4. The boron worth coefficient measurement was within 1.2% of the design prediction, which is within the design tolerance of ±10%.

5. The measured isothermal temperature coefficient (ITC) for the all-rods-out configuration was within 0.85 pcm/°F of the design prediction. This result is within the design tolerance of ±3 pcm/°F. The measured ITC of -0.90 pcm/°F meets the Technical Specification 3.1.1.4 criterion that the moderator temperature coefficient (MTC) be less than or equal to +6.0 pcm/°F. When the Doppler temperature coefficient and a 0.5 pcm/°F uncertainty are accounted for in the MTC limit, the MTC requirement is satisfied as long as the ITC is less than or equal to +3.75 pcm/°F.

6. Mode 1 (See Reference 4) core power distributions were within established design tolerances. Generally, the measured core power distribution was within 1.8% of the design predictions. The heat flux hot channel factors, F-Q(T), and enthalpy rise hot channel factors, F-DH(M), were within the limits of Technical Specifications 3.2.2 and 3.2.3, respectively.

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

Table 1.1

NORTH ANNA 1 - CYCLE 9 STARTUP PHYSICS TESTS
CHRONOLOGY OF TESTS

Test	Date	Time	Power	Reference Procedure
Hot Rod Drop - Hot Full Flow	03/07/91	0930	HSD	1-PT-17.2
Zero Power Testing Range	03/08/91	0005	HZP	1-PT-94.0
Reactivity Computer Checkout	03/08/91	0032	HZP	1-PT-94.0
Boron Endpoint - ARO	03/08/91	0320	HZP	1-PT-94.0
Temperature Coefficient - ARO	03/08/91	0436	HZP	1-PT-94.0
Bank B Worth	03/08/91	0534	HZP	1-PT-94.0
Boron Endpoint - B in	03/08/91	1105	HZP	1-PT-94.0
Bank SA Worth - Rod Swap	03/08/91	1136	HZP	1-PT-94.0
Bank SB Worth - Rod Swap	03/08/91	1301	HZP	1-PT-94.0
Bank A Worth - Rod Swap	03/08/91	1349	HZP	1-PT-94.0
Bank C Worth - Rod Swap	03/08/91	1419	HZP	1-PT-94.0
Bank D Worth - Rod Swap	03/08/91	1454	HZP	1-PT-94.0
Flux Map - 24% Power	03/10/91	1123	24%	1-PT-21.1
Flux Map - Peaking Factor Verification	03/11/91	1125	41%	1-PT-21.1
Flux Map - Peaking Factor Verification	03/12/91	1431	70%	1-PT-21.1
Flux Map - Peaking Factor Verification	03/13/91	0802	89%	1-PT-21.1
Flux Map - Peaking Factor Verification	03/13/91	2358	94%	1-PT-21.1
Flux Map - Monitor FQ(Z)/K(Z) / Hot Full Power	03/19/91	1108	99%	1-PT-21.1
Flux Map - Monitor FQ(Z)/K(Z)	03/25/91	1525	99%	1-PT-21.1
Flux Map - I/E Calibration	04/01/91	1402	99%	1-PT-21.1
Flux Map - I/E Calibration	04/02/91	0627	99%	1-PT-22.2
Flux Map - I/E Calibration	04/02/91	1727	99%	1-PT-22.2

1

IMAGE EVALUATION
TEST TARGET (MT-3)

150mm

6"

1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

Figure 1.1

NORTH ANNA UNIT 1 - CYCLE 9
CORE LOADING MAP

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
						8A H18	10C K70	8A H26							1
				N2/6 T28	10A K35	11B 6A7	10B K52	11B 5A3	10A K33	7A G13					2
			8B H48	11B 4A7	11B 6A2	10C K69	11B 3A4	10C K73	11B 4A1	11B 6A1	8B H30				3
		8B H29	N2/9B X44	11B 6A8	10B K63	11A 0A8	10B K57	11A 2A5	10B K40	11B 5A0	10B K59	8B H55			4
	7A G06	11B 6A0	11B 4A0	10B K49	11A 1A3	10A K15	11A 1A9	10A K27	11A 0A6	10B K54	11B 3A3	11B 4A4	7A G14		5
	10A K22	11B 5A1	10B K38	11A 2A7	10B K44	11A 0A1	10A K32	11A 2A8	10B K39	11A 1A6	10B K55	11B 6A6	10A K13		6
8A H19	11B 3A6	10C K65	11A 0A5	10A K20	11A 2A2	10A K28	11A 1A0	10A K17	11A 3A1	10A K21	11A 0A9	10C K67	11B 5A2	8A H16	7
10C K71	10B K58	11B 6A5	10B K46	11A 3A0	10A K34	11A 1A5	9B AM2	11A 0A4	10A K23	11A 2A0	10B K45	11B 3A7	10B K64	10C K76	8
8A H22	11B 4A5	10C K74	11A 1A7	10A K30	11A 2A4	10A K14	11A 2A1	10A K29	11A 2A6	10A K26	11A 2A9	10C K75	11B 5A9	8A H15	9
	10A K16	11B 5A7	10B K62	11A 0A3	10B K48	11A 3A2	10A K18	11A 0A7	10B K61	11A 1A2	10B K43	11B 4A3	10A K31		10
	7A G54	11B 3A5	11B 4A8	10B K42	11A 1A1	10A K24	11A 1A4	10A K36	11A 1A8	10B K37	11B 5A5	11B 6A3	7A G10		11
		8B H47	10B K56	11B 3A9	10B K51	11A 2A3	10B K53	11A 0A2	10B K50	11B 4A6	10B K60	8B H31			12
			8B H32	11B 5A4	11B 6A4	10C K72	11B 5A8	10C K68	11B 5A6	11B 3A8	8B H46				13
				7A G50	10A K25	11B 4A2	10B K47	11B 4A9	10A K19	7A G03					14
						8A H12	10C '66	8A H01							15

--> BATCH
--> ASSEMBLY ID

FUEL ASSEMBLY DESIGN PARAMETERS

	SUB-BATCH										
	7A	8A	8B	9B	10A	10B	10C	11A	11B	N2/6	N2/9B
INITIAL ENRICHMENT (W/O U-235)	3.60	3.60	3.80	3.99	3.80	4.00	3.82	4.01	4.19	3.60	4.01
BURNUP AT BOC 9 (MWD/MTU)	32943	31980	38876	21136	25491	22850	22246	0	0	33942	19664
ASSEMBLY TYPE	17x17	17x17	17x17	17x17	17x17	17x17	17x17	17x17	17x17	17x17	17x17
NUMBER OF ASSEMBLIES	7	8	8	1	24	27	12	32	36	1	1
FUEL RODS PER ASSEMBLY	264	264	264	264	264	264	264	264	264	264	264

Figure 1.2

NORTH ANNA UNIT 1 - CYCLE 9
BEGINNING OF CYCLE FUEL ASSEMBLY BURNUPS

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							H18 31963	K70 25848	H26 31698						
2					128 33942	K35 25284	6A7 0	K52 19[illegible]93	5A3 0	K33 24968	G13 32868				
3				H48 39007	4A7 0	6A2 0	K69 20422	3A4 0	K73 20762	4A1 0	6A1 0	H30 39249			
4			H29 38588	X44 19664	6A8 0	K63 24108	0A8 0	K57 22936	2A5 0	K40 24665	5A0 0	K59 19867	H55 39046		
5		G06 33189	6A0 0	4A0 0	K49 24120	1A3 0	K15 25569	1A9 0	K27 25930	0A6 0	K54 24382	3A3 0	4A4 0	G14 32750	
6		K22 25403	5A1 P	K38 24501	2A7 0	K44 23713	0A1 0	K32 26038	2A8 0	K39 23795	1A6 0	K55 24473	6A6 0	K13 25365	
7	H19 32128	3A6 0	K65 20138	0A5 0	K20 25530	2A2 0	K28 25786	1A0 0	K17 25941	3A1 0	K21 25622	0A9 0	K67 20709	5A2 0	H16 31541
8	K71 26135	K58 19046	6A5 0	K46 23931	3A0 0	K34 25231	1A5 0	AM2 21136	0A4 0	K23 26017	2A0 0	K45 24153	3A7 0	K64 19446	K76 25420
9	H22 32167	4A5 0	K74 20520	1A7 0	K30 25833	2A4 0	K14 25518	2A1 0	K29 25416	2A6 0	K26 25581	2A9 0	K75 20806	5A9 0	H15 31916
10		K16 24948	5A7 0	K62 24490	0A3 0	K48 22987	3A2 0	K18 25312	0A7 0	K61 23813	1A2 0	K43 24091	4A3 0	K31 25035	
11		G54 32934	3A5 0	4A8 0	K42 24397	1A1 0	K24 25375	1A4 0	K36 25499	1A8 0	K37 23848	5A5 0	6A3 0	F16 33476	
12			H47 38794	K56 19112	3A9 0	K51 24592	2A3 0	K53 23284	0A2 0	K50 24814	4A6 0	K60 19236	H31 38822		
13				H32 38464	5A4 0	6A4 0	K72 21333	5A8 0	K6[illegible] 20078	5A6 0	3A8 0	H46 39043			
14					G50 32634	K25 25536	4A2 0	K47 19985	4A9 0	K19 25238	G03 32756				
15							H12 31435	K66 24764	H01 32987						

--> ASSEMBLY ID
--> ASSEMBLY BURNUP (MWD/MTU)

Figure 1.3

NORTH ANNA UNIT 1 - CYCLE 9
AVAILABLE INCORE MOVEABLE DETECTOR LOCATIONS

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

MD - Moveable Detector

Figure 1.4

NORTH ANNA UNIT 1 - CYCLE 9
BURNABLE POISON AND SOURCE ASSEMBLY LOCATIONS

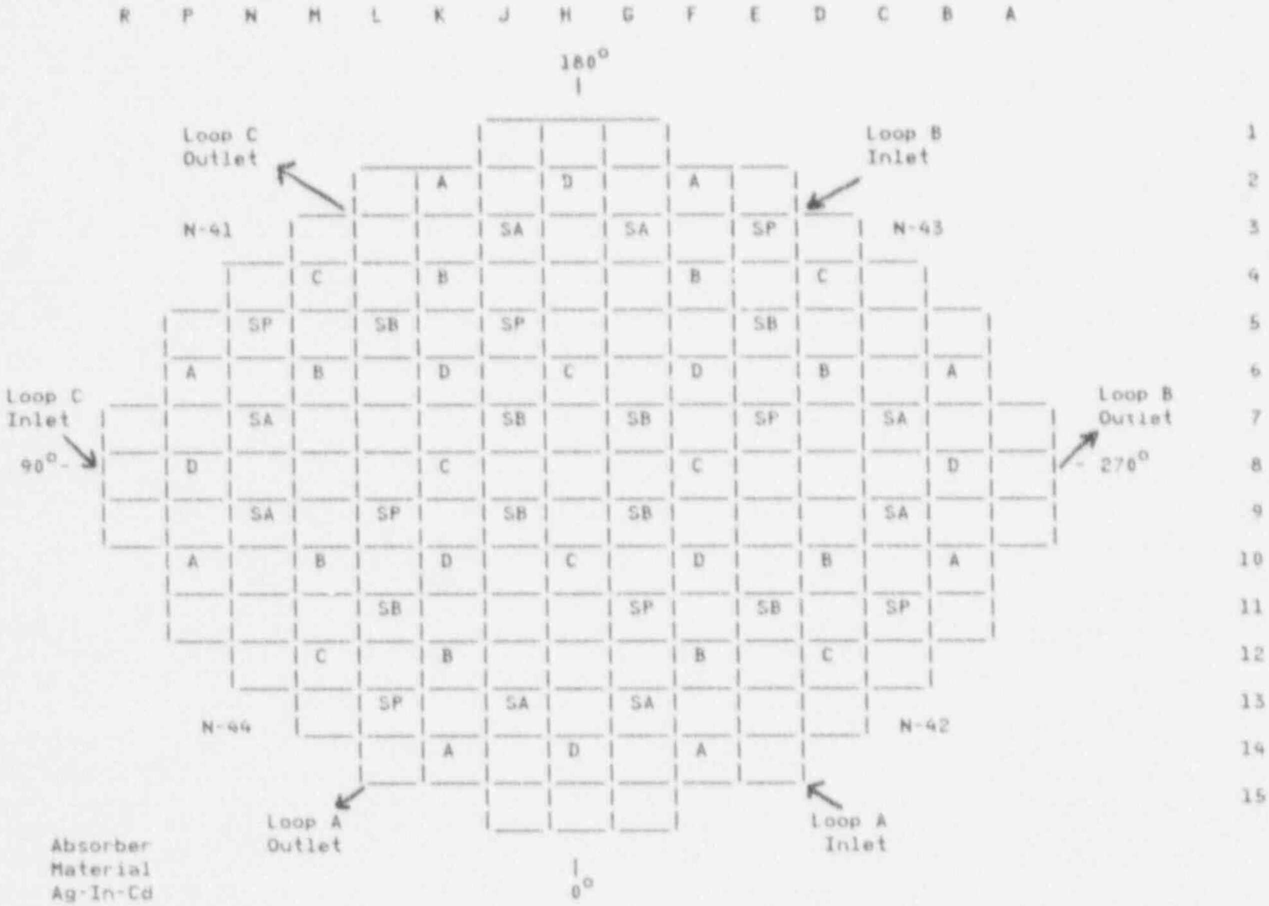
	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1															
2															
3					4P BP121	24P BP109		16P BP081		24P BP110	4P BP123				
4					16P BP082		20P BP093		20P BP094		16P BP083				
5			4P BP122	16P BP084		20P BP095		16P BP069		20P BP096		16P BP085	4P BP124		
6			24P BP111		20P BP097		16P BP070		16P BP071		20P BP098		24P BP112		
7				20P BP099		16P BP072		20P BP065		16P BP073		20P BP100			
8			16P BP086	SS19	16P BP074		20P BP066		20P BP067		16P BP075	SS20	16P BP087		
9				20P BP101		16P BP076		20P BP068		16P BP077		20P BP10[illegible]			
10			24P BP113		20P BP103		16P BP078		16P BP079		20P BP104		24P BP114		
11			4P BP119	16P BP088		20P BP105		16P BP080		20P BP106		16P BP089	4P BP117		
12					16P BP090		20P BP107		20P BP108		16P BP091				
13					4P BP120	24P BP115		16P BP092		24P BP116	4P BP118				
14															
15															

4P - 4 BURNABLE POISON ROD CLUSTER
16P - 16 BURNABLE POISON ROD CLUSTER
20P - 20 BURNABLE POISON ROD CLUSTER
24P - 24 BURNABLE POISON ROD CLUSTER
SSxx - SECONDARY SOURCE

xxP or SSxx	- # OF BP RODS or SECONDARY SOURCE ID
BP***	- BP ASSEMBLY ID

Figure 1.5

NORTH ANNA UNIT 1 - CYCLE 9
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 reactor coolant system (RCS) conditions in order to verify that the time from initiation of the rod drop to the entry of the rod into the dashpot was less than or equal to the maximum allowed by Technical Specification 3.1.3.4. The control rod drop times were measured in Mode 3* with the RCS Tavg above 500°F and all reactor coolant pumps operating.

The rod drop times were measured by withdrawing a rod bank to its fully withdrawn position, and removing the moveable gripper coil fuse and stationary gripper coil fuse for the particular rod of the bank to be dropped. This allowed the rod to drop into the core as it would during a plant trip. The stationary gripper coil voltage and the Individual Rod Position Indication (IRPI) primary coil voltage signals were recorded to determine the rod drop time. This procedure was repeated for each control rod.

As shown on the sample rod drop trace in Figure 2.1, the initiation of the rod drop is indicated by the decay of the stationary gripper coil voltage when the stationary gripper coil fuse is removed. As the rod drops, a voltage is induced in the IRPI primary coil. The magnitude of this voltage is a function of control rod velocity. As the rod enters the dashpot region of the guide tube, its velocity slows causing a voltage decrease in the IRPI coil. This voltage reaches a minimum when the rod reaches the bottom of the dashpot. Subsequent variations in the trace are caused by rod bouncing.

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 2.7 seconds with the RCS at hot, full flow conditions. These test results satisfied this limit.

Table 2.1

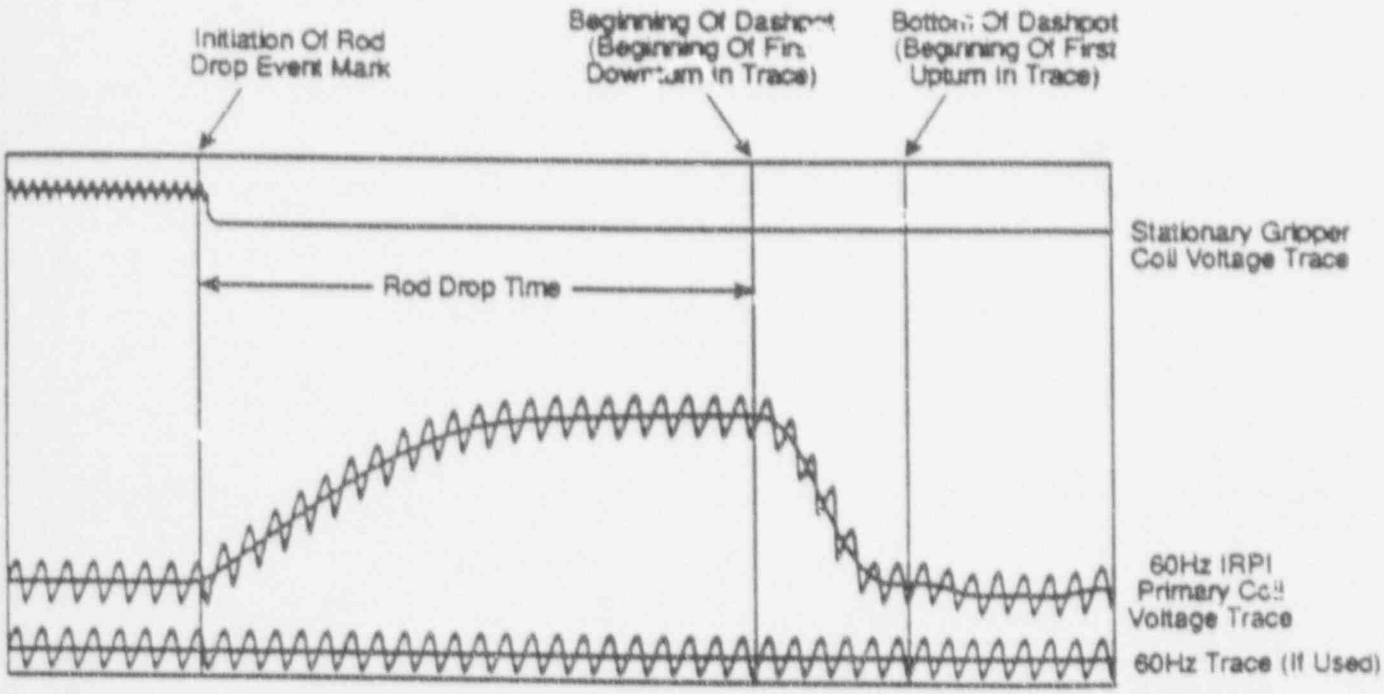
NORTH ANNA UNIT 1 - CYCLE 9 STARTUP PHYSICS TESTS
HOT ROD DROP TIME SUMMARY

ROD DROP TIME TO DASHPOT ENTRY

SLOWEST ROD	FASTEST ROD	AVERAGE TIME
B-06 1.83 sec.	H-02 1.52 sec.	1.62 sec.

Figure 2.1

NORTH ANNA UNIT 1 - CYCLE 9 STARTUP PHYSICS TESTS
TYPICAL ROD DROP TRACE



ROD DROP TIME MEASUREMENT

Figure 2.2

NORTH ANNA UNIT 1 - CYCLE 9 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
					1.63		1.52		1.61						2
						1.60		1.63							3
			1.61		1.57				1.63		1.60				4
				1.68						1.60					5
	1.56		1.64		1.61		1.63		1.65		1.63		1.83		6
		1.62				1.58		1.58				1.64			7
	1.69				1.61				1.61				1.72		8
		1.63				1.60		1.58				1.54			9
	1.65		1.62		1.59		1.64		1.64		1.60		1.68		10
				1.72						1.58					11
			1.55		1.69				1.54		1.58				12
						1.59		1.64							13
					1.77		1.66		1.62						14
															15

| X.XX | --> ROD DROP TIME TO DASHPOT ENTRY (SEC)

SECTION 3

CONTROL ROD BANK WORTH MEASUREMENTS

Control rod bank worths were measured for the control and shutdown banks using the rod swap technique[2,5]. The initial step of the rod swap method diluted the predicted most reactive control rod bank (hereafter referred to as the reference bank) into the core and measured its reactivity worth using conventional test techniques. The reactivity changes resulting from the reference bank movements were recorded continuously by the reactivity computer and were used to determine the differential and integral worth of the reference bank. For Cycle 9, Control Bank B was used as the reference bank.

After the completion of the reference bank reactivity worth measurement, the reactor coolant system temperature and boron concentration were stabilized with the reactor just critical and 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. From this point, a rod swap maneuver was performed by withdrawing the reference bank several steps and then one of the other control rod banks (i.e., a test bank) was inserted to balance the reactivity of the reference bank withdrawal. This sequence was repeated until the test bank was fully inserted and the reference bank was positioned such that the core was just critical. This measured critical position (MCP) of the reference bank with the test bank fully inserted was used to determine the integral reactivity worth of the test bank.

The 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 then was repeated in reverse such that the reference bank again was near full insertion with the test bank fully withdrawn from the core. This rod swap process was then repeated for each of the other control and shutdown banks.

A summary of the test results is given in Table 3.1. As shown in 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% or 100 pcm, whichever is greater, for the test banks). The sum of the individual measured rod bank worths was within 0.2% 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 1 - CYCLE 9 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	1214.4	1207.0	0.6
SA	897.6	891.5	0.7
SB	1047.5	1040.6	0.7
A	266.9	258.2	3.4 *
C	807.8	819.8	-1.5
D	1004.8	1014.3	-0.9
Total Worth	5239.0	5231.4	0.2

* Difference is less than 100 pcm.

Figure 3.1

NORTH ANNA UNIT 1 - CYCLE 9 STARTUP PHYSICS TESTS
BANK B INTEGRAL ROD WORTH - HZP
ALL OTHER RODS WITHDRAWN

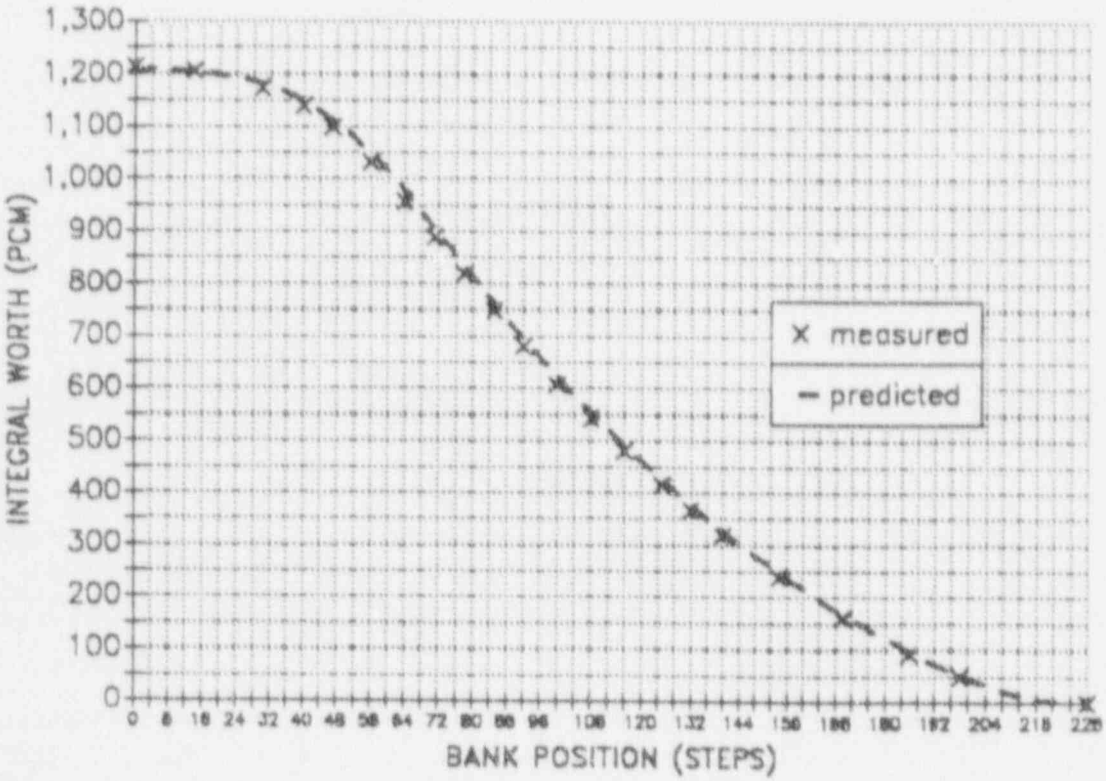
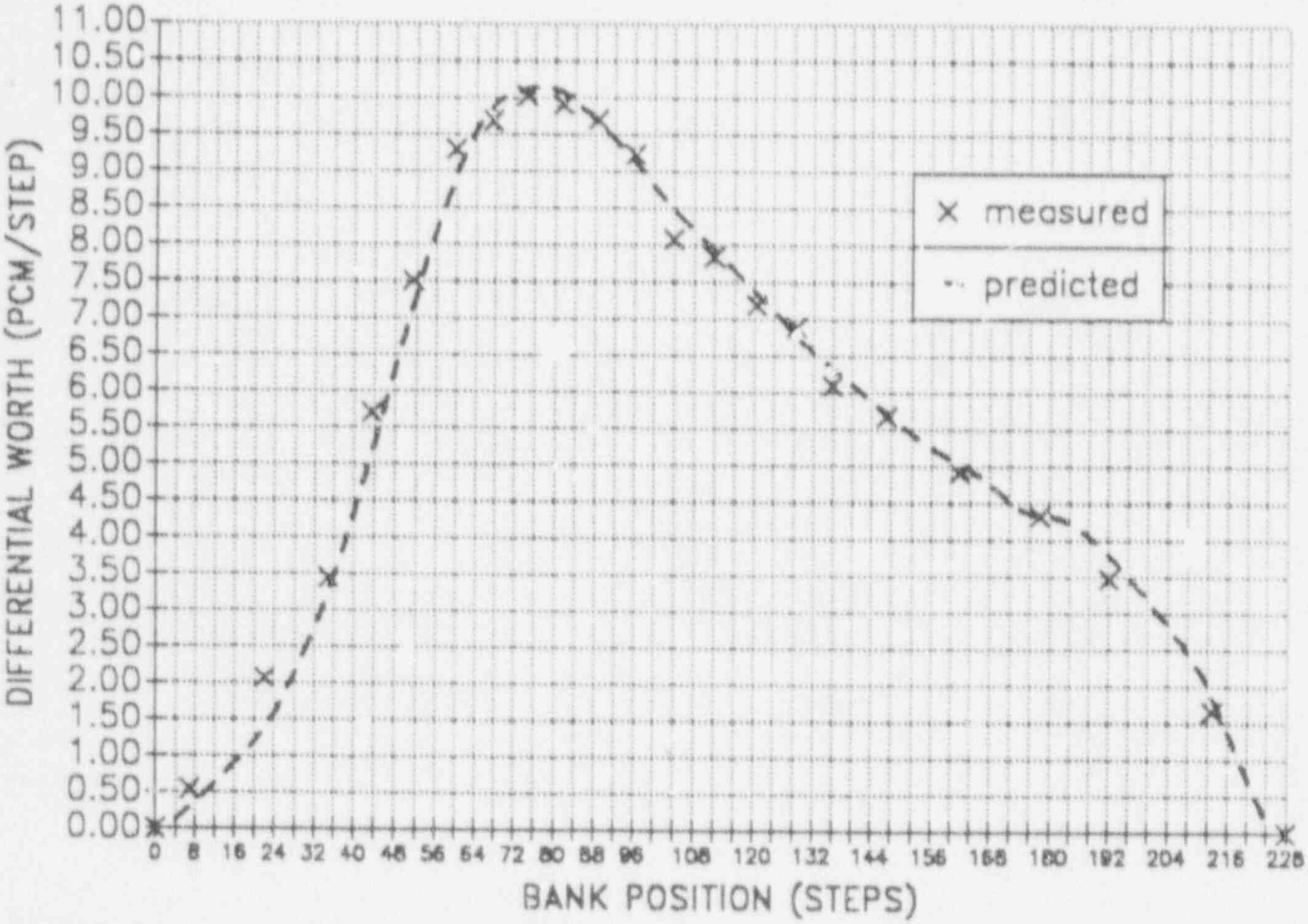


Figure 3.2

NORTH ANNA UNIT 1 - CYCLE 9 STARTUP PHYSICS TESTS
BANK B DIFFERENTIAL ROD WORTH - HZP
ALL OTHER RODS WITHDRAWN



SECTION 4

BORON ENDPOINT AND WORTH MEASUREMENTS

Boron Endpoint

With the reactor critical at hot zero power, reactor coolant system (RCS) boron concentrations were measured at selected rod bank configurations to enable a direct comparison of measured boron endpoints with design predictions. For each critical boron concentration measurement, the RCS conditions were stabilized with the control banks at or very near a selected endpoint position. Adjustments to the measured critical boron concentration values were made to account for off-nominal control rod position and moderator temperature, if necessary.

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 ARO endpoint comparison to the predicted value met the requirements of Technical Specification 4.1.1.1.2 regarding core reactivity balance. 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 or differential boron worth (DBW) was determined. 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 DBW over the range of boron endpoint concentrations was obtained.

A plot of the boron concentration versus inserted control rod worth is shown in Figure 4.1. As indicated in this figure and in the Appendix, the measured DBW was -6.82 pcm/ppm. This is within 1.2% of the predicted value of -6.90 pcm/ppm and is well within the design tolerance of ±10%. In summary, the measured boron worth coefficient was satisfactory.

Table 4.1

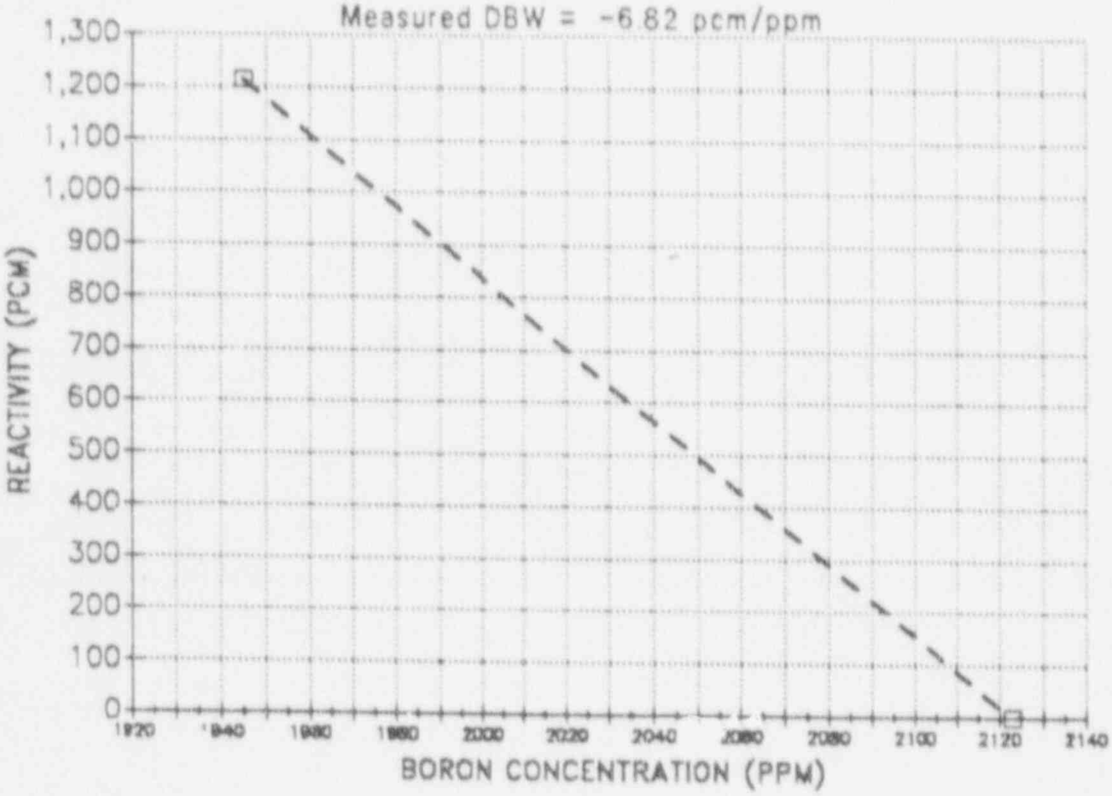
NORTH ANNA UNIT 1 - CYCLE 9 STARTUP PHYSICS TESTS
BORON ENDPOINT SUMMARY

Control Rod Configuration	Measured Endpoint (ppm)	Predicted Endpoint (ppm)	Difference M-P (ppm)
ARO	2123	2091	+32
B Bank In	1945	1948*	-3

* The predicted endpoint for the B Bank In configuration was 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 Tests Results and Evaluation Sheets in the Appendix.

Figure 4.1

NORTH ANNA UNIT 1 - CYCLE 9 STARTUP PHYSICS TESTS
BORON WORTH COEFFICIENT



SECTION 5

TEMPERATURE COEFFICIENT MEASUREMENT

The isothermal temperature coefficient (ITC) at the all-rods-out condition is measured by controlling the reactor coolant system (RCS) temperature with the steam dump valves to the condenser, establishing a constant heatup or cooldown rate, and monitoring the resulting reactivity changes on the reactivity computer. This test sequence included a cooldown followed by a heatup.

Reactivity was measured during the RCS cooldown of approximately 5.5°F and the RCS heatup of approximately 3.3°F. Reactivity and temperature data were taken from the reactivity computer and strip chart recorders. Using the statepoint method, the temperature coefficient was determined by dividing the change in reactivity by the change in RCS temperature. An X-Y plotter, which plotted reactivity versus temperature, confirmed the statepoint method in calculating the measured ITC.

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 Tests Results and Evaluation Sheet given in the Appendix, the measured isothermal temperature coefficient value was within the design tolerance of ±3 pcm/°F. The moderator temperature coefficient was determined to be +0.85 pcm/°F which met the requirements of Technical Specification 3.1.1.4. In summary, the measured result was satisfactory.

Table 5.1

NORTH ANNA UNIT 1 - CYCLE 9 STARTUP PHYSICS TESTS
ISOTHERMAL TEMPERATURE COEFFICIENT SUMMARY

BANK POSITION	TEMPERATURE RANGE (°F)	BORON CONCENTRATION (ppm)	ISOTHERMAL TEMPERATURE COEFFICIENT (PCM/°F)				
			C/D	H/U	AVE. MEAS.	PRED.	DIFFER. (M-P)
D/204	544.1 to 549.6	2119	-0.73	-1.06	-0.90	-0.05	-0.85

SECTION 6

POWER DISTRIBUTION MEASUREMENTS

The core power distributions were measured using the moveable incore detector flux mapping system. This system consists of five fission chamber detectors which traverse fuel assembly instrumentation thimbles in up to 50 core locations. Figure 1.3 shows the available locations monitored by the moveable detectors for Cycle 9. For each traverse, the detector voltage output is continuously monitored on a strip chart recorder, and scanned for 61 discrete axial points by the PRODAC P-250 process computer. Full core, three-dimensional power distributions are determined from this data using the Westinghouse computer program, INCORE[3]. INCORE couples the measured voltages 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 startup test program and the measured values of the important power distribution parameters is given in Table 6.1. A comparison of these measured values with their Technical Specification limits is given in Table 6.2. Flux Map 1 was taken at 24% power to verify the radial power distribution (RPD) predictions at low power. Figure 6.1 shows the measured RPDs from this flux map. Flux maps 2, 3, 4, and 5 were taken at 41%, 70%, 89%, and 94% power levels respectively with different control rod configurations. These flux maps were taken to check at-power design predictions versus measured core power distributions at various operating conditions. The radial power distribution for the 70% power level flux map (flux map 3) is given in Figure 6.2. Flux maps 6 and 7 were taken at a power level of 99% to monitor FQ(Z)/K(Z) every seven effective full power days (EFPD) in accordance with Technical Specification 4.2.2.2e. The radial power distribution for flux map 6 is given in Figure 6.3. The radial power distributions for the maps given in Figures 6.1, 6.2 and 6.3 show that the measured relative assembly power values were generally within 1.7% of the predicted values (1.8% including flux maps 2, 4, 5, 7, and 8). Further, the measured F-Q(T) and F-DH(M) peaking factor values for the at-power flux maps were within the limits of Technical Specifications 3.2.2 and 3.2.3, respectively. Flux maps 8, 9, and 10 were used to perform an Incore/Excore detector calibration.

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 9.

TABLE 6.1

NORTH ANNA UNIT 1 - CYCLE 9 STARTUP PHYSICS TESTS
INCORE FLUX MAP SUMMARY

MAP DESCRIPTION	MAP NO.	DATE	BURN UP MWD/MTU	PWR (%)	BANK D STEPS	(1) F-Q(T) HOT CHANNEL FACTOR ASSY	PIN	AXIAL POINT	F-Q(T)	F-DH(N) HOT CHNL.FACTOR ASSY	PIN	F-DH(N)	CORE F(Z) MAX AXIAL POINT	F(Z)	(2) CORE TILT MAX	LOC	AXIAL OFF SET (%)	NO. OF THIMBLES
LOW POWER	1	03-10-91	14	24	133	H 3	IB	38	2.239	L 3	QA	1.498	37	1.417	1.014	NW	-14.28	44
P.F.V. (3)	2	03-11-91	24	41	146	L 4	PI	31	2.195	L 3	QA	1.486	36	1.395	1.015	NW	-9.86	46
P.F.V. (3)	3	03-12-91	47	70	186	H 3	IB	29	2.013	H 3	IB	1.437	29	1.302	1.016	NW	-1.19	46
P.F.V. (3)	4	03-13-91	68	89	215	H 3	IB	36	1.926	H 3	IB	1.420	36	1.244	1.014	NW	-2.38	46
P.F.V. (3)	5	03-13-91	92	94	220	H 3	IB	37	1.946	H 3	IB	1.418	36	1.255	1.014	NW	-3.59	46
MONITOR FQ(Z)/K(Z)	6	03-19-91	305	99	228	H 3	IB	37	1.922	J 8	PI	1.413	37	1.245	1.012	NW	-3.86	46
MONITOR FQ(Z)/K(Z)	7	03-25-91	549	99	228	H 3	IB	36	1.915	J 8	PI	1.417	37	1.243	1.010	NW	-4.23	45
HOT FULL POWER	8	04-01-91	823	99	228	H 3	IB	37	1.911	J 8	PI	1.421	37	1.242	1.010	NW	-3.89	46

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) CORE TILT - DEFINED AS THE AVERAGE AXIAL QUADRANT POWER TILT FROM INCORE.

(3) P.F.V. - PEAKING FACTOR VERIFICATION.

(4) MAPS 9 AND 10 WERE QUARTER-CORE FLUX MAPS TAKEN FOR INCORE/EXCORE CALIBRATION. (I/E CALIBRATION)

Table 6.2

NORTH ANNA UNIT 1 - CYCLE 9 STARTUP PHYSICS TESTS
COMPARISION OF MEASURED POWER DISTRIBUTION PARAMETERS
WITH THEIR TECHNICAL SPECIFICATION LIMITS

MAP NO.	PEAK F-Q(T) HOT CHANNEL FACTOR*			F-Q(T) HOT CHANNEL FACTOR** (AT NODE OF MINIMUM MARGIN)				F-DH(N) HOT CHANNEL FACTOR		
	MEAS	LIMIT	NODE	MEAS	LIMIT	NODE	MARGIN (%)	MEAS	LIMIT	MARGIN (%)
1	2.239	4.380	38	2.239	4.380	38	48.9	1.498	1.828	18.1
2	2.195	4.380	31	2.195	4.380	31	49.9	1.486	1.754	15.3
3	2.013	3.112	29	2.013	3.103	28	35.1	1.437	1.624	11.5
4	1.926	2.470	36	1.926	2.470	36	22.0	1.420	1.541	7.9
5	1.946	2.339	37	1.946	2.339	37	16.8	1.418	1.518	6.6
6	1.922	2.211	37	1.922	2.211	37	13.0	1.413	1.494	5.4
7	1.915	2.203	36	1.915	2.203	36	13.1	1.417	1.493	5.1
8	1.911	2.207	37	1.911	2.207	37	13.4	1.421	1.494	4.9

* The Technical Specification's limit for the heat flux hot channel factor, F-Q(T), is a function of core height and power level. 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 value for F-Q(T) listed above is the value at the plane of minimum margin. 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 8.15% total uncertainty.

Figure 6.1

NORTH ANNA UNIT 1 - CYCLE 9 STARTUP PHYSICS TESTS
ASSEMBLYWISE POWER DISTRIBUTION
24% 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							0.25 0.26 6.5	0.31 0.33 6.1	0.25 0.26 4.0						
2					0.29 0.31 5.9	0.58 0.58 -0.4	1.07 1.11 3.1	0.79 0.82 2.7	1.07 1.10 2.5	0.58 0.59 1.1	0.30 0.30 0.2				
3				0.33 0.35 3.5	1.15 1.19 3.2	1.27 1.28 0.6	1.14 1.15 0.1	1.32 1.33 0.1	1.15 1.15 0.1	1.28 1.28 0.1	1.16 1.15 -0.2	0.34 0.33 -0.8			
4			0.33 0.34 3.5	0.82 0.84 2.6	1.33 1.36 2.8	1.22 1.24 2.0	1.33 1.35 1.2	1.22 1.24 1.1	1.33 1.33 -0.2	1.22 1.21 -1.2	1.33 1.32 -1.1	0.82 0.81 -1.2	0.33 0.33 -1.0		
5		0.30 0.30 1.3	1.14 1.16 1.3	1.32 1.33 1.2	1.18 1.19 1.2	1.29 1.31 1.6	1.14 1.16 1.7	1.34 1.36 1.6	1.14 1.15 0.3	1.29 1.28 -1.2	1.18 1.17 -1.3	1.32 1.30 -1.6	1.14 1.13 -1.0	0.30 0.29 -1.0	
6		0.58 0.59 2.3	1.26 1.29 2.3	1.21 1.23 1.8	1.29 1.30 1.2	1.06 1.08 1.6	1.29 1.31 1.9	1.13 1.14 1.4	1.29 1.29 0.4	1.06 1.05 -1.0	1.29 1.25 -3.1	1.21 1.18 -3.2	1.26 1.23 -2.5	0.58 0.57 -1.4	
7	0.25 0.25 3.2	1.06 1.07 1.2	1.13 1.15 1.3	1.32 1.33 0.6	1.14 1.14 -0.2	1.29 1.29 0.4	1.12 1.14 1.3	1.30 1.32 0.9	1.12 1.12 -0.1	1.29 1.28 -0.6	1.14 1.11 -3.0	1.32 1.26 -4.6	1.13 1.10 -3.1	1.06 1.04 -[illegible].5	0.25 0.24 -1.6
8	0.31 0.30 -1.1	0.78 0.79 0.9	1.31 1.32 1.0	1.22 1.27 0.	1.34 1.34 0.4	1.13 1.13 0.8	1.30 1.33 1.6	1.26 1.27 0.8	1.30 1.28 -1.6	1.13 1.11 -1.7	1.34 1.30 -3.2	1.22 1.16 -4.6	1.31 1.27 -3.1	0.78 0.78 -0.7	0.31 0.31 0.8
9	0.25 0.25 0.5	1.06 1.06 -0.3	1.13 1.13 -0.3	1.32 1.32 0.1	1.14 15 5	1.29 1.28 -0.5	1.13 1.10 -2.4	1.31 1.28 -2.4	1.13 1.10 -2.5	1.29 1.26 -2.6	1.14 1.12 -1.4	1.32 1.30 -1.7	1.13 1.12 -1.5	1.06 1.06 -0.2	0.25 0.25 1.5
10		0.58 0.58 0.5	1.26 1.27 0.5	1.21 1.23 1.5	1.29 1.32 2.1	1.06 1.07 0.5	1.29 1.26 -2.3	1.13 1.10 -2.3	1.29 1.25 -3.0	1.06 1.04 -2.5	1.29 1.27 -1.4	1.21 1.22 0.5	1.26 1.26 -0.2	0.58 0.59 2.1	
11		0.30 0.30 2.4	1.14 1.17 2.4	1.32 1.35 2.5	1.18 1.21 2.7	1.29 1.29 -0.4	1.15 1.12 [illegible].1	1.34 1.32 -2.1	1.14 1.12 -2.5	1.29 1.27 -1.5	1.18 1.18 -0.6	1.32 1.32 0.0	1.14 1.14 -0.3	0.30 0.29 -0.6	
12			0.33 0.35 4.3	0.82 0.85 3.5	1.33 1.36 2.6	1.22 1.23 0.4	1.33 1.31 -1.8	1.23 1.20 -1.8	1.33 1.30 -2.1	1.22 1.20 -1.6	1.33 1.31 -1.4	0.82 0.82 -0.3	0.33 0.33 -0.4		
13				0.34 0.35 4.2	1.16 1.20 4.2	1.28 1.29 1.3	1.15 1.1[illegible] -1.5	1.33 1.31 -1.5	1.15 1.13 -1.7	1.27 1.25 -2.2	1.16 1.14 -1.5	0.34 0.33 -0.4			
14					0.30 0.31 4.2	0.58 0.61 4.4	1.08 1.09 1.6	0.80 0.81 1.4	1.07 1.05 -1.6	0.58 0.57 -2.1	0.30 0.29 -2.2				
15							0.25 0.26 4.4	0.31 0.32 4.3	0.24 0.25 4.4						

STANDARD DEVIATION =1.304

AVERAGE PCT DIFFERENCE = 1.7

SUMMARY

MAP NO: N1-9-01 | DATE: 03/10/91 | POWER: 24%

CONTROL ROD POSITIONS: | F-Q(T) = 2.239 | CORE TILT:

D BANK AT 133 STEPS | F-DH(M) = 1.498

NW 1.014	NE 0.991
SW 1.007	SE 0.987

F(Z) = 1.417

BURNUP = 14 MWD/MTU | A.O. = -14.28%

Figure 6.2

NORTH ANNA UNIT 1 - CYCLE 9 STARTUP PHYSICS TESTS
ASSEMBLYWISE POWER DISTRIBUTION
70% POWFR

PREDICTED
MEASURED
PCT DIFFERENCE

Row	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							0.27	0.35	0.27						
							0.28	0.36	0.28						
							3.5	3.2	2.0						
2					0.30	0.59	1.11	0.89	1.11	0.59	0.30				
					0.31	0.59	1.13	0.90	1.12	0.59	0.31				
					2.8	-0.4	1.6	1.2	1.2	0.4	1.0				
3				0.34	1.11	1.23	1.14	1.33	1.14	1.23	1.11	0.34			
				0.34	1.14	1.26	1.15	1.33	1.15	1.24	1.12	0.34			
				2.8	2.8	2.7	0.5	0.4	0.6	0.7	1.0	1.6			
4			0.33	0.80	1.27	1.19	1.30	1.21	1.30	1.19	1.28	0.80	0.33		
			0.34	0.82	1.31	1.22	1.32	1.23	1.31	1.19	1.27	0.80	0.33		
			2.1	2.3	2.6	2.9	1.6	1.5	0.7	0.1	-0.3	-0.8	-1.5		
5		0.30	1.10	1.27	1.16	1.29	1.14	1.32	1.16	[illegible]	1.16	1.27	1.10	0.30	
		0.30	1.12	1.29	1.18	1.32	1.17	1.35	1.16	1.29	1.15	1.24	1.07	0.29	
		1.4	1.4	1.7	1.8	2.3	2.2	2.1	1.1	-0.0	-1.0	-2.1	-3.1	-3.2	
6		0.59	1.23	1.18	1.29	1.16	1.31	1.13	1.31	1.16	1.29	1.19	1.23	0.59	
		0.60	1.25	1.20	1.30	1.18	1.34	1.15	1.32	1.15	1.27	1.16	1.20	0.57	
		1.9	1.9	1.6	1.2	2.0	2.4	2.0	0.9	-0.3	-1.7	-1.8	-2.4	-2.6	
7	0.27	1.10	1.13	1.30	1.14	1.31	1.14	1.30	1.14	1.31	1.14	1.30	1.13	1.10	0.27
	0.28	1.10	1.14	1.30	1.14	1.32	1.16	1.32	1.14	1.31	1.14	1.26	1.11	1.07	0.27
	2.4	0.5	0.6	0.1	-0.4	0.6	1.8	1.5	0.6	0.4	-0.7	-2.6	-2.6	-3.0	-2.5
8	0.35	0.88	1.31	1.20	1.32	1.13	1.30	1.25	1.30	1.13	1.32	1.20	1.31	0.88	0.35
	0.34	0.88	1.32	1.21	1.33	1.14	1.33	1.27	1.29	1.13	1.31	1.17	1.28	0.86	0.35
	-1.6	0.3	0.3	0.4	0.4	1.1	2.6	1.7	-0.6	-0.5	-1.2	-2.8	-2.7	-2.1	-1.1
9	0.27	1.10	1.13	1.30	1.14	1.31	1.14	1.30	1.14	1.31	1.14	1.30	1.13	1.10	0.27
	0.27	1.08	1.12	1.29	1.15	1.31	1.12	1.28	1.13	1.29	1.14	1.27	1.12	1.09	0.28
	-1.5	-1.6	-1.6	-0.5	0.6	-0.1	-1.4	-1.4	-1.2	-1.3	-0.6	-1.7	-1.0	-0.5	0.7
10		0.59	1.23	1.18	1.29	1.16	1.31	1.13	1.31	1.16	1.29	1.19	1.23	0.59	
		0.58	1.20	1.19	1.32	1.17	1.29	1.11	1.28	1.14	1.28	1.19	1.25	0.60	
		-1.8	-1.8	0.7	2.0	0.8	-1.7	-1.7	-2.1	-1.5	-0.8	0.4	1.5	2.4	
11		0.30	1.10	1.27	1.16	1.29	1.15	1.32	1.15	1.29	1.16	1.27	1.10	0.30	
		0.30	1.10	1.27	1.19	1.29	1.13	1.30	1.12	1.28	1.16	1.26	1.11	0.30	
		0.0	0.0	0.7	[illegible]	-0.2	-1.6	-1.6	-1.9	-0.9	-0.5	-0.4	0.1	0.6	
12			0.33	0.80	1.28	1.19	1.30	1.21	1.30	1.19	1.28	0.80	0.33		
			0.34	0.82	1.30	1.19	1.28	1.19	1.28	1.17	1.26	0.80	0.33		
			1.9	1.8	1.8	0.2	-1.6	-1.6	-1.9	-1.3	-1.2	-0.7	-1.2		
13				0.34	1.11	1.24	1.14	1.33	1.14	1.23	1.11	0.34			
				0.34	1.12	1.23	1.13	1.31	1.13	1.21	1.09	0.33			
				1.3	0.7	-0.3	-1.4	-1.2	-1.6	-1.7	-1.8	-1.2			
14					0.30	0.59	1.11	0.89	1.11	0.59	0.30				
					0.31	0.60	1.12	0.89	1.09	0.58	0.30				
					0.7	1.8	0.8	0.1	-1.5	-1.6	-2.5				
15							0.28	0.35	0.27						
							0.28	0.35	0.27						
							[illegible]	1.1	-0.8						

STANDARD DEVIATION =0.824

AVERAGE PCT DIFFERENCE = 1.4

SUMMARY

MAP NO: N1-9-03 DATE: 03/12/91 POWER: 70%

CONTROL ROD POSITIONS: F-Q(T) = 2.013 CORE TILT:

D BANK AT 186 STEPS F-DH(M) = 1.437

F(Z) = 1.302

NW 1.014	NE 0.996
SW 1.000	SE 0.990

BURNUP = 47 MWD/MTU A.O. = -1.19%

Figure 6.3

NORTH ANNA UNIT 1 - CYCLE 9 STARTUP PHYSICS TESTS
ASSEMBLYWISE POWER DISTRIBUTION
99% POWER

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
		PREDICTED				0.30	0.38	0.30				PREDICTED			
		MEASURED				0.30	0.39	0.30				MEASURED			1
		PCT DIFFERENCE				1.8	1.8	1.3				PCT DIFFERENCE			
				0.31	0.60	1.13	0.95	1.14	0.61	0.31					
				0.32	0.59	1.14	0.95	1.14	0.61	0.32					2
				3.8	-1.5	0.2	0.2	0.3	0.7	1.5					
			0.34	1.10	1.21	1.14	1.33	1.14	1.22	1.10	0.35				
			0.35	1.12	1.22	1.14	1.33	1.15	1.22	1.11	0.35				3
			2.2	2.0	0.2	0.0	-0.0	0.3	0.6	1.2	2.4				
		0.34	0.80	1.25	1.17	1.28	1.19	1.28	1.17	1.25	0.81	0.34			
		0.35	0.82	1.28	1.20	1.30	1.21	1.28	1.17	1.25	0.80	0.34			4
		1.9	1.7	2.1	2.3	1.5	1.4	0.2	0.2	-0.1	-0.2	-0.6			
	0.31	1.09	1.24	1.15	1.28	1.14	1.30	1.14	1.28	1.15	1.24	1.10	0.31		
	0.31	1.09	1.25	1.17	1.31	1.17	1.34	1.16	1.28	1.14	1.22	1.07	0.31		5
	0.0	0.0	0.9	1.2	1.9	3.1	3.1	1.8	0.1	-0.8	-1.6	-2.1	-1.3		
	0.60	1.21	1.17	1.28	1.19	1.30	1.12	1.30	1.19	1.28	1.17	1.21	0.60		
	0.61	1.22	1.18	1.30	1.22	1.35	1.16	1.34	1.20	1.25	1.14	1.18	0.59		6
	0.7	0.7	1.1	1.5	2.8	3.8	3.4	2.7	1.0	-2.1	-2.1	-2.7	-2.4		
0.30	1.13	1.14	1.28	1.14	1.30	1.13	1.28	1.13	1.30	1.14	1.28	1.14	1.13	0.30	
0.30	1.12	1.13	1.28	1.14	1.32	1.17	1.32	1.16	1.33	1.13	1.23	1.10	1.09	0.29	7
1.4	-0.5	-0.4	-0.2	0.1	1.3	3.5	3.1	2.3	1.9	-0.9	-3.8	-3.4	-3.6	-2.9	
0.38	0.94	1.32	1.19	1.30	1.12	1.28	1.23	1.28	1.12	1.30	1.19	1.32	0.94	0.38	
0.37	0.93	1.31	1.19	1.32	1.15	1.33	1.27	1.29	1.13	1.29	1.14	1.27	0.92	0.38	8
-2.5	-0.6	-0.7	0.3	1.2	2.1	3.8	3.0	0.8	0.8	-1.0	-3.8	-3.4	-2.3	-1.5	
0.30	1.13	1.14	1.28	1.14	1.30	1.13	1.28	1.13	1.30	1.14	1.28	1.14	1.13	0.30	
0.29	1.10	1.11	1.27	1.15	1.31	1.12	1.27	1.13	1.30	1.14	1.26	1.13	1.12	0.30	9
-2.4	-2.4	-2.4	-0.5	1.5	0.7	-0.8	-0.8	0.0	-0.0	0.2	-1.8	-1.0	-0.7	0.5	
	0.60	1.21	1.17	1.28	1.19	1.30	1.12	1.30	1.19	1.28	1.17	1.21	0.60		
	0.59	1.18	1.18	1.31	1.21	1.29	1.11	1.28	1.18	1.28	1.18	1.23	0.61		10
	-2.4	-2.6	0.9	2.6	1.4	-1.0	-1.0	-1.3	-0.7	-0.4	0.6	1.5	1.8		
	0.31	1.09	1.24	1.15	1.28	1.14	1.30	1.14	1.28	1.15	1.24	1.09	0.31		
	0.31	1.10	1.25	1.18	1.28	1.12	1.29	1.12	1.28	1.15	1.25	1.10	0.32		11
	0.1	0.1	0.8	2.1	-0.0	-1.2	-1.2	-1.2	-0.4	-0.1	0.2	0.6	1.7		
		0.34	0.81	1.25	1.17	1.28	1.19	1.28	1.17	1.25	0.81	0.34			
		0.35	0.82	1.28	1.18	1.26	1.17	1.25	1.16	1.24	0.81	0.34			12
		2.5	2.3	2.1	0.3	-1.9	-1.9	-2.2	-1.4	-1.1	-0.0	-0.2			
			0.35	1.10	1.22	1.14	1.33	1.14	1.22	1.10	0.35				
			0.35	1.11	1.21	1.12	1.30	1.11	1.18	1.08	0.34				13
			1.7	0.9	-0.3	-2.2	-2.4	-3.0	-3.1	-2.0	-0.2				
				0.31	0.61	1.14	0.95	1.13	0.60	0.31					
				0.32	0.62	1.14	0.94	1.10	0.59	0.30					14
				0.9	2.1	0.3	-0.8	-3.0	-3.0	-3.5					
		STANDARD				0.30	0.38	0.29				AVERAGE			
		DEVIATION				0.31	0.39	0.28				PCT DIFFERENCE			15
		=1.067				3.4	0.5	-2.5				= 1.5			

SUMMARY

MAP NO: N1-9-06 DATE: 03/19/91 POWER: 99%

CONTROL ROD POSITIONS: F-Q(T) = 1.922 CORE TILT:

D BANK AT 228 STEPS F-DH(M) = 1.413

NW 1.012	NE 0.997
SW 1.000	SE 0.990

F(Z) = 1.245

BURNUP = 305 MWD/MTU A.O. = -3.86%

SECTION 7

REFERENCES

1. T. S. Psuik, "North Anna Unit 1, Cycle 9 Design Report", Technical Report NE-824, Revision 0, Virginia Power, February, 1991.

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

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

4. North Anna Unit 1 Technical Specifications, Sections 1.18, 3.1.3.4, 3.2.2, 3.2.3, 3.1.1.4, 4.1.1.1.2, and 4.2.2.2.

5. Letter from W. L. Stewart (Virginia Power) to the U.S.N.R.C, "Surry Power Station Units 1 and 2, North Anna Power Station Units 1 and 2: Modification of Startup Physics Test Program - Inspector Followup Item 280, 281/88-29-01", Serial No. 89-541, December 8, 1989.

APPENDIX

STARTUP PHYSICS TESTS RESULTS
AND EVALUATION SHEETS

NORTH ANNA POWER STATION UNIT 1 CYCLE 9
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Reactivity Computer Checkout Proc No /Section: 1-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~~ 223 CD: 95	RCS Temperature (°F): 548.0°F Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 3/8/91 00:32	
IV Test Results	Measured Parameter (Description)	ρ_c = Meas. Reactivity from ρ-computer ρ_t = Predicted Reactivity
	Measured Value	ρ_c = -58.0 +50.0 ρ_t = -58.6 +49.8 |%D| = 1.0% 0.4%
	Design Value (Actual Conditions)	$\%D = ((\rho_c - \rho_t)/\rho_t) \times 100\% \le 4.0\%$
	Design Value (Design Conditions)	$\%D = ((\rho_c - \rho_t)/\rho_t) \times 100\% \le 4.0\%$
	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 : ✓ YES ___NO Acceptance Criteria is met : ✓ YES ___NO	
	* At The Just Critical Position Allowable Range = ± -58, +49	

Prepared By: [signature] Reviewed By: [signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 9
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET
(PRELIMINARY ANALYSIS)

I Reference	Test Description: Critical Boron Concentration - ARO Proc No /Section: 1-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): 549.0 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 8/8/91 0320		
IV Test Results	Meas Parameter (Description)	$(C_B)^M_{ARO}$; Critical Boron Conc - ARO	
	Measured Value	$(C_B)^M_{ARO}$ = 2123	
	Design Value (Actual Cond)	C_B = 2091 ± 50 ppm	
	Design Value (Design Cond)	C_B =2091 ± 50 ppm	
	Reference	Technical Report NE-824 Rev. 0	
V Acceptance Criteria	FSAR/Tech Spec	$\alpha C_B \times C_B^D \leq 1000$ pcm	
	Reference	Technical Specification 4.1.1.1.2	
VI Comments	Design Tolerance is met : ✓ YES ___NO Acceptance Criteria is met : ✓ YES ___NO		
	αC_B = -6.90 pcm/ppm for preliminary analysis $C_B^D = \lvert(C_B)^M_{ARO} - C_B\rvert$; C_B is design value at actual conditions.		

Prepared By: [signature] Reviewed By: [signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 9
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET
(FINAL ANALYSIS)

I Reference	Test Description: Critical Boron Concentration - ARO Proc No /Section: 1-PT-94.0 Sequence Step No: 4a	
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): 549.0 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 5/8/91 0320	
IV Test Results	Meas Parameter (Description)	$(C_B)^M_{ARO}$: Critical Boron Conc - ARO
	Measured Value	$(C_B)^M_{ARO}$ = 2123
	Design Value (Actual Cond)	C_B = 2091 ± 50 ppm
	Design Value (Design Cond)	C_B =2091 ± 50 ppm
	Reference	Technical Report NE-824 Rev. 0
V Acceptance Criteria	FSAR/Tech Spec	$\alpha C_B \times C_B^D \leq 1000$ pcm
	Reference	Technical Specification 4.1.1.1.2
VI Comments	Design Tolerance is met : ✓ YES __NO Acceptance Criteria is met : ✓ YES __NO	
	αC_B = -6.90 pcm/ppm $C_B^D = \lvert (C_B)^M_{ARO} - C_B \rvert$; C_B is design value at actual conditions.	

Prepared By: [signature] Reviewed By: Thomas Smith

NORTH ANNA POWER STATION UNIT 1 CYCLE 9
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Isothermal Temperature Coefficient - ARO Proc No /Section: 1-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 CD: 204 Date/Time Test Performed: 3/8/91 0436	RCS Temperature (°F): 546.9 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
IV Test Results	Meas Parameter (Description)	$(\alpha_T^{ISO})_{ARO}$ Isothermal Temp Coeff - ARO
	Measured Value	$(\alpha_T^{ISO})_{ARO}$ = -0.90 pcm/°F (C_B = 2119 ppm)
	Design Value (Actual Cond)	$(\alpha_T^{ISO})_{ARO}$ = -0.05 pcm/°F (C_B = 2119 ppm)
	Design Value (Design Cond)	$(\alpha_T^{ISO})_{ARO}$ = -0.31 ± 3.0 pcm/°F (C_B = 2091 ppm)
	Reference	Technical Report NE-824 Rev. 0
V Acceptance Criteria	FSAR/Tech Spec	$\alpha_T^{ISO} \leq 3.75^*$ pcm/°F α_T^{Dop} = -1.75 pcm/°F ISO
	Reference	TS 3.1.1.4, Technical Report NE-824 Rev. 0
VI Comments	Design Tolerance is met : ✓ YES ___NO Acceptance Criteria is met : ✓ YES ___NO	
	* Uncertainty on αT_{MOD} = 0.5 pcm/°F (Reference: memorandum from C. T. Snow to E. J. Lozito dated June 27, 1980).	

Prepared By: Pamela D Bonnin[signature] Reviewed By: [signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 9
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

<table>
<tr><td>I
Reference</td><td colspan="2">Test Description: Cntl Bank B Worth Meas.,Rod Swap Ref. Bank
Proc No /Section: 1-PT-94.0 Sequence Step No: 6</td></tr>
<tr><td>II
Test
Conditions
(Design)</td><td>Bank Positions (Steps)
SDA: 228 SDB: 228 CA: 228
CB:Moving CC: 228 CD: 228</td><td>RCS Temperature (°F): 547
Power Level (% F.P.): 0
Other (specify):
Below Nuclear Heating</td></tr>
<tr><td>III
Test
Conditions
(Actual)</td><td>Bank Positions (Steps)
SDA: 228 SDB: 228 CA: 228
CB:Moving CC: 228 CD: 228</td><td>RCS Temperature (°F): 548.4
Power Level (% F.P.): 0
Other (Specify):
Below Nuclear Heating</td></tr>
<tr><td rowspan="6">IV
Test
Results</td><td>Date/Time Test Performed:
3/8/91 0534</td><td></td></tr>
<tr><td>Measured Parameter
(Description)</td><td>I_B^{REF} ; Integral Worth of Cntl Bank B, All Other Rods Out</td></tr>
<tr><td>Measured Value</td><td>I_B^{REF} = 1214.4 pcm</td></tr>
<tr><td>Design Value
(Actual Conditions)</td><td>I_B^{REF} = 1207 ± 121 pcm</td></tr>
<tr><td>Design Value
(Design Conditions)</td><td>I_B^{REF} = 1207 ± 121 pcm</td></tr>
<tr><td>Reference</td><td>Technical Report NE-824 Rev. 0</td></tr>
<tr><td rowspan="2">V
Acceptance
Criteria</td><td>FSAR/Tech Spec</td><td>If Design Tolerance is exceeded, SNSOC shall evaluate impact of test result on safety analysis. SNSOC may specify that additional testing be performed.</td></tr>
<tr><td>Reference</td><td>VEP-FRD-36A</td></tr>
<tr><td>VI
Comments</td><td colspan="2">Design Tolerance is met : ✓ YES __ NO
Acceptance Criteria is met : ✓ YES __ NO</td></tr>
</table>

Prepared By: Thomas S Paine 3/8/91 Reviewed By: C A Ford 3-8-91

NORTH ANNA POWER STATION UNIT 1 CYCLE 9
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET
(FINAL ANALYSIS)

I Reference	Test Description: Critical Boron Concentration - B Bank In Proc No /Section: 1-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): 545.4 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 3/8/91 1105		
IV Test Results	Meas Parameter (Description)	$(C_B)^M_B$; Critical Boron Conc - B Bank In	
	Measured Value	$(C_B)^M_B$ = 1945 ppm	
	Design Value (Actual Cond)	C_B = 1948 ppm ± 27 ppm	
	Design Value (Design Cond)	$C_B = 1916 + \Delta C_B^{Prev} \pm (10 + 120.7/\lvert \alpha C_B \rvert)$ ppm	
	Reference	Technical Report NE-824 Rev. 0	
V Acceptance Criteria	FSAR/Tech Spec	Not Applicable	
	Reference	Not Applicable	
VI Comments	Design Tolerance is met : ✓ YES ___ NO Acceptance Criteria is met : ✓ YES ___ NO		
	αC_B = -6.92 pcm/ppm $\Delta C_B^{Prev} = (C_B)^M_{ARO} - 2091$		

Prepared By: Thomas S Pink Reviewed By: C A Ford

NORTH ANNA POWER STATION UNIT 1 CYCLE 9
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET
(FINAL ANALYSIS)

I Reference	Test Description: HZP Boron Worth Coefficent Measurement Proc No /Section: 1-PT-94.0 Sequence Step No: 7a		
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): 549.0 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating	
	Date/Time Test Performed: 3/8/91 0320		
IV Test Results	Measured Parameter (Description)	αC_B, Boron Worth Coefficient	
	Measured Value	$\alpha C_B = -6.82 \frac{pcm}{1 ppm}$	
	Design Value (Actual Conditions)	$\alpha C_B = -6.90 \pm 0.69$ pcm/ppm	
	Design Value (Design Conditions)	$\alpha C_B = -6.90 \pm 0.69$ pcm/ppm	
	Reference	Technical Report NE-824 Rev. 0	
V Acceptance Criteria	FSAR/Tech Spec	Not Applicable	
	Reference	Not Applicable	
VI Comments	Design Tolerance is met : ✓ YES __NO Acceptance Criteria is met : ✓ YES __NO		

Prepared By: Thomas S Puch

Reviewed By: C A Ford

NORTH ANNA POWER STATION UNIT 1 CYCLE 9
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Cntl Bank D Worth Measurement-Rod Swap Proc No /Section: 1-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): 546.6 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 3/8/91 1454	
	Meas Parameter (Description)	I_D^{RS} : Int Worth of Cntl Bank D-Rod Swap
	Measured Value	I_D^{RS} = 1004.9 (Adj. Meas. Crit. Ref Bank Position = 160 steps)
	Design Value (Actual Cond)	I_D^{RS} = 1014.3 ± 152 (Adj. Meas. Crit. Ref Bank Position = 160 steps)
	Design Value (Design Cond)	I_D^{RS} = 1015 ± 152 pcm (Critical Ref Bank Position = 165 steps)
	Reference	Technical Report NE-824 Rev. 0, VEP-FRD-36A
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	

Prepared By: Thomas S Pant Reviewed By: P A Ford

NORTH ANNA POWER STATION UNIT 1 CYCLE 9
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Cntl Bank C Worth Measurement-Rod Swap Proc No /Section: 1-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): 546.3 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 3/8/91 1419	
	Meas Parameter (Description)	I_C^{RS} : Int Worth of Cntl Bank C-Rod Swap
	Measured Value	I_C^{RS} = 807.8 (Adj. Meas. Crit. Ref Bank Position = 126.3 steps)
	Design Value (Actual Cond)	I_C^{RS} = 819.8 ± 123 (Adj. Meas. Crit. Ref Bank Position = 126.3 steps)
	Design Value (Design Cond)	I_C^{RS} = 815 ± 122 pcm (Critical Ref Bank Position = 130 steps)
	Reference	Technical Report NE-824 Rev. 0, VEP-FRD-36A
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	

Prepared By: Thomas S. Blink Reviewed By: C. C. Ford

NORTH ANNA POWER STATION UNIT 1 CYCLE 9
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Cntl Bank A Worth Measurement-Rod Swap Proc No /Section: 1-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): 547.7 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 3/8/91 1349	
IV Test Results	Meas Parameter (Description)	I_A^{RS} ; Int Worth of Cntl Bank A - Rod Swap
	Measured Value	I_A^{RS} = 266.9 (Adj. Meas. Crit. Ref Bank Position = 65 steps)
	Design Value (Actual Cond)	I_A^{RS} = 258.2 ± 100 (Adj. Meas. Crit. Ref Bank Position = 65 steps)
	Design Value (Design Cond)	I_A^{RS} = 259 ± 100 pcm (Critical Ref Bank Position = 67 steps)
	Reference	Technical Report NE-824 Rev. 0, VEP-FRD-36A
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	

Prepared By: Thomas S Pink Reviewed By: P. C. Ford

NORTH ANNA POWER STATION UNIT 1 CYCLE 9
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Shutdown Bank B Worth Meas. - Rod Swap Proc No /Section: 1-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): 547.9 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 3/8/91 1301	
IV Test Results	Meas Parameter (Description)	I_{SB}^{RS}: Int Worth of Shutdown Bank B-Rod Swap
	Measured Value	I_{SB}^{RS} = 1047.5 (Adj. Meas. Crit. Ref Bank Position = 168.7 steps)
	Design Value (Actual Cond)	I_{SB}^{RS} = 1040.6±156 (Adj. Meas. Crit. Ref Bank Position = 168.7 steps)
	Design Value (Design Cond)	I_{SB}^{RS} = 1039 ± 156 pcm (Critical Ref Bank Position = 170 steps)
	Reference	Technical Report NE-824 Rev. 0, VEP-FRD-36A
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	

Prepared By: Thomas S. Park

Reviewed By: C C Ford

NORTH ANNA POWER STATION UNIT 1 CYCLE 9
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Shutdown Bank A Worth Meas. - Rod Swap Proc No /Section: 1-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): 546.9 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 3/8/91 1136	
	Meas Parameter (Description)	I_{SA}^{RS}; Int Worth of Shutdown Bank A-Rod Swap
	Measured Value	I_{SA}^{RS} = 897.6 (Adj. Meas. Crit. Ref Bank Position = 140.3 steps)
	Design Value (Actual Cond)	I_{SA}^{RS} = 891.5 ± 134 (Adj. Meas. Crit. Ref Bank Position = 140.3 steps)
	Design Value (Design Cond)	I_{SA}^{RS} = 890 ± 134 pcm (Critical Ref Bank Position = 142 steps)
	Reference	Technical Report NE-824 Rev. 0, VEP-FRD-36A
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	

Prepared By: Thomas S Paint

Reviewed By: C A Ford

NORTH ANNA POWER STATION UNIT 1 CYCLE 9
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Total Rod Worth - Rod Swap Proc No /Section: 1-PT-94.0		Sequence Step No: 13A
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): 548.4 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 3/8/91 0541		
	Meas Parameter (Description)	I_{Total}; Int Worth of All Banks - Rod Swap	
	Measured Value	I_{Total} = 5239 pcm	
	Design Value (Actual Cond)	I_{Total} = 5231.4 ± 523 pcm	
	Design Value (Design Cond)	I_{Total} = 5225 ± 523 pcm	
	Reference	Technical Report NE-824 Rev. 0, VEP-FRD-36A	
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		

Prepared By: Thomas 8Pierl

Reviewed By: R A Ford

ATTACHMENT 7

NORTH ANNA POWER STATION UNIT 1 CYCLE 9
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: M/D Flux Map-Banks D,C at Insert. Limits Proc No / Section: 1-PT-21.1 Sequence Step No: 41	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB : 228 CC : * 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: 133	RCS Temperature(°F): T_{REF} ±1 Power Level (% F.P.): 24.32% Other (Specify): 44 THIMBLES
IV	Date/Time Test Performed: 3/10/91 11:23	

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	-4.6% for P; ≥ 0.90 6.5% for P; < 0.90	1.498	2.234	1.0143
	Design Value (Design Conds)	[illegible]	NA	NA	≤ 1.02
	Reference	WCAP-7905 REV.1	NONE	NONE	WCAP-7905 REV.1
V Acceptance Criteria	FSAR/Tech Spec	NONE	[illegible]	[illegible]	NONE
	Reference	NONE	TS 3.2.3	TS 3.2.2	NONE

VI Comments	Design Tolerance is met : ✓ YES ___NO Acceptance Criteria is met : ✓ YES ___NO
	* Near Control Rod Insertion Limits

Prepared By: [signature] Reviewed By: C. Ford [signature]

NORTH ANNA POWER STATI ON UNIT 1 CYCLE 9
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: M/D Flux Map-At Power Proc No / Section: 1-PT-21.1	Sequence Step No: 43
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: 186	RCS Temperature(°F): T_{ave} ± 1 Power Level (% F.P.): 70.03% Other (Specify): 46 thimbles
	Date/Time Test Performed: 3/12/91 ~~1125~~ 14:31	

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	-3.1% @ P ≥ 0.90 3.5% @ P < 0.90	1.437	2.013	1.0143
	Design Value (Design Conds)	[illegible]	NA	NA	≤ 1.02
	Reference	WCAP-7905 REV.1	NONE	NONE	WCAP-7905 REV.1
V Acceptance Criteria	FSAR/Tech Spec	NONE	[illegible]	[illegible]	NONE
	Reference	NONE	TS 3.2.3	TS 3.2.2	NONE

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

Prepared By: [signature]   Reviewed By: [signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 9
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: M/D Flux Map - HFP, ARO, Eq. Xe Proc No / Section: 1-PT-21.1 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): 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} ±1 Power Level (% F.P.): 99.07 Other (Specify): 46 Thimbles MAP 6		
	Date/Time Test Performed: 3/19/91 at 1107				
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	3.8% @ P ≥ .9 3.8% @ P < .9	1.413	1.922	1.0121
	Design Value (Design Conds)	[illegible]	NA	NA	≤ 1.02
	Reference	WCAP-7905 REV.1	NONE	NONE	WCAP-7905 REV.1
V Acceptance Criteria	FSAR/Tech Spec	NONE	[illegible]	[illegible]	NONE
	Reference	NONE	TS 3.2.3	TS 3.2.2	NONE
VI Comments	Design Tolerance is met : ✓ YES ___ NO Acceptance Criteria is met : ✓ YES ___ NO				
	* As Required				

Prepared By: R8McCandrew Reviewed By: [illegible signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 9
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: M/D Flux Map- NI Calibration Proc No / Section: 1-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 ±1° Power Level (% F.P.): 99.21% Other (Specify): MAP 8		
	Date/Time Test Performed: 4/1/91		46 THIMBLES		
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	-3.7% For P ≥ .9 +4.7% For P < .9	1.421	~~1.767~~ WPW 4-2-91 1.911	~~1.00~~ PRM 4-23-91 1.0102
	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	$F^N_{\Delta H} \le 1.49(1+.3(1-P))$ 1.494	$F_Q^T(Z) \le 2.19/P \times K(Z)$ 1.911	NONE
	Reference	NONE	TS 3.2.3	TS 3.2.2	NONE
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				

Prepared By: [signature] Reviewed By: [signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 9
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: M/D Flux Map- NI Calibration Proc No / Section: 1-PT-22.2 Sequence Step No: 47				
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): Tref±1 Power Level (% F.P.): 99.24% Other (Specify): MAP QUARTER CORE MAP 31 THIMBLES		
	Date/Time Test Performed: 4/2/91				
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	NA	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	$F^N_{\Delta H} \leq 1.49(1+.3(1-P))$	$F^T_Q(Z) \leq 2.19/P \times K(Z)$	NONE
	Reference	NONE	TS 3.2.3	TS 3.2.2	NONE
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				

Prepared By: RB McCandrew

Reviewed By: [illegible]

NORTH ANNA POWER STATION UNIT 1 CYCLE 9
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: M/D Flux Map- NI Calibration Proc No / Section: 1-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 ±1° Power Level (% F.P.): 99.43% Other (Specify): MAP 10 QUARTER CORE MAP 31 THIMBLES
	Date/Time Test Performed: 4/2/91	

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	NA	NA	NA	NA
	Design Value (Design Conds)	[illegible]	NA	NA	≤ 1.02
	Reference	WCAP-7905 REV.1	NONE	NONE	WCAP-7905 REV.1
V Acceptance Criteria	FSAR/Tech Spec	NONE	$F^N_{\Delta H} \le 1.49(1+.3(1-P))$	$F^T_Q(Z) \le 2.19/P \times K(Z)$	NONE
	Reference	NONE	TS 3.2.3	TS 3.2.2	NONE

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

Prepared By: RSMcAndrew

Reviewed By: [signature]