North Anna Unit 1 Cycle 12 Startup Physics Tests Report

Nuclear Analysis and Fuel
Nuclear Engineering & Services

May, 1996

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TECHNICAL REPORT NE-1073 - REV. 0

NORTH ANNA UNIT 1, CYCLE 12

STARTUP PHYSICS TESTS REPORT

NUCLEAR ANALYSIS AND FUEL
NUCLEAR ENGINEERING & SERVICES
VIRGINIA POWER
MAY 1996

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QA Category: Nuclear Safety Related

Keywords: N1C12, Startup

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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 Unit 1, Cycle 12 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 Unit 1, Cycle 12 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 (at design conditions) 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 February 11, 1996 Unit No. 1 of the North Anna Power Station shutdown for its eleventh refueling. During this shutdown, 73 of the 157 fuel assemblies in the core were replaced with 64 fresh fuel assemblies, 1 once-burned fuel assembly, and 8 twice-burned fuel assemblies. The twelfth cycle core consists of 8 sub-batches of fuel: three once-burned batches, two from Cycle 11 (batches 13A and 13B) and one from North Anna Unit 2, Cycle 9 (batch N2/11B); three twice-burned batches, two from Cycles 10 and 11 (batches 12A and 12B) and one from Cycles 9 and 10 (batch 11B), and two fresh batches (batches 14A and 14B). Batches N1/11, N1/12 and N2/11 have top and bottom grids of Inconel-718 while the inner six grids are made of Zircaloy-4. Batches N1/13 and N1/14 have top and bottom grids of Inconel-718, six inner grids made of ZIRLO (ZIRLO provides improved corrosion resistance and dimensional stability under irradiation relative to Zircaloy-4 components), and one Inconel-718 protective grid placed below the fuel and above the bottom nozzle for debris resistance.

Cycle 12, similar to Cycle 11, incorporated the burnable poison rod design made of B_4C in Alumina, which is available in various enrichments of B_4C. There are no thimble plugging devices inserted in N1C12. Due to the conversion of the core barrel by-pass flow from downflow to upflow during the N1C11/N1C12 refueling outage, no baffle clips were necessary in N1C12 (to help protect against baffle jetting degradation). There are 28 vibration suppression damping assemblies inserted in peripherally

loaded fuel assemblies that have non-rotated Zircaloy-4 grids. Reference 1 provides a more detailed description of the Cycle 12 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 and documented in Reference 6. The available incore moveable detector locations used for the flux map analyses are identified in Figure 1.3. Figure 1.4 identifies the location and number of burnable poison rods and source assemblies for Cycle 12, and Figure 1.5 identifies the location and number of control rods in the Cycle 12 core.

On March 10, 1996 at 23:51, the Cycle 12 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[2,5] and the results were within 2.9% of the design predictions. The sum of the individual measured control rod bank worths was within 1.9% 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 6 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 0.3% of the design prediction, which is within the design tolerance of ±10%.

5. The measured isothermal temperature coefficient (ITC) for the all-rods-out (ARO) configuration was within 0.60 pcm/°F of the design prediction. This result is within the design tolerance of ±3 pcm/°F. The measured ITC of -2.60 pcm/°F meets the Core Operating Limits Report (COLR) 2.1.1 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 1.5% of the design predictions. The heat flux hot channel factors, F-Q(Z), and enthalpy rise hot channel factors, F-DH(N), were within the limits of COLR Sections 2.5.1 and 2.6, 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 UNIT 1 - CYCLE 12 STARTUP PHYSICS TESTS
CHRONOLOGY OF TESTS

Test	Date	Time	Power	Reference Procedure
Hot Rod Drop - Hot Full Flow	3/10/96	1110	HSD	1-PT-17.2
Zero Power Testing Range	3/11/96	0126	HZP	1-PT-94.0
Reactivity Computer Checkout	3/11/96	0236	HZP	1-PT-94.0
Temperature Coefficient - ARO	3/11/96	0612	HZP	1-PT-94.0
Boron Endpoint - ARO	3/11/96	0615	HZP	1-PT-94.0
Bank B Worth	3/11/96	0759	HZP	1-PT-94.0
Boron Endpoint - B in	3/11/96	1200	HZP	1-PT-94.0
Bank D Worth - Rod Swap	3/11/96	1259	HZP	1-PT-94.0
Bank C Worth - Rod Swap	3/11/96	1345	HZP	1-PT-94.0
Bank A Worth - Rod Swap	3/11/96	1418	HZP	1-PT-94.0
Bank SB Worth - Rod Swap	3/11/96	1451	HZP	1-PT-94.0
Bank SA Worth - Rod Swap	3/11/96	1524	HZP	1-PT-94.0
Flux Map - 30% Power	3/12/96	0845	30%	1-PT-94.0
Peaking Factor Verification				1-PT-21.1
& Power Range Calibration *				1-PT-21.2
				1-PT-22.4
Flux Map - 74% Power	3/13/96	1034	74%	1-PT-94.0
Peaking Factor Verification				1-PT-21.1
& Power Range Calibration *				1-PT-21.2
				1-PT-22.4
Flux Map - 100% Power	4/01/96	0825	100%	1-PT-94.0
Peaking Factor Verification				1-PT-21.1
& Power Range Calibration				1-PT-21.2
				1-PT-22.4

* Power range calibration calculation was performed which verified that the existing calibration was satisfactory.

Figure 1.1

NORTH ANNA UNIT 1 - CYCLE 12
CORE LOADING MAP

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							12B 5B2	12A 0B4	12B 2B6						
2					11B 4A5	13A 2C2	14B 2D9	13B 4C8	14B 3D7	13A 0C5	11B 4A9				
3				12B 4B3	14B 4D4	14B 5D1	13B 5C8	14B 4D1	13B 3C4	14B 4D5	14B 3D8	12B 4B0			
4			12A 1B0	13A 2C6	14B 6D2	13B 5C6	14A 1D4	13A 2C0	14A 2D7	13B 3C5	14B 5D4	13A 0C9	12A 0B8		
5		11B 5A9	14B 5D6	14B 4D7	13B 6C3	14A 1D6	13A 2C1	14A 0D2	13A 1C1	14A 1D3	13B 2C9	14B 3D0	14B 5D2	11B 4A2	
6		13A 2C4	14B 3D3	13B 6C1	14A 0D7	13A 2C3	14A 1D9	13B 4C1	14A 0D9	13A 1C3	14A 2D5	13B 5C5	14B 6D0	13A 0C7	
7	12B 4B5	14B 4D0	13B 3C9	14A 1D2	13A 1C7	14A 1D0	13B 3C3	13B 3C6	13B 4C3	14A 1D5	13A 0C6	14A 1D7	13B 5C9	14B 3D9	12B 6B0
8	12A 0B1	13B 4C7	14B 4D8	13A 0C8	14A 2D2	13B 3C1	13B 5C0	N2/11B 4L8	13B 5C7	13B 6C4	14A 1D8	13A 0C3	14B 5D3	13B 5C4	12A 1B7
9	12B 3B8	14B 3D4	13B 4C9	14A 0D5	13A 1C4	14A 2D0	13B 6C2	13B 5C1	13B 4C6	14A 2D3	13A 2C8	14A 0D6	13B 4C5	14B 3D5	12B 3B0
10		13A 1C0	14B 4D3	13B 5C3	14A 2D1	13A 1C8	14A 2D8	13B 5C2	14A 0D3	13A 0C4	14A 0D8	13B 4C0	14B 4D6	13A 0C2	
11		11B 5A3	14B 6D1	14B 3D6	13B 4C2	14A 2D4	13A 1C5	14A 0D1	13A 0C1	14A 0D4	13B 3C8	14B 4D9	14B 5D7	11B 3A6	
12			12A 1B5	13A 2C5	14B 3D1	13B 3C2	14A 2D6	13A 2C7	14A 1D1	13B 3C7	14B 4D2	13A 1C9	12A 2B3		
13				12B 3B5	14B 5D5	14B 6D3	13B 3C0	14B 6D4	13B 6C0	14B 3D2	14B 5D9	12B 2B8			
14					11B 6A7	13A 1C6	14B 5D8	13B 4C4	14B 5D0	13A 1C2	11B 5A2				
15							12B 4B1	12A 0B9	12B 4B7						

--> BATCH
--> ASSEMBLY ID

FUEL ASSEMBLY DESIGN PARAMETERS

	SUB-BATCH							
	N2/11B	11B	12A	12B	13A	13B	14A	14B
INITIAL ENRICHMENT (W/O U-235)	4.2087	4.1923	4.0036	4.2052	4.0082	4.2097	4.0048	4.2048
BURNUP AT BOC 12 (MWD/MTU)	24503	37896	37853	40999	24573	21842	0	0
ASSEMBLY TYPE	17x17	17x17	17x17	17x17	17x17	17x17	17x17	17x17
NUMBER OF ASSEMBLIES	1	8	8	12	28	36	28	36
FUEL RODS PER ASSEMBLY	264	264	264	264	264	264	264	264

Figure 1.2

NORTH ANNA UNIT 1 - CYCLE 12
BEGINNING OF CYCLE FUEL ASSEMBLY BURNUPS

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							5B2 41874	0B4 33120	2B6 42044						
2					4A5 37354	2C2 23670	2D9 0	4C8 20313	3D7 0	0C5 24094	4A9 37485				
3				4B3 37838	4D4 0	5D1 0	5C8 22934	4D1 0	3C4 23304	4D5 0	3D8 0	4B0 39217			
4			1B0 42172	2C6 24744	6D2 0	5C6 24365	1D4 0	2C0 24118	2D7 0	3C5 23640	5D4 0	0C9 25203	0B8 42478		
5		5A9 38577	5D6 0	4D7 0	6C3 20340	1D6 0	2C1 24634	0D2 0	1C1 24214	1D3 0	2C9 20012	3D0 0	5D2 0	4A2 38430	
6		2C4 23933	3D3 0	6C1 24272	0D7 0	2C3 24773	1D9 0	4C1 23635	0D9 0	1C3 25119	2D5 0	5C5 24599	6D0 0	0C7 23893	
7	4B5 42830	4D0 0	3C9 23193	1D2 0	1C7 24973	1D0 0	3C3 19309	3C6 19100	4C3 18990	1D5 0	0C6 24983	1D7 0	5C9 22866	3D9 0	6B0 43047
8	0B1 33886	4C7 20491	4D8 0	0C8 24436	2D2 0	3C1 23791	5C0 19004	4L8 24503	5C7 18780	6C4 23665	1D8 0	0C3 24378	5D3 0	5C4 20324	1B7 34109
9	3B8 42855	3D4 0	4C9 22491	0D5 0	1C4 24484	2D0 0	6C2 19080	5C1 18842	4C6 19157	2D3 0	2C8 24586	0D6 0	4C5 23392	3D5 0	3B0 42034
10		1C0 24166	4D3 0	5C3 24066	2D1 0	1C8 25341	2D8 0	5C2 23487	0D3 0	0C4 25324	0D8 0	4C0 23551	4D6 0	0C2 24326	
11		5A3 38153	6D1 0	3D6 0	4C2 20192	2D4 0	1C5 24657	0D1 0	0C1 24746	0D4 0	3C8 20634	4D9 0	5D7 0	3A6 37855	
12			1B5 41564	2C5 25315	3D1 0	3C2 24380	2D6 0	2C7 24542	1D1 0	3C7 24259	4D2 0	1C9 25201	2B3 41410		
13				3B5 38578	5D5 0	6D3 0	3C0 23048	6D4 0	6C0 22723	3D2 0	5D9 0	2B8 38126			
14					6A7 37824	1C6 24138	5D8 0	4C4 20055	5D0 0	1C2 24068	5A2 37490				
15							4B1 41818	0B9 34079	4B7 41729						

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

Figure 1.3

NORTH ANNA UNIT 1 - CYCLE 12
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				MD			
4					MD			MD		MD					
5			MD		MD		MD				MD	MD		MD	
6					MD			MD		** MD					
7			MD				MD		MD			MD		MD	
8	** MD		MD		MD					MD			MD	MD	
9					MD				** 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

** - Locations Not Available For
Flux Mapping System For Cycle 12

Figure 1.4

NORTH ANNA UNIT 1 - CYCLE 12
ASSEMBLY INSERT LOCATIONS

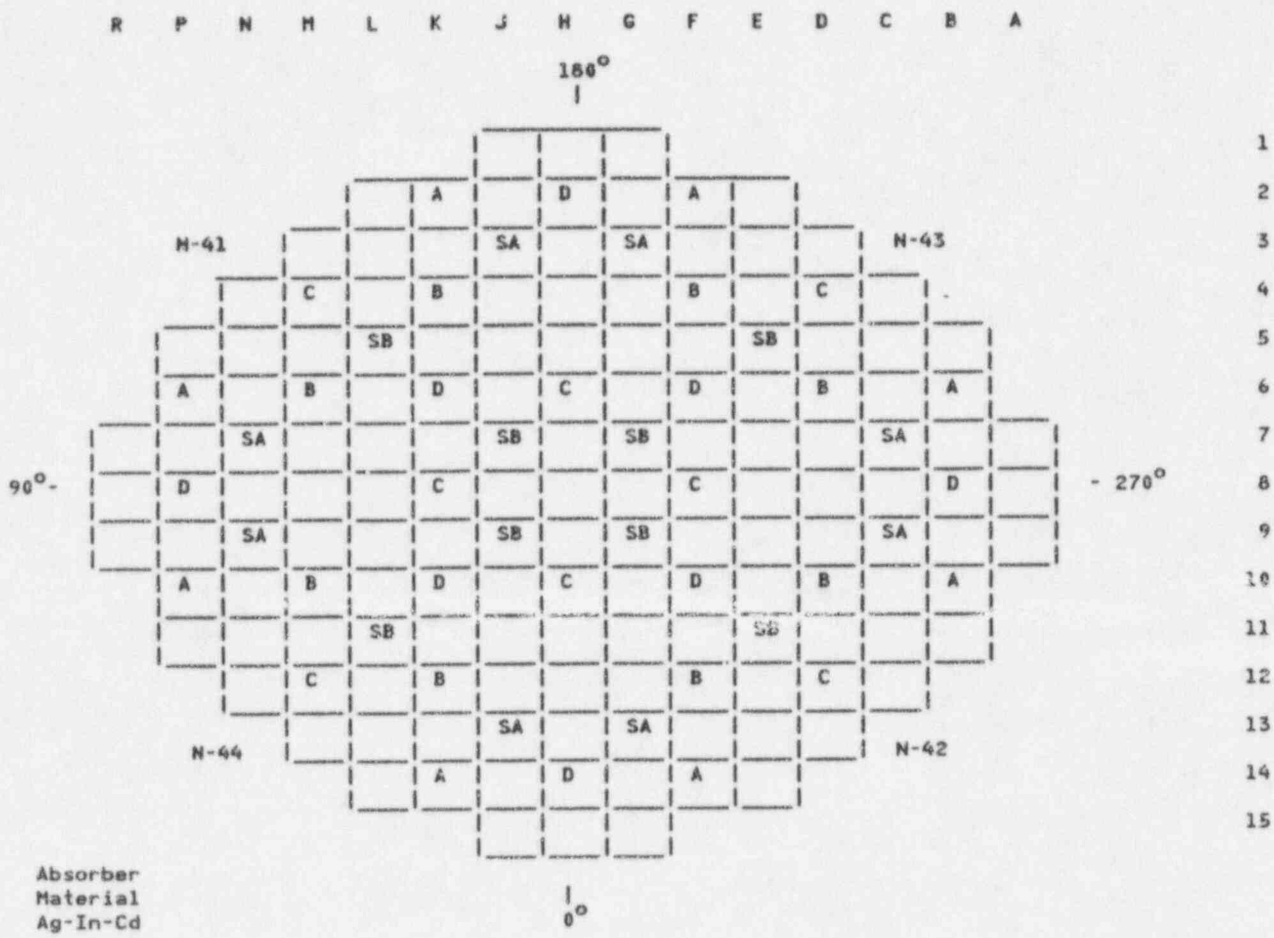
	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							VSDA	VSDA	VSDA						
2					VSDA	RCC	3P BP470	RCC	3P BP469	RCC	VSDA				
3				VSDA	6P BP501	19P BP485	RCC	20P BP457	RCC	19P BP486	6P BP504	VSDA			
4			VSDA	RCC	20P BP493	RCC	24P BP450	SS19	24P BP449	RCC	20P BP496	RCC	VSDA		
5		VSDA	6P BP502	20P BP494	RCC	24P BP481		24P BP448		24P BP480	RCC	20P BP495	6P BP503	VSDA	
6		RCC	19P BP492	RCC	24P BP482	RCC	24P BP462	RCC	24P BP461	RCC	24P BP479	RCC	19P BP487	RCC	
7	VSDA	3P BP475	RCC	24P BP455		24P BP467	RCC	4P BP444	RCC	24P BP464		24P BP456	RCC	3P BP472	VSDA
8	VSDA	RCC	20P BP458		24P BP451	RCC	4P BP443		4P BP442	RCC	24P BP447		20P BP460	RCC	VSDA
9	VSDA	3P BP476	RCC	24P BP454		24P BP468	RCC	4P BP441	RCC	24P BP463		24P BP453	RCC	3P BP471	VSDA
10		RCC	19P BP491	RCC	24P BP483	RCC	24P BP466	RCC	24P BP465	RCC	24P BP478	RCC	19P BP488	RCC	
11		VSDA	6P BP507	20P BP499	RCC	24P BP484		24P BP445		24P BP477	RCC	20P BP498	6P BP506	VSDA	
12			VSDA	RCC	20P BP500	RCC	24P BP452	SS20	24P BP446	RCC	20P BP497	RCC	VSDA		
13				VSDA	6P BP508	19P BP490	RCC	20P BP459	RCC	19P BP489	6P BP505	VSDA			
14					VSDA	RCC	3P BP474	RCC	3P BP473	RCC	VSDA				
15							VSDA	VSDA	VSDA						

3P - 3 BURNABLE POISON ROD CLUSTER
4P - 4 BURNABLE POISON ROD CLUSTER
6P - 6 BURNABLE POISON ROD CLUSTER
19P - 19 BURNABLE POISON ROD CLUSTER
20P - 20 BURNABLE POISON ROD CLUSTER
24P - 24 BURNABLE POISON ROD CLUSTER
RCC - FULL LENGTH CONTROL ROD
SSxx - SECONDARY SOURCE
VSDA - VIBRATION SUPPRESSION DAMPING ASSEMBLY

| xxP or SSxx | - # OF BP RODS or SECONDARY SOURCE ID
| BP###, VSDA or RCC | - BP ASSEMBLY ID, VSDA or RCC

Figure 1.5

NORTH ANNA UNIT 1 - CYCLE 12
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

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 229 steps and then 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. In addition, rod bounce was observed at the end of each trace which demonstrated that no control rod stuck in the dashpot region.

Table 2.1

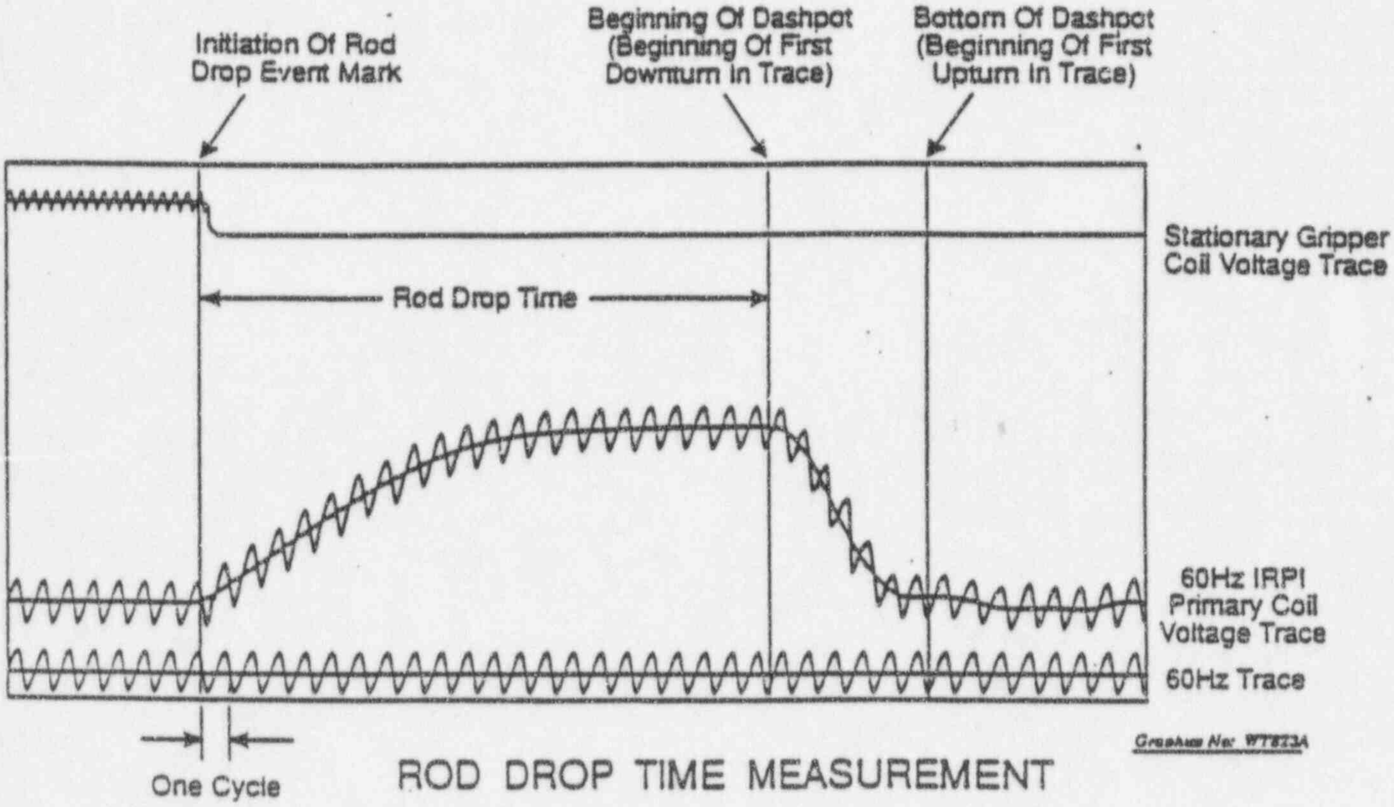
NORTH ANNA UNIT 1 - CYCLE 12 STARTUP PHYSICS TESTS
HOT ROD DROP TIME SUMMARY

ROD DROP TIME TO DASHPOT ENTRY

SLOWEST ROD	FASTEST ROD	AVERAGE TIME
B-06 2.03 sec.	C-09 1.58 sec.	1.73 sec.

Figure 2.1

NORTH ANNA UNIT 1 - CYCLE 12 STARTUP PHYSICS TESTS
TYPICAL ROD DROP TRACE



ROD DROP TIME MEASUREMENT

Figure 2.2

NORTH ANNA UNIT 1 - CYCLE 12 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						1.73		1.60		1.73					
3							1.71		1.74						
4				1.73		1.65				1.71		1.75			
5					1.75						1.70				
6		1.64		1.73		1.69		1.77		1.72		1.75		2.03	
7			1.73				1.65		1.66				1.74		
8		1.78				1.72				1.69				1.82	
9			1.78				1.63		1.71				1.58		
10		1.79		1.73		1.64		1.70		1.73		1.71		1.84	
11					1.80						1.69				
12				1.69		1.79				1.67		1.75			
13							1.71		1.72						
14						1.97		1.73		1.79					
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 12, 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 near critical and the reference bank fully inserted. Initial statepoint data for the rod swap maneuver were obtained with the reference bank at its fully inserted position and all other banks fully withdrawn, 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 inserting one of the other control rod banks (i.e., a test bank) 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 or near the initial statepoint condition. 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 th MCP. The rod swap maneuver then was repeated in reverse such that the reference bank again was fully inserted 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 Test 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, ±15% for test banks of worth greater than 600 pcm, and ±100 pcm for test banks of worth less than or equal to 600 pcm.) The sum of the individual measured rod bank worths was within 1.9% 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 12 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	1233.5	1270.0	-2.9
D	970.0	995.5	-2.6
C	781.8	783.1	-0.2
A	361.0	368.8	-2.1 *
SB	1026.4	1030.2	-0.4
SA	975.7	1003.1	-2.7
Total Worth	5348.4	5450.7	-1.9

* Difference is less than 100 pcm.

Figure 3.1

NORTH ANNA UNIT 1 - CYCLE 12 STARTUP PHYSICS TESTS
CONTROL BANK B INTEGRAL ROD WORTH - HZP
ALL OTHER RODS WITHDRAWN

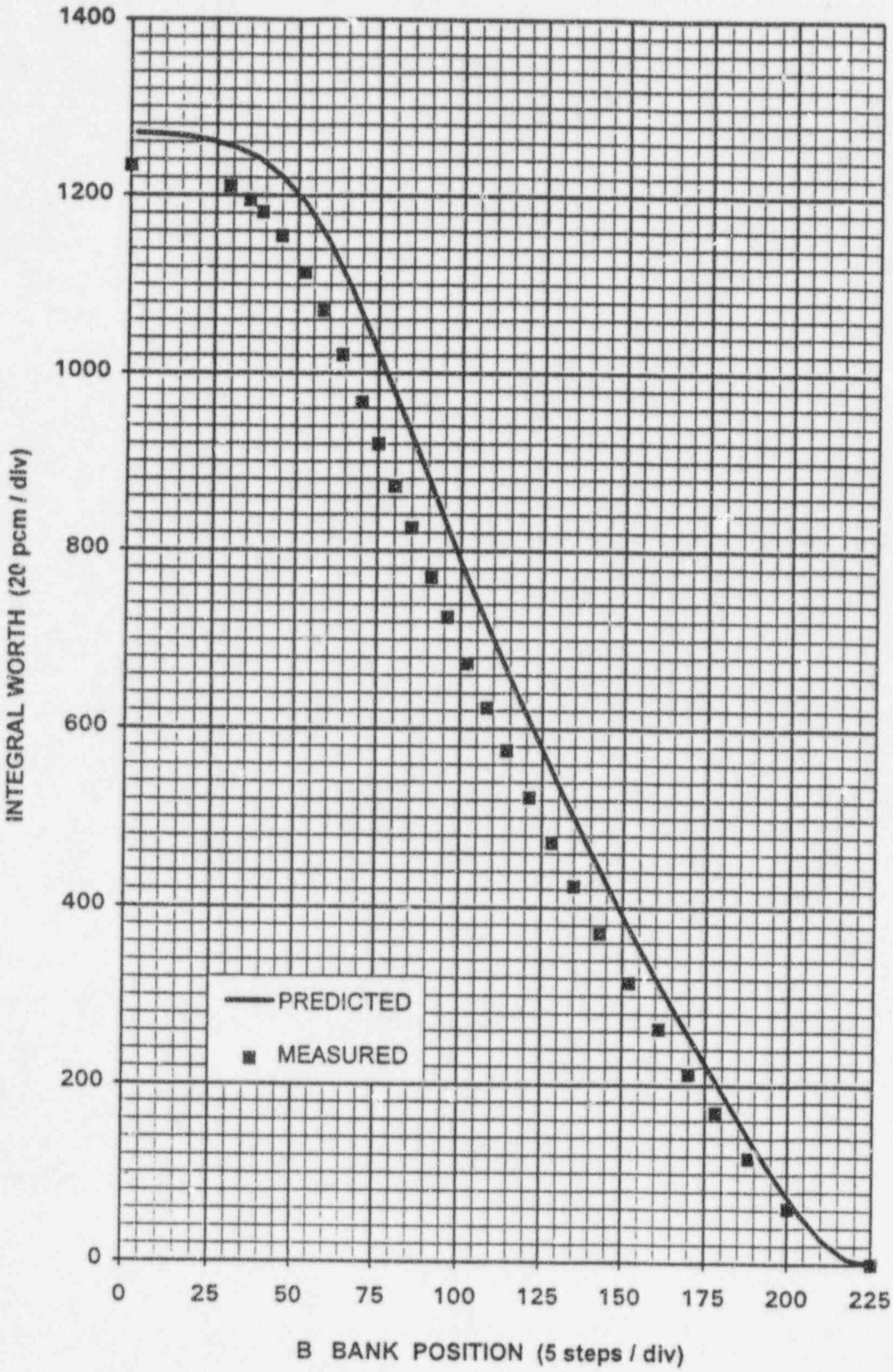
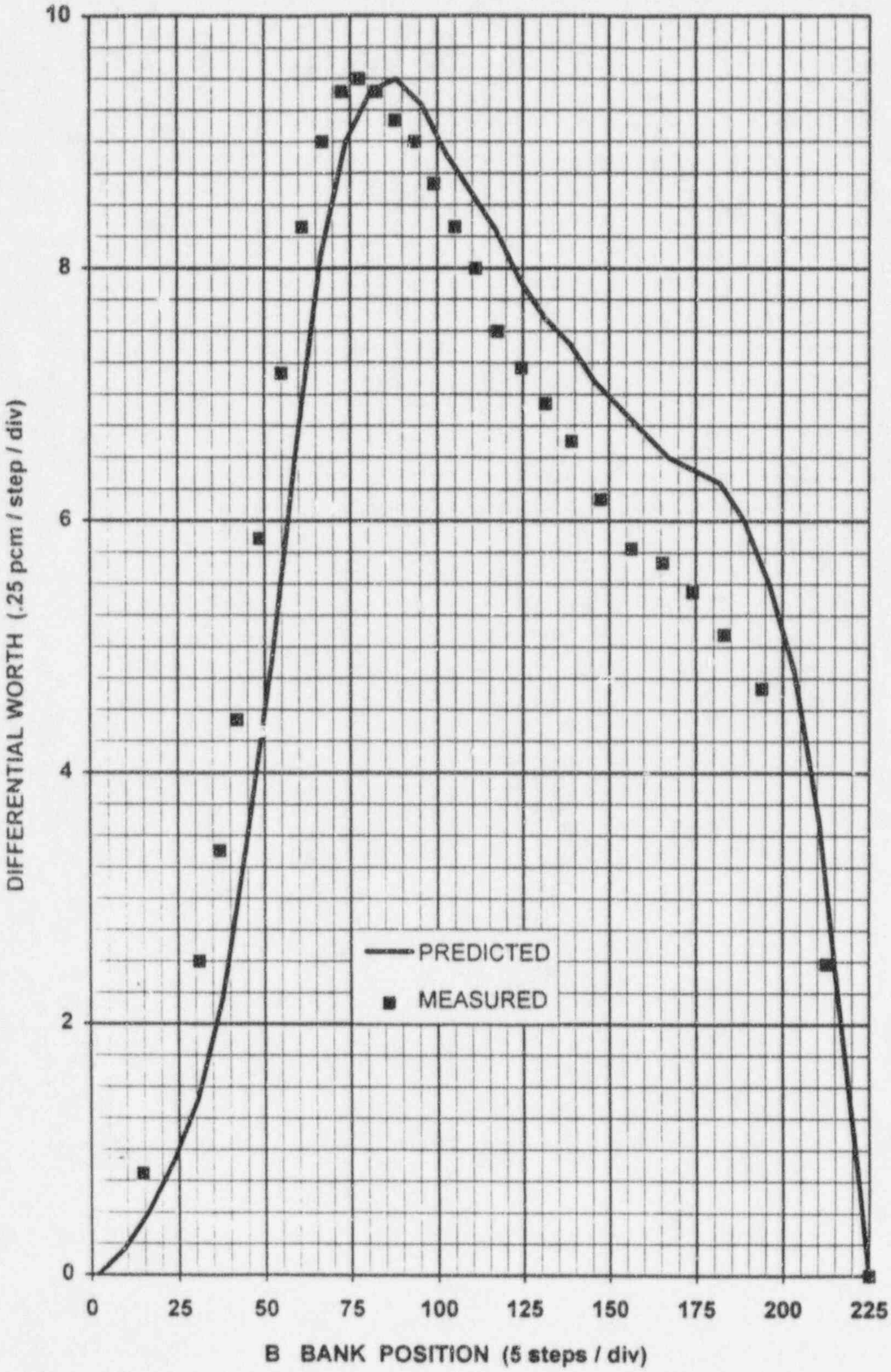


Figure 3.2

NORTH ANNA UNIT 1 - CYCLE 12 STARTUP PHYSICS TESTS
CONTROL 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 Test 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 -6.70 pcm/ppm. This is within 0.3% of the predicted value of -6.68 pcm/ppm and is well within the design tolerance of ±10%. In summary, the measured boron worth coefficient was satisfactory.

Table 4.1

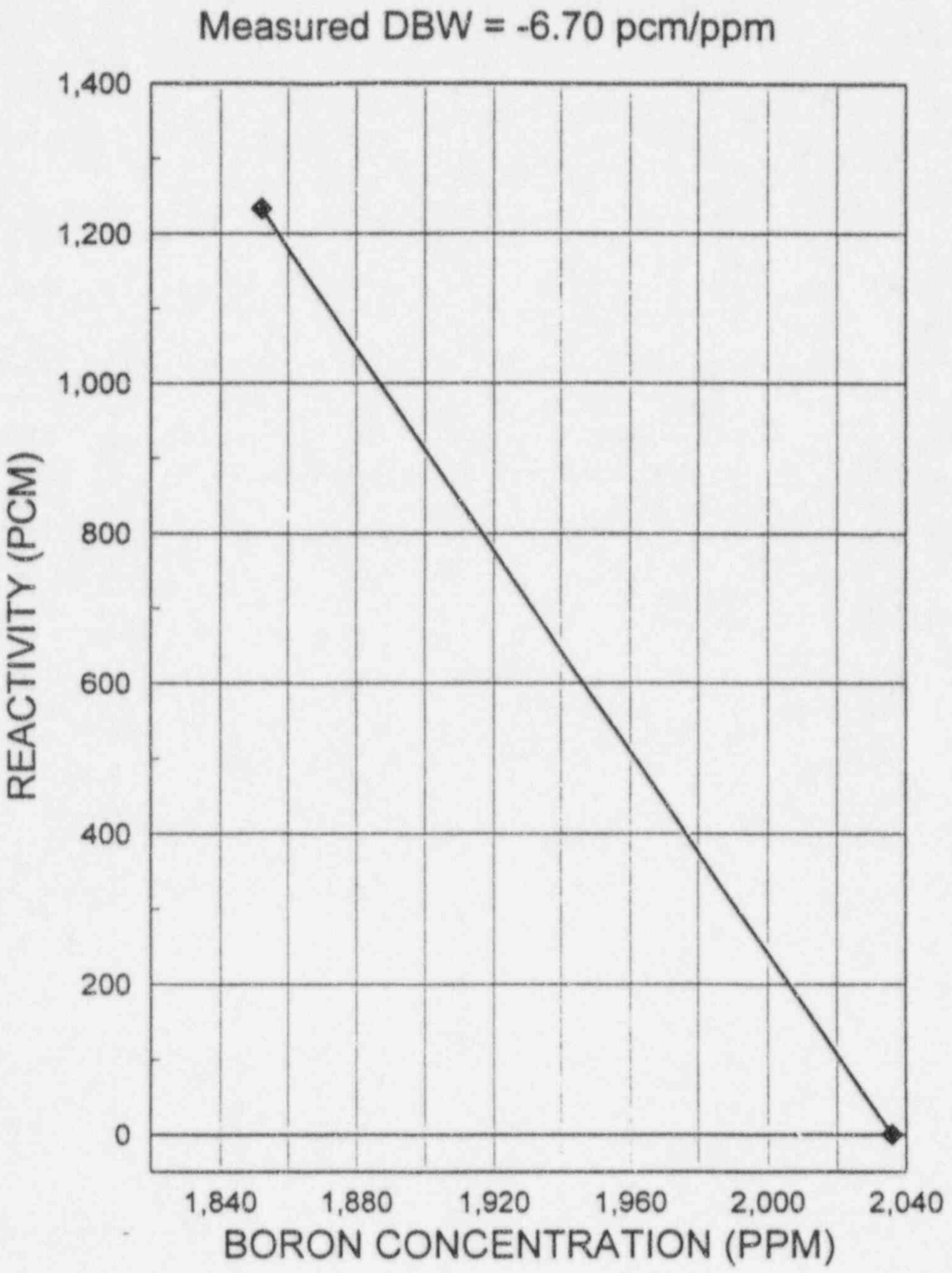
NORTH ANNA UNIT 1 - CYCLE 12 STARTUP PHYSICS TESTS
BORON ENDPOINTS SUMMARY

Control Rod Configuration	Measured Endpoint (ppm)	Predicted Endpoint (ppm)	Difference M-P (ppm)
ARO	2036	2040	-4
B Bank In	1852	1846*	6

* 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 Test Results and Evaluation Sheet in the Appendix.

Figure 4.1

NORTH ANNA UNIT 1 - CYCLE 12 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.

Reactivity was measured during the RCS cooldown of 3.4°F and RCS heatup of 3.5°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 Test 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 COLR Section 2.1.1. In summary, the measured result was satisfactory.

Table 5.1

NORTH ANNA UNIT 1 - CYCLE 12 STARTUP PHYSICS TESTS
ISOTHERMAL TEMPERATURE COEFFICIENT SUMMARY

BANK POSITION (STEPS)	TEMPERATURE RANGE (°F)	BORON CONCENTRATION (ppm)	ISOTHERMAL TEMPERATURE COEFFICIENT (PCM/°F)				
			C/D	H/U	AVE. MEAS.	PRED.	DIFFER. (M-P)
D/216	544.6 to 548.1	2036	-2.50	-2.70	-2.60	-3.20	0.60

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 the ramp to full power flux maps for Cycle 12. 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 a Virginia Power modified version of the Combustion Engineering computer program, CECOR[3]. CECOR 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 are given in Table 6.1. A comparison of these measured values with their COLR limits is given in Table 6.2. Flux map 1 was taken at 30% 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 and 3 were taken at 74% and 100% power, respectively, with different control rod configurations. These flux maps were taken to check 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 and 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 1.5% of the predicted values. Further, the measured F-Q(Z) and F-DH(N) peaking factor values for the at-power flux maps were within the limits of COLR Sections 2.5.1 and 2.6, respectively. Flux maps 1, 2, and 3 were used to perform power range detector calibrations (flux maps 1 and 2 verified that the existing calibration was satisfactory, thus no adjustments to the power range detector calibration were required). The flux map analyses are documented in Reference 7.

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 COLR. It is therefore anticipated that the core will continue to operate safely throughout Cycle 12.

TABLE 6.1

NORTH ANNA UNIT 1 - CYCLE 12 STARTUP PHYSICS TESTS
INCORE FLUX MAP SUMMARY

MAP DESCRIPTION	MAP NO.	DATE	BURN UP MWD/MTU	PWR (%)	BANK D STEPS	(1) F-Q(Z) HOT CHANNEL FACTOR			F-DH(N) HOT CHNL.FACTOR		CORE F(Z) MAX		(2) CORE TILT		AXIAL OFF SET (%)	NO. OF THIMBLES
						ASSY	AXIAL POINT	F-Q(Z)	ASSY	F-DH(N)	AXIAL POINT	F(Z)	MAX	LOC		
LOW POWER	1	03-12-96	5	30	152	N06	31	2.246	N06	1.512	31	1.388	1.0076	NW	-4.13	46
P.F.V. (3)	2	03-13-96	25	74	213	N06	31	1.905	N06	1.432	26	1.223	1.0028	NW	2.07	46
HOT FULL POWER	3	04-01-96	721	100	225	N06	36	1.850	N06	1.400	35	1.214	1.0017	NE	-2.84	46

NOTES: HOT SPOT LOCATIONS ARE SPECIFIED BY GIVING ASSEMBLY LOCATIONS (E.G. H-8 IS THE CENTER-OF-CORE ASSEMBLY) AND CORE HEIGHT (IN THE "Z" DIRECTION THE CORE IS DIVIDED INTO 61 AXIAL POINTS STARTING FROM THE TOP OF THE CORE).

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

(2) CORE TILT - DEFINED AS THE AVERAGE QUADRANT POWER TILT FROM CECOR.

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

(4) MAPS 1, 2, AND 3 WERE USED FOR POWER RANGE DETECTOR CALIBRATIONS. THE CALIBRATION FOR FLUX MAPS 1 AND 2 VERIFIED THE ACCEPTABILITY OF THE EXISTING CALIBRATION.

Table 6.2

NORTH ANNA UNIT 1 - CYCLE 12 STARTUP PHYSICS TESTS
COMPARISION OF MEASURED POWER DISTRIBUTION PARAMETERS
WITH THEIR CORE OPERATING LIMITS

MAP NO.	PEAK F-Q(Z) HOT CHANNEL FACTOR*			F-Q(Z) 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	2.246	4.380	31	2.246	4.380	31	48.7	1.512	1.805	16.2
2	1.905	2.956	31	1.898	2.919	26	35.0	1.432	1.606	10.8
3	1.850	2.190	36	1.850	2.190	36	15.5	1.400	1.490	6.0

* The Core Operating Limit for the heat flux hot channel factor, F-Q(Z), is a function of core height and power level. The value for F-Q(Z) listed above is the maximum value of F-Q(Z) in the core. The COLR limit listed above is evaluated at the plane of maximum F-Q(Z).

** The value for F-Q(Z) 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(Z) and the COLR limit for each map.

The measured F-Q(Z) hot channel factors include 8.15% total uncertainty.

Figure 6.1

NORTH ANNA UNIT 1 - CYCLE 12 STARTUP PHYSICS TESTS
ASSEMBLYWISE POWER DISTRIBUTION
30% POWER

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
		PREDICTED				0.260	0.308	0.259				PREDICTED			
		MEASURED				0.254	0.298	0.255				MEASURED			1
		PCT DIFFERENCE				-2.2	-3.4	-1.3				PCT DIFFERENCE			
				0.338	0.684	1.101	0.883	1.109	0.685	0.338					
				0.334	0.672	1.080	0.868	1.101	0.693	0.340					2
				-1.2	-1.7	-1.9	-1.8	-0.7	1.3	0.5					
			0.371	1.164	1.347	1.222	1.282	1.226	1.347	1.162	0.369				
			0.374	1.153	1.327	1.197	1.250	1.214	1.349	1.163	0.366				3
			0.9	-0.9	-1.5	-2.0	-2.5	-1.0	0.1	0.0	-0.9				
		0.357	0.832	1.291	1.266	1.198	1.182	1.199	1.266	1.288	0.829	0.353			
		0.371	0.842	1.281	1.249	1.171	1.146	1.189	1.275	1.299	0.825	0.352			4
		3.9	1.2	-0.7	-1.3	-2.2	-3.0	-0.8	0.7	0.1	-0.5	-0.4			
	0.338	1.162	1.292	1.267	1.188	1.146	1.148	1.146	1.187	1.264	1.285	1.150	0.333		
	0.355	1.231	1.324	1.278	1.179	1.115	1.136	1.146	1.191	1.265	1.273	1.148	0.340		5
	5.0	5.9	2.5	0.8	-0.7	-2.7	-1.1	0.0	0.4	0.0	-0.9	-0.2	2.1		
	0.688	1.351	1.270	1.189	1.029	1.138	1.167	1.136	1.029	1.187	1.264	1.342	0.683		
	0.713	1.400	1.293	1.180	1.032	1.147	1.183	1.154	1.038	1.185	1.255	1.342	0.696		6
	3.6	3.6	1.8	-0.7	0.3	0.8	1.4	1.6	0.9	-0.1	-0.7	0.0	1.8		
0.259	1.112	1.228	1.200	1.144	1.135	1.224	1.222	1.226	1.138	1.144	1.197	1.220	1.097	0.256	
0.267	1.148	1.270	1.220	1.149	1.151	1.270	1.255	1.273	1.152	1.139	1.175	1.220	1.142	0.265	7
3.2	3.3	3.4	1.7	0.4	1.3	3.8	2.6	3.8	1.2	-0.4	-1.8	0.0	4.1	3.6	
0.307	0.881	1.281	1.182	1.147	1.166	1.220	1.228	1.225	1.168	1.148	1.183	1.282	0.881	0.307	
0.316	0.907	1.311	1.195	1.139	1.173	1.240	1.245	1.240	1.172	1.137	1.162	1.259	0.900	0.313	8
2.8	3.0	2.3	1.1	-0.6	0.7	1.6	1.4	1.3	0.4	-1.0	-1.7	-1.8	2.0	1.7	
0.256	1.096	1.219	1.196	1.142	1.137	1.223	1.222	1.227	1.137	1.145	1.200	1.229	1.113	0.259	
0.262	1.121	1.243	1.208	1.134	1.140	1.230	1.224	1.218	1.103	1.120	1.173	1.206	1.104	0.254	9
2.4	2.3	2.0	1.0	-0.7	0.3	0.5	0.1	-0.7	-3.3	-2.2	-2.3	-1.9	-0.8	-1.9	
	0.683	1.341	1.263	1.186	1.028	1.135	1.167	1.139	1.030	1.190	1.270	1.252	0.688		
	0.698	1.372	1.282	1.196	1.034	1.135	1.158	1.122	1.003	1.161	1.228	1.320	0.673		10
	2.2	2.3	1.5	0.9	0.6	0.0	-0.7	-1.5	-2.6	-2.5	-3.3	-2.4	-2.2		
	0.333	1.150	1.285	1.264	1.186	1.145	1.148	1.146	1.188	1.268	1.292	1.163	0.338		
	0.339	1.173	1.307	1.289	1.192	1.138	1.130	1.122	1.146	1.245	1.267	1.139	0.331		11
	2.0	2.0	1.7	2.0	0.5	-0.6	-1.6	-2.1	-3.6	-1.8	-2.0	-2.1	-2.1		
		0.353	0.828	1.287	1.266	1.198	1.182	1.199	1.267	1.291	0.833	0.357			
		0.360	0.840	1.300	1.266	1.182	1.164	1.178	1.240	1.272	0.833	0.354			12
		2.1	1.3	1.0	0.0	-1.4	-1.5	-1.7	-2.1	-1.5	0.0	-0.9			
			0.369	1.162	1.347	1.226	1.282	1.222	1.347	1.164	0.371				
			0.372	1.170	1.346	1.215	1.263	1.211	1.323	1.146	0.367				13
			0.9	0.7	-0.1	-0.9	-1.5	-0.9	-1.8	-1.6	-0.9				
				0.338	0.684	1.109	0.883	1.101	0.684	0.338					
				0.347	0.685	1.103	0.884	1.121	0.681	0.334					14
				2.6	0.1	-0.5	0.0	1.7	-0.4	-1.1					
		STANDARD				0.259	0.308	0.260				AVERAGE			
		DEVIATION				0.254	0.308	0.263				PCT DIFFERENCE			15
		=1.090				-2.0	-0.1	1.3				= 1.5			

SUMMARY

MAP NO: N1-12-01	DATE: 03/12/96	POWER: 30%
CONTROL ROD POSITIONS:	F-Q(Z) = 2.246	CORE TILT:
D BANK AT 152 STEPS	F-DH(N) = 1.512	NW 1.0076 | NE 1.0007
	F(Z) = 1.388	SW 1.0051 | SE 0.9866
	BURNUP = 5 MWD/MTU	A.O. = -4.13%

Figure 6.2

NORTH ANNA UNIT 1 - CYCLE 12 STARTUP PHYSICS TESTS
ASSEMBLYWISE POWER DISTRIBUTION
74% POWER

PREDICTED / MEASURED / PCT DIFFERENCE

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							0.286 0.278 -2.8	0.349 0.333 -4.6	0.285 0.279 -2.1						
2					0.342 0.336 -1.7	0.691 0.678 -1.9	1.137 1.112 -2.2	0.996 0.972 -2.4	1.144 1.130 -1.3	0.692 0.695 0.5	0.342 0.342 0.2				
3				0.370 0.365 -1.4	1.122 1.104 -1.6	1.301 1.278 -1.7	1.215 1.190 -2.1	1.289 1.256 -2.6	1.219 1.204 -1.2	1.302 1.299 -0.2	1.121 1.122 0.0	0.369 0.371 0.4			
4			0.357 0.365 2.2	0.814 0.814 0.0	1.237 1.218 -1.5	1.229 1.212 -1.4	1.174 1.152 -1.9	1.169 1.136 -2.8	1.175 1.165 -0.9	1.229 1.233 0.3	1.236 1.236 0.1	0.811 0.807 -0.5	0.354 0.352 -0.5		
5		0.341 0.352 3.1	1.121 1.164 3.8	1.238 1.254 1.3	1.239 1.242 0.2	1.187 1.181 -0.5	1.147 1.133 -1.2	1.138 1.133 -0.5	1.147 1.150 3	1.186 1.192 0.4	1.238 1.240 0.2	1.234 1.217 -1.3	1.111 1.106 -0.5	0.337 0.339 0.7	
6		0.695 0.709 2.0	1.305 1.332 2.1	1.232 1.245 1.0	1.188 1.183 -0.4	1.136 1.139 0.3	1.159 1.174 1.3	1.173 1.193 1.7	1.158 1.180 1.9	1.135 1.146 1.0	1.187 1.189 0.2	1.228 1.222 -0.5	1.298 1.297 -0.1	0.691 0.700 1.2	
7	0.284 0.288 1.4	1.147 1.164 1.5	1.220 1.241 1.7	1.175 1.185 0.9	1.146 1.150 0.4	1.157 1.175 1.5	1.239 1.291 4.2	1.228 1.267 3.2	1.241 1.296 4.4	1.160 1.182 1.9	1.146 1.149 0.3	1.173 1.162 -0.9	1.212 1.212 0.0	1.133 1.165 2.9	0.281 0.288 2.3
8	0.348 0.351 0.9	0.994 1.003 0.9	1.287 1.297 0.7	1.169 1.173 0.4	1.137 1.130 -0.5	1.173 1.185 1.0	1.226 1.253 2.2	1.231 1.258 2.2	1.231 1.258 2.2	1.174 1.191 1.5	1.137 1.138 0.0	1.169 1.158 -0.9	1.288 1.266 -1.7	0.994 1.004 1.0	0.348 0.350 0.6
9	0.281 0.283 0.7	1.133 1.139 0.6	1.212 1.218 0.5	1.172 1.175 0.2	1.145 1.141 -0.3	1.158 1.165 0.6	1.239 1.254 1.2	1.228 1.242 1.1	1.241 1.247 0.5	1.158 1.145 -1.1	1.147 1.138 -0.7	1.176 1.164 -1.0	1.221 1.210 -0.9	1.147 1.146 -0.1	0.285 0.276 -2.9
10		0.691 0.694 0.4	1.297 1.300 0.3	1.227 1.233 0.4	1.186 1.192 0.5	1.135 1.140 0.5	1.157 1.169 1.0	1.173 1.177 0.3	1.160 1.157 -0.3	1.136 1.122 -1.2	1.188 1.178 -0.9	1.232 1.214 -1.5	1.305 1.295 -0.7	0.695 0.701 0.8	
11		0.337 0.338 0.4	1.110 1.115 0.4	1.233 1.241 0.7	1.237 1.253 1.3	1.186 1.190 0.3	1.147 1.145 -0.2	1.138 1.131 -0.6	1.148 1.137 -1.0	1.187 1.165 -1.8	1.240 1.236 -0.3	1.239 1.232 -0.5	1.121 1.114 -0.6	0.341 0.341 -0.1	
12			0.354 0.354 0.0	0.811 0.815 0.4	1.235 1.239 0.4	1.229 1.225 -0.3	1.174 1.156 -1.5	1.169 1.155 -1.2	1.174 1.160 -1.1	1.229 1.212 -1.4	1.238 1.229 -0.7	0.814 0.820 0.7	0.357 0.352 -1.5		
13				0.369 0.370 0.2	1.121 1.122 0.1	1.302 1.295 -0.5	1.219 1.205 -1.2	1.289 1.268 -1.7	1.215 1.204 -0.9	1.301 1.274 -2.1	1.122 1.109 -1.2	0.371 0.369 -0.4			
14					0.342 0.344 0.8	0.692 0.688 -0.6	1.144 1.131 -1.1	0.996 0.989 -0.7	1.137 1.153 1.4	0.691 0.688 -0.5	0.342 0.338 -0.9				
15							0.285 0.273 -4.0	0.349 0.346 -1.0	0.286 0.288 0.9						

STANDARD DEVIATION =0.920

AVERAGE PCT DIFFERENCE = 1.1

SUMMARY

MAP NO: N1-12-02   DATE: 03/13/96   POWER: 74%

CONTROL ROD POSITIONS: F-Q(Z) = 1.905   CORE TILT:

D BANK AT 213 STEPS   F-DH(N) = 1.432   NW 1.0028 | NE 1.0015

F(Z) = 1.223   SW 1.0005 | SE 0.9953

BURNUP = 25 MWD/MTU   A.O. = 2.07%

Figure 6.3

NORTH ANNA UNIT 1 - CYCLE 12 STARTUP PHYSICS TESTS
ASSEMBLYWISE POWER DISTRIBUTION
100% POWER

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1			PREDICTED MEASURED PCT DIFFERENCE				0.290 0.283 -2.5	0.355 0.346 -2.6	0.289 0.284 -1.7				PREDICTED MEASURED PCT DIFFERENCE		
2					0.347 0.339 -2.2	0.692 0.676 -2.3	1.123 1.095 -2.4	0.995 0.971 -2.5	1.130 1.114 -1.4	0.693 0.695 0.3	0.347 0.348 0.5				
3				0.377 0.375 -0.4	1.113 1.089 -2.1	1.288 1.260 -2.2	1.260 1.170 -2.5	1.281 1.239 -3.3	1.204 1.186 -1.5	1.289 1.286 -0.3	1.112 1.118 0.6	0.376 0.394 4.8			
4			0.363 0.366 1.0	0.819 0.813 -0.7	1.234 1.202 -2.6	1.221 1.198 -1.9	1.178 1.154 -2.1	1.168 1.138 -2.5	1.179 1.168 -0.9	1.221 1.220 -0.1	1.233 1.234 0.1	0.817 0.814 -0.3	0.360 0.358 -0.6		
5		0.346 0.352 1.8	1.111 1.136 2.2	1.234 1.241 0.6	1.235 1.238 0.2	1.200 1.192 -0.7	1.153 1.138 -1.3	1.150 1.148 -0.2	1.153 1.157 0.4	1.199 1.205 0.5	1.234 1.238 0.3	1.231 1.203 -2.3	1.102 1.093 -0.8	0.342 0.352 2.9	
6		0.695 0.703 1.1	1.292 1.307 1.2	1.223 1.226 0.2	1.201 1.186 -1.3	1.154 1.157 0.3	1.173 1.192 1.5	1.175 1.203 2.4	1.171 1.198 2.3	1.154 1.168 1.3	1.200 1.203 0.3	1.220 1.209 -0.9	1.285 1.279 -0.5	0.692 0.699 0.9	
7	0.289 0.290 0.5	1.132 1.140 0.7	1.205 1.219 1.2	1.179 1.183 0.3	1.152 1.151 -0.1	1.171 1.189 1.5	1.235 1.291 4.6	1.222 1.266 3.6	1.236 1.294 4.8	1.174 1.199 2.2	1.152 1.157 0.4	1.177 1.165 -1.1	1.198 1.192 -0.6	1.119 1.139 1.8	0.286 0.290 1.5
8	0.354 0.354 0.0	0.993 0.992 -0.1	1.280 1.274 -0.5	1.167 1.164 -0.3	1.149 1.140 -0.8	1.175 1.187 1.0	1.220 1.249 2.4	1.224 1.253 2.4	1.224 1.255 2.5	1.176 1.201 2.1	1.149 1.153 0.3	1.168 1.156 -1.0	1.280 1.251 -2.3	0.993 1.003 1.0	0.354 0.357 0.7
9	0.286 0.285 -0.3	1.119 1.114 -0.4	1.198 1.192 -0.5	1.176 1.175 -0.1	1.151 1.155 0.3	1.172 1.182 0.8	1.234 1.251 1.3	1.222 1.237 1.2	1.237 1.245 0.7	1.172 1.163 -0.8	1.152 1.147 -0.5	1.179 1.170 -0.8	1.205 1.201 -0.3	1.132 1.148 1.4	0.289 0.286 -1.1
10		0.692 0.687 -0.7	1.285 1.271 -1.1	1.220 1.219 -0.1	1.199 1.206 0.5	1.153 1.160 0.6	1.171 1.182 0.9	1.175 1.179 0.3	1.174 1.172 -0.1	1.155 1.146 -0.7	1.201 1.196 -0.5	1.224 1.208 -1.3	1.292 1.301 0.7	0.695 0.735 5.7	
11		0.342 0.341 -0.3	1.102 1.101 -0.1	1.230 1.235 0.4	1.234 1.248 1.2	1.199 1.203 0.3	1.153 1.149 -0.3	1.150 1.143 -0.6	1.154 1.143 -0.9	1.200 1.182 -1.5	1.235 1.242 0.5	1.235 1.240 0.5	1.111 1.121 0.9	0.346 0.356 2.8	
12			0.360 0.367 2.1	0.817 0.822 0.6	1.232 1.238 0.5	1.221 1.217 -0.3	1.178 1.158 -1.7	1.168 1.150 -1.5	1.178 1.163 -1.3	1.221 1.205 -1.3	1.234 1.234 0.0	0.819 0.839 2.4	0.363 0.368 1.4		
13				0.376 0.377 0.5	1.112 1.115 0.3	1.289 1.285 -0.3	1.204 1.189 -1.2	1.281 1.251 -2.4	1.200 1.184 -1.4	1.288 1.258 -2.4	1.113 1.102 -1.0	0.377 0.378 0.5			
14					0.347 0.354 2.2	0.693 0.693 0.0	1.130 1.127 -0.3	0.995 0.990 -0.6	1.123 1.131 0.8	0.692 0.686 -0.9	0.347 0.344 -1.0				
15			STANDARD DEVIATION =1.041				0.289 0.301 4.0	0.355 0.357 0.5	0.290 0.292 0.7				AVERAGE PCT DIFFERENCE = 1.2		

SUMMARY

MAP NO: N1-12-03   DATE: 04/01/96   POWER: 100%

CONTROL ROD POSITIONS: F-Q(Z) = 1.850   CORE TILT:

D BANK AT 225 STEPS   F-DH(N) = 1.400

NW 0.9987	NE 1.0017
SW 0.9999	SE 0.9997

F(Z) = 1.214

BURNUP = 721 MWD/MTU   A.O. = -2.84%

SECTION 7

REFERENCES

1. T. S. Psuik, "North Anna Unit 1, Cycle 12 Design Report", Technical Report NE-1063, Revision 0, Virginia Power, February, 1996.

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

3. T. W. Schleicher, "The Virginia Power CECOR Code Package", Technical Report NE-831, Revision 3, Virginia Power, July, 1995.

4. North Anna Unit 1 Technical Specifications, Sections 1.19, 3.1.3.4, 3.2.2, 3.2.3, 3.1.1.4, 4.1.1.1.2, and 4.2.2.2 and Core Operating Limits Report (COLR) for North Anna 1, Cycle 12 Pattern BL, Revision 0 (February, 1996) Sections 2.1.1, 2.5.1, and 2.6.

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.

6. J. M. Mirilovich, "North Anna Unit 1, Cycle 12 TOTE Calculations", PM-642 Revision 0, March, 1996.

7. R. A. Hall, et al, "North Anna 1, Cycle 12 Flux Map Analysis", PM-646, Revision 0, and Addenda A and B, March-April, 1996.

8. R. T. Robins, "Reload Safety Evaluation, North Anna 1 Cycle 12 Pattern BL", Technical Report NE-1058, Revision 0, January, 1996.

APPENDIX

STARTUP PHYSICS TEST RESULTS
AND EVALUATION SHEETS

NORTH ANNA POWER STATION UNIT 1 CYCLE 12
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Zero Power Testing Range Determination Proc No / Section: 1-PT-94.0	Sequence Step No:
II Test Conditions (Design)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: 225 CC: * CD: *	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: 225 CC: 220 CD: 92	RCS Temperature (°F): 546.9 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 3/11/96 01:26	
	Reactivity Computer Initial Flux Background Reading	1.6×10^{-9} amps
	Flux Reading At Point Of Nuclear Heating	3.5×10^{-7} amps
	Zero Power Testing Range	$\times 10^{-8}$ to 10×10^{-8} amps
	Reference	Not Applicable
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 ** Design Tolerance and Acceptance Criteria are met if ZPTR is below the Point of Nuclear Heating and above background.	

Prepared By: [illegible] Reviewed By: Thomas [illegible]

NORTH ANNA POWER STATION UNIT 1 CYCLE 12
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Reactivity Computer Checkout Proc No / Section: 1-PT-94.0	Sequence Step No:
II Test Conditions (Design)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: 225 CC: * CD: *	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: 225 CC: 224 CD: 96	RCS Temperature (°F): 548.2 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 3/11/96 02:36	
	Measured Parameter (Description)	ρ_c= Measured Reactivity using ρ-computer ρ_t= Predicted Reactivity
	Measured Value	ρ_c= 51pcm, −29 pcm ρ_t= 51 pcm, −28.3 pcm %D= 0%, 2.5%
	Design Value	%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 : ✓ YES ___ NO Acceptance Criteria is met : ✓ YES ___ NO	
	* At The Just Critical Position The allowable range will be set based on the above results, as well as results from the benchmark test. Allowable Range = −29 pcm to +50 pcm	

Prepared By: Thomas S. Psurek   Reviewed By: [signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 12
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Critical Boron Concentration - ARO Proc No / Section: 1-PT-94.0		Sequence Step No:
II Test Conditions (Design)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: 225 CC: 225 CD: 225		RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: 225 CC: 225 CD: 225		RCS Temperature (°F): 548.1 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 3/11/96 0720		
	Measured Parameter (Description)	$(C_B)^M_{ARO}$: Critical Boron Concentration - ARO	
	Measured Value (Design Conditions)	$(C_B)^M_{ARO}$= 2036	
	Design Value (Design Conditions)	C_B= 2040 ± 50 ppm	
	Reference	Technical Report NE-1063, 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 = -6.64 pcm/ppm $C_B^D = \lvert (C_B)^M_{ARO} - C_B \rvert$; C_B is design value		

Prepared By: [signature]

Reviewed By: Pamela D. Banning

NORTH ANNA POWER STATION UNIT 1 CYCLE 12
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

<table>
<tr><td>I
Reference</td><td colspan="2">Test Description: Isothermal Temperature Coefficient - ARO
Proc No / Section: 1-PT-94.0 Sequence Step No:</td></tr>
<tr><td>II
Test
Conditions
(Design)</td><td>Bank Positions (Steps)
SDA: 225 SDB: 225 CA: 225
CB: 225 CC: 225 CD: 225</td><td>RCS Temperature (^{O}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: 225 SDB: 225 CA: 225
CB: 225 CC: 225 CD: 216</td><td>RCS Temperature (^{O}F): 544.6 - 548.1
Power Level (% F.P.): 0
Other (specify):
Below Nuclear Heating</td></tr>
<tr><td rowspan="6">IV
Test
Results</td><td colspan="2">Date/Time Test Performed:
3/11/96 0612</td></tr>
<tr><td>Measured Parameter
(Description)</td><td>$(\alpha_T^{ISO})_{ARO}$: Isothermal Temperature Coefficient - ARO</td></tr>
<tr><td>Measured Value</td><td>$(\alpha_T^{ISO})_{ARO}$ = − 2.6 pcm/^{O}F
(C_B= 2036 ppm)</td></tr>
<tr><td>Design Value
(Actual Conditions)</td><td>$(\alpha_T^{ISO})_{ARO}$ = − 3.2013 pcm/^{O}F
(C_B= 2036 ppm)</td></tr>
<tr><td>Design Value
(Design Conditions)</td><td>$(\alpha_T^{ISO})_{ARO}$ = -3.16 ± 3 pcm/^{O}F
(C_B= 2040 ppm)</td></tr>
<tr><td>Reference</td><td>Technical Report NE-1063, Rev. 0</td></tr>
<tr><td rowspan="2">V
Acceptance
Criteria</td><td>FSAR/COLR</td><td>α_T^{ISO} ≤ 3.75 pcm/^{O}F*
α_T^{DOP} = -1.75 pcm/^{O}F</td></tr>
<tr><td>Reference</td><td>COLR 2.1.1,
Technical Report NE-1063, Rev. 0</td></tr>
<tr><td rowspan="2">VI
Comments</td><td colspan="2">Design Tolerance is met : ✓ YES ____ NO
Acceptance Criteria is met : ✓ YES ____ NO</td></tr>
<tr><td colspan="2">*Uncertainty on αT_{MOD} = 0.5 pcm/^{O}F (Reference: memorandum from C.T. Snow to E.J. Lozito dated June 27, 1980.)</td></tr>
</table>

Prepared By: [signature] Reviewed By: Pamela D. Barnes

NORTH ANNA POWER STATION UNIT 1 CYCLE 12
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Control Bank B Worth Measurement, Rod Swap Ref. Bank Proc No / Section: 1-PT-94.0 Sequence Step No:	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: moving CC: 225 CD: 225	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: moving CC: 225 CD: 225	RCS Temperature (°F): 548.3 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 3/11/96 07:59	
	Measured Parameter (Description)	I_B^{REF}; Integral Worth Of Control Bank B, All Other Rods Out
	Measured Value	I_B^{REF}= 1233.5
	Design Value (Design Conditions)	I_B^{REF}= 1270 ± 127 pcm
	Reference	Technical Report NE-1063, Rev. 0
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: Randa D. Bandi

Reviewed By: [signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 12
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

<table>
<tr><td>I
Reference</td><td colspan="2">Test Description: Critical Boron Concentration - B Bank In
Proc No / Section: 1-PT-94.0 Sequence Step No:</td></tr>
<tr><td>II
Test
Conditions
(Design)</td><td>Bank Positions (Steps)
SDA: 225 SDB: 225 CA: 225
CB: 0 CC: 225 CD: 225</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: 225 SDB: 225 CA: 225
CB: 0 CC: 225 CD: 225</td><td>RCS Temperature (°F): 548.3
Power Level (% F.P.): 0
Other (specify):
Below Nuclear Heating</td></tr>
<tr><td rowspan="5">IV
Test
Results</td><td colspan="2">Date/Time Test Performed:
3/11/96 07:59</td></tr>
<tr><td>Measured Parameter
(Description)</td><td>$(C_B)^M_B$: Critical Boron Concentration, B Bank In</td></tr>
<tr><td>Measured Value
(Design Conditions)</td><td>$(C_B)^M_B$= 1852</td></tr>
<tr><td>Design Value
(Design Conditions)</td><td>$C_B = 1850+\Delta C_B^{Prev} \pm (10 + 127.0/|\alpha C_B|)$ppm
C_B = 1846 ppm</td></tr>
<tr><td>Reference</td><td>Technical Report NE-1063, Rev. 0</td></tr>
<tr><td rowspan="2">V
Acceptance
Criteria</td><td>FSAR/Tech Spec</td><td>Not Applicable</td></tr>
<tr><td>Reference</td><td>Not Applicable</td></tr>
<tr><td rowspan="2">VI
Comments</td><td colspan="2">Design Tolerance is met : ✓ YES ___ NO
Acceptance Criteria is met : ✓ YES ___ NO</td></tr>
<tr><td colspan="2">αC_B = -6.68 pcm/ppm
$\Delta C_B^{Prev} = (C_B)^M_{ARO}$ - 2040 ppm</td></tr>
</table>

Prepared By: Pamela D Banning

Reviewed By: [signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 12
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: HZP Boron Worth Coefficient Measurement Proc No / Section: 1-PT-94.0		Sequence Step No:
II Test Conditions (Design)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: moving CC: 225 CD: 225		RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: moving CC: 225 CD: 225		RCS Temperature (°F): 548.3 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 3/11/96 07:59		
	Measured Parameter (Description)	αC_B ; Boron Worth Coefficient	
	Measured Value	αC_B = -6.70	
	Design Value (Design Conditions)	αC_B = -6.68 ± 0.67 pcm/ppm	
	Reference	Technical Report NE-1063, 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: Pamela D Barnes

Reviewed By: [signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 12
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Control Bank D Worth Measurement, Rod Swap Proc No / Section: 1-PT-94.0	Sequence Step No:
II Test Conditions (Design)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: moving CC: 225 CD: moving	RCS Temperature (^{o}F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: moving CC: 225 CD: moving	RCS Temperature (^{o}F): 547.1 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 3/11/96 1259	
	Measured Parameter (Description)	I_D^{RS}; Integral Worth of Control Bank D, Rod Swap
	Measured Value	I_D^{RS}= 970 (Adjusted Measured Critical Reference Bank Position = 161 steps)
	Design Value (Actual Conditions)	I_D^{RS}= 995.5 (Adjusted Measured Critical Reference Bank Position = ~~169~~ 161 RAB 3/11/96 steps)
	Design Value (Design Conditions)	I_D^{RS}= 995 ± 149 pcm (Critical Reference Bank Position = 167 steps)
	Reference	Technical Report NE-1063, 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: Daniel D Banning

Reviewed By: [signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 12
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Control Bank C Worth Measurement, Rod Swap Proc No / Section: 1-PT-94.0 Sequence Step No:	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: moving CC: moving CD: 225	RCS Temperature (^{o}F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: moving CC: moving CD: 225	RCS Temperature (^{o}F): 547.2 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 3/11/96 1345	
	Measured Parameter (Description)	I_C^{RS}: Integral Worth of Control Bank C, Rod Swap
	Measured Value	I_C^{RS}= 781.8 (Adjusted Measured Critical Reference Bank Position = 131 steps)
	Design Value (Actual Conditions)	I_C^{RS}= 783.1 (Adjusted Measured Critical Reference Bank Position = 131 steps)
	Design Value (Design Conditions)	I_C^{RS}= 777 ± 117 pcm (Critical Reference Bank Position = 136 steps)
	Reference	Technical Report NE-1063, 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: Pamela D. Banning

Reviewed By: [signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 12
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Control Bank A Worth Measurement, Rod Swap Proc No / Section: 1-PT-94.0 Sequence Step No:	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: moving CB: moving CC: 225 CD: 225	RCS Temperature (^{o}F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: moving CB: moving CC: 225 CD: 225	RCS Temperature (^{o}F): 547.3 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 3/11/96 1418	
	Measured Parameter (Description)	I_A^{RS}: Integral Worth of Control Bank A, Rod Swap
	Measured Value	I_A^{RS} = 361 (Adjusted Measured Critical Reference Bank Position = 80 steps)
	Design Value (Actual Conditions)	I_A^{RS} = 368.8 (Adjusted Measured Critical Reference Bank Position = 80 steps)
	Design Value (Design Conditions)	$I_A^{RS} = 378 \pm 100$ pcm (Critical Reference Bank Position = 89 steps)
	Reference	Technical Report NE-1063, 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: Pamela D. Barnes Reviewed By: [signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 12
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Shutdown Bank B Worth Measurement, Rod Swap Proc No / Section: 1-PT-94.0	Sequence Step No:
II Test Conditions (Design)	Bank Positions (Steps) SDA: 225 SDB: moving CA: 225 CB: moving CC: 225 CD: 225	RCS Temperature (^{o}F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 225 SDB: moving CA: 225 CB: moving CC: 225 CD: 225	RCS Temperature (^{o}F): 547.4 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 3/11/96 14:51	
	Measured Parameter (Description)	I_{SB}^{RS}; Integral Worth of Shutdown Bank B, Rod Swap
	Measured Value	I_{SB}^{RS}= 1026.4 (Adjusted Measured Critical Reference Bank Position = 171 steps)
	Design Value (Actual Conditions)	I_{SB}^{RS}= 1030.2 (Adjusted Measured Critical Reference Bank Position = 171 steps)
	Design Value (Design Conditions)	I_{SB}^{RS}= 1033 ± 155 pcm (Critical Reference Bank Position = 173 steps)
	Reference	Technical Report NE-1063, 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	

P ared By: Pamela D. Banning   Reviewed By: [signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 12
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Shutdown Bank A Worth Measurement, Rod Swap Proc No / Section: 1-PT-94.0	Sequence Step No:
II Test Conditions (Design)	Bank Positions (Steps) SDA: moving SDB: 225 CA: 225 CB: moving CC: 225 CD: 225	RCS Temperature (^{O}F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: moving SDB: 225 CA: 225 CB: moving CC: 225 CD: 225	RCS Temperature (^{O}F): 547.6 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 11 MARCH 1996, 15:24	
	Measured Parameter (Description)	I_{SA}^{RS}; Integral Worth of Shutdown Bank A, Rod Swap
	Measured Value	I_{SA}^{RS}= 975.7 (Adjusted Measured Critical Reference Bank Position = 162 steps)
	Design Value (Actual Conditions)	I_{SA}^{RS}= 1003.1 (Adjusted Measured Critical Reference Bank Position = 162 steps)
	Design Value (Design Conditions)	I_{SA}^{RS}= 1008 ± 151 pcm (Critical Reference Bank Position = 169 steps)
	Reference	Technical Report NE-1063, 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: [signature] 3/11/96

Reviewed By: [signature] 3-11-96

NORTH ANNA POWER STATION UNIT 1 CYCLE 12
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

<table>
<tr><td>I
Reference</td><td colspan="2">Test Description: Total Rod Worth, Rod Swap
Proc No / Section: 1-PT-94.0 Sequence Step No:</td></tr>
<tr><td>II
Test
Conditions
(Design)</td><td>Bank Positions (Steps)
SDA: moving SDB: moving CA: moving
CB: moving CC: moving CD: moving</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: moving SDB: moving CA: moving
CB: moving CC: moving CD: moving</td><td>RCS Temperature (°F): 548.3
Power Level (% F.P.): 0
Other (specify):
Below Nuclear Heating</td></tr>
<tr><td rowspan="6">IV
Test
Results</td><td colspan="2">Date/Time Test Performed:
3-11-96 0759</td></tr>
<tr><td>Measured Parameter
(Description)</td><td>I_{Total}: Integral Worth of All Banks,
Rod Swap</td></tr>
<tr><td>Measured Value</td><td>I_{Total}= 5348.4</td></tr>
<tr><td>Design Value
(Actual Conditions)</td><td>I_{Total}= 5450.7</td></tr>
<tr><td>Design Value
(Design Conditions)</td><td>I_{Total}= 5461 ± 546 pcm</td></tr>
<tr><td>Reference</td><td>Technical Report NE-1063, Rev. 0 ,VEP-FRD-36A</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. Additional testing must be performed.</td></tr>
<tr><td>Reference</td><td>VEP-FRD-36A</td></tr>
<tr><td rowspan="2">VI
Comments</td><td colspan="2">Design Tolerance is met : ✓ YES ___ NO
Acceptance Criteria is met : ✓ YES ___ NO</td></tr>
<tr><td colspan="2"></td></tr>
</table>

Prepared By: T. L. Wheeler 3-11-96

Reviewed By: [signature] 3-11-96

NORTH ANNA POWER STATION UNIT 1 CYCLE 12
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: M/D Flux Map - At Power Proc No / Section: 1-PT-94.0, 1-PT-21.1,1-PT-21.2	Sequence Step No:
II Test Conditions (Design)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: 225 CC: * CD: *	RCS Temperature (°F): $T_{REF} \pm 1$ Power Level (% F.P.): ≤ 30 Other (specify): Must have ≥ 38 thimbles**
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: 225 CC: 225 CD: 152	RCS Temperature (°F): Tref Power Level (% F.P.): 29.61 Other (specify): 46 Thimbles
IV Test Results	Date/Time Test Performed: 3/12/96 0845	

		Maximum Relative Assembly Power %DIFF (M-P)/P	Nuclear Enthalpy Rise Hot Channel Factor FΔH(N)	Total Heat Flux Hot Channel Factor $F_Q(Z)$	Maximum Positive Incore Quadrant Power Tilt
IV Test Results	Measured Parameter (Description)				
	Measured Value	5.9 $P_i \geq 0.9$ 5.0 $P_i < 0.9$	1.512	2.246	1.0076
	Design Value (Design Conditions)	±10% for $P_i \geq 0.9$ ±15% for $P_i < 0.9$ (P_i = assy power)	N/A	N/A	≤ 1.0213
	Reference	WCAP-7905, Rev. 1	None	None	WCAP-7905, Rev. 1
V Acceptance Criteria	FSAR/COLR	None	$F\Delta H(N) \leq 1.49(1+0.3(1-P))$	$F_Q(Z) \leq 4.38*K(Z)$	None
	Reference	None	COLR 2.6	COLR 2.5.1	None

VI Comments	Design Tolerance is met : ✓ YES ____ NO Acceptance Criteria is met : ✓ YES ____ NO
	* As required ** Must have at least 16 thimbles for quarter core maps for multi-point calibrations

Prepared By: Robert O'Neill

Reviewed By: [signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 12
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: M/D Flux Map - At Power Proc No / Section: 1-PT-94.0, 1-PT-21.1, 1-PT-21.2			Sequence Step No:	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: 225 CC: 225 CD: *			RCS Temperature (°F): $T_{REF} \pm 1$ Power Level (% F.P.): $65 \le P \le 75$ Other (specify): Must have ≥ 38 thimbles**	
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: 225 CC: 225 CD: 213			RCS Temperature (°F): T_{REF} Power Level (% F.P.): 74.08% Other (specify): 46 thimbles	
IV Test Results	Date/Time Test Performed: 3/13/96 10:34				
	Measured Parameter (Description)	Maximum Relative Assembly Power %DIFF (M-P)/P	Nuclear Enthalpy Rise Hot Channel Factor FΔH(N)	Total Heat Flux Hot Channel Factor $F_Q(Z)$	Maximum Positive Incore Quadrant Power Tilt
	Measured Value	RPD ≥0.9, 4.4% RPD <0.9, -4.6%	1.432	1.898	1.0028
	Design Value (Design Conditions)	±10% for $P_i \ge 0.9$ ±15% for $P_i < 0.9$ (P_i = assy power)	N/A	N/A	≤ 1.0209
	Reference	WCAP-7905, Rev. 1	None	None	WCAP-7905, Rev. 1
V Acceptance Criteria	FSAR/COLR	None	$F\Delta H(N) \le 1.49(1+0.3(1-P))$	$F_Q(Z) \le 2.19/P^*K(Z)$	None
	Reference	None	COLR 2.6	COLR 2.5.1	None
VI Comments	Design Tolerance is met : ✓ YES ____ NO Acceptance Criteria is met : ✓ YES ____ NO				
	* As required ** Must have at least 16 thimbles for quarter core maps for multi-point calibrations				

Prepared By: Thomas S. Psuik

Reviewed By: [signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 12
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

<table>
<tr><td>I
Reference</td><td colspan="5">Test Description: M/D Flux Map - At Power
Proc No / Section: 1-PT-94.0, 1-PT-21.1,1-PT-21.2 Sequence Step No: 37</td></tr>
<tr><td>II
Test
Conditions
(Design)</td><td colspan="2">Bank Positions (Steps)
SDA: 225 SDB: 225 CA: 225
CB: 225 CC: 225 CD: *</td><td colspan="3">RCS Temperature (°F): $T_{REF} \pm 1$
Power Level (% F.P.): $95 \leq P \leq 100$
Other (specify):
Must have ≥ 38 thimbles**</td></tr>
<tr><td>III
Test
Conditions
(Actual)</td><td colspan="2">Bank Positions (Steps)
SDA: 225 SDB: 225 CA: 225
CB: 225 CC: 225 CD: 225</td><td colspan="3">RCS Temperature (°F): 580.8 °F
Power Level (% F.P.): 100.03%
Other (specify): D/225</td></tr>
<tr><td rowspan="5">IV
Test
Results</td><td colspan="2">Date/Time Test Performed:
4/1/96 @ 0825</td><td colspan="3"></td></tr>
<tr><td>Measured Parameter (Description)</td><td>Maximum Relative Assembly Power %DIFF (M-P)/P</td><td>Nuclear Enthalpy Rise Hot Channel Factor FΔH(N)</td><td>Total Heat Flux Hot Channel Factor $F_Q(Z)$</td><td>Maximum Positive Incore Quadrant Power Tilt</td></tr>
<tr><td>Measured Value</td><td>4.8% For $P_i \geq 0.9$
5.7% For $P_i < 0.9$</td><td>1.400</td><td>1.850</td><td>1.0017</td></tr>
<tr><td>Design Value (Design Conditions)</td><td>±10% for $P_i \geq 0.9$
±15% for $P_i < 0.9$
(P_i = assy power)</td><td>N/A</td><td>N/A</td><td>≤ 1.0209</td></tr>
<tr><td>Reference</td><td>WCAP-7905, Rev. 1</td><td>None</td><td>None</td><td>WCAP-7905, Rev. 1</td></tr>
<tr><td rowspan="2">V
Acceptance
Criteria</td><td>FSAR/COLR</td><td>None</td><td>$F\Delta H(N) \leq 1.49(1+0.3(1-P))$</td><td>$F_Q(Z) \leq 2.19/P^*K(Z)$</td><td>None</td></tr>
<tr><td>Reference</td><td>None</td><td>COLR 2.6</td><td>COLR 2.5.1</td><td>None</td></tr>
<tr><td>VI
Comments</td><td colspan="5">Design Tolerance is met : X YES ____ NO
Acceptance Criteria is met : X YES ____ NO
* As required
** Must have at least 16 thimbles for quarter core maps for multi-point calibrations</td></tr>
</table>

Prepared By: RDMcAndrew Reviewed By: E M Kohlrosen

ENCLOSURE 2

NORTH ANNA UNIT 1

CYCLE 11 CORE PERFORMANCE REPORT