North Anna Unit 2 Cycle 14 Startup Physics Tests Report

Nuclear Analysis and Fuel
Nuclear Engineering & Services

December, 1999

VIRGINIA POWER

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NORTH ANNA UNIT 2, CYCLE 14

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 Unit 2, Cycle 14 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 2, Cycle 14 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 September 12, 1999 Unit No. 2 of the North Anna Power Station shut down for its thirteenth refueling. During this shutdown, 93 of the 157 fuel assemblies in the core were replaced with 64 fresh Batch 16 assemblies, four North Anna 1 Batch 14B assemblies last irradiated in N1C13, eight North Anna 1 Batch 13B assemblies last irradiated in N1C12, eight Batch 12B assemblies last irradiated in N2C11, eight Batch 13B assemblies last irradiated in N2C12, and one North Anna 1 Batch 11B fuel assembly (3A4) last irradiated in N1C9. Sixty-four assemblies from Cycle 13 are being reused in Cycle 14. The fresh fuel consists of Batch 16A (28 assemblies), and Batch 16B (36 assemblies).

Special features of the N2C14 reload core include: burnable poison inserts with a 127.2 inch axial absorber region, one reconstituted fuel assembly, and the incorporation of vibration suppression damping assemblies (VSDAs) to prevent grid to rod fretting caused by assembly vibration. The reconstituted assembly, 3A4, had eight additional fuel rods removed. These were replaced with ZIRLO clad fuel rods that were irradiated for three cycles in North Anna Unit 1 in Westinghouse demonstration assembly AM2.

Cycle 14 marks the first use of a BPRA product with an active absorber length of 127.2 inches. The 127.2 inch design is similar to the 126 inch design used in Cycle 13 with the only exception being the location of the bottom of the absorber. The 127.2 inch design is located such that the bottom of the absorber is approximately 9 inches above the bottom of the active fuel length and the top of the absorber is approximately 7.8 inches below the top of the active fuel length relative to the NAIF/P+Z fuel design. The BP assembly and pellet design are the same for both products.

Cycle 14, similar to Cycle 13, 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 or secondary sources inserted in N2C14. There are 28 vibration suppression damping assemblies (VSDAs) inserted in peripherally loaded fuel assemblies, as well as one VSDA inserted in the core center fuel assembly, to help prevent grid to rod fretting caused by assembly vibration. Reference 1 provides a more detailed description of the Cycle 14 core.

The core loading pattern and the design parameters for each sub-batch are shown in Figure 1.1, as well as the location and number of burnable poison rods and VSDAs for Cycle 14. Beginning of cycle 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 control rods in the Cycle 14 core.

On October 9, 1999 at 15:38, the Cycle 14 core achieved initial criticality. Prior to and following criticality, startup physics tests were performed as outlined in Table 1.1. A summary of the results of these tests follows:

The measured drop time of each control rod was within the 2.7 second limit of Technical Specification 3.1.3.4. Westinghouse, however, has performed an analysis to determine an appropriate drop time testing criterion which excludes the seismic component but retains other necessary conservatism's relating to component mechanical design tolerances and hydraulic performance uncertainties. The Westinghouse recommended drop time limit is 2.13 seconds for RCCA entry into the dashpot region. Technical Report NE-1205, Rev 1, dated September 1999, further analyzed Rod Drop Time criteria and concluded that the 2.13 second time limit is not adequate to ensure compliance with the safety analysis basis for control rod drop time in all conceivable cases. Because of higher outlet plenum cross flows in the vicinity of the outlet nozzles, the RCCA drop times for Control Bank A rods could exceed the 2.7 seconds when seismic effects are considered. Since the basis for rod drop times is to ensure the collective group of rods insert the required negative reactivity, and Control Bank A rods, located on the outer core periphery, have a minimal impact on trip reactivity, NA&F has determined that the following rod drop time criteria should be used:

- All Control Rods EXCEPT the 8 Control Bank A Rods: ≤2.03 seconds
- Each of the 8 Control Bank A Rods: ≤2.25 seconds
- AVERAGE of the 8 Control Bank A Rods: ≤2.03 seconds

All of these new criteria were met for North Anna Unit 2 Cycle 14.

Individual control rod bank worths were measured using the rod swap technique[2,5]. The sum of the individual measured control rod bank worths was within 0.015% of the design prediction and the reference bank worth was within 1.39% of its design prediction. The other control rod banks were within 4.99% of the design predictions. These results are within the design tolerances of ±15% for individual banks worth more than 600 pcm (±10% for the rod swap reference bank worth), ±100 pcm for individual banks worth 600 pcm or less. and ±10% for the sum of the individual control rod bank worths.

Measured critical boron concentrations for two control bank configurations were within 23 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% $\Delta k/k$ of the design prediction.

The boron worth coefficient measurement was within 2.0% of the design prediction. which is within the design tolerance of ±10%.

The measured isothermal temperature coefficient (ITC) for the all-rods-out (ARO) configuration was within 0.22 pcm/°F of the design prediction. This result is within the design tolerance of ±3 pcm/°F. The measured ITC of -2.45 pcm/°F meets the Core design tolerance of ±3 pcm/°F. The measured ITC of -2.45 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 +3.76 pcm/°F.

Mode 1 (see Reference 4) core power distributions were within established design tolerances. Generally, the measured core power distributions were within 1.0% 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.

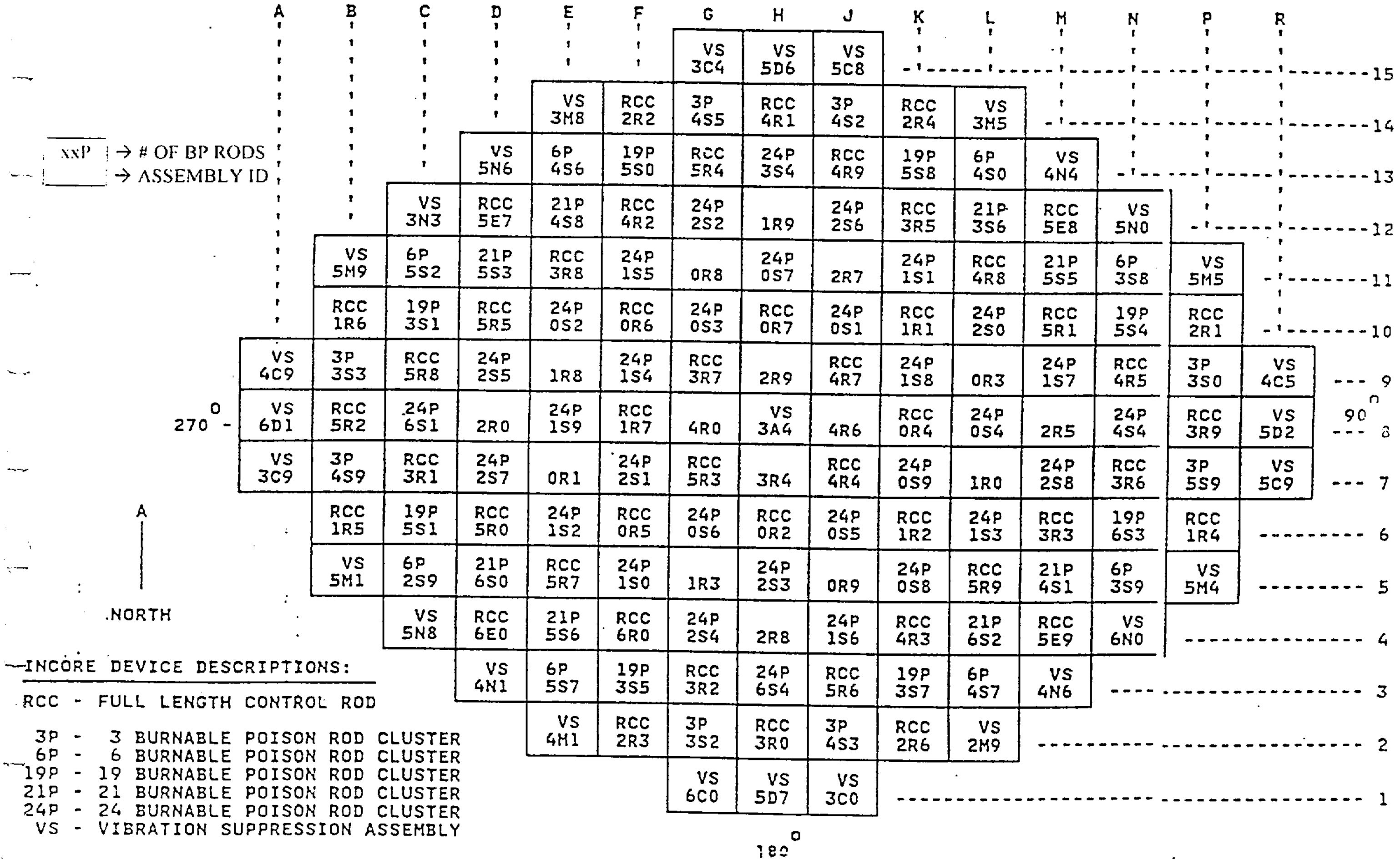
In summary, all startup physics test results were acceptable. Detailed results, specific design tolerances and acceptance criteria for each measurement are presented in the following sections of this report.

Table 1.1

NORTH ANNA UNIT 2 - CYCLE 14 STARTUP PHYSICS TESTS
CHRONOLOGY OF TESTS

Test	Date	Time	Power	Reference Procedure
Hot Rod Drop-Hot Full Flow	10/8/99	2319	HSD	2-PT-17.2
Zero Power Testing Range	10/9/99	1620	HZP	2-PT-94.0
Reactivity Computer Checkout	10/9/99	1700	HZP	2-PT-94.0
Boron Endpoint - ARO	10/9/99	1725	HZP	2-PT-94.0
Temperature Coefficient - ARO	10/9/99	2110	HZP	2-PT-94.0
Bank B Worth	10/9/99	2215	HZP	2-PT-94.0
Boron Endpoint - B in	10/10/99	0230	HZP	2-PT-94.0
Bank D Worth - Rod Swap	10/10/99	0248	HZP	2-PT-94.0
Bank C Worth - Rod Swap	10/10/99	0344	HZP	2-PT-94.0
Bank A Worth - Rod Swap	10/10/99	0416	HZP	2-PT-94.0
Bank SB Worth - Rod Swap	10/10/99	0446	HZP	2-PT-94.0
Bank SA Worth - Rod Swap	10/10/99	0525	HZP	2-PT-94.0
Flux Map - 30% Power	10/11/99	0027	30%	2-PT-94.0
Peaking Factor Verification				2-PT-21.1
& Power Range Calibration				2-PT-21.2
				2-PT-22.4
Flux Map - 75% Power	10/13/99	2238	75%	2-PT-94.0
Peaking Factor Verification				2-PT-21.1
& Power Range Calibration				2-PT-21.2
				2-PT-22.4
Flux Map - 100% Power	10/20/99	1041	100%	2-PT-94.0
Peaking Factor Verification				2-PT-21.1
& Power Range Calibration				2-PT-21.2
				2-PT-22.4

Figure 1.1
NORTH ANNA UNIT 2 - CYCLE 14
CORE LOADING MAP



	A	B	C	D	E	F	G	H	J	K	L	M	N	P	R
15							VS 3C4	VS 5D6	VS 5C8						
14					VS 3M8	RCC 2R2	3P 4S5	RCC 4R1	3P 4S2	RCC 2R4	VS 3M5				
13				VS 5N6	6P 4S6	19P 5S0	RCC 5R4	24P 3S4	RCC 4R9	19P 5S8	6P 4S0	VS 4N4			
12			VS 3N3	RCC 5E7	21P 4S8	RCC 4R2	24P 2S2	1R9	24P 2S6	RCC 3R5	21P 3S6	RCC 5E8	VS 5N0		
11		VS 5M9	6P 5S2	21P 5S3	RCC 3R8	24P 1S5	0R8	24P 0S7	2R7	24P 1S1	RCC 4R8	21P 5S5	6P 3S8	VS 5M5	
10		RCC 1R6	19P 3S1	RCC 5R5	24P 0S2	RCC 0R6	24P 0S3	RCC 0R7	24P 0S1	RCC 1R1	24P 2S0	RCC 5R1	19P 5S4	RCC 2R1	
9	VS 4C9	3P 3S3	RCC 5R8	24P 2S5	1R8	24P 1S4	RCC 3R7	2R9	RCC 4R7	24P 1S8	0R3	24P 1S7	RCC 4R5	3P 3S0	VS 4C5
8	VS 6D1	RCC 5R2	24P 6S1	2R0	24P 1S9	RCC 1R7	4R0	VS 3A4	4R6	RCC 0R4	24P 0S4	2R5	24P 4S4	RCC 3R9	VS 5D2
7	VS 3C9	3P 4S9	RCC 3R1	24P 2S7	0R1	24P 2S1	RCC 5R3	3R4	RCC 4R4	24P 0S9	1R0	24P 2S8	RCC 3R6	3P 5S9	VS 5C9
6		RCC 1R5	19P 5S1	RCC 5R0	24P 1S2	RCC 0R5	24P 0S6	RCC 0R2	24P 0S5	RCC 1R2	24P 1S3	RCC 3R3	19P 6S3	RCC 1R4	
5		VS 5M1	6P 2S9	21P 6S0	RCC 5R7	24P 1S0	1R3	24P 2S3	0R9	24P 0S8	RCC 5R9	21P 4S1	6P 3S9	VS 5M4	
4			VS 5N8	RCC 6E0	21P 5S6	RCC 6R0	24P 2S4	2R8	24P 1S6	RCC 4R3	21P 6S2	RCC 5E9	VS 6N0		
3				VS 4N1	6P 5S7	19P 3S5	RCC 3R2	24P 6S4	RCC 5R6	19P 3S7	6P 4S7	VS 4N6			
2					VS 4M1	RCC 2R3	3P 3S2	RCC 3R0	3P 4S3	RCC 2R6	VS 2M9				
1							VS 6C0	VS 5D7	VS 3C0						

INCORE DEVICE DESCRIPTIONS:

RCC - FULL LENGTH CONTROL ROD

3P - 3 BURNABLE POISON ROD CLUSTER
6P - 6 BURNABLE POISON ROD CLUSTER
19P - 19 BURNABLE POISON ROD CLUSTER
21P - 21 BURNABLE POISON ROD CLUSTER
24P - 24 BURNABLE POISON ROD CLUSTER
VS - VIBRATION SUPPRESSION ASSEMBLY

FUEL ASSEMBLY DESIGN PARAMETERS

	SUB-BATCH									
	N1/11B	12B	N1/13B	13B	N1/14B	N1/15B	15A	15B	16A	16B
ASSEMBLY IDs	3A4	#M#	#C#	#N#	#D#	#E#	0R1- 2R8	2R9- 6R0	0S1- 2S8	2S9- 6S4
INITIAL ENRICHMENT (W/O U-235)	4.1923	4.2012	4.2097	4.2061	4.2048	4.2097	4.1026	4.2489	4.1608	4.2434
BURNUP AT BOC 14 (MWD/MTU)	25784	41021	41614	42811	39430	24383	25530	22311	0	0
ASSEMBLY TYPE	17x17	17x17	17x17	17x17	17x17	17x17	17x17	17x17	17x17	17x17
NUMBER OF ASSEMBLIES	1	8	8	8	4	4	28	32	28	36
FUEL RODS PER ASSEMBLY	264[1]	264	264	264	264	264	264	264	264	264

[1] The assembly in this sub-batch contains one dummy fuel rod. and eight high burnup rods from Assembly AM2.

Figure 1.1 (continued)

NORTH ANNA UNIT 2 - CYCLE 14
CORE LOADING MAP

BP CORE LOCATIONS

CORE LOC	ASSM ID	BP IDENT
G14	4S5	BP792
J14	4S2	BP793
E13	4S6	BP827
F13	5S0	BP808
H13	3S4	BP780
K13	5S8	BP809
L13	4S0	BP824
E12	4S8	BP816
G12	2S2	BP773
J12	2S6	BP774
L12	3S6	BP815
C11	5S2	BP826
D11	5S3	BP821
F11	1S5	BP801
H11	0S7	BP768
K11	1S1	BP802
M11	5S5	BP818
N11	3S8	BP825
C10	3S1	BP811
E10	0S2	BP800
G10	0S3	BP785
J10	0S1	BP786
L10	2S0	BP803
N10	5S4	BP812
B09	3S3	BP797
D09	2S5	BP772
F09	1S4	BP784
K09	1S8	BP787
M09	1S7	BP775
P09	3S0	BP794
C08	6S1	BP779
E08	1S9	BP767
L08	0S4	BP769
N08	4S4	BP781
B07	4S9	BP796
D07	2S7	BP771
F07	2S1	BP783
K07	0S9	BP788
M07	2S8	BP776
P07	5S9	BP795
C06	5S1	BP810
E06	1S2	BP799
G06	0S6	BP782
J06	0S5	BP789
L06	1S3	BP804
N06	6S3	BP813
C05	2S9	BPC015
D05	6S0	BP820
F05	1S0	BP798
H05	2S3	BP766
K05	0S8	BP805
M05	4S1	BP819
N05	3S9	BP822
E04	5S6	BP817
G04	2S4	BP770
J04	1S6	BP777
L04	6S2	BP814
E03	5S7	BPC014
F03	3S5	BP807
H03	6S4	BP778
K03	3S7	BP806
L03	4S7	BP823
G02	3S2	BP791
J02	4S3	BP790

Figure 1.2

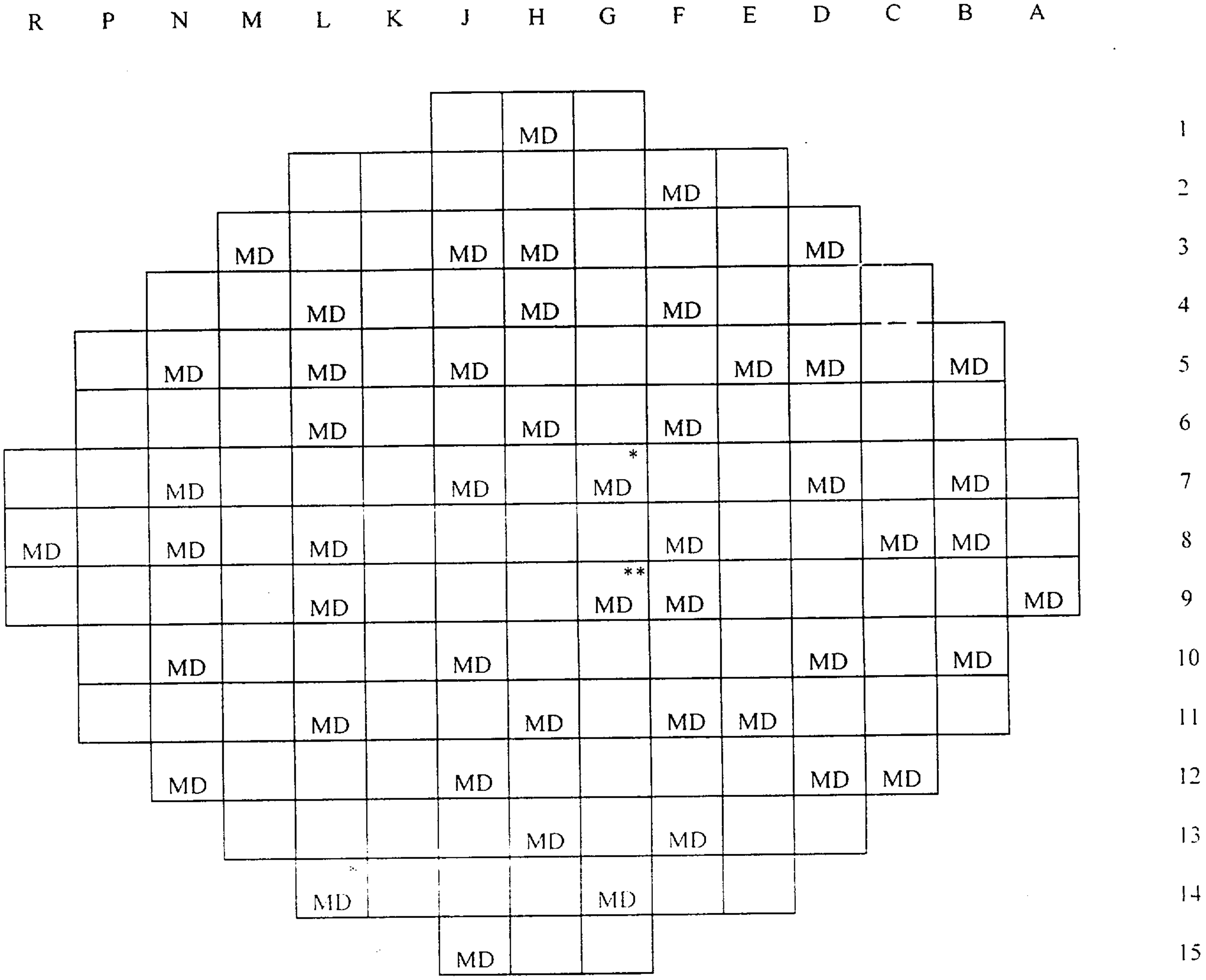
NORTH ANNA UNIT 2 - CYCLE 14
BEGINNING OF CYCLE FUEL ASSEMBLY BURNUPS

A	B	C	D	E	F	G	H	J	K	L	M	N	P	R	
						41874	39398	41336							15
				40503	25288	0	19679	0	25224	40547					14
			42111	0	0	23605	0	23888	0	0	42419				13
		43407	24410	0	24982	0	26032	0	25096	0	24276	42950			12
	41370	0	0	20987	0	25713	0	25596	0	20583	0	0	41771		11
	25097	0	24374	0	25488	0	25968	0	25265	0	24950	0	24847		10
41009	0	24078	0	25607	0	20559	19935	20775	0	25805	0	23350	0	42109	9
39287	19654	0	25990	0	26038	19465	25784	19791	26001	0	26044	0	19863	39235	8
42063	0	23717	0	25572	0	20886	20121	20754	0	25696	0	24054	0	41513	7
	25005	0	25062	0	25311	0	25935	0	25392	0	24962	0	25006		6
	41676	0	0	20544	0	25488	0	25597	0	21094	0	0	41619		5
		42886	24404	0	24444	0	25627	0	24881	0	24444	43908			4
			42397	0	0	24105	0	23847	0	0	42411				3
				40504	25035	0	19847	0	25171	40176					2
						41333	39799	41672							1

☐ ===> Assembly Burnup (MWD/MTU)

Figure 1.3

NORTH ANNA UNIT 2 - CYCLE 14
AVAILABLE INCORE MOVEABLE DETECTOR LOCATIONS



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

MD - Moveable Detector

* - Locations Not Available For
Flux Mapping System for Cycle 14

** - Location Not Available For
Flux Map 03 for Cycle 14

Figure 1.4

NORTH ANNA UNIT 2 - CYCLE 14
CONTROL ROD LOCATIONS

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

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[4] 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. Technical Report NE-1205 Rev. 1. however. cited the following criteria to be achieved as well:

- All Control Rods EXCEPT the 8 Control Bank A Rods: ≤2.03 seconds
- Each of the 8 Control Bank A Rods: ≤2.25 seconds
- AVERAGE of the 8 Control Bank A Rods: ≤2.03 seconds

These test results satisfied the above limits. 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

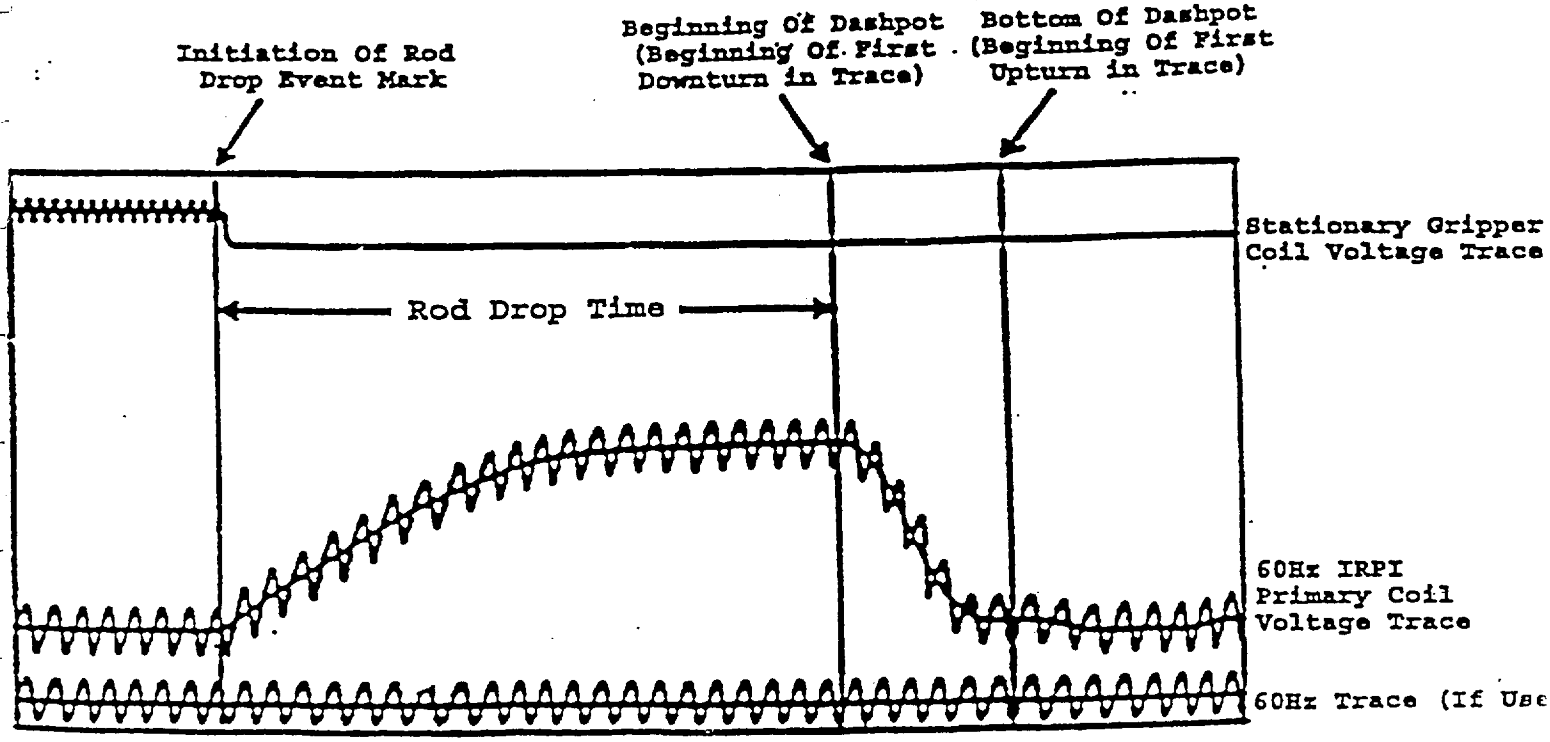
NORTH ANNA UNIT 2 - CYCLE 14 STARTUP PHYSICS TESTS HOT ROD DROP TIME SUMMARY

ROD DROP TIME TO DASHPOT ENTRY

SLOWEST ROD	FASTEST ROD	AVERAGE TIME
B-06 2.04 sec.	M-04 1.57 sec.	1.74 sec.

Figure 2.1

NORTH ANNA UNIT 2 - CYCLE 14 STARTUP PHYSICS TESTS
TYPICAL ROD DROP TRACE



ROD DROP TIME MEASUREMENT

Figure 2.2

NORTH ANNA UNIT 2 - CYCLE 14 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						1.81		1.73		1.73					
3							1.73		1.70						
4				1.57		1.82				1.76		1.82			
5					1.72						1.77				
6		1.71		1.73		1.71		1.68		1.70		1.70		2.04	
7			1.68				1.66		1.68				1.73		
8		1.80				1.71				1.68				1.95	
9			1.74				1.66		1.68				1.58		
10		1.77		1.68		1.71		1.71		1.68		1.75		1.81	
11					1.75						1.70				
12				1.77		1.68				1.70		1.82			
13							1.70		1.71						
14						1.99		1.81		1.83					
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 14, 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 the 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 0.015% of the design prediction. This is well within the design tolerance of ±10% for the sum of the individual control rod bank worths.

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

Table 3.1

NORTH ANNA UNIT 2 - CYCLE 14 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	1280.5	1263	1.39
D	993.3	1016.5	-2.28
C	810.9	833.8	-2.75
A	329.6	314.6	4.77*
SB	1107.1	1139.2	-2.82
SA	947.3	902.3	4.99
Total Worth	5468.7	5469.5	-0.01

* Difference is less than 100 pcm.

Figure 3.1

NORTH ANNA UNIT 2 - CYCLE 14 STARTUP PHYSICS TESTS
CONTROL BANK B INTEGRAL ROD WORTH - HZP
ALL OTHER RODS WITHDRAWN

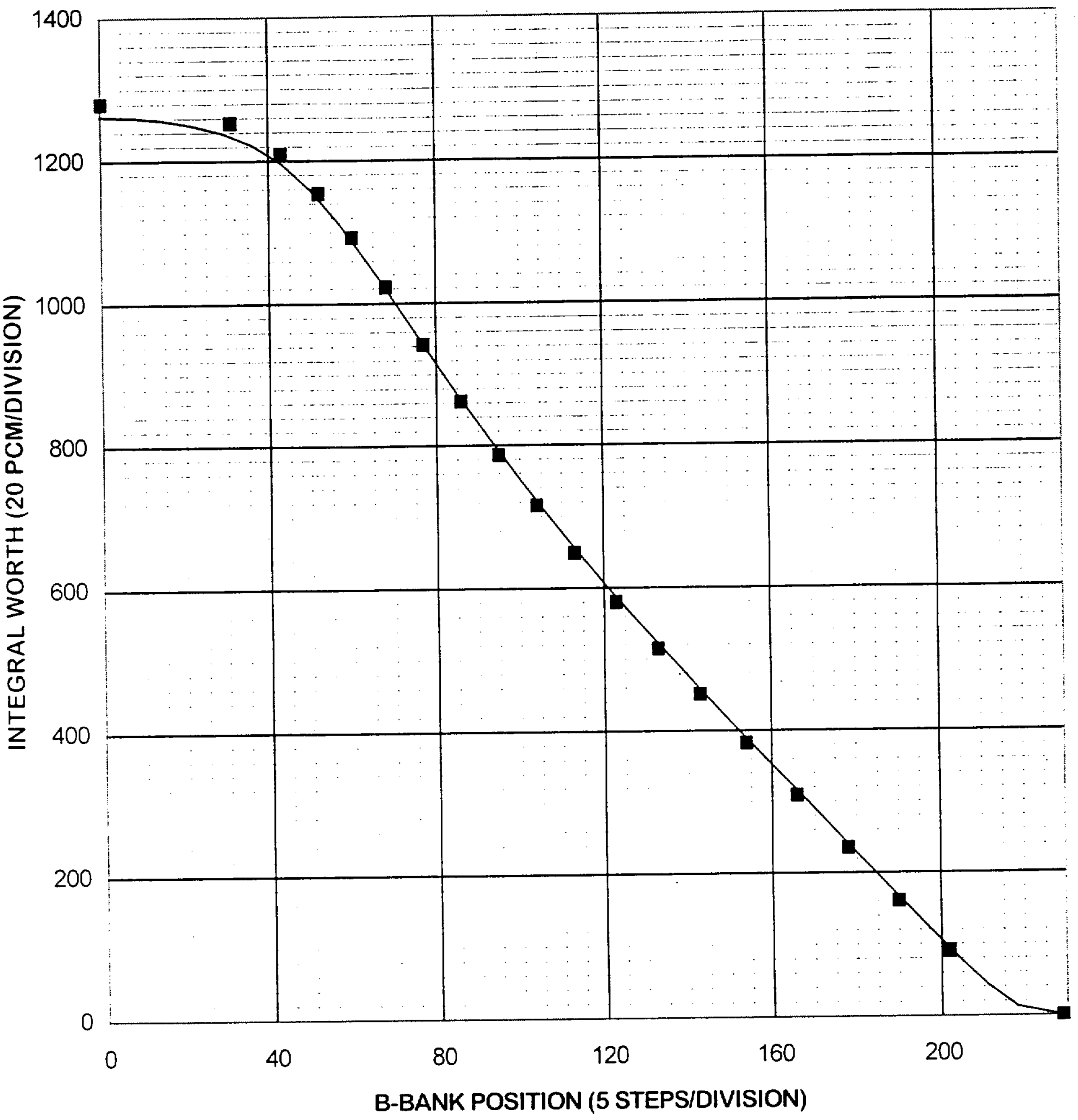
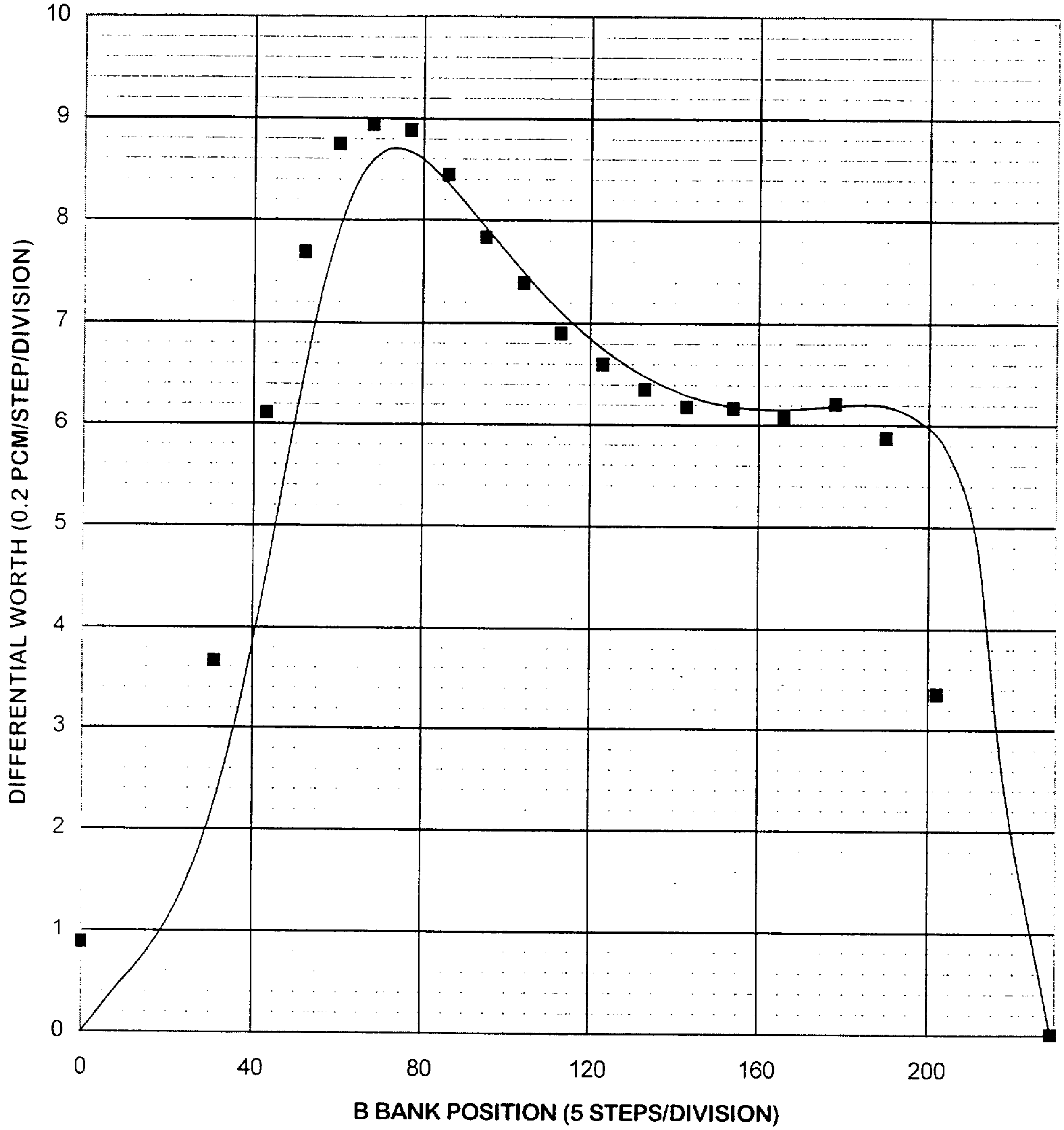


Figure 3.2

NORTH ANNA UNIT 2 - CYCLE 14 STARTUP PHYSICS TESTS
CONTROL BANK B DIFFERENTIAL ROD WORTH - HZP
ALL OTHER RODS WITHDRAWN



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 summary of the measured and predicted DBW is shown in Table 4.2. As indicated in this table and in the Appendix, the measured DBW was well within the design tolerance of ±10%. In summary, the measured boron worth coefficient was satisfactory.

Table 4.1

NORTH ANNA UNIT 2 - CYCLE 14 STARTUP PHYSICS TESTS
BORON ENDPOINTS SUMMARY

Control Rod Configuration	Measured Endpoint (ppm)	Predicted Endpoint (ppm)	Difference M-P (ppm)
ARO	2141	2118	23
B Bank In	1949	1948*	1

* 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.

Table 4.2

NORTH ANNA UNIT 2 - CYCLE 14 STARTUP PHYSICS TESTS
BORON WORTH COEFFICIENT

Measured Boron Worth (pcm/ppm)	Predicted Boron Worth (pcm/ppm)	Percent Difference (%) (M-P)/P x 100
-6.67	-6.54	2.0

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 3.0°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 -0.70 pcm/°F which met the requirements of COLR Section 2.1.1. In summary, the measured results were satisfactory.

Table 5.1

NORTH ANNA UNIT 2 - CYCLE 14 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/211	545.5 to 548.9	2135	-2.06	-2.83	-2.45	-2.67	0.22

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 14. For each traverse, the detector voltage output is continuously monitored on a strip chart recorder, and scanned for 61 discrete axial points (map 1), or 610 discrete axial points (maps 2, 3, and 4), by the plant 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, 3, and 4 were taken at 43%, 75%, 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 maps 3 and 4 are given in Figures 6.2 and 6.3, respectively. 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 1.0% 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 map 2 was also used to perform power range detector calibrations. The flux map analyses are documented in References 7, 8, and 9 (for maps 1, 3, and 4. Map 2 is documented in PM-0816, 0A).

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 14.

Table 6.1

NORTH ANNA UNIT 2 - CYCLE 14 STARTUP PHYSICS TESTS
INCORE FLUX MAP SUMMARY

Map Description	Map No.	Date	Burn up MWD/MTU	Pwr %	Bank D Steps	Peak F-Q(Z) Hot(1) Channel Factor			F-DH(N) Hot Channel 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	10/11/99	5	30	151	N05	28	2.086	E04	1.470	29	1.332	1.0081	NE	0.64	48
Int. Pwr (3)	2	10/12/99	22	43	171	B07	28	1.916	E04	1.429	27	1.250	1.0074	NE	-0.04	48
Int. Pwr (3)	3	10/13/99	56	75	190	B07	36	1.819	E04	1.400	27	1.195	1.0063	NE	-1.24	47
Hot Full Pwr	4	10/20/99	289	100	229	B07	36	1.741	E04	1.364	31	1.141	1.0045	NE	-0.27	48

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) Int. Pwr – intermediate power flux map.

(4) Map 2 was used for power range detector calibrations.

Table 6.2

NORTH ANNA UNIT 2 - CYCLE 14 STARTUP PHYSICS TESTS COMPARISION OF MEASURED POWER DISTRIBUTION PARAMETERS WITH THEIR CORE OPERATING LIMITS

Map	Peak F-Q(Z) Hot Channel Factor*			F-Q(Z) Hot Channel Factor** (At Node of Minimum Margin)				F-DH(N) Hot Channel Factor		
No.	Meas.	Limit	Node	Meas.	Limit	Node	Margin (%)	Meas.	Limit	Margin (%)
1	2.086	4.347	28	2.080	4.325	26	51.9	1.470	1.803	18.5
2	1.916	4.347	28	1.909	4.325	26	55.9	1.429	1.743	18.0
3	1.819	2.937	36	1.808	2.900	26	37.7	1.400	1.604	12.7
4	1.741	2.193	36	1.741	2.193	36	20.6	1.364	1.491	8.5

*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 2 - CYCLE 14 STARTUP PHYSICS TESTS
ASSEMBLYWISE POWER DISTRIBUTION
30% POWER

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
		PREDICTED MEASURED PCT DIFFERENCE				0.231 0.232 0.4	0.257 0.256 -0.4	0.231 0.234 1.2				PREDICTED MEASURED PCT DIFFERENCE			1
				0.309 0.308 -0.5	0.646 0.646 0.0	1.047 1.053 0.6	0.825 0.834 1.2	1.043 1.061 1.7	0.645 0.664 2.9	0.307 0.313 1.9					2
			0.351 0.342 -2.5	1.162 1.154 -0.7	1.310 1.307 -0.2	1.184 1.189 0.4	1.264 1.281 1.4	1.181 1.198 1.4	1.307 1.329 1.7	1.158 1.175 1.4	0.350 0.348 -0.7				3
		0.349 0.354 1.3	0.871 0.869 -0.3	1.360 1.349 -0.8	1.273 1.266 -0.5	1.242 1.239 -0.2	1.176 1.183 0.6	1.240 1.252 0.9	1.272 1.292 1.6	1.359 1.380 1.5	0.869 0.875 0.6	0.348 0.349 0.4			4
	0.303 0.309 2.0	1.157 1.188 2.6	1.360 1.366 0.4	1.321 1.318 -0.2	1.266 1.254 -0.9	1.168 1.154 -1.2	1.199 1.191 -0.7	1.168 1.170 0.2	1.265 1.278 1.1	1.320 1.349 2.2	1.357 1.359 0.1	1.155 1.160 0.5	0.303 0.299 -1.1		5
	0.642 0.648 1.1	1.305 1.318 1.0	1.272 1.268 -0.3	1.266 1.234 -2.5	1.059 1.041 -1.7	1.203 1.179 -2.0	1.144 1.120 -2.1	1.204 1.195 -0.7	1.059 1.061 0.2	1.265 1.275 0.8	1.271 1.278 0.5	1.304 1.319 1.1	0.642 0.656 2.3		6
0.230 0.231 0.4	1.041 1.050 0.9	1.180 1.190 0.9	1.240 1.235 -0.4	1.168 1.148 -1.7	1.204 1.181 -2.0	1.212 1.180 -2.6	1.219 1.198 -1.7	1.212 1.202 -0.9	1.203 1.198 -0.4	1.167 1.168 0.1	1.239 1.242 0.2	1.181 1.202 1.8	1.043 1.094 4.8	0.230 0.240 4.3	7
0.257 0.253 -1.4	0.823 0.830 0.9	1.262 1.276 1.1	1.175 1.172 -0.3	1.197 1.172 -2.1	1.144 1.125 -1.7	1.218 1.198 -1.7	1.079 1.065 -1.2	1.218 1.208 -0.8	1.144 1.133 -0.9	1.197 1.194 -0.3	1.175 1.180 0.4	1.262 1.282 1.6	0.823 0.848 3.1	0.257 0.263 2.5	8
0.230 0.231 0.4	1.043 1.052 0.8	1.181 1.190 0.8	1.239 1.239 0.0	1.167 1.156 -0.9	1.202 1.190 -1.0	1.210 1.196 -1.1	1.214 1.204 -0.8	1.210 1.208 -0.1	1.203 1.183 -1.7	1.167 1.160 -0.6	1.239 1.240 0.1	1.179 1.190 0.9	1.040 1.056 1.5	0.230 0.227 -1.3	9
	0.642 0.648 0.9	1.304 1.318 1.1	1.270 1.277 0.5	1.264 1.267 0.2	1.058 1.055 -0.2	1.202 1.190 -1.0	1.141 1.131 -0.9	1.201 1.191 -0.8	1.058 1.047 -1.1	1.265 1.257 -0.6	1.271 1.269 -0.2	1.305 1.309 0.4	0.641 0.651 1.5		10
	0.303 0.305 0.8	1.155 1.163 0.8	1.356 1.367 0.8	1.319 1.336 1.3	1.264 1.268 0.3	1.166 1.163 -0.3	1.197 1.183 -1.1	1.167 1.153 -1.2	1.265 1.242 -1.7	1.320 1.313 -0.6	1.359 1.354 -0.4	1.157 1.155 -0.2	0.303 0.304 0.4		11
		0.347 0.345 -0.9	0.869 0.874 0.6	1.358 1.368 0.7	1.271 1.277 0.5	1.239 1.246 0.5	1.175 1.169 -0.5	1.241 1.228 -1.0	1.272 1.251 -1.6	1.359 1.343 -1.2	0.871 0.864 -0.7	0.349 0.343 -1.7			12
			0.350 0.352 0.5	1.157 1.164 0.6	1.306 1.311 0.4	1.180 1.182 0.2	1.263 1.256 -0.5	1.183 1.177 -0.5	1.309 1.276 -2.5	1.161 1.141 -1.7	0.351 0.346 -1.4				13
				0.307 0.308 0.4	0.645 0.647 0.3	1.042 1.045 0.2	0.824 0.831 0.8	1.046 1.074 2.7	0.646 0.643 -0.4	0.309 0.305 -1.4					14
		STANDARD DEVIATION =0.797				0.231 0.226 -2.0	0.257 0.258 0.5	0.231 0.236 2.2				AVERAGE PCT DIFFERENCE = 1.0			15

Summary

Map No: N2-14-01

Control Rod Position:

D Bank at 151 Steps

Date: 10/11/99

F-Q(Z) = 2.086

F-DH(N) = 1.470

F(Z) = 1.332

Burnup = 4.8 MWD/MTU

Power: 30.01%

QPTR:

0.9964	1.0081
1.0000	0.9955

A.O. = 0.639

Figure 6.2
NORTH ANNA UNIT 2 - CYCLE 14 STARTUP PHYSICS TESTS
ASSEMBLYWISE POWER DISTRIBUTION
75% POWER

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

                 ................                   .........................                   ................
                 .  PREDICTED   .                   . 0.253 . 0.290 . 0.253 .                   .  PREDICTED   .
                 .  MEASURED    .                   . 0.252 . 0.286 . 0.253 .                   .  MEASURED    .                   1
                 .PCT DIFFERENCE.                   .  -0.2 .  -1.3 .   0.0 .                   .PCT DIFFERENCE.
                 ................   .........................................................   ................
                                    . 0.314 . 0.656 . 1.081 . 0.919 . 1.078 . 0.656 . 0.312 .
                                    . 0.311 . 0.654 . 1.082 . 0.920 . 1.082 . 0.659 . 0.314 .                                      2
                                    .  -0.9 .  -0.3 .   0.1 .   0.1 .   0.4 .   0.6 .   0.5 .
                            .........................................................................
                            . 0.352 . 1.126 . 1.272 . 1.181 . 1.271 . 1.178 . 1.270 . 1.123 . 0.351 .
                            . 0.341 . 1.113 . 1.266 . 1.185 . 1.277 . 1.185 . 1.278 . 1.129 . 0.345 .                              3
                            .  -3.1 .  -1.1 .  -0.5 .   0.4 .   0.5 .   0.5 .   0.6 .   0.6 .  -1.7 .
                    .........................................................................................
                    . 0.350 . 0.852 . 1.305 . 1.239 . 1.218 . 1.166 . 1.217 . 1.238 . 1.304 . 0.851 . 0.349 .
                    . 0.352 . 0.845 . 1.286 . 1.229 . 1.214 . 1.170 . 1.224 . 1.248 . 1.317 . 0.853 . 0.350 .                      4
                    .   0.5 .  -0.8 .  -1.5 .  -0.8 .  -0.4 .   0.4 .   0.5 .   0.8 .   1.0 .   0.3 .   0.3 .
            .........................................................................................................
            . 0.308 . 1.122 . 1.305 . 1.289 . 1.258 . 1.168 . 1.189 . 1.168 . 1.258 . 1.288 . 1.303 . 1.120 . 0.308 .
            . 0.311 . 1.140 . 1.306 . 1.289 . 1.247 . 1.154 . 1.187 . 1.173 . 1.270 . 1.314 . 1.304 . 1.126 . 0.307 .              5
            .   1.0 .   1.6 .   0.1 .   0.0 .  -0.8 .  -1.2 .  -0.2 .   0.5 .   1.0 .   2.0 .   0.1 .   0.5 .  -0.3 .
            .........................................................................................................
            . 0.652 . 1.268 . 1.238 . 1.259 . 1.147 . 1.221 . 1.154 . 1.222 . 1.147 . 1.258 . 1.237 . 1.268 . 0.652 .
            . 0.653 . 1.271 . 1.230 . 1.229 . 1.131 . 1.209 . 1.152 . 1.225 . 1.155 . 1.270 . 1.245 . 1.280 . 0.664 .              6
            .   0.2 .   0.2 .  -0.6 .  -2.4 .  -1.4 .  -0.9 .  -0.2 .   0.3 .   0.7 .   1.0 .   0.6 .   0.9 .   1.8 .
    .........................................................................................................................
    . 0.253 . 1.076 . 1.177 . 1.217 . 1.168 . 1.222 . 1.231 . 1.232 . 1.231 . 1.222 . 1.167 . 1.217 . 1.179 . 1.079 . 0.252 .
    . 0.251 . 1.074 . 1.176 . 1.210 . 1.153 . 1.209 . 1.219 . 1.229 . 1.232 . 1.227 . 1.173 . 1.221 . 1.193 . 1.116 . 0.260 .      7
    .  -0.7 .  -0.1 .  -0.1 .  -0.6 .  -1.3 .  -1.1 .  -0.9 .  -0.3 .   0.1 .   0.4 .   0.5 .   0.3 .   1.2 .   3.4 .   2.8 .
    .........................................................................................................................
    . 0.290 . 0.918 . 1.269 . 1.165 . 1.188 . 1.154 . 1.232 . 1.093 . 1.232 . 1.154 . 1.188 . 1.165 . 1.269 . 0.918 . 0.290 .
    . 0.282 . 0.915 . 1.275 . 1.162 . 1.174 . 1.147 . 1.227 . 1.091 . 1.232 . 1.158 . 1.191 . 1.168 . 1.274 . 0.928 . 0.292 .      8
    .  -2.6 .  -0.3 .   0.4 .  -0.3 .  -1.2 .  -0.6 .  -0.4 .  -0.2 .   0.0 .   0.4 .   0.2 .   0.2 .   0.4 .   1.0 .   0.7 .
    .........................................................................................................................
    . 0.252 . 1.079 . 1.179 . 1.217 . 1.167 . 1.221 . 1.229 . 1.228 . 1.228 . 1.222 . 1.167 . 1.217 . 1.177 . 1.076 . 0.253 .
    . 0.251 . 1.079 . 1.181 . 1.219 . 1.172 . 1.221 . 1.229 . 1.227 . 1.225 . 1.213 . 1.165 . 1.216 . 1.180 . 1.080 . 0.245 .      9
    .  -0.6 .   0.0 .   0.2 .   0.2 .   0.4 .   0.0 .   0.0 .  -0.1 .  -0.3 .  -0.7 .  -0.2 .  -0.1 .   0.2 .   0.4 .  -2.9 .
    .........................................................................................................................
            . 0.652 . 1.268 . 1.237 . 1.257 . 1.147 . 1.220 . 1.152 . 1.219 . 1.147 . 1.258 . 1.238 . 1.268 . 0.652 .
            . 0.653 . 1.270 . 1.242 . 1.265 . 1.150 . 1.226 . 1.152 . 1.213 . 1.136 . 1.253 . 1.233 . 1.269 . 0.658 .              10
            .   0.1 .   0.1 .   0.4 .   0.6 .   0.3 .   0.5 .   0.0 .  -0.5 .  -0.9 .  -0.4 .  -0.4 .   0.1 .   0.9 .
            .........................................................................................................
            . 0.308 . 1.120 . 1.302 . 1.288 . 1.257 . 1.167 . 1.188 . 1.167 . 1.258 . 1.289 . 1.305 . 1.122 . 0.308 .
            . 0.308 . 1.124 . 1.311 . 1.304 . 1.265 . 1.171 . 1.186 . 1.158 . 1.237 . 1.288 . 1.305 . 1.121 . 0.309 .              11
            .   0.2 .   0.3 .   0.7 .   1.3 .   0.6 .   0.4 .  -0.1 .  -0.7 .  -1.6 .  -0.1 .   0.0 .   0.0 .   0.3 .
            .........................................................................................................
                    . 0.349 . 0.851 . 1.304 . 1.237 . 1.217 . 1.165 . 1.218 . 1.238 . 1.304 . 0.852 . 0.350 .
                    . 0.347 . 0.856 . 1.314 . 1.245 . 1.222 . 1.163 . 1.209 . 1.223 . 1.298 . 0.859 . 0.345 .                      12
                    .  -0.4 .   0.6 .   0.8 .   0.6 .   0.5 .  -0.2 .  -0.7 .  -1.3 .  -0.5 .   0.9 .  -1.4 .
                    .........................................................................................
                            . 0.351 . 1.122 . 1.270 . 1.178 . 1.270 . 1.180 . 1.272 . 1.125 . 0.352 .
                            . 0.353 . 1.129 . 1.275 . 1.176 . 1.262 . 1.173 . 1.243 . 1.112 . 0.351 .                              13
                            .   0.6 .   0.6 .   0.4 .   0.0 .  -0.7 .  -0.6 .  -2.3 .  -1.2 .  -0.4 .
                            .........................................................................
                                    . 0.312 . 0.655 . 1.077 . 0.919 . 1.080 . 0.656 . 0.314 .
                                    . 0.313 . 0.656 . 1.075 . 0.918 . 1.097 . 0.652 . 0.311 .                                      14
                                    .   0.4 .   0.2 .  -0.2 .   0.0 .   1.5 .  -0.6 .  -1.0 .
                 ................   .........................................................   ................
                 .   STANDARD   .                   . 0.253 . 0.290 . 0.253 .                   .    AVERAGE   .
                 .   DEVIATION  .                   . 0.244 . 0.289 . 0.256 .                   .PCT DIFFERENCE.                  15
                 .   =0.672     .                   .  -3.6 .  -0.4 .   1.1 .                   .    =  0.7    .
                 ................                   .........................                   ................
```

Summary

Map No: N2-14-03
Control Rod Position:
D Bank at 190 Steps

Date: 10/13/99
F-Q(Z) = 1.819
F-DH(N) = 1.400
F(Z) = 1.195
Burnup = 55.7 MWD/MTU

Power: 74.57%

QPTR:		
	0.9954	1.0063
	1.0015	0.9968

A.O. = -1.239

Figure 6.3
NORTH ANNA UNIT 2 - CYCLE 14 STARTUP PHYSICS TESTS
ASSEMBLYWISE POWER DISTRIBUTION
100% POWER

PREDICTED
MEASURED
PCT DIFFERENCE

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							0.265 0.264 -0.1	0.308 0.306 -0.6	0.265 0.266 0.2						
2					0.316 0.313 -0.9	0.658 0.656 -0.3	1.085 1.085 0.0	0.964 0.964 0.0	1.082 1.087 0.4	0.658 0.667 1.3	0.314 0.317 0.8				
3				0.353 0.346 -1.9	1.099 1.087 -1.2	1.247 1.240 -0.5	1.173 1.175 0.2	1.268 1.265 -0.3	1.171 1.174 0.2	1.245 1.253 0.6	1.097 1.103 0.6	0.353 0.349 -1.1			
4			0.351 0.353 0.6	0.843 0.836 -0.8	1.275 1.253 -1.7	1.221 1.211 -0.8	1.209 1.205 -0.3	1.162 1.162 0.0	1.208 1.211 0.2	1.220 1.227 0.6	1.275 1.285 0.8	0.842 0.841 -0.1	0.350 0.350 -0.1		
5		0.311 0.314 1.2	1.096 1.116 1.8	1.275 1.274 -0.1	1.273 1.267 -0.5	1.261 1.251 -0.8	1.173 1.168 -0.4	1.191 1.188 -0.2	1.173 1.176 0.3	1.260 1.271 0.8	1.273 1.297 1.9	1.274 1.264 -0.8	1.094 1.095 0.0	0.310 0.313 0.8	
6		0.655 0.656 0.2	1.244 1.246 0.2	1.220 1.211 -0.8	1.261 1.229 -2.5	1.207 1.192 -1.2	1.238 1.230 -0.7	1.165 1.159 -0.5	1.239 1.241 0.1	1.206 1.213 0.5	1.261 1.270 0.7	1.220 1.222 0.2	1.244 1.250 0.5	0.655 0.665 1.5	
7	0.265 0.264 -0.5	1.080 1.079 -0.2	1.170 1.167 -0.2	1.208 1.198 -0.8	1.173 1.157 -1.4	1.240 1.229 -0.9	1.243 1.239 -0.3	1.242 1.241 -0.1	1.244 1.247 0.3	1.239 1.244 0.4	1.173 1.178 0.4	1.208 1.209 0.1	1.171 1.181 0.8	1.083 1.115 2.9	0.264 0.270 2.3
8	0.308 0.304 -1.5	0.963 0.960 -0.3	1.267 1.265 -0.2	1.162 1.155 -0.6	1.190 1.174 -1.3	1.166 1.159 -0.6	1.242 1.240 -0.1	1.107 1.109 0.2	1.242 1.250 0.6	1.166 1.171 0.4	1.190 1.192 0.2	1.162 1.163 0.1	1.267 1.266 -0.1	0.963 0.971 0.8	0.308 0.309 0.4
9	0.264 0.263 -0.6	1.083 1.079 -0.4	1.171 1.167 -0.3	1.208 1.206 -0.2	1.173 1.177 0.3	1.238 1.239 0.0	1.242 1.243 0.1	1.239 1.245 0.5	1.242 1.261 1.5	1.239 1.231 -0.7	1.173 1.172 -0.1	1.208 1.209 0.1	1.170 1.173 0.3	1.080 1.087 0.6	0.265 0.258 -2.5
10		0.655 0.652 -0.5	1.243 1.235 -0.6	1.220 1.220 0.1	1.260 1.266 0.5	1.206 1.209 0.3	1.238 1.237 -0.1	1.164 1.165 0.1	1.237 1.239 0.2	1.206 1.201 -0.4	1.261 1.260 -0.1	1.220 1.221 0.1	1.244 1.251 0.6	0.655 0.668 2.0	
11		0.310 0.310 -0.2	1.094 1.095 0.1	1.273 1.280 0.5	1.272 1.289 1.3	1.260 1.267 0.5	1.173 1.174 0.1	1.190 1.185 -0.4	1.173 1.167 -0.5	1.260 1.244 -1.3	1.273 1.277 0.3	1.275 1.282 0.6	1.096 1.102 0.6	0.311 0.314 1.1	
12			0.350 0.353 0.7	0.842 0.847 0.7	1.274 1.284 0.8	1.220 1.226 0.5	1.208 1.212 0.3	1.162 1.156 -0.5	1.208 1.200 -0.7	1.221 1.209 -1.0	1.275 1.274 -0.1	0.843 0.857 1.7	0.351 0.351 -0.1		
13				0.352 0.354 0.5	1.097 1.102 0.5	1.245 1.248 0.2	1.171 1.167 -0.3	1.268 1.251 -1.3	1.173 1.166 -0.6	1.247 1.223 -1.9	1.099 1.091 -0.8	0.353 0.354 0.2			
14					0.314 0.315 0.3	0.658 0.658 0.0	1.082 1.079 -0.3	0.964 0.964 0.0	1.085 1.104 1.8	0.658 0.657 -0.2	0.316 0.314 -0.6				
15							0.265 0.258 -2.6	0.308 0.307 -0.3	0.265 0.268 1.3						

PREDICTED
MEASURED
PCT DIFFERENCE

STANDARD
DEVIATION
=0.586

AVERAGE
PCT DIFFERENCE
= 0.6

Summary

Map No: N2-14-04
Control Rod Position:
D Bank at 229 Steps

Date: 10/20/99
F-Q(Z) = 1.741
F-DH(N) = 1.364
F(Z) = 1.141
Burnup = 289 MWD/MTU

Power: 99.88%

QPTR:

0.9952	1.0045
1.0001	1.0002

A.O. = -0.265

SECTION 7

REFERENCES

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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 4, Virginia Power. August. 1998.

4. North Anna Unit 2 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 14 Pattern XY. Revision 0 (September. 1998) 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. C. D. Clemens. "North Anna 2. Cycle 14 TOTE Calculations". PM-0814. Revision 0. October. 1999.

7. R. A. Hall. "North Anna 2. Cycle 14 Flux Map Analysis". PM-0816. Revision 0. October. 1999.

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9. R. A. Wright. "North Anna 2. Cycle 14 Flux Map Analysis". PM-0816. Revision 0. Add. C. October. 1999.

10. D. M. Knee. "Reload Safety Evaluation. North Anna 2 Cycle 14 Pattern SU", Technical Report NE-1210. Revision 0. September. 1999.

11. Engineering Transmittal NAF 99-0102, Revision 0. from W. M. Oppenhimer to D. A. Sommers. "Approved Core Operating Limits Report, North Anna 2 Cycle 14", October 7. 1999.

APPENDIX

STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEETS

NORTH ANNA POWER STATION UNIT 2 CYCLE 14
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Zero Power Testing Range Determination Proc No / Section: 2-PT-94.0	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 229 SDB: 229 CA: 229 CB: 229 CC: * CD: *	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 229 SDB: 229 CA: 229 CB: 229 CC: 229 CD: 93	RCS Temperature (°F): 547.6 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 10/9/99 16:20	
	Reactivity Computer Initial Flux Background Reading	1.2×10^{-9} amps
	Flux Reading At Point Of Nuclear Heating	5.0×10^{-7} amps
	Zero Power Testing Range	1×10^{-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: Thomas S.

Reviewed By:

NORTH ANNA POWER STATION UNIT 2 CYCLE 14
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Reactivity Computer Checkout Proc No / Section: 2-PT-94.0	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 229 SDB: 229 CA: 229 CB: 229 CC: * CD: *	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 229 SDB: 229 CA: 229 CB: 229 CC: 229 CD: 88	RCS Temperature (°F): 547.6 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 10/9/99 17:00	
	Measured Parameter (Description)	ρ_c= Measured Reactivity using ρ-computer ρ_t= Predicted Reactivity
	Measured Value	ρ_c= -44.0pcm , +50.5pcm ρ_t= -45.3pcm , +51.0pcm %D= -2.9% , -1.0%
	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. Allowable Range = -44.0 pcm to +50.0 pcm	

Prepared By: Thomas S. [illegible]

Reviewed By:

NORTH ANNA POWER STATION UNIT 2 CYCLE 14
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Critical Boron Concentration - ARO Proc No / Section: 2-PT-94.0	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 229 SDB: 229 CA: 229 CB: 229 CC: 229 CD: 229	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 229 SDB: 229 CA: 229 CB: 229 CC: 229 CD: 229	RCS Temperature (°F): Power Level (% F.P.): 0 549 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 10/9/98 1725	
	Measured Parameter (Description)	$(C_B)^M_{ARO}$; Critical Boron Concentration - ARO
	Measured Value (Design Conditions)	$(C_B)^M_{ARO}$= 2141 ppm
	Design Value (Design Conditions)	C_B = 2118 ± 50 ppm
	Reference	Technical Report NE-1212, Rev. 0
V Acceptance Criteria	FSAR/Tech Spec	$\lvert \alpha C_B \times C_B^D \rvert \leq 1000$ 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 = -6.51 pcm/ppm $C_B^D = \lvert (C_B)^M_{ARO} - C_B \rvert$; C_B is design value	

Prepared By: Bill Dott

Reviewed By: Thomas S. Pad

NORTH ANNA POWER STATION UNIT 2 CYCLE 14
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Isothermal Temperature Coefficient - ARO Proc No / Section: 2-PT-94.0	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 229 SDB: 229 CA: 229 CB: 229 CC: 229 CD: 229	RCS Temperature (^{O}F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 229 SDB: 229 CA: 229 CB: 229 CC: 229 CD: 211	RCS Temperature (^{O}F): 548.9 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 10/9/99 21:16	
	Measured Parameter (Description)	$(\alpha_T^{ISO})_{ARO}$; Isothermal Temperature Coefficient - ARO
	Measured Value	$(\alpha_T^{ISO})_{ARO} =$ -245 pcm/^{O}F (C_B= 2135 ppm)
	Design Value (Actual Conditions)	$(\alpha_T^{ISO})_{ARO} =$ -2.67 ±3.0 pcm/^{O}F (C_B= 2135 ppm)
	Design Value (Design Conditions)	$(\alpha_T^{ISO})_{ARO} =$ -2.82±3.0 pcm/^{O}F (C_B= 2118 ppm)
	Reference	Technical Report NE-1212, Rev. 0
V Acceptance Criteria	FSAR/COLR	$\alpha_T^{ISO} \leq 3.75$ pcm/^{O}F * $\alpha_T^{DOP} = -1.75$ pcm/^{O}F
	Reference	COLR 2.1.1, Technical Report NE-1212, Rev. 0
VI Comments	Design Tolerance is met : ✓ YES ____ NO Acceptance Criteria is met : ✓ YES ____ NO	
	*Uncertainty on αT_{MOD} = 0.5 pcm/^{O}F (Reference: memorandum from C.T. Snow to E.J. Lozito dated June 27, 1980.)	

Prepared By: Neil Dett.

Reviewed By: Thomas S. Paul

NORTH ANNA POWER STATION UNIT 2 CYCLE 14
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Critical Boron Concentration - B Bank In Proc No / Section: 2-PT-94.0	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 229 SDB: 229 CA: 229 CB: 0 CC: 229 CD: 229	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 229 SDB: 229 CA: 229 CB: 0 CC: 229 CD: 229	RCS Temperature (°F): 547.5 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 10/10/99 0230	
	Measured Parameter (Description)	$(C_B)^M{}_B$; Critical Boron Concentration, B Bank In
	Measured Value (Design Conditions)	$(C_B)^M{}_B =$ 1949 ppm
	Design Value (Design Conditions)	$C_B = 1925 + \Delta C_B{}^{Prev} \pm (10 + 126.3/\lvert\alpha C_B\rvert)$ ppm $C_B =$ 1948 ± 29 ppm
	Reference	Technical Report NE-1212, 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	
	$\alpha C_B = -6.54$ pcm/ppm $\Delta C_B{}^{Prev} = (C_B)^M{}_{ARO} - 2118$ ppm	

Prepared By: Marc A.

Reviewed By:

NORTH ANNA POWER STATION UNIT 2 CYCLE 14
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: HZP Boron Worth Coefficient Measurement Proc No / Section: 2-PT-94.0	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 229 SDB: 229 CA: 229 CB: moving CC: 229 CD: 229	RCS Temperature (^{O}F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 229 SDB: 229 CA: 229 CB: moving CC: 229 CD: 229	RCS Temperature (^{O}F): 549.0 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: MAH ~~10/10/99~~ 10/9/99 2025	
	Measured Parameter (Description)	αC_B; Boron Worth Coefficient
	Measured Value	αC_B = -6.67 pcm/ppm
	Design Value (Design Conditions)	αC_B = -6.54 ± 0.65 pcm/ppm
	Reference	Technical Report NE-1212, 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:

Reviewed By:

NORTH ANNA POWER STATION UNIT 2 CYCLE 14
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Control Bank B Worth Measurement, Rod Swap Ref. Bank Proc No / Section: 2-PT-94.0	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 229 SDB: 229 CA: 229 CB: moving CC: 229 CD: 229	RCS Temperature (^{O}F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 229 SDB: 229 CA: 229 CB: moving CC: 229 CD: 229	RCS Temperature (^{O}F): 547.6 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 10/9/99 22:15	
	Measured Parameter (Description)	I_B^{REF}; Integral Worth Of Control Bank B, All Other Rods Out
	Measured Value	I_B^{REF} = 1280.5 pcm
	Design Value (Design Conditions)	$I_B^{REF} = 1263 \pm 126$ pcm
	Reference	Technical Report NE-1212, Rev. 0 and Engineering Transmittal NAF 99-0107, 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 : X YES ____ NO Acceptance Criteria is met : X YES ____ NO	

Prepared By:

Reviewed By:

NORTH ANNA POWER STATION UNIT 2 CYCLE 14
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Control Bank D Worth Measurement, Rod Swap Proc No / Section: 2-PT-94.0	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 229 SDB: 229 CA: 229 CB: moving CC: 229 CD: moving	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 229 SDB: 229 CA: 229 CB: moving CC: 229 CD: moving	RCS Temperature (°F): 547.4 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 10/10/99 0248	
	Measured Parameter (Description)	I_D^{RS}; Integral Worth of Control Bank D, Rod Swap
	Measured Value	I_D^{RS}= 993.3 (Adjusted Measured Critical Reference Bank Position = 169.5 steps)
	Design Value (Actual Conditions)	I_D^{RS}= 1016.5 (Adjusted Measured Critical Reference Bank Position = 169.5 steps)
	Design Value (Design Conditions)	I_D^{RS}= 1016 ± 152 pcm (Critical Reference Bank Position = 177 steps)
	Reference	Engineering Transmittal NAF 99-0107, 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 : Acceptance Criteria is met :	✓ YES ____ NO ✓ YES ____ NO

Prepared By: Marc A.

Reviewed By:

NORTH ANNA POWER STATION UNIT 2 CYCLE 14
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Control Bank C Worth Measurement, Rod Swap Proc No / Section: 2-PT-94.0	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 229 SDB: 229 CA: 229 CB: moving CC: moving CD: 229	RCS Temperature (^{O}F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 229 SDB: 229 CA: 229 CB: moving CC: moving CD: 229	RCS Temperature (^{O}F): 547.4 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 10/10/99 0344	
	Measured Parameter (Description)	I_C^{RS}; Integral Worth of Control Bank C, Rod Swap
	Measured Value	I_C^{RS}= 810.9 (Adjusted Measured Critical Reference Bank Position = 140.0steps)
	Design Value (Actual Conditions)	I_C^{RS}= 833.8 (Adjusted Measured Critical Reference Bank Position = 140.0 steps)
	Design Value (Design Conditions)	I_C^{RS}= 831 ± 125 pcm (Critical Reference Bank Position = 147 steps)
	Reference	Engineering Transmittal NAF 99-0107, 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: Marc A.

Reviewed By:

NORTH ANNA POWER STATION UNIT 2 CYCLE 14
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Control Bank A Worth Measurement, Rod Swap Proc No / Section: 2-PT-94.0	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 229 SDB: 229 CA: moving CB: moving CC: 229 CD: 229	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 229 SDB: 229 CA: moving CB: moving CC: 229 CD: 229	RCS Temperature (°F): 547.45 CAC 10/10/99 MAH 10/10/99 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 10/10/99 0416	
	Measured Parameter (Description)	I_A^{RS}; Integral Worth of Control Bank A, Rod Swap
	Measured Value	I_A^{RS}= 329.6 (Adjusted Measured Critical Reference Bank Position = 76 steps)
	Design Value (Actual Conditions)	I_A^{RS}= 314.6 (Adjusted Measured Critical Reference Bank Position = 76 steps)
	Design Value (Design Conditions)	I_A^{RS}= 313 ± 100 pcm (Critical Reference Bank Position = 76 steps)
	Reference	Engineering Transmittal NAF 99-0107, 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: Christopher A. Clemmer

Reviewed By: Marc A. Hoffmann

NORTH ANNA POWER STATION UNIT 2 CYCLE 14
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Shutdown Bank B Worth Measurement, Rod Swap Proc No / Section: 2-PT-94.0	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 229 SDB: moving CA: 229 CB: moving CC: 229 CD: 229	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 229 SDB: moving CA: 229 CB: moving CC: 229 CD: 229	RCS Temperature (°F): 547.4 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 10/10/99 0446	
	Measured Parameter (Description)	I_{SB}^{RS}; Integral Worth of Shutdown Bank B, Rod Swap
	Measured Value	1107.1 CAC 10/10/99 I_{SB}^{RS}= ~~1125.4~~ (Adjusted Measured Critical Reference Bank Position = 188 steps)
	Design Value (Actual Conditions)	I_{SB}^{RS}= 1139.2 (Adjusted Measured Critical Reference Bank Position = 188 steps)
	Design Value (Design Conditions)	I_{SB}^{RS}= 1140 ± 171 pcm (Critical Reference Bank Position = 197 steps)
	Reference	Engineering Transmittal NAF 99-0107, 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: Christopher A. Cowan

Reviewed By: Marc A. Hoffman

NORTH ANNA POWER STATION UNIT 2 CYCLE 14
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Shutdown Bank A Worth Measurement, Rod Swap Proc No / Section: 2-PT-94.0	
II Test Conditions (Design)	Bank Positions (Steps) SDA: moving SDB: 229 CA: 229 CB: moving CC: 229 CD: 229	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: moving SDB: 229 CA: 229 CB: moving CC: 229 CD: 229	RCS Temperature (°F): 547.4 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 10/10/99 0525	
	Measured Parameter (Description)	I_{SA}^{RS}; Integral Worth of Shutdown Bank A, Rod Swap
	Measured Value	I_{SA}^{RS}= 947.3 (Adjusted Measured Critical Reference Bank Position = 162steps)
	Design Value (Actual Conditions)	I_{SA}^{RS}= 902.3 (Adjusted Measured Critical Reference Bank Position = 162 steps)
	Design Value (Design Conditions)	I_{SA}^{RS}= 899 ± 135 pcm (Critical Reference Bank Position = 158 steps)
	Reference	Engineering Transmittal NAF 99-0107, 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:

Reviewed By: Marc A.

NORTH ANNA POWER STATION UNIT 2 CYCLE 14
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Total Rod Worth, Rod Swap Proc No / Section: 2-PT-94.0	
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): 547.6 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 10/9/99 22:15	
	Measured Parameter (Description)	I_{Total}: Integral Worth of All Banks, Rod Swap
	Measured Value	I_{Total}= 5468.7 pcm
	Design Value (Actual Conditions)	I_{Total}= 5469.5 pcm
	Design Value (Design Conditions)	I_{Total}= 5460 ± 546 pcm
	Reference	Engineering Transmittal NAF 99-0107, 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. Additional testing must be performed.
	Reference	VEP-FRD-36A
VI Comments	Design Tolerance is met : ✓ YES ____ NO Acceptance Criteria is met : ✓ YES ____ NO	

Prepared By: Marc A. Hoffmann Reviewed By:

NORTH ANNA POWER STATION UNIT 2 CYCLE 14
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: M/D Flux Map - At Power Proc No / Section: 2-PT-94.0, 2-PT-21.1, 2-PT-21.2				
II Test Conditions (Design)	Bank Positions (Steps) SDA: 229 SDB: 229 CA: 229 CB: 229 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: 229 SDB: 229 CA: 229 CB: 229 CC: 229 CD: 151		RCS Temperature (°F): Tref Power Level (% F.P.): 30,0 % Other (specify):		
IV Test Results	Date/Time Test Performed: 10/11/99 00:27				
	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	+4.8% for P≥.9 +4.3% for P<.9	1,470	2,086	1,0081
	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	≤ 1.0206
	Reference	WCAP-7905, Rev. 1 NE-1212, Rev. 0	None	None	WCAP-7905, Rev. 1 NE-1212, Rev. 0
V Acceptance Criteria	FSAR/COLR	None	$F\Delta H(N) \leq 1.49(1+0.3(1-P))$	$F_Q(Z) \leq 4.38 \cdot K(Z)$	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 C Hay

Reviewed By:

NORTH ANNA POWER STATION UNIT 2 CYCLE 14
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: M/D Flux Map - At Power Proc No / Section: 2-PT-94.0, 2-PT-21.1, 2-PT-21.2				
II Test Conditions (Design)	Bank Positions (Steps) SDA: 229 SDB: 229 CA: 229 CB: 229 CC: 229 CD: *			RCS Temperature (°F): $T_{REF} \pm 1$ Power Level (% F.P.):$65 \leq P \leq 75$ Other (specify): Must have ≥ 38 thimbles**	
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 229 SDB: 229 CA: 229 CB: 229 CC: 229 CD: 190			RCS Temperature (°F): TREF Power Level (% F.P.): 74.57% Other (specify):	
IV Test Results	Date/Time Test Performed: 10/13/99 22:38				
	Measured Parameter (Description)	Maximum Relative Assembly Power %DIFF (M-P)/P	Nuclear Enthalpy Rise Hot Channel Factor $F_{\Delta H}(N)$	Total Heat Flux Hot Channel Factor $F_O(Z)$	Maximum Positive Incore Quadrant Power Tilt
	Measured Value	3.4% $P \geq 0.9$ -3.6% $P < 0.9$	1.400	1.819	1.0063
	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	≤ 1.0204
	Reference	WCAP-7905, Rev. 1 NE-1212, Rev. 0	None	None	WCAP-7905, Rev. 1 NE-1212, Rev. 0
V Acceptance Criteria	FSAR/COLR	None	$F_{\Delta H}(N) \leq 1.49(1+0.3(1-P))$	$F_O(Z) \leq \{2.19/P\}^*K(Z)$	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: Pamela D. Banning

Reviewed By:

NORTH ANNA POWER STATION UNIT 2 CYCLE 14
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: M/D Flux Map - At Power Proc No / Section: 2-PT-94.0, 2-PT-21.1, 2-PT-21.2	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 229 SDB: 229 CA: 229 CB: 229 CC: 229 CD: *	RCS Temperature (°F): $T_{REF} \pm 1$ Power Level (% F.P.):95 ≤ P ≤ 100 Other (specify): Must have ≥ 38 thimbles**
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 229 SDB: 229 CA: 229 CB: 229 CC: 229 CD: 229	RCS Temperature (°F): 580.7° Power Level (% F.P.): 99.9% Other (specify): EQ. Xenon
IV Test Results	Date/Time Test Performed: 10/20/99 1041	

	Measured Parameter (Description)	Maximum Relative Assembly Power %DIFF (M-P)/P	Nuclear Enthalpy Rise Hot Channel Factor $F\Delta H(N)$	Total Heat Flux Hot Channel Factor $F_Q(Z)$	Maximum Positive Incore Quadrant Power Tilt
IV Test Results	Measured Value	[illegible] -2.606, P<.9 ~~-3.571~~ 3.927 P ≥ .9	1.364	1.741	1.0045
	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	≤ 1.0204
	Reference	WCAP-7905, Rev. 1 NE-1212, Rev. 0	None	None	WCAP-7905, Rev. 1 NE-1212, Rev. 0
V Acceptance Criteria	FSAR/COLR	None	$F\Delta H(N) \leq 1.49(1+0.3(1-P))$	$F_Q(Z) \leq \{2.19/P\}*K(Z)$	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: Robert A. Wright

Reviewed By: