VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

December 20, 2001

Mr. Luis Reyes, Administrator
United States Nuclear Regulatory Commission
Region II
Atlanta Federal Center
61 Forsyth St., SW, Suite 23 T85
Atlanta, GA 30303-8931

Serial No.: 01-745
NLOS/MM
Docket No.: 50-338
License No.: NPF-4

Dear Mr. Reyes:

VIRGINIA ELECTRIC AND POWER COMPANY
NORTH ANNA POWER STATION UNIT 1
CYCLE 16 STARTUP PHYSICS TESTS REPORT

Pursuant to North Anna Technical Specification 6.9.1.3, enclosed is the Virginia Electric and Power Company (Dominion) Technical Report NE-1299, Revision 0, entitled "North Anna Unit 1, Cycle 16 Startup Physics Tests Report." This report summarizes the results of the physics testing program performed after initial criticality of Cycle 16 on October 9, 2001. The results of the physics tests were within required design tolerance and applicable Technical Specification limits.

If you have any questions or require additional information, please contact us.

Very truly yours,

S. P. Sarver, Director
Nuclear Licensing and Operations Support

Enclosure

Commitment Summary: There are no new commitments as a result of this letter.

cc: U. S. Nuclear Regulatory Commission – 5 copies
Attention: Document Control Desk
Washington, DC 20555-0001

Mr. M. J. Morgan
NRC Senior Resident Inspector
North Anna Power Station

IE26

Dominion[SM]

North Anna Unit 1 Cycle 16 Startup Physics Tests Report

Nuclear Analysis and Fuel
Nuclear Engineering & Services

December 2001

TECHNICAL REPORT NE-1299 - REV. 0

NORTH ANNA UNIT 1, CYCLE 16
STARTUP PHYSICS TESTS REPORT

NUCLEAR ANALYSIS AND FUEL
NUCLEAR ENGINEERING & SERVICES
DOMINION

DECEMBER, 2001

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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 16 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 16 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 occurring during the tests.

SECTION 1

INTRODUCTION AND SUMMARY

On September 9, 2001 Unit No. 1 of the North Anna Power Station shut down for its fifteenth refueling. During this shutdown, 88 of the 157 fuel assemblies in the core were replaced with 64 fresh assemblies and 24 twice-burned assemblies. The Cycle 16 core consists of 8 sub-batches of fuel: two once-burned batches from Cycle 15 (batches 17A and 17B); four twice-burned batches, one batch from Cycle 13 and North Anna 2 Cycle 14 (batch 15B), one batch from North Anna 2 Cycles 12 and 13 (batch N2/14B), and two batches from North Anna 2 Cycles 13 and 14 (batches N2/15A and N2/15B); and two fresh batches (batches 18A and 18B). The fresh batches are of a similar design to the Westinghouse batch 17 fuel (fresh fuel in Cycle 15).

Special features of the N1C16 reload core include: all Westinghouse NAIF/P+Z fuel and burnable poison inserts with a 127.2" axial absorber region. All fuel assemblies are of the Westinghouse NAIF/P+Z design which includes ZIRLO fuel cladding, intermediate grids, guide tubes, and instrumentation tubes as well as debris resistance features that are part of the Westinghouse Performance+ design.

The burnable poison rod design for this cycle is B_4C in Alumina, which has an active absorber length of 127.2 inches and is available in various B_4C enrichments. 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. There are no thimble plugging devices or secondary sources inserted in N1C16. There are no vibration suppression damping assemblies inserted in N1C16 since they have not shown to successfully prevent grid to rod fretting caused by assembly vibration. Reference 1 provides a more detailed description of the Cycle 16 core.

The core loading pattern and the design parameters for each sub-batch are shown in Figure 1.1. 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 burnable poison rods for Cycle 16, and Figure 1.5 identifies the location and number of control rods in the Cycle 16 core.

On October 9, 2001 at 13:15, the Cycle 16 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 appropriate limit specified in Technical Specification 3.1.3.4. Reference 10 set an additional administrative limit for rod drops times such that all rods must drop within 2.03 seconds,

with the exception of "A"-bank rods. The "A" bank rods must drop within 2.25 seconds, with an average "A"-bank drop time limit of 2.03 seconds.

This cycle marks the second Unit 1 use of the FTI Reactivity Measurement and Analysis System (RMAS) to perform startup physics testing. The tests performed are the same as in previous cycles. However, the analysis of data taken during the tests has been simplified and thus the analysis time has been reduced.

Individual control rod bank worths were measured using the rod swap technique (References 2 and 5), incorporating the recommendations of Reference 11. The sum of the individual measured control rod bank worths was within 1.43% of the design prediction and the reference bank worth was within 0.20% of its design prediction. The other control rod banks were within 4.05% or 39.3 pcm (for bank "SB") 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 24 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 2.01% 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 0.42 pcm/°F of the design prediction. This result is within the design tolerance of ±3 pcm/°F. The measured ITC of –2.87 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.

Mode 1 (see Reference 4) core power distributions were within established design tolerances. Generally, the measured core power distributions were within 5% of the design predictions, with a maximum deviation of 10.6% for the 29% power map, which decreased to 4.5% for the 100% power map. 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 16 STARTUP PHYSICS TESTS
CHRONOLOGY OF TESTS

Test	Date	Time	Power	Reference Procedure
Hot Rod Drop-Hot Full Flow	10/9/01	0059	HSD	1-PT-17.2
Reactivity Computer Checkout	10/9/01	1512	HZP	1-PT-94.0
Boron Endpoint – ARO	10/9/01	1512	HZP	1-PT-94.0
Zero Power Testing Range	10/9/01	1527	HZP	1-PT-94.0
Temperature Coefficient - ARO	10/9/01	1606	HZP	1-PT-94.0
Bank B Worth	10/9/01	1712	HZP	1-PT-94.0
Boron Endpoint - B in	10/9/01	2048	HZP	1-PT-94.0
Bank A Worth - Rod Swap	10/9/01	2058	HZP	1-PT-94.0
Bank C Worth - Rod Swap	10/9/01	2116	HZP	1-PT-94.0
Bank SB Worth - Rod Swap	10/9/01	2139	HZP	1-PT-94.0
Bank D Worth - Rod Swap	10/9/01	2158	HZP	1-PT-94.0
Bank SA Worth - Rod Swap	10/9/01	2219	HZP	1-PT-94.0
Flux Map - 29% Power Peaking Factor Verification & Power Range Calibration	10/10/01	1530	29%	1-PT-94.0 1-PT-21.1 1-PT-21.2 1-PT-22.4
Flux Map - 74% Power Peaking Factor Verification & Power Range Calibration	10/11/01	1851	74%	1-PT-94.0 1-PT-21.1 1-PT-21.2 1-PT-22.4
Flux Map - 100% Power Peaking Factor Verification & Power Range Calibration	10/22/01	0830	100%	1-PT-94.0 1-PT-21.1 1-PT-21.2 1-PT-22.4

Figure 1.1
NORTH ANNA UNIT 1 - CYCLE 16
CORE LOADING MAP

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							15B* 3R4	15B* 4R1	15B* 4R0						
2					14B^ 3P6	17B 3G8	18B 3H5	17B 3G2	18B 4H8	17B 6G0	14B^ 4P1				
3				15B* 4R4	18B 5H7	18B 5H0	17A 1G9	18B 6H2	17A 0G6	18B 3H9	18B 5H3	15B* 5R3			
4			15B* 3R8	17B 5G2	18B 2H9	17B 5G7	18A 1H0	17B 4G3	18A 1H5	17B 3G3	18B 6H0	17B 6G5	15B* 4R8		
5		15A# 1R6	18B 3H8	18B 6H3	17A 1G4	18A 2H7	17A 0G7	18A 2H2	17A 2G5	18A 0H2	17A 2G7	18B 3H4	18B 4H5	15A# 2R1	
6		17B 4G5	18B 4H6	17B 4G6	18A 1H3	17A 2G8	18A 0H6	17A 2G3	18A 1H8	17A 0G2	18A 2H6	17B 3G9	18B 3H0	17B 4G8	
7	15B 5E7	18B 5H5	17A 2G9	18A 2H4	17A 2G6	18A 2H0	17B 4G0	17B 6G2	17B 5G9	18A 1H2	17A 0G4	18A 0H7	17A 0G1	18B 4H0	15B 5E8
8	15B* 5R2	17B 4G2	18B 3H3	17B 5G5	18A 0H3	17A 0G3	17B 3G1	17A 1G0	17B 5G3	17A 1G7	18A 1H6	17B 3G4	18B 5H4	17B 5G6	15B* 3R9
9	15B 6E0	18B 6H4	17B 2G1	18A 0H9	17A 1G1	18A 2H8	17B 4G7	17B 5G1	17B 3G7	18A 0H1	17A 1G6	18A 2H3	17B 1G3	18B 4H1	15B 5E9
10		17B 6G1	18B 5H2	17B 5G0	18A 2H1	17A 0G5	18A 1H4	17A 2G0	18A 0H8	17A 1G8	18A 1H1	17B 4G4	18B 5H8	17B 3G0	
11		15A# 1R5	18B 4H3	18B 5H9	17A 2G2	18A 0H5	17A 2G4	18A 1H9	17A 0G9	18A 1H7	17A 1G2	18B 3H7	18B 4H9	15A# 1R4	
12			15B* 5R7	17B 4G1	18B 4H7	17B 5G8	18A 2H5	17B 6G3	18A 0H4	17B 5G4	18B 4H4	17B 3G6	15B* 5R9		
13				15B* 4R7	18B 5H6	18B 3H6	17A 0G8	18B 4H2	17A 1G5	18B 6H1	18B 3H2	15B* 3R7			
14					14B^ 4P6	17B 3G5	18B 3H1	17B 4G9	18B 5H1	17B 6G4	14B^ 3P4				
15							15B* 4R6	15B* 3R0	15B* 2R9						

===> Batch
===> Assembly ID

^- Assembly is part of batch N2/14B.

*- Assembly is part of batch N2/15B.

- Assembly is part of batch N2/15A.

FUEL ASSEMBLY DESIGN PARAMETERS

	SUB-BATCH							
	N2/14B	N2/15A	N2/15B	15B	17A	17B	18A	18B
INITIAL ENRICHMENT (W/O U-235)	4.2050	4.1026	4.2489	4.2097	4.1522	4.2524	4.2548	4.3995
BURNUP AT BOC 16 (MWD/MTU)	37413	37664	42387	40929	25846	22989	0	0
ASSEMBLY TYPE	17x17	17x17	17x17	17x17	17x17	17x17	17x17	17x17
NUMBER OF ASSEMBLIES	4	4	16	4	29	36	28	36
FUEL RODS PER ASSEMBLY	264	264	264	264	264	264	264	264

Figure 1.2

NORTH ANNA UNIT 1 - CYCLE 16
BEGINNING OF CYCLE FUEL ASSEMBLY BURNUPS

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							3R4 42657	4R1 37485	4R0 42053						
2					3P6 37242	3G8 25629	3H5 0	3G2 19805	4H8 0	6G0 25079	4P1 37583				
3				4R4 43846	5H7 0	5H0 0	1G9 25151	6H2 0	0G6 25111	3H9 0	5H3 0	5R3 44119			
4			3R8 45587	5G2 20482	2H9 0	5G7 21171	1H0 0	4G3 25467	1H5 0	3G3 21264	6H0 0	6G5 19766	4R8 45131		
5		1R6 37934	3H8 0	6H3 0	1G4 26101	2H7 0	0G7 26209	2H2 0	2G5 26086	0H2 0	2G7 26356	3H4 0	4H5 0	2R1 37370	
6		4G5 25474	4H6 0	4G6 21048	1H3 0	2G8 26269	0H6 0	2G3 26171	1H8 0	0G2 26459	2H6 0	3G9 21400	3H0 0	4G8 25132	
7	5E7 41288	5H5 0	2G9 25291	2H4 0	2G6 26082	2H0 0	4G0 24591	6G2 24431	5G9 24800	1H2 0	0G4 26334	0H7 0	0G1 25238	4H0 0	5E8 40788
8	5R2 37700	4G2 20159	3H3 0	5G5 25434	0H3 0	0G3 26111	3G1 24387	1G0 22525	5G3 24162	1G7 26257	1H6 0	3G4 25336	5H4 0	5G6 19740	3R9 37702
9	6E0 40855	6H4 0	2G1 25035	0H9 0	1G1 26123	2H8 0	4G7 24411	5G1 24249	3G7 24415	0H1 0	1G6 26286	2H3 0	1G3 25229	4H1 0	5E9 40783
10		6G1 25227	5H2 0	5G0 21507	2H1 0	0G5 26412	1H4 0	2G0 26151	0H8 0	1G8 26361	1H1 0	4G4 20958	5H8 0	3G0 24752	
11		1R5 37731	4H3 0	5H9 0	2G2 26561	0H5 0	2G4 26340	1H9 0	0G9 26284	1H7 0	1G2 26615	3H7 0	4H9 0	1R4 37620	
12			5R7 45477	4G1 20244	4H7 0	5G8 20909	2H5 0	6G3 25302	0H4 0	5G4 21257	4H4 0	3G6 19746	5R9 45639		
13				4R7 43900	5H6 0	3H6 0	0G8 25289	4H2 0	1G5 25109	6H1 0	3H2 0	3R7 44141			
14					4P6 37381	3G5 24900	3H1 0	4G9 19912	5H1 0	6G4 25077	3P4 37444				
15							4R6 42262	3R0 37804	2R9 42694						

===> Assembly ID
===> Assembly Burnup (MWD/MTU)

Figure 1.3

NORTH ANNA UNIT 1 - CYCLE 16
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 Maps 1-3 for Cycle 16

** - Locations Not Available For Flux Maps 1 and 2 for Cycle 16

*# - Location Not Available For Flux Map 3 for Cycle 16

Figure 1.4

NORTH ANNA UNIT 1 - CYCLE 16
BURNABLE POISON AND VIBRATION SUPPRESSION DAMPING ASSEMBLY LOCATIONS

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1															
2							5P BP990		5P BP991						
3					6P BP1014	21P BP998		24P BP970		21P BP999	6P BP1017				
4					22P BP1006		24P BP974		24P BP975		22P BP1009				
5			6P BP1015	22P BP1013		24P BP962		24P BP958		24P BP963		22P BP1012	6P BP1016		
6			21P BP1005		24P BP964		24P BP976		24P BP977		24P BP965		21P BP1002		
7		5P BP995		24P BP978		24P BP979				24P BP980		24P BP981		5P BP996	
8			24P BP971		24P BP959						24P BP960		24P BP972		
9		5P BP994		24P BP982		24P BP983				24P BP984		24P BP985		5P BP997	
10			21P BP1004		24P BP966		24P BP986		24P BP987		24P BP967		21P BP1003		
11			6P BP1018	22P BP1010		24P BP968		24P BP961		24P BP969		22P BP1011	6P BP1021		
12					22P BP1007		24P BP988		24P BP989		22P BP1008				
13					6P BP1019	21P BP1001		24P BP973		21P BP1000	6P BP1020				
14							5P BP993		5P BP992						
15															

5P – 5 Burnable Poison Rod Cluster
6P – 6 Burnable Poison Rod Cluster
21P- 21 Burnable Poison Rod Cluster
22P- 22 Burnable Poison Rod Cluster
24P- 24 Burnable Poison Rod Cluster

Figure 1.5

NORTH ANNA UNIT 1 - CYCLE 16
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															

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 Specifications 3.1.3.4, specifies a maximum rod time such that the time from loss of stationary gripper coil voltage to dashpot entry is within 2.7 seconds. These Technical Specifications require that the RCS is at hot, full flow conditions. In reference 10, an additional administrative limit was implemented such that all rods must drop within 2.03 seconds with the exception of "A"-Bank rods. The "A"-Bank rods must drop within 2.25 seconds with an average time within 2.03 seconds. These test results satisfied these limits. In addition, rod bounce was observed at the end of each trace, which demonstrated that no control rod stuck in the dashpot region.

To provide adequate surveillance of rod drop times and so that adverse performance trends can be readily identified and addressed, rod drop time curves have been generated. Based on historical surveillance data of previous and current cycle drop times, trending curves have been developed and are displayed within Figure 2.3. Figure 2.3 was developed in conjunction with reference 12.

Table 2.1

NORTH ANNA UNIT 1 - CYCLE 16 STARTUP PHYSICS TESTS
HOT ROD DROP TIME SUMMARY

ROD DROP TIME TO DASHPOT ENTRY

SLOWEST ROD	FASTEST ROD	AVERAGE TIME
B-06 2.14 sec.	C-09 1.58 sec.	1.76 sec.

SLOWEST NON- BANK "A" ROD	AVERAGE OF BANK "A" RODS
B-08 1.92 sec.	1.83 sec.

Figure 2.1

NORTH ANNA UNIT 1 - CYCLE 16 STARTUP PHYSICS TESTS
TYPICAL ROD DROP TRACE

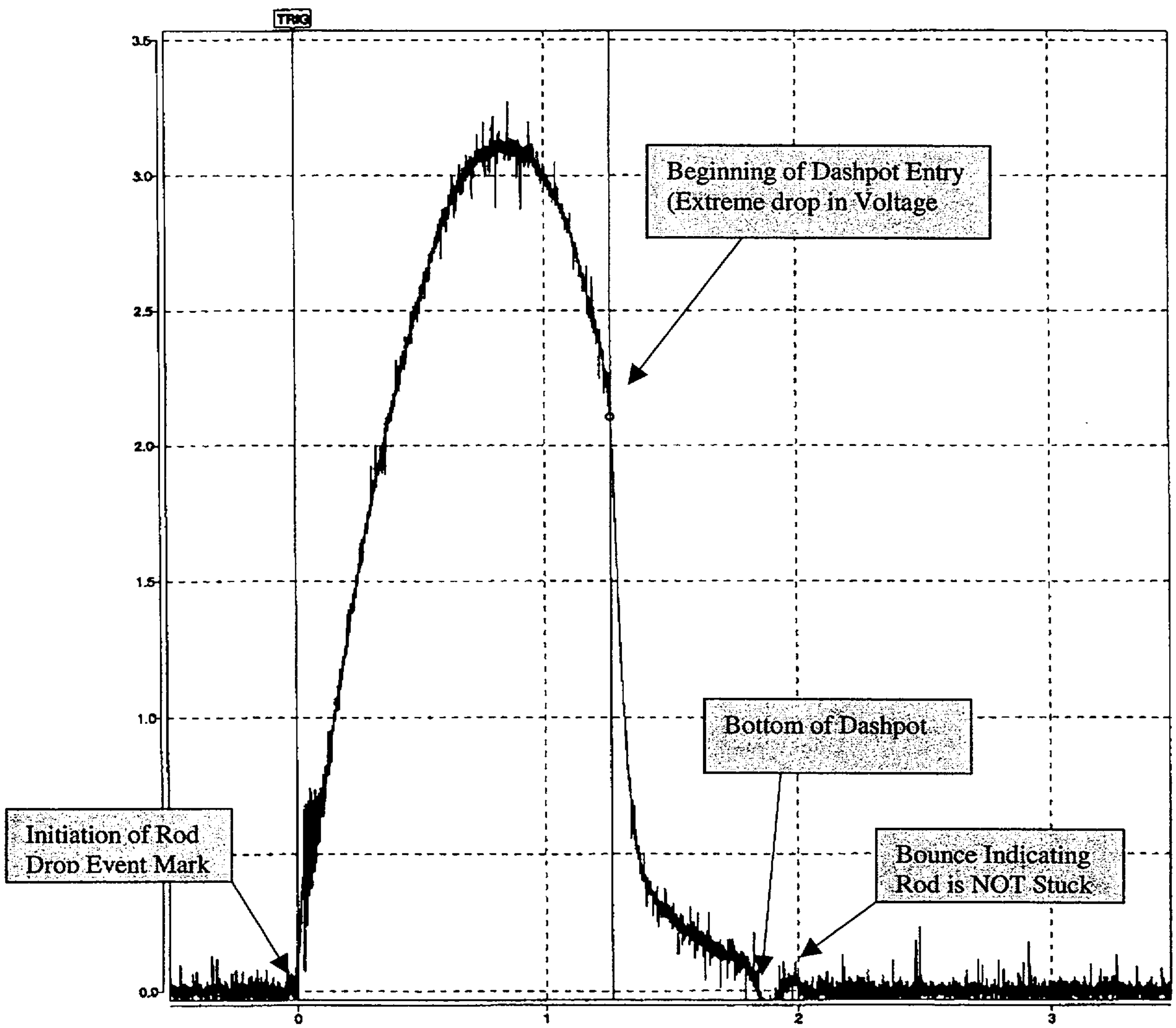


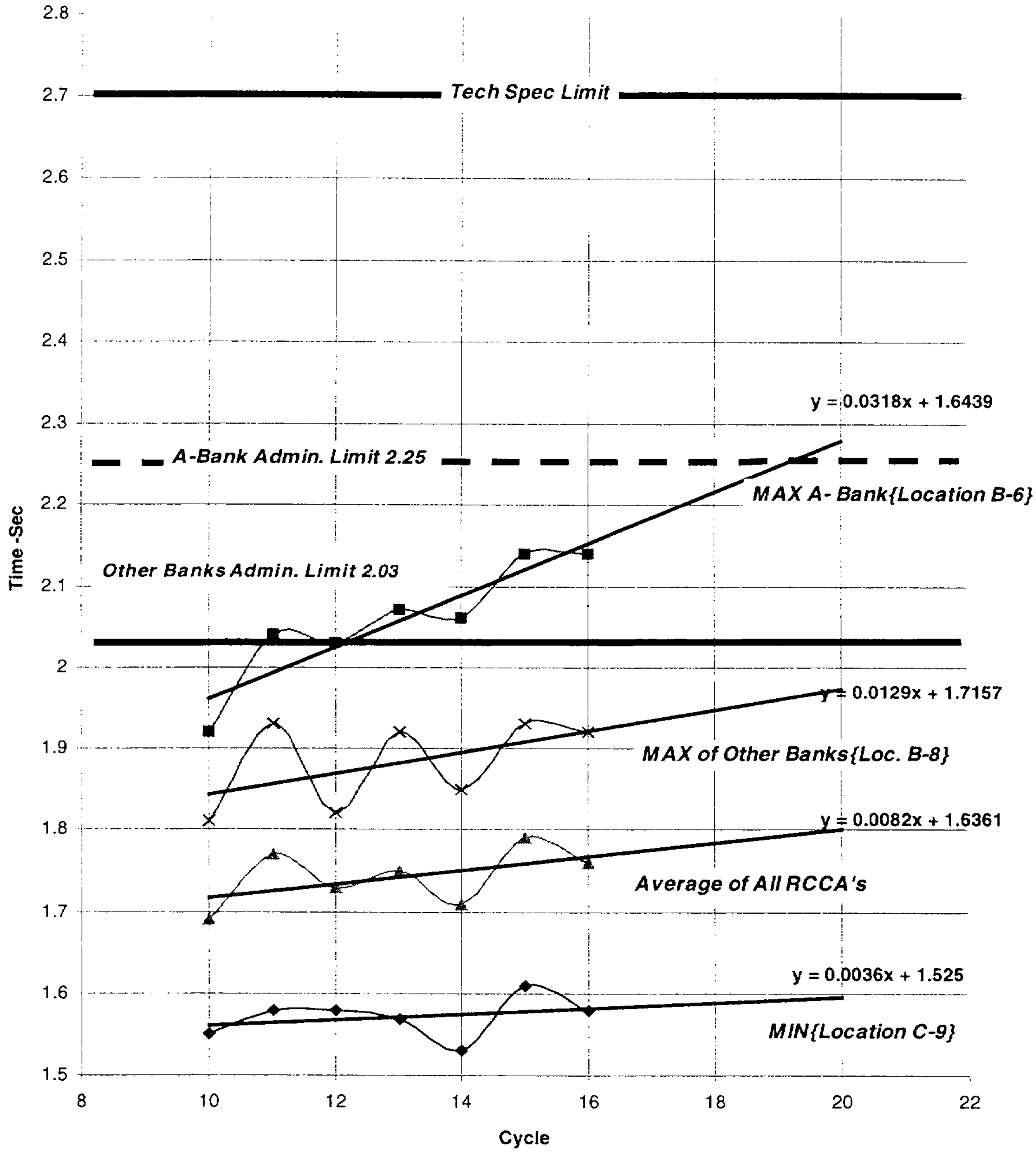
Figure 2.2

NORTH ANNA UNIT 1 - CYCLE 16 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						1.74		1.63		1.71					
3							1.71		1.70						
4				1.78		1.68				1.75		1.74			
5					1.78						1.76				
6		1.66		1.81		1.73		1.73		1.76		1.78		2.14	
7			1.74				1.67		1.69				1.75		
8		1.80				1.79				1.72				1.92	
9			1.76				1.68		1.69				1.58		
10		1.78		1.78		1.69		1.73		1.76		1.76		1.83	
11					1.83						1.77				
12				1.71		1.84				1.72		1.72			
13							1.73		1.72						
14						1.97		1.78		1.81					
15															

x.xx ===> Rod drop time to dashpot entry (sec.)

Figure 2.3
NORTH ANNA UNIT 1 – CYCLE 16 STARTUP
PHYSICS TESTS
ROD DROP TIME TRENDS



Data located in "P:\NCD\ROD_DROP\natrending_N1C16.xls" and is saved with statistics on 10-19-2001 at 12:31.

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 16, 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. As recommended in Reference 11, the test bank sequence used for rod swap was to exchange test bank with test bank, instead of returning to the initial condition after each test bank measurement (as done for previous cycles).

Test bank swaps proceed in sequential order from the bank with the smallest worth to the bank with the largest worth. (The second test bank should have a predicted

worth higher than the first bank in order to ensure the first bank will be moved fully out.) The rod swap maneuver was performed by withdrawing the previous test bank (or reference bank for the first maneuver) several steps and then inserting the next test bank to balance the reactivity of the reference bank withdrawal. This sequence was repeated until the previous test bank was fully withdrawn and the test bank was nearly inserted. The next step was to swap the rest of the test bank in by balancing the reactivity with the withdrawal of the reference bank, 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 differential worth of the reference bank were recorded with the reference bank at the MCP. The rod swap maneuver was then repeated for the remainder of the test banks. Note that after the final test bank was fully inserted, the test bank was swapped with the reference bank until the reference bank was fully inserted and the last test bank was fully withdrawn. Here the final statepoint data for the rod swap maneuver was obtained (core reactivity and moderator temperature) in order to verify the reactivity drift for the rod swap test.

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 ($\pm$10% for the reference bank, $\pm$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 1.43% 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 16 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	1393.2	1396.0	-0.20
D	944.6	979.0	-3.51
C	760.4	779.3	-2.43
A	356.6	348.4	2.35 *
SB	930.5	969.8	-4.05
SA	1012.5	1003.4	0.91
Total Worth	5397.6	5476.0	-1.43

*Difference is less than 100 pcm.

Figure 3.1

NORTH ANNA UNIT 1 - CYCLE 16 STARTUP PHYSICS TESTS
CONTROL BANK B INTEGRAL ROD WORTH - HZP
ALL OTHER RODS WITHDRAWN

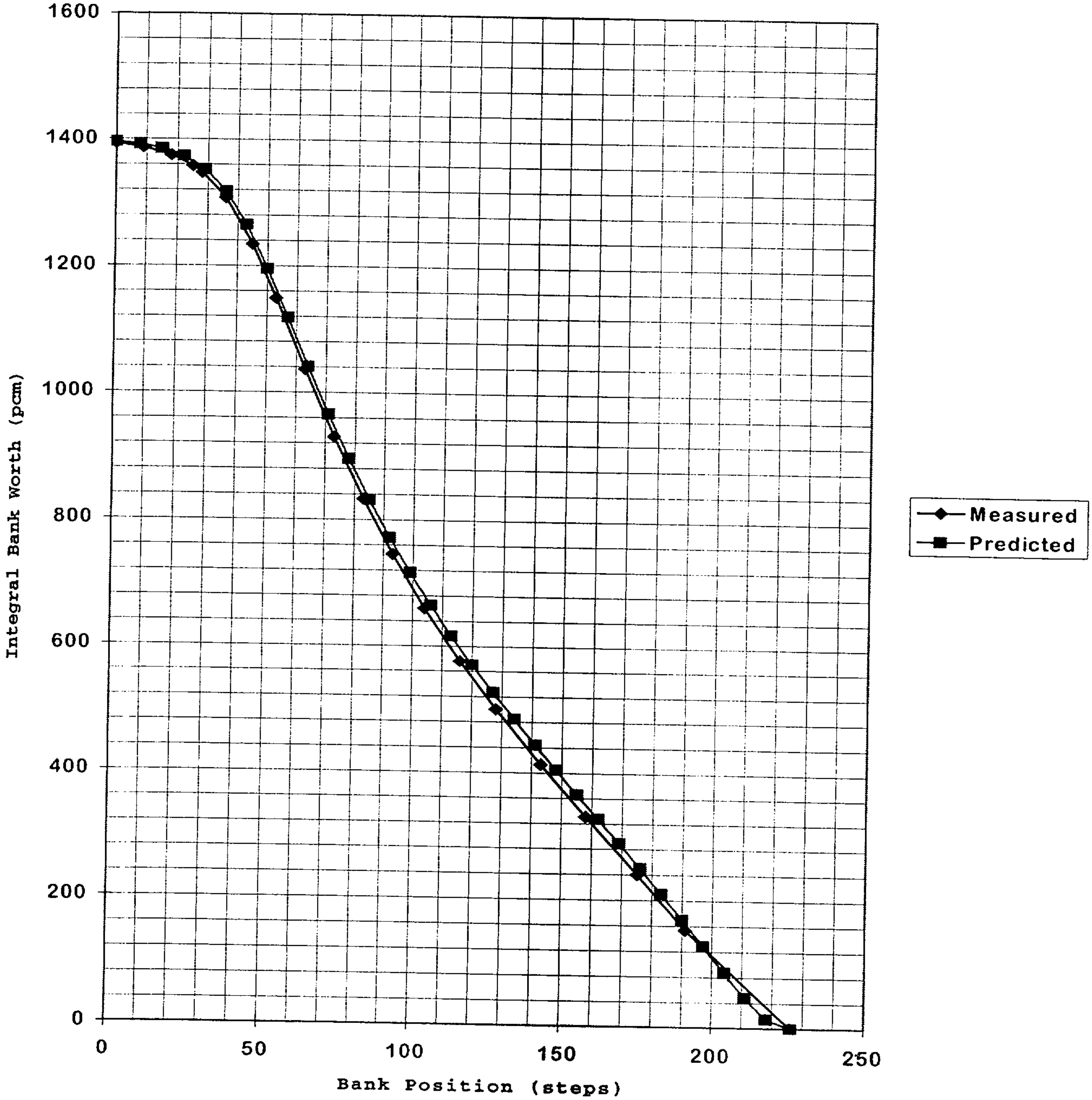
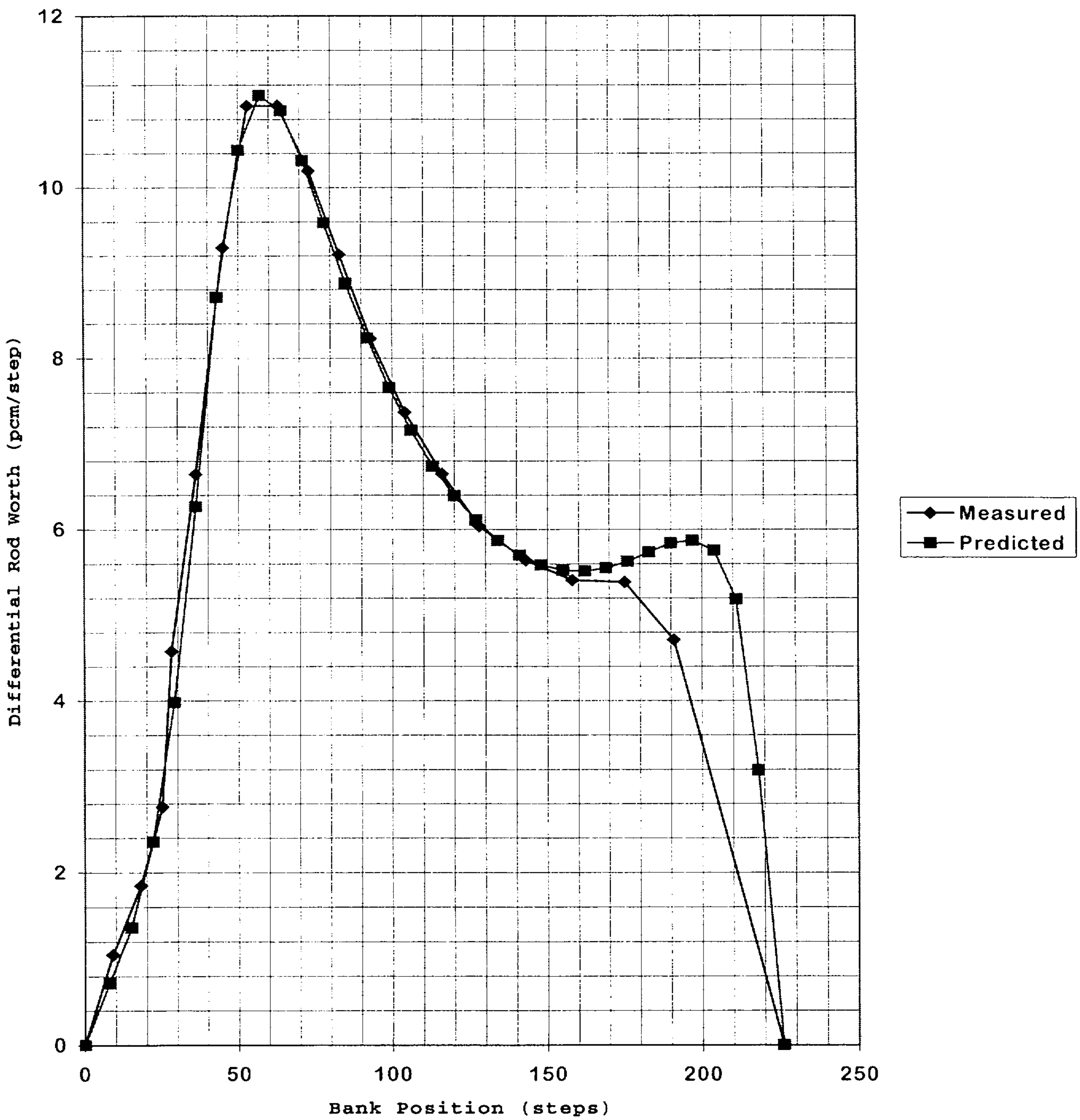


Figure 3.2

NORTH ANNA UNIT 1 - CYCLE 16 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 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 $\pm 10\%$. In summary, the measured boron worth coefficient was satisfactory.

Table 4.1

NORTH ANNA UNIT 1 - CYCLE 16 STARTUP PHYSICS TESTS
BORON ENDPOINTS SUMMARY

Control Rod Configuration	Measured Endpoint (ppm)	Predicted Endpoint (ppm)	Difference M-P (ppm)
ARO	2109	2133	-24
B Bank In	1897	1892.5*	4.5

* 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 1 - CYCLE 16 STARTUP PHYSICS TESTS
BORON WORTH COEFFICIENT

Measured Boron Worth (pcm/ppm)	Predicted Boron Worth (pcm/ppm)	Percent Difference (%) (M-P)/P x 100
-6.59	-6.46	2.01

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 4.2°F and RCS heatup of 3.4°F. Reactivity and temperature data were taken from the reactivity computer. Using the statepoint method, the temperature coefficient was determined by dividing the change in reactivity by the change in RCS temperature. Plots of reactivity verses 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 –1.13 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 1 - CYCLE 16 STARTUP PHYSICS TESTS
ISOTHERMAL TEMPERATURE COEFFICIENT SUMMARY

BANK POSITION (STEPS)	TEMPERATURE RANGE (°F)	BORON CONCENTRATION (ppm)	ISOTHERMAL TEMPERATURE COEFFICIENT (PCM/°F)				
			Cool-down	Heat -up	AVE MEAS	PRED	DIFFER (M-P)
D/202	543.8 to 549.3	2109	-3.01	-2.73	-2.87	-3.29	0.42

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 16. For each traverse, the detector voltage output is continuously monitored on a strip chart recorder, and scanned for 610 discrete axial points. Full core, three-dimensional power distributions are determined from this data using a Dominion 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 29% 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 5% of the predicted values, and the largest difference was 10.6% for the 29% power map, which decreased to 4.5% for the 100% power map.

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 also used to perform power range detector calibrations. 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 16.

Table 6.1

NORTH ANNA UNIT 1 - CYCLE 16 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	10/10/01	5.0	29	150	N5	31	2.108	N5	1.546	31	1.283	1.0037	NW	-6.233	43
Int. Pwr (3)	2	10/11/01	24.0	74	192	N5	30	1.848	N5	1.451	26	1.184	1.0039	NE	0.088	43
Hot Full Pwr	3	10/22/01	436.4	100	226	C10	39	1.786	C10	1.405	37	1.139	1.0035	NE	-2.537	45

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) MAPS 1, 2, and 3 were used for power range detector calibrations.

Table 6.2

NORTH ANNA UNIT 1 - CYCLE 16 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	2.108	4.380	31	2.108	4.380	31	51.9	1.546	1.809	14.5
2	1.848	2.970	30	1.832	2.918	23	37.2	1.451	1.608	9.8
3	1.786	2.191	39	1.786	2.191	39	18.5	1.405	1.490	5.7

*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% total uncertainty.

Figure 6.1
NORTH ANNA UNIT 1 - CYCLE 16 STARTUP PHYSICS TESTS
ASSEMBLYWISE POWER DISTRIBUTION
29% POWER

Each cell: PREDICTED / MEASURED / PCT DIFFERENCE

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
1							0.246 0.249 1.0	0.275 0.280 1.8	0.242 0.246 1.6							1
2					0.331 0.336 1.5	0.649 0.656 1.0	1.053 1.061 0.8	0.836 0.844 1.0	1.045 1.062 1.6	0.647 0.674 4.3	0.331 0.338 2.2					2
3				0.365 0.381 4.3	1.179 1.200 1.8	1.299 1.313 1.1	1.170 1.177 0.6	1.301 1.301 0.0	1.168 1.175 0.6	1.299 1.312 1.0	1.183 1.196 1.1	0.368 0.379 3.0				3
4			0.368 0.381 3.6	0.898 0.919 2.3	1.333 1.358 1.9	1.323 1.335 0.9	1.305 1.309 0.3	1.243 1.244 0.0	1.304 1.303 -0.1	1.324 1.318 -0.4	1.338 1.343 0.4	0.897 0.908 1.2	0.365 0.369 1.1			4
5		0.356 0.367 3.1	1.204 1.259 4.6	1.346 1.370 1.8	1.221 1.228 0.6	1.262 1.265 0.2	1.168 1.168 0.0	1.236 1.233 -0.2	1.168 1.164 -0.3	1.261 1.258 -0.3	1.220 1.222 0.1	1.339 1.358 1.4	1.197 1.212 1.2	0.355 0.361 1.9		5
6		0.665 0.668 0.5	1.321 1.334 0.9	1.334 1.338 0.3	1.266 1.252 -1.1	1.017 1.012 -0.5	1.145 1.139 -0.6	1.071 1.065 -0.5	1.143 1.133 -0.8	1.017 1.012 -0.4	1.265 1.261 -0.3	1.332 1.333 0.1	1.319 1.330 0.8	0.665 0.677 1.9		6
7	0.258 0.256 -1.0	1.070 1.060 -0.9	1.186 1.166 -1.7	1.317 1.306 -0.8	1.174 1.164 -0.9	1.145 1.135 -0.9	1.038 1.027 -1.1	1.005 0.993 -1.2	1.038 1.018 -1.9	1.148 1.135 -1.1	1.174 1.163 -0.9	1.316 1.294 -1.7	1.187 1.195 0.7	1.074 1.108 3.2	0.259 0.267 3.1	7
8	0.284 0.282 -1.0	0.853 0.845 -1.0	1.320 1.298 -1.7	1.255 1.244 -0.9	1.243 1.232 -0.9	1.074 1.065 -0.9	1.005 0.994 -1.1	0.996 0.984 -1.2	1.005 0.991 -1.4	1.074 1.063 -1.0	1.243 1.233 -0.7	1.255 1.251 -0.3	1.320 1.333 1.0	0.853 0.879 3.0	0.284 0.293 2.9	8
9	0.259 0.258 -0.6	1.074 1.069 -0.5	1.187 1.181 -0.5	1.316 1.310 -0.5	1.174 1.172 -0.2	1.148 1.139 -0.8	1.038 1.025 -1.2	1.005 0.991 -1.4	1.038 1.024 -1.3	1.145 1.133 -1.1	1.174 1.167 -0.6	1.317 1.319 0.2	1.186 1.201 1.3	1.070 1.097 2.5	0.258 0.264 2.4	9
10		0.665 0.665 0.1	1.319 1.326 0.6	1.332 1.330 -0.1	1.265 1.259 -0.5	1.017 1.007 -0.9	1.143 1.123 -1.7	1.071 1.053 -1.7	1.145 1.127 -1.6	1.017 1.003 -1.4	1.266 1.255 -0.9	1.334 1.339 0.4	1.321 1.344 1.8	0.665 0.691 3.8		10
11		0.355 0.356 0.3	1.197 1.203 0.5	1.339 1.337 -0.1	1.220 1.211 -0.7	1.261 1.246 -1.2	1.168 1.147 -1.8	1.236 1.211 -2.0	1.168 1.146 -1.9	1.262 1.229 -2.6	1.221 1.198 -1.9	1.346 1.361 1.1	1.204 1.235 2.6	0.356 0.366 3.0		11
12			0.365 0.373 2.4	0.897 0.897 -0.1	1.338 1.329 -0.7	1.324 1.307 -1.3	1.304 1.276 -2.2	1.243 1.218 -2.0	1.305 1.286 -1.5	1.323 1.309 -1.1	1.333 1.334 0.1	0.898 0.939 4.5	0.368 0.407 10.6			12
13				0.368 0.367 -0.3	1.183 1.179 -0.3	1.299 1.286 -1.0	1.168 1.149 -1.6	1.301 1.270 -2.4	1.170 1.163 -0.7	1.299 1.292 -0.5	1.179 1.180 0.1	0.365 0.372 1.9				13
14					0.331 0.342 3.4	0.647 0.644 -0.4	1.045 1.037 -0.7	0.836 0.834 -0.1	1.053 1.077 2.3	0.649 0.653 0.6	0.331 0.332 0.2					14
15							0.242 0.243 0.3	0.275 0.276 0.2	0.246 0.251 1.8							15
	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	

STANDARD DEVIATION =1.235

AVERAGE PCT DIFFERENCE = 1.3

SUMMARY

MAP NO: N1-16-01

DATE: 10/10/01

POWER: 29%

CONTROL ROD POSITIONS:

D BANK AT 150 STEPS

F-Q(Z) = 2.108

F-DH(N) = 1.546

F(Z) = 1.283

BURNUP = 5.0 MWD/MTU

CORE TILT:

NW 1.0037	NE 1.0031
SW 0.9922	SE 1.0010

A.O. = -6.233

Figure 6.2
NORTH ANNA UNIT 1 - CYCLE 16 STARTUP PHYSICS TESTS
ASSEMBLYWISE POWER DISTRIBUTION
74% POWER

Legend: PREDICTED / MEASURED / PCT DIFFERENCE

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
1							0.271 0.272 0.4	0.311 0.311 0.1	0.267 0.269 0.9							1
2					0.339 0.342 0.8	0.660 0.664 0.6	1.082 1.088 0.6	0.921 0.927 0.7	1.074 1.087 1.2	0.657 0.678 3.1	0.339 0.344 1.6					2
3				0.369 0.376 2.0	1.140 1.152 1.1	1.258 1.267 0.7	1.164 1.169 0.4	1.297 1.300 0.2	1.162 1.168 0.6	1.258 1.268 0.9	1.143 1.152 0.8	0.372 0.375 0.8				3
4			0.371 0.381 2.5	0.880 0.892 1.4	1.278 1.293 1.2	1.285 1.292 0.6	1.275 1.279 0.3	1.227 1.230 0.2	1.274 1.276 0.2	1.285 1.286 0.1	1.282 1.287 0.4	0.879 0.886 0.8	0.368 0.371 0.7			4
5		0.361 0.369 2.1	1.159 1.199 3.5	1.287 1.302 1.2	1.196 1.198 0.2	1.253 1.255 0.1	1.172 1.174 0.2	1.227 1.227 0.0	1.171 1.172 0.1	1.253 1.254 0.1	1.195 1.199 0.3	1.281 1.296 1.1	1.154 1.164 0.9	0.360 0.362 0.5		5
6		0.673 0.672 0.0	1.274 1.279 0.4	1.291 1.291 0.0	1.256 1.244 -0.9	1.103 1.101 -0.2	1.176 1.173 -0.3	1.100 1.098 -0.2	1.173 1.171 -0.2	1.103 1.104 0.1	1.255 1.255 0.0	1.290 1.292 0.2	1.272 1.281 0.7	0.673 0.682 1.3		6
7	0.283 0.279 -1.3	1.094 1.081 -1.3	1.174 1.152 -1.9	1.282 1.270 -0.9	1.175 1.167 -0.7	1.175 1.169 -0.6	1.084 1.077 -0.7	1.053 1.048 -0.5	1.084 1.079 -0.5	1.177 1.173 -0.4	1.175 1.171 -0.4	1.282 1.269 -1.0	1.176 1.184 0.7	1.098 1.125 2.4	0.284 0.290 2.2	7
8	0.319 0.315 -1.3	0.935 0.923 -1.3	1.310 1.282 -2.1	1.235 1.223 -1.0	1.231 1.226 -0.4	1.101 1.097 -0.4	1.053 1.048 -0.6	1.049 1.043 -0.5	1.053 1.048 -0.5	1.101 1.096 -0.5	1.231 1.228 -0.3	1.235 1.235 0.0	1.310 1.321 0.8	0.935 0.951 1.7	0.319 0.324 1.6	8
9	0.284 0.281 -1.0	1.098 1.089 -0.9	1.176 1.166 -0.8	1.282 1.276 -0.5	1.175 1.178 0.2	1.177 1.173 -0.3	1.084 1.078 -0.6	1.053 1.046 -0.7	1.084 1.078 -0.6	1.175 1.169 -0.5	1.175 1.174 -0.1	1.282 1.287 0.4	1.174 1.186 1.0	1.094 1.112 1.6	0.283 0.284 0.5	9
10		0.673 0.671 -0.3	1.272 1.275 0.2	1.290 1.287 -0.2	1.255 1.252 -0.3	1.103 1.098 -0.4	1.173 1.163 -0.9	1.100 1.089 -0.9	1.176 1.166 -0.9	1.103 1.097 -0.6	1.256 1.254 -0.2	1.291 1.303 0.9	1.274 1.291 1.4	0.673 0.692 2.8		10
11		0.360 0.360 -0.1	1.154 1.155 0.1	1.281 1.278 -0.2	1.195 1.190 -0.5	1.253 1.243 -0.8	1.171 1.158 -1.1	1.227 1.211 -1.3	1.172 1.158 -1.2	1.253 1.234 -1.5	1.196 1.186 -0.8	1.287 1.302 1.1	1.159 1.176 1.5	0.361 0.368 1.9		11
12			0.368 0.371 0.7	0.879 0.877 -0.3	1.282 1.274 -0.6	1.285 1.273 -0.9	1.274 1.256 -1.5	1.227 1.209 -1.5	1.275 1.261 -1.1	1.285 1.275 -0.8	1.278 1.282 0.3	0.880 0.914 3.9	0.371 0.380 2.3			12
13				0.372 0.370 -0.5	1.143 1.138 -0.5	1.258 1.247 -0.9	1.162 1.146 -1.4	1.297 1.270 -2.1	1.164 1.155 -0.7	1.258 1.248 -0.8	1.140 1.140 0.0	0.369 0.375 1.6				13
14					0.339 0.343 1.2	0.657 0.653 -0.7	1.074 1.064 -0.9	0.921 0.916 -0.5	1.082 1.096 1.3	0.660 0.661 0.1	0.339 0.339 0.0					14
15							0.267 0.263 -1.4	0.311 0.310 -0.4	0.271 0.273 0.9							15
	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	

STANDARD DEVIATION =0.694

AVERAGE PCT DIFFERENCE = 0.8

SUMMARY

MAP NO: N1-16-02

DATE: 10/11/01

POWER: 74%

CONTROL ROD POSITIONS:

D BANK AT 192 STEPS

F-Q(Z) = 1.848

F-DH(N) = 1.451

F(Z) = 1.184

BURNUP = 24.0 MWD/MTU

CORE TILT:

NW 1.0014	NE 1.0039
SW 0.9933	SE 1.0014

A.O. = 0.088

Figure 6.3
NORTH ANNA UNIT 1 - CYCLE 16 STARTUP PHYSICS TESTS
ASSEMBLYWISE POWER DISTRIBUTION
100% POWER

Legend (upper left): PREDICTED / MEASURED / PCT DIFFERENCE

Legend (upper right): PREDICTED / MEASURED / PCT DIFFERENCE

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
1							0.283 0.283 0.1	0.330 0.334 1.3	0.279 0.281 0.9							1
2					0.342 0.343 0.2	0.662 0.662 -0.1	1.087 1.085 -0.2	0.963 0.961 -0.2	1.080 1.089 0.8	0.660 0.682 3.3	0.342 0.349 2.0					2
3				0.371 0.384 3.4	1.118 1.122 0.4	1.239 1.238 -0.1	1.156 1.150 -0.5	1.297 1.279 -1.4	1.154 1.155 0.1	1.239 1.251 1.0	1.121 1.135 1.3	0.373 0.384 2.9				3
4			0.372 0.379 1.6	0.871 0.878 0.8	1.255 1.254 -0.1	1.263 1.262 -0.1	1.265 1.262 -0.3	1.217 1.213 -0.3	1.265 1.266 0.1	1.264 1.269 0.4	1.259 1.268 0.7	0.870 0.876 0.6	0.370 0.371 0.4			4
5		0.362 0.367 1.2	1.133 1.160 2.3	1.263 1.272 0.7	1.185 1.190 0.4	1.258 1.257 -0.1	1.173 1.173 0.0	1.228 1.230 0.2	1.173 1.176 0.3	1.258 1.262 0.3	1.185 1.192 0.6	1.258 1.257 -0.1	1.128 1.133 0.4	0.361 0.371 2.8		5
6		0.673 0.669 -0.6	1.251 1.248 -0.2	1.268 1.261 -0.5	1.260 1.242 -1.5	1.158 1.154 -0.3	1.196 1.199 0.3	1.110 1.119 0.9	1.194 1.198 0.4	1.158 1.158 0.0	1.259 1.259 0.0	1.267 1.262 -0.4	1.250 1.250 0.0	0.673 0.679 0.9		6
7	0.294 0.289 -1.6	1.097 1.079 -1.6	1.164 1.139 -2.1	1.270 1.255 -1.2	1.176 1.165 -0.9	1.195 1.192 -0.2	1.100 1.108 0.7	1.067 1.074 0.7	1.100 1.107 0.6	1.197 1.202 0.4	1.176 1.173 -0.2	1.270 1.253 -1.4	1.165 1.159 -0.5	1.101 1.117 1.4	0.295 0.299 1.5	7
8	0.337 0.332 -1.7	0.975 0.958 -1.8	1.307 1.276 -2.4	1.223 1.208 -1.2	1.231 1.222 -0.7	1.111 1.109 -0.2	1.067 1.069 0.2	1.062 1.065 0.3	1.067 1.073 0.5	1.111 1.126 1.4	1.231 1.231 0.0	1.223 1.213 -0.8	1.307 1.282 -1.9	0.975 0.994 2.0	0.337 0.343 1.9	8
9	0.295 0.291 -1.3	1.101 1.087 -1.2	1.165 1.152 -1.1	1.270 1.264 -0.5	1.176 1.184 0.7	1.197 1.198 0.1	1.100 1.100 -0.1	1.067 1.066 -0.1	1.100 1.098 -0.2	1.195 1.187 -0.7	1.176 1.174 -0.1	1.270 1.272 0.1	1.164 1.167 0.3	1.097 1.116 1.7	0.294 0.300 2.0	9
10		0.673 0.668 -0.7	1.250 1.245 -0.4	1.267 1.265 -0.1	1.259 1.261 0.1	1.158 1.156 -0.1	1.194 1.189 -0.4	1.110 1.103 -0.6	1.196 1.188 -0.7	1.158 1.150 -0.7	1.260 1.260 0.0	1.268 1.281 1.0	1.251 1.270 1.5	0.673 0.696 3.5		10
11		0.361 0.361 -0.1	1.128 1.131 0.3	1.258 1.259 0.1	1.185 1.186 0.1	1.258 1.252 -0.4	1.173 1.162 -0.9	1.228 1.214 -1.1	1.173 1.161 -1.1	1.258 1.239 -1.5	1.185 1.183 -0.2	1.263 1.285 1.7	1.133 1.157 2.1	0.362 0.372 2.6		11
12			0.370 0.381 3.0	0.870 0.874 0.4	1.259 1.258 -0.1	1.264 1.255 -0.7	1.265 1.242 -1.8	1.217 1.198 -1.6	1.265 1.252 -1.1	1.263 1.254 -0.7	1.255 1.264 0.7	0.871 0.913 4.8	0.372 0.389 4.5			12
13				0.373 0.374 0.2	1.121 1.122 0.1	1.239 1.231 -0.6	1.154 1.138 -1.4	1.297 1.267 -2.3	1.156 1.147 -0.8	1.239 1.225 -1.2	1.118 1.120 0.2	0.371 0.379 2.1				13
14					0.342 0.351 2.6	0.660 0.659 -0.2	1.080 1.073 -0.6	0.963 0.959 -0.4	1.087 1.108 1.9	0.662 0.664 0.2	0.342 0.343 0.1					14
15							0.279 0.279 0.2	0.330 0.330 0.0	0.283 0.287 1.4							15
	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	

STANDARD DEVIATION =0.906

AVERAGE PCT DIFFERENCE = 0.9

SUMMARY

MAP NO: N1-16-03 DATE: 10/23/01 POWER: 100%

CONTROL ROD POSITIONS: F-Q(Z) = 1.786 CORE TILT:

D BANK AT 226 STEPS F-DH(N) = 1.405

NW 0.9982	NE 1.0035
SW 0.9954	SE 1.0029

F(Z) = 1.139

BURNUP = 436.4 MWD/MTU A.O. = -2.537

SECTION 7

REFERENCES

1. R. W. Twitchell, "North Anna Unit 1, Cycle 16 Design Report", Technical Report NE-1292, Revision 0, Dominion, September 2001.

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 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 16 Pattern UY, Revision 0 (September, 2001) 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. M. T. Langschwager, "North Anna 1, Cycle 16 TOTE Calculations", PM-0897, Revision 0, September 2001.

7. C. D. Clemens, et al, "North Anna 1, Cycle 16 Flux Map Analysis", PM-0899, Revision 0, and Addenda A and B, October 2001.

8. T. R. Flowers, "Reload Safety Evaluation, North Anna 1 Cycle 16 Pattern UY", Technical Report NE-1284, Revision 0, August 2001.

9. Engineering Transmittal NAF 2001-0098, Revision 0, from W. M. Oppenhimer to R. G. McAndrew, "Core Operating Limits Report, North Anna 1 Cycle 16 Pattern UY", September 26, 2001.

10. N. A. Smith, "Modified Control Rod Drop Time Test Criteria and Safety Analysis Basis – North Anna Units 1 and 2", Technical Report NE-1205, Revision 1, September 1999.

11. P. D. Banning, "Implementation of RMAS for Startup Physics Testing", PM-0824, Revision 0, March 2000.

12. N. A. Smith, "Control Rod Drop Time Performance Trending North Anna 1 and 2", Technical Report NE-1253, Rev. October 2000.

13. Engineering Transmittal NAF 2000-0112, Revision 0, from W. M. Oppenhimer to K. L. Basehore, "Control Rod Drop Time Performance Trending North Anna Power Station, Units 1 and 2", October 9, 2000.

APPENDIX

STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEETS

NORTH ANNA POWER STATION UNIT 1 CYCLE 16
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Reactivity Computer Checkout Proc No / Section: 1-PT-94.0	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: 226 CB: 226 CC: * CD: *	RCS Temperature (^{o}F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: 226 CB: 226 CC: 226 CD: 199	RCS Temperature (^{o}F): 546.82 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 10-9-01 15:12	
	Measured Parameter (Description)	ρ_c= Measured Reactivity using ρ-computer ρ_t= Predicted Reactivity
	Measured Value	ρ_c= +50.32 pcm, −33.59 pcm ρ_t= +49.78 pcm, −34.02 pcm %D= +1.66 % , −1.20 %
	Design Value	%D= $\{(\rho_c - \rho_t)/\rho_t\} \times 100\% \leq 4.0\ \%$
V Acceptance Criteria	Reference	WCAP 7905, Rev. 1, Table 3.6
	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 and/or the pre-critical bench test. Pre-critical Bench Test Results = +/- 110 pcm Allowable Range = +/- 110 pcm	

Prepared By: ____________ Reviewed By: ____________

NORTH ANNA POWER STATION UNIT 1 CYCLE 16
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Critical Boron Concentration - ARO Proc No / Section: 1-PT-94.0	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: 226 CB: 226 CC: 226 CD: 226	RCS Temperature (^{O}F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: 226 CB: 226 CC: 226 CD: 226	RCS Temperature (^{O}F): 546.82 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 10/9/2001 15:12	
	Measured Parameter (Description)	$(C_B)^M_{ARO}$; Critical Boron Concentration - ARO
	Measured Value (Design Conditions)	$(C_B)^M_{ARO}$= 2109 ppm
	Design Value (Design Conditions)	C_B = 2133 ± 50 ppm
	Reference	Technical Report NE-1292, 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 = -6.43 pcm/ppm $C_B^D = \lvert(C_B)^M_{ARO} - C_B\rvert$; C_B is design value	

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

NORTH ANNA POWER STATION UNIT 1 CYCLE 16
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: HZP Boron Worth Coefficient Measurement Proc No / Section: 1-PT-94.0		
II Test Conditions (Design)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: 226 CB: moving CC: 226 CD: 226		RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: 226 CB: moving CC: 226 CD: 226		RCS Temperature (°F): 546.82 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 10/09/01 15:12		
	Measured Parameter (Description)	αC_B; Boron Worth Coefficient	
	Measured Value	αC_B = -6.59 pcm/ppm	
	Design Value (Design Conditions)	αC_B = -6.46 ± 0.65 pcm/ppm	
	Reference	Technical Report NE-1292, 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: Rebecca D Kyl[signature]   Reviewed By: Billy C Clark[signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 16
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Zero Power Testing Range Determination Proc No / Section: 1-PT-94.0		
II Test Conditions (Design)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: 226 CB: 226 CC: * CD: *		RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: 226 CB: 226 CC: 226 CD: 226		RCS Temperature (°F): 546.82 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 10-9-01 15:27		
	Reactivity Computer Initial Flux Background Reading	1×10^{-9} amps	
	Flux Reading At Point Of Nuclear Heating	5.8×10^{-7} amps	
	Zero Power Testing Range	2×10^{-9} to 2.9×10^{-7} 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: [signature]

Reviewed By: C J Wells [signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 16
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Isothermal Temperature Coefficient - ARO Proc No / Section: 1-PT-94.0	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: 226 CB: 226 CC: 226 CD: 226	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: 226 CB: 226 CC: 226 CD: 202	RCS Temperature (°F): 549.3-543.8 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 10/9/01 16:06	
	Measured Parameter (Description)	$(\alpha_T^{ISO})_{ARO}$: Isothermal Temperature Coefficient - ARO
	Measured Value	$(\alpha_T^{ISO})_{ARO}$ = -2.87 pcm/°F (C_B= 2108 ppm)
	Design Value (Actual Conditions)	$(\alpha_T^{ISO})_{ARO}$ = -3.29 ±3.0 pcm/°F (C_B= 2108 ppm)
	Design Value (Design Conditions)	$(\alpha_T^{ISO})_{ARO}$ = -3.08±3.0 pcm/°F (C_B= 2133 ppm)
	Reference	Technical Report NE-1292, Rev. 0
V Acceptance Criteria	FSAR/COLR	$\alpha_T^{ISO} \leq 3.76$ pcm/°F * α_T^{DOP} = -1.74 pcm/°F
	Reference	COLR 2.1.1, Technical Report NE-1292, Rev. 0
VI Comments	Design Tolerance is met : ✓ YES ___ NO Acceptance Criteria is met : ✓ YES ___ NO	
	*Uncertainty on αT_{MOD} = 0.5 pcm/°F (Reference: memorandum from C.T. Snow to E.J. Lozito dated June 27, 1980.)	

Prepared By: Rebecca D Hyde (signature)

Reviewed By: (signature)

NORTH ANNA POWER STATION UNIT 1 CYCLE 16
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	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: 226 CB: moving CC: 226 CD: 226	RCS Temperature (^{O}F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: 226 CB: moving CC: 226 CD: 226	RCS Temperature (^{O}F): 546.9 - 547.4 Power Level (% F.P.): 0 Other (specify): 546.9 - 547.4 Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 10/9/01 17:12	
	Measured Parameter (Description)	I_B^{REF}; Integral Worth Of Control Bank B, All Other Rods Out
	Measured Value	I_B^{REF} = 1393.2 pcm
	Design Value (Design Conditions)	$I_B^{REF} = 1396 \pm 140$ pcm
	Reference	Technical Report NE-1292, Rev. 0 and Engineering Transmittal NAF 2001-0104, 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: [signature]

Reviewed By: [signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 16
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Total Rod Worth, Rod Swap Proc No / Section: 1-PT-94.0	
II Test Conditions (Design)	Bank Positions (Steps) SDA: moving SDB: moving CA: moving CB: moving CC: moving 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: moving SDB: moving CA: moving CB: moving CC: moving CD: moving Date/Time Test Performed: 10/9/01 17:12	RCS Temperature (^{o}F): 546.9 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Measured Parameter (Description)	I_{Total}: Integral Worth of All Banks, Rod Swap
	Measured Value	I_{Total}= 5397.6 pcm
	Design Value (Actual Conditions)	I_{Total}= 5476.0 pcm
	Design Value (Design Conditions)	I_{Total}= 5471 ± 547 pcm
	Reference	Engineering Transmittal NAF 2001-0104, 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: [signature]

Reviewed By: [signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 16
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Critical Boron Concentration - B Bank In Proc No / Section: 1-PT-94.0		
II Test Conditions (Design)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: 226 CB: 0 CC: 226 CD: 226		RCS Temperature (^{O}F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: 226 CB: 0 CC: 226 CD: 226		RCS Temperature (^{O}F): 547.13 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 10/09/01 20:48		
	Measured Parameter (Description)	$(C_B)^M{}_B$: Critical Boron Concentration, B Bank In	
	Measured Value (Design Conditions)	$(C_B)^M{}_B$= 1897 ppm	
	Design Value (Design Conditions)	$C_B = 1917 + \Delta C_B{}^{Prev} \pm (10 + 139.6/\lvert\alpha C_B\rvert)$ ppm C_B= 1892.5 ± 32 ppm	
	Reference	Technical Report NE-1292, Rev. 0	
V Acceptance Criteria	FSAR/Tech Spec	Not Applicable	
	Reference	Not Applicable	
VI Comments	Design Tolerance is met : ✓ YES ____ NO Acceptance Criteria is met : ✓ YES ____ NO		
	αC_B = -6.46 pcm/ppm $\Delta C_B{}^{Prev} = (C_B)^M{}_{ARO}$ - 2133 ppm		

Prepared By: [signature]

Reviewed By: [signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 16
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		
II Test Conditions (Design)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: moving CB: moving CC: 226 CD: 226		RCS Temperature (^{O}F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: moving CB: moving CC: 226 CD: 226		RCS Temperature (^{O}F): 547.3 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 10/9/01 20:58		
	Measured Parameter (Description)	I_A^{RS}; Integral Worth of Control Bank A, Rod Swap	
	Measured Value	I_A^{RS}= 356.6 (Adjusted Measured Critical Reference Bank Position = 63 steps)	
	Design Value (Actual Conditions)	I_A^{RS}= 348.4 (Adjusted Measured Critical Reference Bank Position = 63 steps)	
	Design Value (Design Conditions)	I_A^{RS}= 345 ± 100 pcm (Critical Reference Bank Position = 63 steps)	
	Reference	Engineering Transmittal NAF 2001-0104, 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]

Reviewed By: [signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 16
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		
II Test Conditions (Design)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: 226 CB: moving CC: moving CD: 226		RCS Temperature (^{o}F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: 226 CB: moving CC: moving CD: 226		RCS Temperature (^{o}F): 547.3 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 10/9/01 21:16		
	Measured Parameter (Description)	I_C^{RS}; Integral Worth of Control Bank C, Rod Swap	
	Measured Value	I_C^{RS}= 760.4 (Adjusted Measured Critical Reference Bank Position = 107.9 steps)	
	Design Value (Actual Conditions)	I_C^{RS}= 779.3 (Adjusted Measured Critical Reference Bank Position = 107.9 steps)	
	Design Value (Design Conditions)	I_C^{RS}= 780 ± 117 pcm (Critical Reference Bank Position = 113 steps)	
	Reference	Engineering Transmittal NAF 2001-0104, 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]* Reviewed By: *[signature]*

NORTH ANNA POWER STATION UNIT 1 CYCLE 16
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		
II Test Conditions (Design)	Bank Positions (Steps) SDA: 226 SDB: moving CA: 226 CB: moving CC: 226 CD: 226		RCS Temperature (^{O}F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 226 SDB: moving CA: 226 CB: moving CC: 226 CD: 226 Date/Time Test Performed: 10/9/01 21:39		RCS Temperature (^{O}F): 547.2 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Measured Parameter (Description)	I_{SB}^{RS}; Integral Worth of Shutdown Bank B, Rod Swap	
	Measured Value	I_{SB}^{RS}= 930.5 (Adjusted Measured Critical Reference Bank Position = 134.5 steps)	
	Design Value (Actual Conditions)	I_{SB}^{RS}= 969.8 (Adjusted Measured Critical Reference Bank Position = 134.5 steps)	
	Design Value (Design Conditions)	I_{SB}^{RS}= 969 ± 145 pcm (Critical Reference Bank Position = 144 steps)	
	Reference	Engineering Transmittal NAF 2001-0104, 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]

Reviewed By: [signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 16
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	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: 226 CB: moving CC: 226 CD: moving	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: 226 CB: moving CC: 226 CD: moving	RCS Temperature (°F): 547.2 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 10/9/01 21:58	
	Measured Parameter (Description)	I_D^{RS}; Integral Worth of Control Bank D, Rod Swap
	Measured Value	I_D^{RS}= 944.6 (Adjusted Measured Critical Reference Bank Position = 136.9 steps)
	Design Value (Actual Conditions)	I_D^{RS}= 979.0 (Adjusted Measured Critical Reference Bank Position = 136.9 steps)
	Design Value (Design Conditions)	I_D^{RS}= 980 ± 147 pcm (Critical Reference Bank Position = 146 steps)
	Reference	Engineering Transmittal NAF 2001-0104, 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]

Reviewed By: [signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 16
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	
II Test Conditions (Design)	Bank Positions (Steps) SDA: moving SDB: 226 CA: 226 CB: moving CC: 226 CD: 226	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: moving SDB: 226 CA: 226 CB: moving CC: 226 CD: 226	RCS Temperature (°F): 547.2 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 10/9/01 22:19	
	Measured Parameter (Description)	I_{SA}^{RS}; Integral Worth of Shutdown Bank A, Rod Swap
	Measured Value	I_{SA}^{RS}= 1012.5 (Adjusted Measured Critical Reference Bank Position = 148.9 steps)
	Design Value (Actual Conditions)	I_{SA}^{RS}= 1003.4 (Adjusted Measured Critical Reference Bank Position = 148.9 steps)
	Design Value (Design Conditions)	I_{SA}^{RS}= 1002 ± 150 pcm (Critical Reference Bank Position = 150 steps)
	Reference	Engineering Transmittal NAF 2001-0104, 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: Rebecca D Kyle [signature]

Reviewed By: [signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 16
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	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: 226 CB: 226 CC: * CD: *	RCS Temperature (^{O}F): $T_{REF} \pm 1$ Power Level (% F.P.): ≤ 30 Other (specify): Must have ≥ 38 thimbles**
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: 226 CB: 226 CC: 226 CD: 150	RCS Temperature (^{O}F): T_{REF} Power Level (% F.P.): 28.61 Other (specify): 43 thimbles
	Date/Time Test Performed: 10/10/01 15:30	

	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
IV Test Results	Measured Value	+4.6 for P ≥ 0.9 +10.6 for P<0.9	1.546	2.108	1.0037
	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	≤ 1.0203
	Reference	WCAP-7905, Rev. 1 NE-1292, Rev. 0	None	None	WCAP-7905, Rev. 1 NE-1292, Rev. 0
V Acceptance Criteria	FSAR/COLR	None	FΔH(N)≤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:

Reviewed By:

NORTH ANNA POWER STATION UNIT 1 CYCLE 16
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</td></tr>
<tr><td>II
Test
Conditions
(Design)</td><td colspan="2">Bank Positions (Steps)
SDA: 226 SDB: 226 CA: 226
CB: 226 CC: 226 CD: *</td><td colspan="3">RCS Temperature (°F): $T_{REF} \pm 1$
Power Level (% F.P.): $65 \leq P \leq 75$
Other (specify):
Must have ≥ 38 thimbles**</td></tr>
<tr><td>III
Test
Conditions
(Actual)</td><td colspan="2">Bank Positions (Steps)
SDA: 226 SDB: 226 CA: 226
CB: 226 CC: 226 CD: 192</td><td colspan="3">RCS Temperature (°F): Tref
Power Level (% F.P.): 73.6%
Other (specify):</td></tr>
<tr><td rowspan="5">IV
Test
Results</td><td colspan="5">Date/Time Test Performed:
10/11/01 1851</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>3.9% for P≥0.9
3.1% for P<0.9</td><td>1.451</td><td>1.848</td><td>1.0039</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>≤ 1.0203</td></tr>
<tr><td>Reference</td><td>WCAP-7905, Rev. 1
NE-1292, Rev. 0</td><td>None</td><td>None</td><td>WCAP-7905, Rev. 1
NE-1292, Rev. 0</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 : ✓ YES ____ NO
Acceptance Criteria is met : ✓ YES ____ NO
* As required
** Must have at least 16 thimbles for quarter core maps for multi-point calibrations</td></tr>
</table>

Prepared By: [signature]

Reviewed By: [signature]

NORTH ANNA POWER STATION UNIT 1 CYCLE 16
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	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: 226 CB: 226 CC: 226 CD: *	RCS Temperature (°F): $T_{REF} \pm 1$ Power Level (% F.P.): $95 \le P \le 100$ Other (specify): Must have ≥ 38 thimbles**
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: 226 CB: 226 CC: 226 CD: 226 Date/Time Test Performed: 10-22-01 / 0830	RCS Temperature (°F): 580.8°F Power Level (% F.P.): 99.95% Other (specify): Avg AO = -2.537%

IV Test Results	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
	Measured Value	4.8% $P_i \ge 0.9$ 4.5% $P_i < 0.9$	1.405	1.786	1.0035
	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	≤ 1.0203
	Reference	WCAP-7905, Rev. 1 NE-1292, Rev. 0	None	None	WCAP-7905, Rev. 1 NE-1292, Rev. 0
V Acceptance Criteria	FSAR/COLR	None	$F\Delta H(N) \le 1.49(1+0.3(1-P))$ (1.490)	$F_Q(Z) \le (2.19/P)*K(Z)$ (2.191)	None
	Reference	None	COLR 2.6	COLR 2.5.1	None

VI Comments

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

Prepared By: RMcAndrew (signature)

Reviewed By: Robert A. Wright (signature)

NORTH ANNA POWER STATION UNIT 1 CYCLE 16
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: RCS Flow Measurement Proc No / Section: 1-PT-27		
II Test Conditions (Design)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: 226 CB: 226 CC: 226 CD: *	RCS Temperature (°F): $T_{REF} \pm 1$ Power Level (% F.P.): $95 \leq P \leq 100$ Other (specify): T_{ave} = 580.8 100% Power	
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 226 SDB: 226 CA: 226 CB: 226 CC: 226 CD: 226	RCS Temperature (°F): 580.8 °F Power Level (% F.P.): 100% Other (specify):	
IV Test Results	Date/Time Test Performed: 10-25-01 / 1520-1615 hrs		
	Measured Parameter (Description)	F_{Total}; Total RCS Flow Rate	
	Measured Value	F_{Total}= 313,504 gpm	
	Design Value (Actual Conditions)	Not Applicable	
	Design Value (Design Conditions)	Not Applicable	
	Reference	Not Applicable	
V Acceptance Criteria	FSAR/Tech Spec	$F_{Total} \geq 295{,}000$ gpm	
	Reference	Technical Specification 3.2.5	
VI Comments	Design Tolerance is met : NA YES NA NO Acceptance Criteria is met : X YES ___ NO		
	* As required		

Prepared By: [signature]

Reviewed By: [signature]