Surry Unit 1 Cycle 15 Startup Physics Tests Report

Nuclear Analysis and Fuel
Nuclear Engineering & Services

July, 1997

VIRGINIA POWER

9708180114 970724
PDR ADOCK 05000280
P PDR

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TECHNICAL REPORT NE-1132 - Rev. 0

SURRY UNIT 1, CYCLE 15
STARTUP PHYSICS TESTS REPORT

NUCLEAR ANALYSIS AND FUEL
NUCLEAR ENGINEERING & SERVICES
VIRGINIA POWER
JULY 1997

PREPARED BY: ______________ 7/7/97
G. P. Anderson Date

REVIEWED BY: ______________ 7/7/97
A. H. Nicholson Date

REVIEWED BY: ______________ 7/9/97
M. E. Paul Date

APPROVED BY: ______________ 7/14/97
D. Dziadosz Date

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TABLE OF CONTENTS

		PAGE
Classification/Disclaimer		1
Table of Contents		2
List of Tables		3
List of Figures		4
Preface		5
Section 1	Introduction and Summary	7
Section 2	Control Rod Drop Time Measurements	16
Section 3	Control Rod Bank Worth Measurements	21
Section 4	Boron Endpoint and Worth Measurements	26
Section 5	Temperature Coefficient Measurement	30
Section 6	Power Distribution Measurements	32
Section 7	References	39
APPENDIX	Startup Physics Test Results and Evaluation Sheets	40

LIST OF TABLES

TABLE	TITLE	PAGE
1.1	Chronology of Tests....................................	10
2.1	Hot Rod Drop Time Summary..............................	18
3.1	Control Rod Bank Worth Summary.........................	23
4.1	Boron Endpoints Summary................................	28
5.1	Isothermal Temperature Coefficient Summary....	31
6.1	Incore Flux Map Summary................................	34
6.2	Comparison of Measured Power Distribution Parameters With Their Core Operating Limits......................	35

LIST OF FIGURES

FIGURE	TITLE	PAGE
1.1	Core Loading Map	11
1.2	Beginning of Cycle Fuel Assembly Burnups	12
1.3	Incore Thimble Locations	13
1.4	Burnable Poison and Flux Suppression Insert Locations	14
1.5	Control Rod Locations	15
2.1	Typical Rod Drop Trace	19
2.2	Rod Drop Time - Hot Full Flow Conditions	20
3.1	Bank B Integral Rod Worth - HZP	24
3.2	Bank B Differential Rod Worth - HZP	25
4.1	Boron Worth Coefficient	29
6.1	Assemblywise Power Distribution - 29% Power	36
6.2	Assemblywise Power Distribution - 68% Power	37
6.3	Assemblywise Power Distribution -100% Power	38

PREFACE

This report presents the analysis and evaluation of the physics tests which were performed to verify that the Surry 1, Cycle 15 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, coupled with the detailed startup procedures, are on file at the Surry 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 Surry 1, Cycle 15 Startup Physics Test 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 these design conditions for 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 March 7, 1997 Surry Unit 1 shut down for its fourteenth refueling. During this shutdown, 62 of the 157 fuel assemblies in the core were replaced with 60 fresh assemblies and 2 once-burned assemblies. The Cycle 15 core consists of seven sub-batches of fuel: two fresh batches (batches 17A and 17B); three once-burned batches, two from Cycle 14 (batches 16A and 16B) and one from Cycle 13 (batch 15A); two twice-burned batches from Surry 1 Cycles 13 and 14 (batches 15A and 15B); and one thrice-burned batch from Surry 1 Cycles 12, 13, and 14 (batch 14B). The fresh fuel is of a similar design to the S1/16 fuel (fresh fuel in Cycle 14), and the burnable poison rod assemblies and flux suppression inserts are the same design used in the previous cycle. Note that S1C15 is the first Surry 1 core loaded without secondary sources.

The core loading pattern and the design parameters for each sub-batch are shown in Figure 1.1. Beginning-of-cycle (BOC) fuel assembly burnups are given in Figure 1.2. The incore thimble locations available during startup physics testing are identified in Figure 1.3. Figure 1.4 identifies the location and number of burnable poison rods and flux suppression insert locations for Cycle 15, while Figure 1.5 identifies the control rod locations.

The Cycle 15 core achieved initial criticality at 1224 on April 28, 1997. Prior to and following criticality, startup physics tests were performed as outlined in Table 1.1. A summary of the physics test results follows.

1. The measured drop time of each control rod was within the 2.4 second limit of Technical Specification 3.12.C.1.

2. The reference control rod bank was measured with the dilution method, and the result was within -0.8% of the design prediction. Individual control rod bank worths were measured using the rod swap technique[2,3] and all results were within -13.1% of the design predictions. The sum of the individual measured control rod bank worths was within -4.8% of the design prediction. All results were within the design tolerance of ±15% for individual bank worths (±10% for the rod swap reference bank worth) and the design tolerance of ±10% for the sum of the individual control rod bank worths.

3. Measured critical boron concentrations for two control bank configurations were within 14 ppm of the design predictions. The all-rods-out (ARO) result was within the 50 ppm design tolerance, and met the Technical Specification 4.10.A criterion that the overall core reactivity balance shall be within ±1% Δk/k of the design prediction. The reference bank in critical boron concentration was within its design tolerance.

4. The boron worth coefficient measurement was within 0.3% of the design prediction, which is within the design tolerance of ±10%.

5. The measured isothermal temperature coefficient (ITC) for the all-rods-out configuration was within 0.53 pcm/°F of the design prediction. This result is within the design tolerance of ±3 pcm/°F. The measured ITC was -0.85 pcm/°F. When the Doppler temperature coefficient (-1.69 pcm/°F) and a 0.5 pcm/°F uncertainty are accounted for in the +6.0 pcm/°F MTC limit of Core Operating Limits Report (COLR) Section 2.1, the MTC acceptance criteria is satisfied as long as the ITC is less positive than 3.81 pcm/°F.

6. Measured core power distributions were within established acceptance criteria and COLR limits. The average relative assembly power distribution measured/predicted percent difference was 2.4% or less for the three initial power ascension flux maps. 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 2.3 and 2.4, 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

SURRY 1 - CYCLE 15 STARTUP PHYSICS TESTS
CHRONOLOGY OF TESTS

Test	Date	Time	Power	Reference Procedure
Hot Rod Drop - Hot Full Flow...	4/27/97	1256	HSD	1-NPT-RX-014
Zero Power Testing Range.......	4/28/97	1350	HZP	1-NPT-RX-008
Reactivity Computer Checkout...	4/28/97	1445	HZP	1-NPT-RX-008
Boron Endpoint - ARO...........	4/28/97	1710	HZP	1-NPT-RX-008
Boron Worth Coefficient - ARO..	4/28/97	1710	HZP	1-NPT-RX-008
Temperature Coefficient - ARO..	4/28/97	1822	HZP	1-NPT-RX-008
Bank B Worth...................	4/28/97	1927	HZP	1-NPT-RX-008
Boron Endpoint - B in..........	4/28/97	2250	HZP	1-NPT-RX-008
Reactivity Computer Checkout... (Re-verification)	5/01/97	1115	HZP	1-NPT-RX-008
Bank SA Worth - Rod Swap.......	5/01/97	1445	HZP	1-NPT-RX-008
Bank SB Worth - Rod Swap.......	5/01/97	1516	HZP	1-NPT-RX-008
Bank A Worth - Rod Swap........	5/01/97	1554	HZP	1-NPT-RX-008
Bank C Worth - Rod Swap........	5/01/97	1644	HZP	1-NPT-RX-008
Bank D Worth - Rod Swap........	5/01/97	1738	HZP	1-NPT-RX-008
Flux Map - 29% Power........... Peaking Factor Verification & Power Range Calibration	5/02/97	2302	28.5%	1-NPT-RX-002 1-NPT-RX-005 1-NPT-RX-008
Flux Map - 68% Power........... Peaking Factor Verification & Power Range Calibration	5/08/97	0950	68.5%	1-NPT-RX-002 1-NPT-RX-005 1-NPT-RX-008
Flux Map - 100% Power.......... Peaking Factor Verification	5/16/97	1442	100.0%	1-NPT-RX-002 1-NPT-RX-005 1-NPT-RX-008

Note: Due to problems with the rod control system, startup physics testing was suspended during the initial start of rod swap bank worth measurements. After the rod control system was fixed, startup physics testing was resumed beginning with a re-verification of the reactivity computer checkout.

Figure 1.1

SURRY UNIT 1 - CYCLE 15
CORE LOADING MAP

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
						14B 5J8	15B 4K9	14B 3J9							1
				15B 3K4	16B 43A	17B 55B	16B 38A	17B 33B	16B 60A	15B 4K3					2
			15B 5K8	17A 01B	17B 51B	16B 49A	17B 48B	16B 59A	17B 43B	17A 13B	15A 1K3				3
		15B 4K8	15B 3K3	17B 37B	16B 56A	17A 09B	16A 34A	17A 16B	16B 46A	17B 38B	15B 5K6	15B 4K7			4
	15B 5K9	17A 28B	17B 44B	16A 02A	17A 31B	16A 31A	16A 01A	16A 26A	17A 17B	16A 29A	17B 56B	17A 05B	15B 4K2		5
	16B 48A	17B 59B	16B 61A	17A 26B	16A 28A	17A 03B	16A 06A	17A 07B	16A 19A	17A 25B	16B 50A	17B 60B	16B 40A		6
14B 3J8	17B 45B	16B 44A	17A 18B	16A 22A	17A 12B	16A 07A	16A 21A	16A 25A	17A 32B	16A 33A	17A 11B	16B 62A	17B 39B	15B 5K5	7
15B 3K6	16B 64A	17B 36B	16A 04A	16A 24A	16A 30A	16A 12A	15A 0K9	16A 11A	16A 35A	16A 36A	16A 13A	17B 47B	16B 45A	15B 3K5	8
15B 4K1	17B 52B	16B 58A	17A 22B	16A 17A	17A 04B	16A 10A	16A 27A	15A 1K7	17A 19B	16A 09A	17A 21B	16B 41A	17B 53B	14B 3J6	9
	16B 39A	17B 57B	16B 51A	17A 27B	16A 05A	17A 15B	16A 32A	17A 08B	16A 08A	17A 30B	16B 55A	17B 35B	16B 53A		10
	15B 4K8	17A 06B	17B 46B	16A 18A	17A 29B	16A 03A	16A 14A	16A 15A	17A 24B	16A 23A	17B 41B	17A 20B	15B 5K2		11
		15B 6K0	15B 5K1	17B 40B	16B 47A	17A 23B	16A 20A	17A 10B	16B 63A	17B 54B	15B 4K4	15B 3K7			12
			15B 5K4	17A 14B	17B 49B	16B 37A	17B 58B	16B 57A	17B 50B	17A 02B	15B 3K8				13
				15B 3K9	16B 52A	17B 34B	16B 54A	17B 42B	16B 42A	15B 4K6					14
						14B 5J6	15B 5K0	14B 4J9							15

|--> BATCH
|--> ASSEMBLY ID

FUEL ASSEMBLY DESIGN PARAMETERS

	SUB-BATCH						
	14B	15A	15B	16A	16B	17A	17B
INITIAL ENRICHMENT (W/O U-235)	4.02	3.82	3.99	3.81	4.01	3.81	4.01
BURNUP AT BOC 15 (MWD/MTU)	38544	28394	38456	21362	20087	0	0
ASSEMBLY TYPE	15x15	15X15	15X15	15X15	15X15	15X15	15X15
NUMBER OF ASSEMBLIES	6	3	25	35	28	32	28
FUEL RODS PER ASSEMBLY	204	204	204	204	204	204	204

Figure 1.2

SURRY UNIT 1 - CYCLE 15
BEGINNING OF CYCLE FUEL ASSEMBLY BURNUPS

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
						5J8 39.11	4K9 36.31	3J9 37.82							1
				3K4 40.28	43A 21.39	55B 0.00	38A 21.26	33B 0.00	60A 21.19	4K3 40.16					2
			5K8 41.35	01B 0.00	51B 0.00	49A 17.24	48B 0.00	59A 17.53	43B 0.00	13B 0.00	1K3 40.72				3
		4K0 41.54	3K3 32.08	37B 0.00	56A 20.78	09B 0.00	34A 22.85	16B 0.00	46A 21.13	38B 0.00	5K6 31.78	4K7 41.26			4
	5K9 40.42	28B 0.00	44B 0.00	02A 22.04	31B 0.00	31A 16.83	01A 22.78	26A 17.07	17B 0.00	29A 22.17	56B 0.00	05B 0.00	4K2 40.13		5
	48A 21.52	59B 0.00	61A 21.07	26B 0.00	28A 22.10	03B 0.00	06A 23.13	07B 0.00	19A 22.25	25B 0.00	50A 20.87	60B 0.00	40A 21.10		6
3J8 38.00	45B 0.00	44A 17.44	18B 0.00	22A 16.83	12B 0.00	07A 23.23	21A 22.60	25A 23.11	32B 0.00	33A 16.97	11B 0.00	62A 17.45	39B 0.00	5K5 38.97	7
3K6 36.75	64A 21.58	36B 0.00	04A 22.67	24A 22.74	30A 22.96	12A 22.76	0K9 22.07	11A 22.86	35A 23.16	36A 22.56	13A 22.78	47B 0.00	45A 21.28	3K5 36.31	8
4K1 38.89	52B 0.00	58A 17.51	22B 0.00	17A 16.73	[illegible] 0.00	10A 23.19	27A 22.79	1K7 22.41	19B 0.00	09A 17.10	21B 0.00	41A 17.49	53B 0.00	3J6 38.53	9
	39A 21.01	57B 0.00	51A 20.83	27B 0.00	05A 22.13	15B 0.00	32A 23.08	08B 0.00	08A 22.30	30B 0.00	55A 21.26	35B 0.00	53A 21.32		10
	4K8 40.07	06B 0.00	46B 0.00	18A 22.13	29B 0.00	03A 17.33	14A 22.74	15A 17.00	24B 0.00	23A 21.88	41B 0.00	20B 0.00	5K2 40.32		11
		6K0 40.99	5K1 31.49	40B 0.00	47A 20.97	23B 0.00	20A 22.87	10B 0.00	63A 20.79	54B 0.00	4K4 31.69	3K7 41.44			12
			5K4 41.70	14B 0.00	49B 0.00	37A 17.40	58B 0.00	57A 17.61	50B 0.00	02B 0.00	3K8 41.07				13
				3K9 40.25	52A 21.24	34B 0.00	54A 21.42	62B 0.00	42A 20.74	4K6 39.73					14
						5J6 38.95	5K0 36.37	4J9 38.87							15

|--> ASSEMBLY ID
|--> ASSEMBLY BURNUP (GWD/MTU)

Figure 1.3

SURRY UNIT 1 - CYCLE 15
INCORE THIMBLE LOCATIONS

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

IT - Incore Thimble
* - Unavailable Location

Figure 1.4

SURRY UNIT 1 - CYCLE 15
BURNABLE POISON AND FLUX SUPPRESSION INSERT LOCATIONS

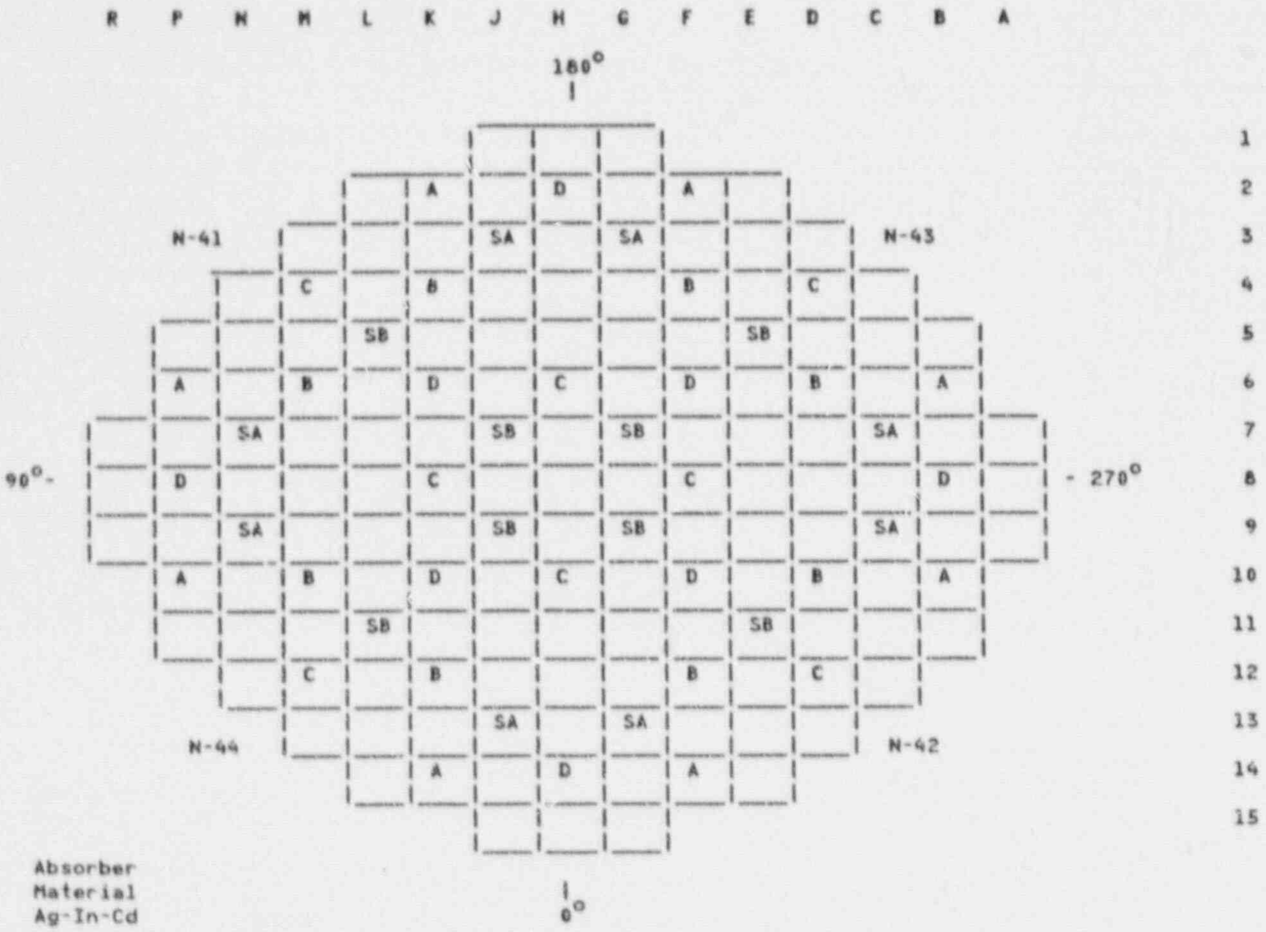
R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
							FSIS FS004								1
						3P BP528		3P BP530							2
			FSIL FS013	3P BP527	20P BP558		20P BP510		20P BP557	P BP529	FSIL FS012				3
		FSIL FS011		20P BP556		20P BP526		20P BP525		20P BP555		FSIL FS010			4
		3P BP542	20P BP554		20P BP524				20P BP523		20P BP553	3P BP532			5
		20P BP552		20P BP522		20P BP509		20P BP508		20P BP521		20P BP551			6
	3P BP541		20P BP520		20P BP507				20P BP506		20P BP519		3P BP531		7
FSIS FS003		20P BP505										20P BP504		FSIS FS002	8
	3P BP540		20P BP518		20P BP503				20P BP502		20P BP517		3P BP534		9
		20P BP550		20P BP5/5		20P BP501		20P BP500		20P BP515		20P BP549			10
		3P BP539	20P BP548		20P BP514				20P BP513		20P BP547	3P BP533			11
		FSIL FS009		20P BP546		20P BP512		20P BP511		20P BP545		FSIL FS008			12
			FSIL FS007	3P BP538	20P BP544		20P BP499		20P BP543	3P BP536	FSIL FS014				13
						3P BP537		3P BP535							14
							FSIS FS005								15

3P - 3 BURNABLE POISON ROD CLUSTER
20P - 20 BURNABLE POISON ROD CLUSTER
FSIL - FLUX SUPPRESSION INSERT (LONG)
FSIS - FLUX SUPPRESSION INSERT (SHORT)

xxP	- # OF BP RODS
BP###, FS###	- BP ASSEMBLY ID, FLUX SUPPRESSION INSERT ID

Figure 1.5

SURRY UNIT 1 - CYCLE 15
CONTROL ROD LOCATIONS



Absorber
Material
Ag-In-Cd

Function	Number of Clusters
Control Bank D	8
Control Bank C	8
Control Bank B	8
Control Bank A	8
Shutdown Bank SB	8
Shutdown Bank SA	8

SECTION 2

CONTROL ROD DROP TIME MEASUREMENTS

The drop time of each control rod was measured at hot full-flow reactor coolant system (RCS) conditions (Tavg of 547±5°F) 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 3.12.C.1. This test was performed at approximately 2217 psig.

The rod drop times were measured by withdrawing a bank to its fully withdrawn position and tripping all eight control rods within the bank by opening the reactor trip breakers. This allowed the rods to drop into the core as they would during a plant trip. The stationary gripper coil voltage and the Individual Rod Position Indication (IRPI) primary coil voltage signals were recorded for each rod in the bank to determine each rod's drop time. This procedure was repeated for each bank.

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 3.12.C.1 specifies a maximum rod drop time from loss of stationary gripper coil voltage to dashpot entry of 2.4 seconds with the RCS at hot, full flow conditions. The test results satisfy this limit.

Table 2.1

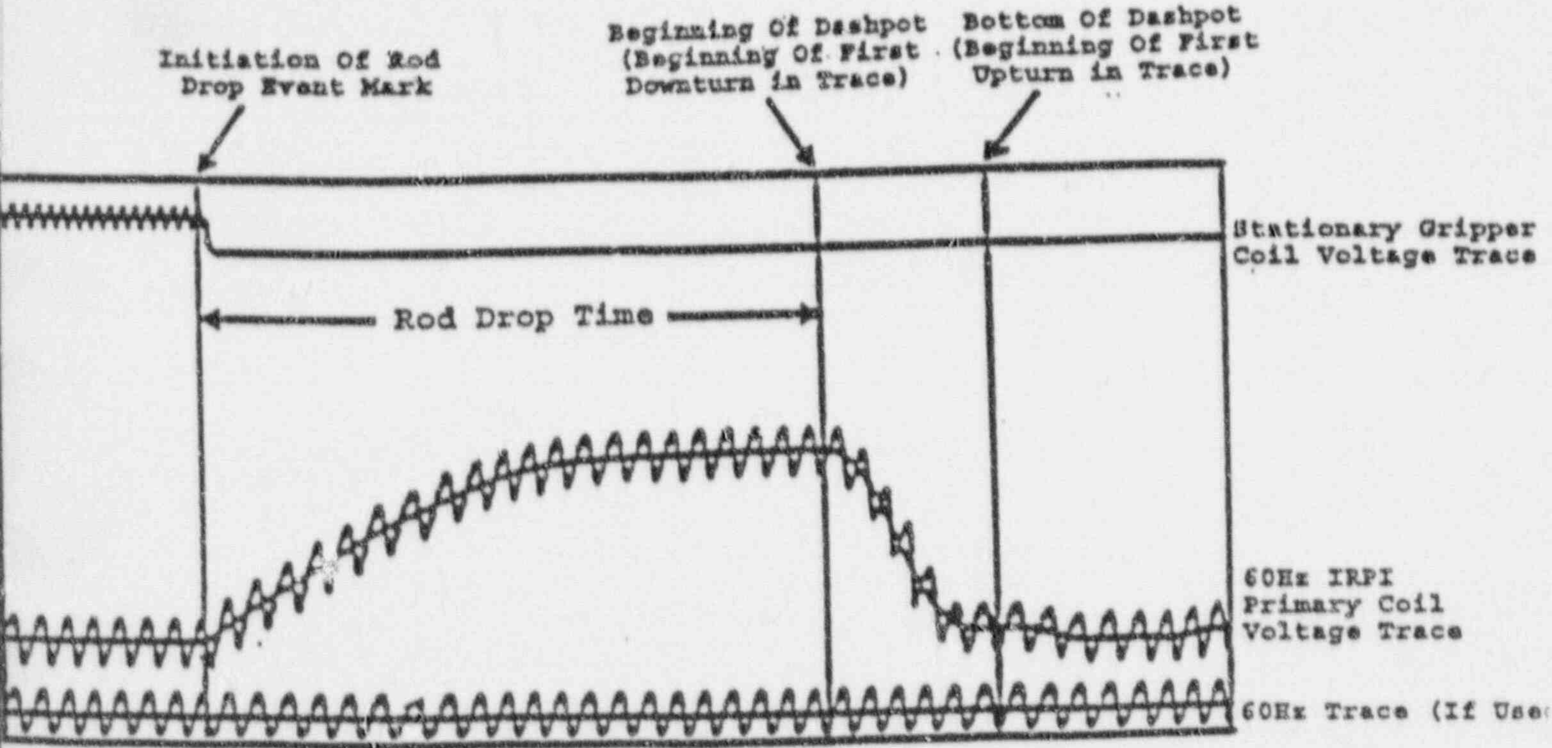
SURRY UNIT 1 - CYCLE 15 STARTUP PHYSICS TESTS
HOT ROD DROP TIME SUMMARY

ROD DROP TIME TO DASHPOT ENTRY

SLOWEST ROD	FASTEST RODS	AVERAGE TIME
F-08 1.37 sec.	H-02/P-10 1.25 sec.	1.29 sec.

Figure 2.1

SURRY UNIT 1 - CYCLE 15 STARTUP PHYSICS TESTS
TYPICAL ROD DROP TRACE



ROD DROP TIME MEASUREMENT

Figure 2.2

SURRY UNIT 1 - CYCLE 15 STARTUP PHYSICS TESTS
ROD DROP TIME - HOT FULL FLOW CONDITIONS

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
															1
					1.28		1.25		1.27						2
						1.30		1.29							3
			1.28		1.27				1.28		1.32				4
				1.28						1.28					5
	1.26		1.28		1.29		1.30		1.30		1.28		1.33		6
		1.29				1.32		1.30				1.28			7
	1.28				1.29				1.37				1.31		8
		1.30				1.30		1.33				1.28			9
	1.25		1.26		1.29		1.29		1.31		1.30		1.29		10
				1.27						1.29					11
			1.27		1.29				1.29		1.31				12
						1.30		1.31							13
					1.30		1.27		1.34						14
															15

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

SECTION 3

CONTROL ROD BANK WORTH MEASUREMENTS

Control rod bank worths were measured for the control and shutdown banks using the rod swap technique[2,3]. 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 15, 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 near full insertion. Initial statepoint data for the rod swap maneuver were obtained by moving the reference bank to its fully inserted position with all other banks fully withdrawn and recording the core reactivity and moderator temperature. From this point, a rod swap maneuver was performed by withdrawing the reference bank several steps and then one of the other control rod banks (i.e. a test bank) was inserted to balance the reactivity of the reference bank withdrawal. This sequence was repeated until the test bank was fully inserted and the reference bank was positioned such that the core was just critical or near the initial statepoint reactivity. 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, all of 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 worth greater than 600 pcm, and ±100 pcm for test banks worth less than or equal to 600 pcm). The sum of the individual measured rod bank worths was within 4.8% 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

SURRY UNIT 1 - CYCLE 15 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	1392.5	1404.0	-0.8
D	1002.4	1080.0	-7.2
C	595.5	684.9	-13.1
A	372.7	378.8	-1.6*
SB	862.2	957.7	-10.0
SA	1169.8	1163.9	0.5
Total Worth	5395.1	5669.3	-4.8

* Difference is less than 100 pcm.

Figure 3.1

SURRY UNIT 1 - CYCLE 15 STARTUP PHYSICS TESTS
BANK B INTEGRAL ROD WORTH - HZP
ALL OTHER RODS WITHDRAWN

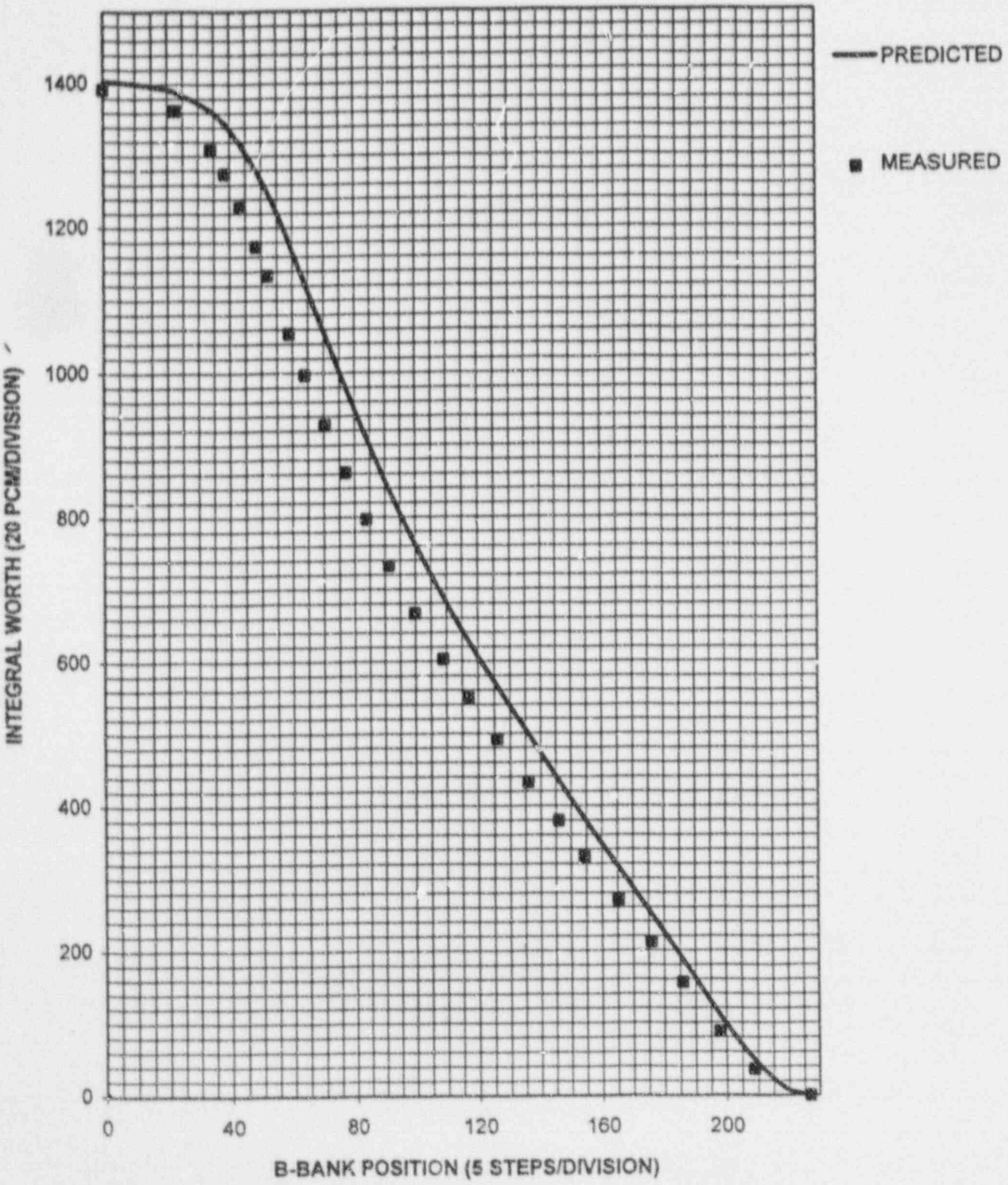
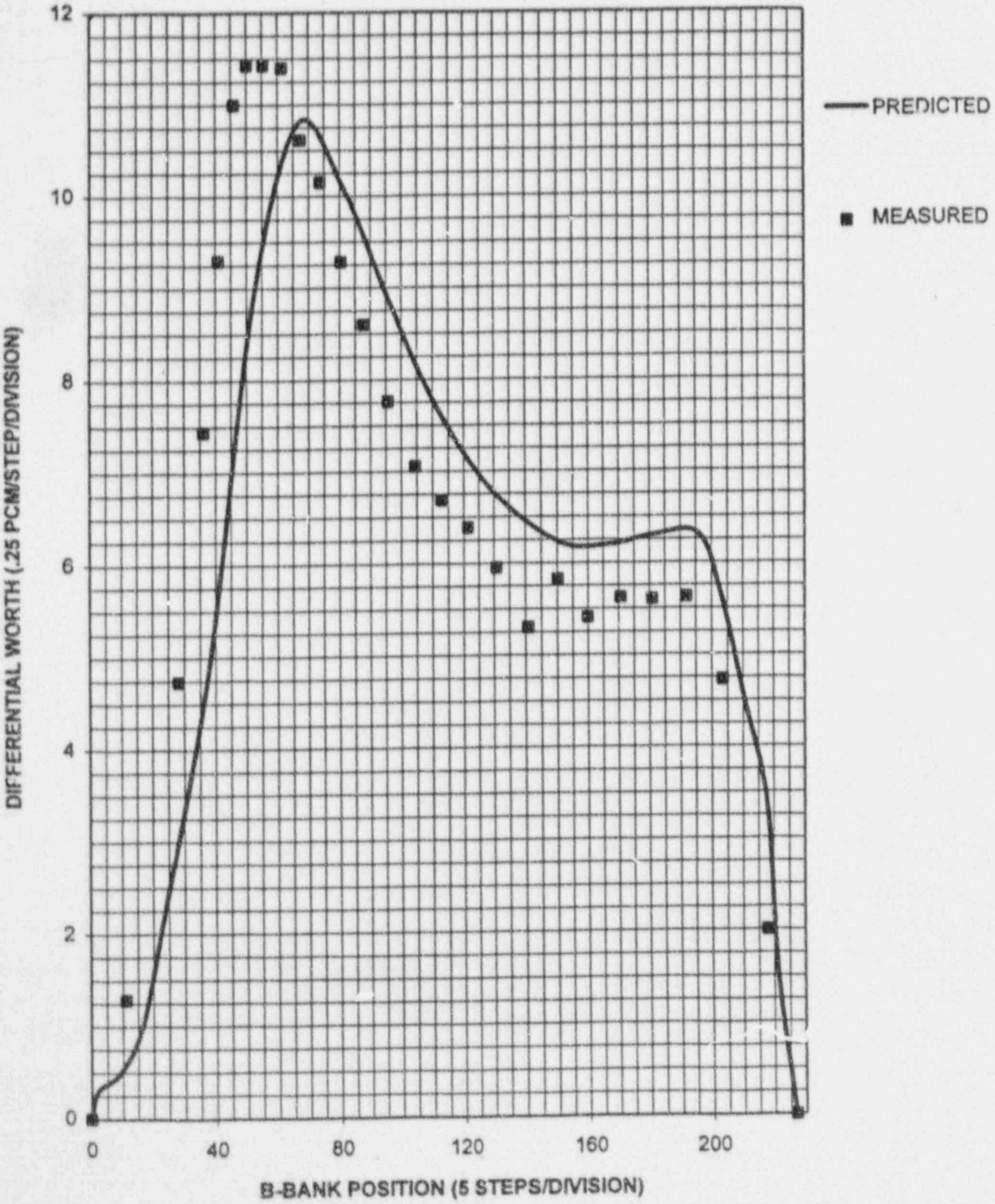


Figure 3.2

SURRY UNIT 1 - CYCLE 15 STARTUP PHYSICS TESTS
BANK B DIFFERENTIAL ROD WORTH - HZP
ALL OTHER RODS WITHDRAWN



SECTION 4

BORON ENDPOINT AND WORTH MEASUREMENTS

Boron Endpoint

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

The results of these measurements are given in Table 4.1. As shown in this table and in the Startup Physics Test Results and Evaluation Sheets given in the Appendix, the measured critical boron endpoint values were within their respective design tolerances. The all-rods-out (ARO) endpoint comparison to the predicted value met the requirements of Technical Specification 4.10.A regarding core reactivity balance. In summary, the boron endpoint results were satisfactory.

Boron Worth Coefficient

The measured boron endpoint values provide stable statepoint data from which the boron worth coefficient or differential boron worth (DBW) was determined. By relating each endpoint concentration to the integrated rod worth present in the core at the time of the endpoint measurement, the value of the DBW over the range of boron endpoint concentrations was obtained.

A plot of the boron concentration versus inserted control rod worth is shown in Figure 4.1. As indicated in this figure and in the Appendix, the measured DBW was -7.22 pcm/ppm. This is within 0.3% of the predicted value of -7.20 pcm/ppm and is well within the design tolerance of ±10%. In summary, the measured boron worth coefficient was satisfactory.

Table 4.1

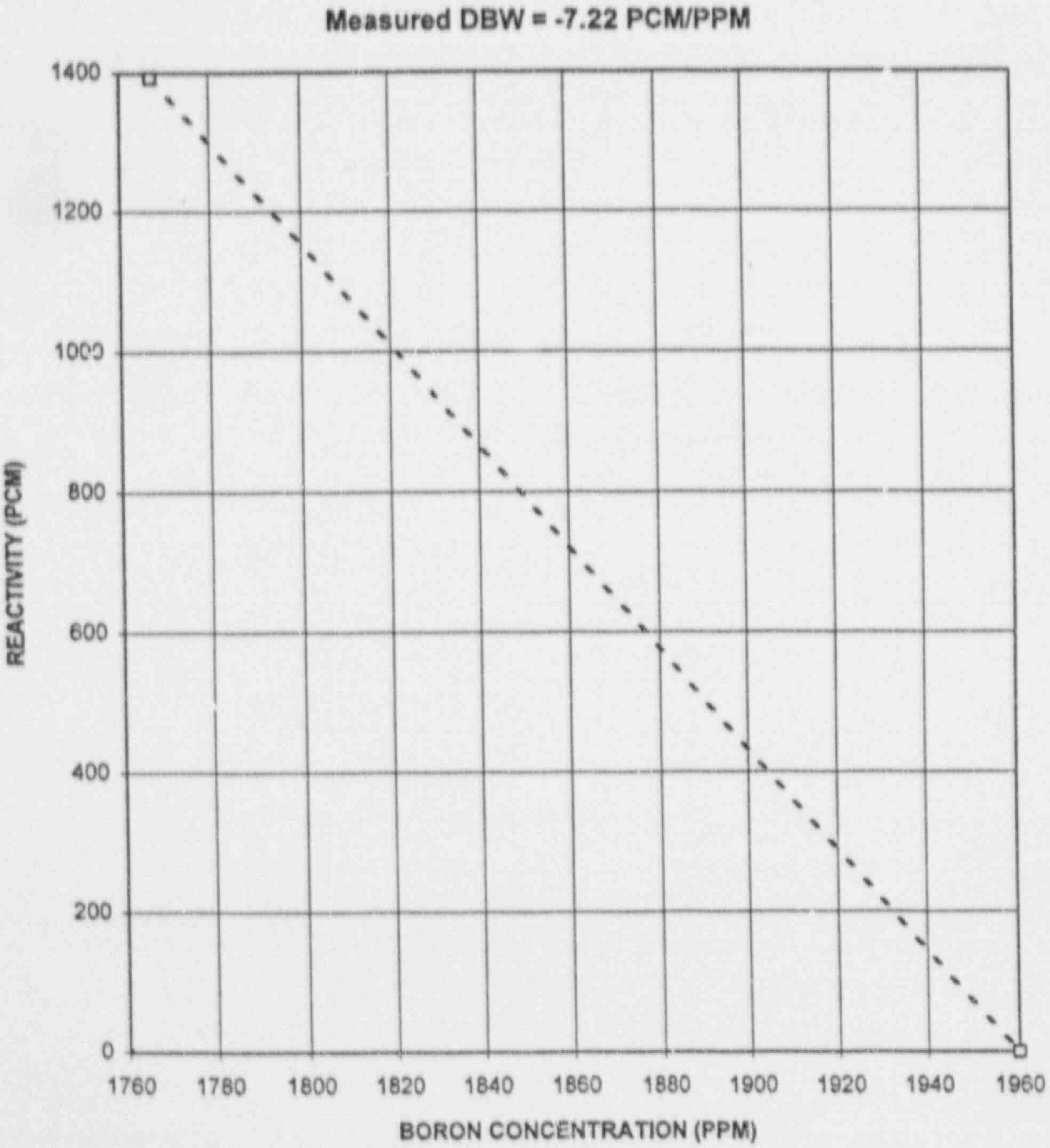
SURRY UNIT 1 - CYCLE 15 STARTUP PHYSICS TESTS
BORON ENDPOINTS SUMMARY

Control Rod Configuration	Measured Endpoint (ppm)	Predicted Endpoint (ppm)	Difference M-P (ppm)
ARO	1960	1974	-14
B Bank In	1767	1765*	2

* The predicted endpoint for the B Bank In configuration was adjusted for the difference between the measured and predicted values of the endpoint taken at the ARO configuration as shown in the boron endpoint Startup Physics Test Results and Evaluation Sheet in the Appendix.

Figure 4.1

SURRY UNIT 1 - CYCLE 15 STARTUP PHYSICS TESTS
BORON WORTH COEFFICIENT



SECTION 5

TEMPERATURE COEFFICIENT MEASUREMENT

The isothermal temperature coefficient (ITC) at the all-rods-out condition is measured by controlling the reactor coolant system (RCS) temperature through varying the steam generator blowdown flow, establishing a constant heatup or cooldown rate, and monitoring the resulting reactivity changes on the reactivity computer. This test sequence includes a cooldown followed by a heatup.

Reactivity was measured during an RCS cooldown of 3.2°F and an RCS heatup of 3.4°F. Reactivity and temperature data was 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. Accounting for the Doppler temperature coefficient (-1.69 pcm/°F) and a 0.5 pcm/°F uncertainty, the moderator temperature coefficient was 1.34 pcm/°F, which meets the requirement of Core Operating Limits Report Section 2.1. In summary, the measured result was satisfactory.

Table 5.1

SURRY UNIT 1 - CYCLE 15 STARTUP PHYSICS TESTS
ISOTHERMAL TEMPERATURE COEFFICIENT SUMMARY

CORE CONDITIONS			ISOTHERMAL TEMPERATURE COEFFICIENT (PCM/°F)				
BANK POSITION (STEPS)	TEMPERATURE RANGE (°F)	BORON CONCENTRATION (ppm)	C/D	H/U	AVE. MEAS.	PRED.	DIFFER. (M-P)
D/208	544.2 to 547.6	1955	-1.25	-0.44	-0.85	-1.38	0.53

SECTION 6

POWER DISTRIBUTION MEASUREMENTS

The core power distributions were measured using the movable incore detector flux mapping system. This system consists of five fission chamber detectors which traverse fuel assembly instrumentation thimbles depicted in Figure 1.3. For each traverse, the detector voltage output is continuously monitored on a strip chart recorder, and scanned for 61 discrete axial points by the PRODAC P-250 process computer. Full core, three-dimensional power distributions are determined from this data using the CECOR code[4]. CECOR couples the measured voltages with predetermined analytic signal-to-power conversions, pin-to-box factors, and average coupling coefficients 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 Technical Specification limits is given in Table 6.2. Flux map 2 was taken at approximately 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 4 and 5 were taken near 68% 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. These figures show that the average relative assembly power distribution measured/predicted percent difference was 2.4% or less for the three maps. The measured F-Q(Z) and F-DH(N) peaking factor values for all flux maps were within the limits of the Core Operating Limits Report (Reference 6, Appendix A) Sections 2.3 and 2.4, respectively. Flux maps 2 and 4 were used to recalibrate the power range excore detectors.

A larger than typical localized percent power difference in an interior core location was observed in flux map 2. Although the measured to predicted percent difference was within the design tolerance, the power depression warranted further investigation due to its magnitude. In addition, flux map 2 exhibited a core tilt which exceeded the value assumed in the safety evaluation. After examining all plausible explanations, it was determined that none of the modelled scenarios appropriately corresponded to the measured results seen in flux map 2 (Reference 11). An additional analysis was performed which verified that the results and conclusions of the safety evaluation were still bounding for the core tilt measured in flux map 2 (Reference 10). Also, an extra flux map (map 3) was analyzed during the power ascension to verify that both the power depression and the core tilt were decreasing. By full power the core tilt had decreased such that it fell within the typical variations seen in a full power map. The power depression stayed relatively constant at -5.5% between 68% and 100% power which is atypical for an interior core location,however all peaking factors were well within the bounds of the safety evaluation and the Technical Specifications.

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 limits. It is therefore anticipated that the core will continue to operate as designed throughout Cycle 15.

TABLE 6.1

SURRY UNIT 1 - CYCLE 15 STARTUP PHYSICS TESTS
INCORE FLUX MAP SUMMARY

MAP DESCRIPTION [3]	MAP NO.	DATE	BURNUP MWD/MTU	PWR (%)	BANK D STEPS	F-Q(Z) HOT CHANNEL FACTOR [1]			F-DH(N) HOT CHNL.FACTOR		CORE F(Z) MAX		POWER TILT [2]		AXIAL OFF SET (%)	NO. OF THIMBLES
						ASSY	AXIAL POINT	F-Q(Z)	ASSY	F-DH(N)	AXIAL POINT	F(Z)	MAX	LOC		
LESS THN 50% PWR	2	5-02-97	4	29	173	H06	30	2.060	H06	1.508	30	1.271	1.026	NW	-0.80	41
BTWN 65% AND 75%	4	5-08-97	88	68	192	H05	36	1.866	H08	1.454	30	1.191	1.015	NW	-0.68	45
GRT THAN 95% PWR	5	5-16-97	238	100	225	H08	41	1.765	H08	1.433	30	1.140	1.014	NW	-1.65	44

NOTES: HOT SPOT LOCATIONS ARE SPECIFIED BY GIVING ASSEMBLY LOCATIONS (E.G. H08 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 1.08.

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

3. EACH MAP WAS USED TO PERFORM A PEAKING FACTOR VERIFICATION. FLUX MAPS 2 AND 4 WERE USED TO PERFORM A POWER RANGE EXCORE DETECTOR CALIBRATION.

4. FLUX MAP 1 WAS TAKEN AT APPROXIMATELY 30% POWER, BUT DUE TO CORE INSTABILITY, THE ANALYSIS OF THE DATA WAS NOT PERFORMED. FLUX MAP 3 WAS TAKEN AT APPROXIMATELY 50% POWER AND USED TO VERIFY THAT THE POWER TILT MEASURED WITH FLUX MAP 2 WAS DECREASING WITH POWER ASCENSION.

Table 6.2

SURRY UNIT 1 - CYCLE 15 STARTUP PHYSICS TESTS COMPARISON OF MEASURED POWER DISTRIBUTION PARAMETERS WITH THEIR CORE OPERATING LIMITS

	PEAK F-Q(Z) HOT CHANNEL FACTOR*			F-Q(Z) HOT CHANNEL FACTOR** (AT NODE OF MINIMUM MARGIN)				F-DH(N) HOT CHANNEL FACTOR		
MAP NO.	MEAS.	LIMIT	NODE	MEAS.	LIMIT	NODE	MARGIN (%)	MEAS.	LIMIT	MARGIN (%)
2	2.060	4.628	30	2.057	4.582	26	55.1	1.508	1.895	20.4
4	1.866	3.381	30	1.853	3.305	21	43.9	1.454	1.708	14.9
5	1.765	2.321	41	1.726	2.269	22	23.9	1.433	1.560	8.1

* The Technical Specification's limit for the heat flux hot channel factor, F-Q(Z), is a function of core height and power level. The values for F-Q(Z) listed are the maximum value of F-Q(Z) in the core. The Technical Specification's 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 are the minimum percent difference between the measured values of F-Q(Z) and the Technical Specification's limit at that node for each map.

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

Figure 6.1

SURRY UNIT 1 - CYCLE 15 STARTUP PHYSICS TESTS
ASSEMBLYWISE POWER DISTRIBUTION
29% POWER

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
	PREDICTED MEASURED PCT DIFFERENCE					0.267 0.268 0.4	0.269 0.265 -1.5	0.266 0.266 -0.3			PREDICTED MEASURED PCT DIFFERENCE				1
				0.308 0.320 3.7	0.696 0.712 2.6	1.116 1.129 1.1	0.916 0.895 -2.3	1.115 1.119 0.3	0.693 0.703 1.5	0.306 0.313 2.2					2
			0.255 0.281 10.4	1.038 1.080 4.0	1.298 1.338 3.1	1.315 1.344 2.2	1.331 1.329 -0.2	1.313 1.326 1.0	1.295 1.317 1.7	1.032 1.057 2.5	0.247 0.271 9.6				3
		0.254 0.273 7.7	0.631 0.667 5.8	1.238 1.278 3.3	1.312 1.353 3.2	1.320 1.350 2.3	1.257 1.277 1.6	1.318 1.338 1.5	1.310 1.331 1.6	1.232 1.248 1.3	0.627 0.630 0.5	0.252 0.251 -0.4			4
	0.307 0.329 7.0	1.034 1.117 8.0	1.233 1.311 6.3	1.207 1.290 6.9	1.267 1.303 2.9	1.284 1.310 2.0	1.199 1.222 1.9	1.283 1.299 1.3	1.264 1.279 1.1	1.205 1.204 -0.1	1.231 1.201 -2.4	1.033 1.023 -0.9	0.307 0.312 1.6		5
	0.693 0.727 4.9	1.296 1.363 5.2	1.311 1.368 4.4	1.267 1.297 2.3	1.167 1.150 -1.5	1.220 1.227 0.6	1.121 1.146 2.2	1.220 1.223 0.2	1.166 1.175 0.7	1.265 1.260 -0.4	1.309 1.295 -1.1	1.294 1.286 -0.6	0.692 0.695 0.5		6
0.266 0.277 3.8	1.115 1.151 3.2	1.314 1.361 3.6	1.319 1.356 2.8	1.285 1.298 1.0	1.221 1.215 -0.4	1.066 1.050 -1.6	1.011 0.997 -1.4	1.067 1.018 -4.6	1.221 1.190 -2.5	1.283 1.259 -1.9	1.318 1.296 -1.7	1.313 1.300 -1.0	1.113 1.124 1.0	0.265 0.265 -0.1	7
0.268 0.289 7.6	0.916 0.916 0.0	1.332 1.368 2.7	1.257 1.279 1.7	1.201 1.188 -1.1	1.121 1.112 -0.9	1.010 0.993 -1.7	0.957 0.933 -2.5	1.012 0.967 -4.4	1.122 1.059 -5.7	1.200 1.159 -3.4	1.256 1.228 -2.2	1.331 1.297 -2.6	0.914 0.873 -4.5	0.268 0.259 -3.2	8
0.266 0.272 2.5	1.114 1.131 1.5	1.314 1.335 1.6	1.319 1.338 1.4	1.285 1.301 1.3	1.221 1.203 -1.5	1.067 1.040 -2.6	1.011 0.978 -3.3	1.064 1.007 -5.4	1.222 1.110 -9.2	1.285 1.227 -4.5	1.319 1.291 -2.2	1.314 1.298 -1.2	1.115 1.108 -0.6	0.266 0.263 -1.1	9
	0.692 0.701 1.3	1.295 1.301 0.5	1.311 1.319 0.6	1.267 1.257 -0.8	1.167 1.111 -4.8	1.221 1.171 -4.0	1.121 1.085 -3.3	1.221 1.171 -4.1	1.167 1.085 -7.0	1.267 1.219 -3.8	1.311 1.294 -1.2	1.295 1.300 0.4	0.693 0.723 4.3		10
	0.307 0.312 1.7	1.034 1.051 1.7	1.233 1.239 0.5	1.207 1.190 -1.4	1.267 1.241 -2.0	1.284 1.255 -2.2	1.200 1.170 -2.5	1.284 1.260 -1.9	1.267 1.261 -0.4	1.207 1.165 -3.5	1.233 1.232 -0.1	1.034 1.047 1.3	0.307 0.315 2.7		11
		0.254 0.280 10.5	0.631 0.639 1.3	1.239 1.236 -0.2	1.313 1.305 -0.6	1.321 1.309 -0.9	1.259 1.248 -0.8	1.321 1.308 -0.9	1.313 1.305 -0.6	1.239 1.234 -0.4	0.631 0.665 5.5	0.254 0.276 8.6			12
			0.255 0.258 1.0	1.039 1.042 0.3	1.299 1.297 -0.1	1.317 1.312 -0.3	1.332 1.333 0.0	1.317 1.305 -0.9	1.299 1.279 -1.6	1.038 1.033 -0.5	0.255 0.259 1.7				13
				0.308 0.312 1.1	0.695 0.694 0.0	1.118 1.108 -0.9	0.918 0.886 -3.5	1.118 1.102 -1.5	0.695 0.686 -1.2	0.308 0.306 -0.6					14
	STANDARD DEVIATION =2.201					0.267 0.267 -0.1	0.269 0.262 -2.6	0.267 0.262 -1.9			AVERAGE PCT DIFFERENCE = 2.4				15

SUMMARY

MAP NO: S1-15-02 DATE: 5/02/97 POWER: 28.5%

CONTROL ROD POSITIONS: F-Q(Z) = 2.060 QPTR:

D BANK AT 173 STEPS F-DH(N) = 1.508

F(Z) = 1.271

NW 1.0258	NE 0.9960
SW 0.9965	SE 0.9817

BURNUP = 4.0 MWD/MTU A.O. = -0.804%

Figure 6.2

SURRY UNIT 1 - CYCLE 15 STARTUP PHYSICS TESTS
ASSEMBLYWISE POWER DISTRIBUTION
68% POWER

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
	PREDICTED MEASURED PCT DIFFERENCE					0.281 0.281 -0.2	0.287 0.283 -1.3	0.281 0.283 0.5			PREDICTED MEASURED PCT DIFFERENCE				1
				0.318 0.323 1.6	0.702 0.710 1.1	1.121 1.125 0.3	0.941 0.923 -1.9	1.120 1.133 1.2	0.701 0.739 5.6	0.317 0.329 4.1					2
			0.263 0.288 9.3	1.032 1.049 1.6	1.272 1.268 1.3	1.297 1.311 1.1	1.311 1.279 -2.4	1.295 1.303 0.7	1.267 1.299 2.5	1.025 1.055 2.9	0.256 0.276 8.1				3
		0.262 0.274 4.6	0.639 0.658 2.9	1.216 1.217 0.1	1.289 1.306 1.3	1.297 1.315 1.4	1.246 1.254 0.6	1.295 1.311 1.3	1.287 1.314 2.1	1.212 1.232 1.7	0.635 0.639 0.5	0.261 0.259 -0.7			4
	0.318 0.332 4.4	1.028 1.085 5.5	1.212 1.255 3.6	1.196 1.234 3.2	1.255 1.278 1.8	1.283 1.317 2.6	1.205 1.226 1.7	1.281 1.304 1.7	1.254 1.282 2.2	1.193 1.202 0.8	1.210 1.184 -2.2	1.026 1.014 -1.2	0.317 0.313 -1.1		5
	0.702 0.719 2.6	1.270 1.306 2.8	1.289 1.322 2.5	1.256 1.279 1.8	1.192 1.189 -0.2	1.232 1.245 1.0	1.142 1.158 1.4	1.232 1.249 1.4	1.192 1.239 4.0	1.254 1.268 1.1	1.287 1.280 -0.5	1.267 1.259 -0.6	0.700 0.700 0.0		6
0.281 0.287 2.0	1.120 1.135 1.4	1.295 1.308 1.0	1.297 1.318 1.6	1.284 1.302 1.4	1.235 1.241 0.5	1.097 1.094 -0.3	1.048 1.043 -0.5	1.098 1.072 -2.4	1.235 1.239 0.3	1.283 1.282 -0.1	1.295 1.282 -1.0	1.295 1.285 -0.8	1.118 1.125 0.7	0.280 0.280 -0.1	7
0.286 0.302 5.5	0.941 0.941 0.0	1.313 1.334 1.7	1.246 1.264 1.4	1.207 1.227 1.6	1.143 1.148 0.4	1.047 1.043 -0.4	1.000 0.988 -1.2	1.048 1.025 -2.2	1.144 1.130 -1.2	1.206 1.194 -1.0	1.245 1.232 -1.1	1.311 1.283 -2.1	0.941 0.921 -2.1	0.286 0.281 -1.8	8
0.281 0.284 1.2	1.119 1.123 0.4	1.295 1.300 0.4	1.297 1.300 0.3	1.284 1.281 -0.2	1.235 1.225 -0.8	1.098 1.085 -1.2	1.048 1.026 -2.1	1.095 1.045 -4.6	1.235 1.168 -5.4	1.284 1.257 -2.1	1.297 1.290 -0.5	1.295 1.291 -0.4	1.120 1.118 -0.1	0.281 0.277 -1.3	9
	0.701 0.699 -0.3	1.269 1.253 -1.2	1.289 1.283 -0.5	1.256 1.264 -1.0	1.192 1.157 -2.9	1.235 1.213 -1.7	1.142 1.122 -1.7	1.235 1.202 -2.7	1.192 1.143 -4.1	1.256 1.235 -1.7	1.289 1.304 1.2	1.269 1.283 1.1	0.701 0.717 2.3		10
	0.317 0.317 -0.1	1.028 1.027 -0.1	1.212 1.207 -0.4	1.196 1.185 -1.0	1.255 1.233 -1.8	1.283 1.258 -2.0	1.206 1.195 -0.8	1.283 1.268 -1.2	1.255 1.250 -0.5	1.196 1.167 -2.5	1.212 1.219 0.6	1.028 1.046 1.7	0.318 0.324 2.1		11
		0.262 0.276 5.3	0.639 0.639 -0.1	1.217 1.204 -1.1	1.290 1.265 -1.9	1.298 1.253 -3.5	1.247 1.225 -1.7	1.298 1.284 -1.1	1.290 1.282 -0.6	1.217 1.211 -0.5	0.639 0.658 2.9	0.262 0.285 8.5			12
			0.263 0.262 -0.5	1.033 1.023 -0.9	1.273 1.252 -1.6	1.298 1.269 -2.2	1.313 1.288 -1.8	1.298 1.281 -1.3	1.273 1.264 -0.7	1.032 1.028 -0.4	0.263 0.265 0.7				13
				0.318 0.322 1.2	0.703 0.693 -1.4	1.121 1.098 -2.1	0.941 0.909 -3.4	1.121 1.102 -1.7	0.703 0.696 -1.0	0.318 0.317 -0.5					14
	STANDARD DEVIATION =1.554					0.282 0.279 -1.1	0.287 0.279 -2.9	0.282 0.276 -2.1			AVERAGE PCT DIFFERENCE = 1.7				15

SUMMARY

MAP NO: S1-15-04   DATE: 5/08/97   POWER: 68.45%

CONTROL ROD POSITIONS: F-Q(Z) = 1.866   QPTR:

D BANK AT 192 STEPS   F-DH(N) = 1.454

NW 1.0152	NE 1.0036
SW 0.9913	SE 0.9899

F(Z) = 1.191

BURNUP = 88 MWD/MTU   A.O. = -0.676%

Figure 6.3

SURRY UNIT 1 - CYCLE 15 STARTUP PHYSICS TESTS
ASSEMBLYWISE POWER DISTRIBUTION
100% POWER

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
	PREDICTED					0.287	0.296	0.287				PREDICTED			1
	MEASURED					0.290	0.297	0.290				MEASURED			
	PCT DIFFERENCE					1.1	0.4	1.0				PCT DIFFERENCE			
				0.320	0.700	1.113	0.962	1.111	0.699	0.319					2
				0.322	0.708	1.127	0.963	1.125	0.733	0.328					
				0.7	1.1	1.3	0.1	1.3	4.9	3.0					
			0.265	1.013	1.248	1.279	1.298	1.277	1.243	1.009	0.258				3
			0.289	1.018	1.261	1.308	1.272	1.280	1.260	1.028	0.281				
			9.0	0.5	1.1	2.2	-2.0	0.2	1.4	1.9	8.9				
		0.264	0.640	1.199	1.274	1.285	1.240	1.283	1.272	1.194	0.637	0.263			4
		0.273	0.649	1.172	1.279	1.299	1.241	1.286	1.277	1.198	0.635	0.259			
		3.5	1.5	-2.2	0.4	1.1	0.1	0.2	0.4	0.3	-0.2	-1.4			
	0.320	1.011	1.197	1.192	1.259	1.285	1.212	1.285	1.257	1.190	1.194	1.010	0.319		5
	0.333	1.063	1.233	1.231	1.278	1.307	1.224	1.287	1.254	1.180	1.165	0.998	0.326		
	4.1	5.2	3.0	3.3	1.6	1.8	0.9	0.2	-0.2	-0.9	-2.4	-1.2	2.0		
	0.699	1.247	1.273	1.258	1.232	1.253	1.165	1.253	1.232	1.258	1.273	1.243	0.699		6
	0.718	1.280	1.298	1.269	1.245	1.267	1.186	1.251	1.224	1.242	1.250	1.230	0.702		
	2.6	2.6	1.9	0.9	1.0	1.1	1.7	-0.1	-0.7	-1.3	-1.8	-1.1	0.4		
0.287	1.111	1.279	1.285	1.286	1.254	1.127	1.082	1.130	1.255	1.286	1.285	1.279	1.110	0.287	7
0.297	1.135	1.297	1.300	1.295	1.259	1.128	1.080	1.111	1.240	1.266	1.254	1.264	1.128	0.291	
3.3	2.1	1.4	1.2	0.7	0.4	0.1	-0.2	-1.7	-1.1	-1.6	-2.4	-1.2	1.6	1.3	
0.296	0.961	1.298	1.241	1.213	1.165	1.080	1.036	1.083	1.166	1.215	1.241	1.298	0.961	0.296	8
0.319	0.982	1.323	1.253	1.215	1.165	1.076	1.028	1.068	1.159	1.196	1.218	1.266	0.966	0.297	
7.9	2.2	1.9	0.9	0.2	0.0	-0.4	-0.8	-1.4	-0.6	-1.6	-1.9	-2.5	0.5	0.6	
0.287	1.110	1.279	1.285	1.286	1.255	1.129	1.082	1.126	1.255	1.287	1.285	1.279	1.111	0.287	9
0.294	1.120	1.283	1.287	1.289	1.250	1.120	1.068	1.097	1.186	1.257	1.271	1.273	1.121	0.290	
2.3	0.9	0.3	0.2	0.2	-0.3	-0.8	-1.3	-2.6	-5.5	-2.4	-1.1	-0.4	0.9	1.1	
	0.699	1.247	1.273	1.258	1.232	1.253	1.165	1.255	1.233	1.260	1.273	1.248	0.700		10
	0.695	1.224	1.265	1.253	1.223	1.238	1.152	1.232	1.203	1.243	1.278	1.261	0.725		
	-0.5	-1.9	-0.6	-0.4	-0.7	-1.2	-1.2	-1.8	-2.5	-1.3	0.4	1.1	3.7		
	0.320	1.011	1.197	1.192	1.260	1.285	1.214	1.286	1.260	1.193	1.197	1.011	0.320		11
	0.318	1.009	1.193	1.186	1.247	1.267	1.210	1.271	1.244	1.183	1.210	1.033	0.328		
	-0.4	-0.1	-0.3	-0.4	-1.1	-1.4	-0.3	-1.1	-1.3	-0.9	1.1	2.1	2.7		
		0.264	0.640	1.199	1.274	1.285	1.241	1.285	1.274	1.200	0.640	0.264			12
		0.285	0.642	1.190	1.254	1.245	1.219	1.269	1.260	1.199	0.668	0.291			
		8.0	0.2	-0.7	-1.6	-3.1	-1.8	-1.2	-1.1	-0.1	4.3	10.4			
			0.265	1.013	1.248	1.279	1.298	1.279	1.248	1.013	0.265				13
			0.264	1.008	1.231	1.254	1.266	1.269	1.226	1.007	0.267				
			-0.5	-0.5	-1.3	-2.0	-2.5	-0.8	-1.7	-0.6	0.8				
				0.320	0.701	1.113	0.962	1.113	0.701	0.320					14
				0.327	0.695	1.102	0.959	1.142	0.702	0.319					
				2.1	-0.7	-0.9	-0.3	2.6	0.2	-0.4					
	STANDARD					0.288	0.296	0.288				AVERAGE			15
	DEVIATION					0.290	0.297	0.293				PCT DIFFERENCE			
	=1.691					0.8	0.3	2.0				= 1.6			

SUMMARY

MAP NO: S1-15-05 DATE: 5/16/97 POWER: 99.96%

CONTROL ROD POSITIONS: F-Q(Z) = 1.765 QPTR:

D BANK AT 225 STEPS F-DH(N) = 1.433

F(Z) = 1.140

NW 1.0136	NE 0.9965
SW 0.9951	SE 0.9948

BURNUP = 238 MWD/MTU A.O. = -1.647%

SECTION 7

REFERENCES

1. P. D. Banning, "Surry Unit 1, Cycle 15 Design Report", Technical Report NE-1119, Revision 0, April, 1997.

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

3. 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.

4. T. W. Schleicher, "Reactor Power Distribution Analysis Using a Moveable In-Core Detector System and the TIP/CECOR Computer Code Package", VEP-NAF-2, November, 1991.

5. Surry Unit 1 and 2 Technical Specifications, Sections 3.1.E.1, 3.12.B.1, 3.12.C.1, 4.10.A, and 5.3.A.6.b.

6. S.S. Kere, "Reload Safety Evaluation Surry 1 Cycle 15 Pattern LT", Technical Report NE-1104, Revision 0, March, 1997.

7. R.A. Hall, et al, "Surry 1, Cycle 15 Flux Map Analysis", PM-705, Revision 0, Addenda A, C, and D, May, 1997.

8. C.B. LaRoe, "Surry 1, Cycle 15 TOTE Calculations", PM-703, Revision 0, April, 1997.

9. C.B. LaRoe, "Surry 1, Cycle 15 Design Report Calculations", PM-697, Revision 0, Addendum B, May, 1997.

10. C.B. LaRoe, "Surry 1, Cycle 15 RSAC Calculations", PM-683, Revision 0, Addenda A and B, March, 1997 and May, 1997.

11. Engineering Transmittal NAF-970129, Rev. 0, "Preliminary Evaluation of Surry 1 Cycle 15 Startup Flux Map Anomalies", from R.A. Hall to J.W. Henderson, dated May 12, 1997.

APPENDIX

STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEETS

SURRY POWER STATION UNIT 1 CYCLE 15
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Zero Power Testing Range Determination Proc No / Section: 1-NPT-RX-008 Sequence Step No:	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 227 SDB: 227 CA: 227 CB: 227 CC: * CD: *	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 227 SDB: 227 CA: 227 CB: 227 CC: 227 CD: 180	RCS Temperature (°F): 544.6 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 4/28/97 1350	
	Reactivity Computer Initial Flux Background Reading	1.285×10^{-9} amps
	Flux Reading At Point Of Nuclear Heating	3.5×10^{-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: ______________

Reviewed By: ______________

SURRY POWER STATION UNIT 1 CYCLE 15
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Reactivity Computer Checkout Proc No / Section: 1-NPT-RX-008	Sequence Step No:
II Test Conditions (Design)	Bank Positions (Steps) SDA: 227 SDB: 227 CA: 227 CB: 227 CC: * CD: *	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 227 SDB: 227 CA: 227 CB: 227 CC: 227 CD: 176	RCS Temperature (°F): 545.7 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 4/28/97 1445	
	Measured Parameter (Description)	ρ_c= Measured Reactivity using ρ-computer ρ_t= Predicted Reactivity
	Measured Value	ρ_c= −45.0, +52.0 ρ_t= −45.9, +52.7 %D: −2.0%, −1.3%
	Design Value	%D= $\{(\rho_c - \rho_t)/\rho_t\} \times 100\% \leq 4.0\ \%$
	Reference	WCAP 7905, Rev. 1, Table 3.6
V Acceptance Criteria	FSAR/Tech Spec	Not Applicable
	Reference	Not Applicable
VI Comments	Design Tolerance is met : ✓ YES ____ NO Acceptance Criteria is met : ✓ YES ____ NO	
	* At The Just Critical Position The allowable range will be set based on the above results, as well as results from the benchmark test. Allowable Range =	

Prepared By: ____________ Reviewed By: ____________

SURRY POWER STATION UNIT 1 CYCLE 15
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Critical Boron Concentration - ARO Proc No / Section: 1-NPT-RX-008 Sequence Step No:	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 227 SDB: 227 CA: 227 CB: 227 CC: 227 CD: 227	RCS Temperature (^oF): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 227 SDB: 227 CA: 227 CB: 227 CC: 227 CD: 227	RCS Temperature (^oF): 545.2 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 4/28/97 17:10	
	Measured Parameter (Description)	$(C_B)^M_{ARO}$: Critical Boron Concentration - ARO
	Measured Value (Design Conditions)	$(C_B)^M_{ARO}$= 1960 ppm
	Design Value (Design Conditions)	$C_B = 1974 \pm 50$ ppm
	Reference	Technical Report NE-1119, Rev. 0
V Acceptance Criteria	FSAR/Tech Spec	$\lvert \alpha C_B \times C_B^D \rvert \le 1000$ pcm
	Reference	Technical Specification 4.10.A
VI Comments	Design Tolerance is met : ✓ YES ___ NO Acceptance Criteria is met : ✓ YES ___ NO	
	αC_B = -7.15 pcm/ppm $C_B^D = \lvert(C_B)^M_{ARO} - C_B\rvert$; C_B is design value	

Prepared By: Pamela D. Barry

Reviewed By: Thomas S.

SURRY POWER STATION UNIT 1 CYCLE 15
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: HZP Boron Worth Coefficient Measurement Proc No / Section: 1-NPT-RX-008	Sequence Step No:
II Test Conditions (Design)	Bank Positions (Steps) SDA: 227 SDB: 227 CA: 227 CB: moving CC: 227 CD: 227	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 227 SDB: 227 CA: 227 CB: moving CC: 227 CD: 227	RCS Temperature (°F): 545.2 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 4/28/97 17:10	
	Measured Parameter (Description)	αC_B : Boron Worth Coefficient
	Measured Value	αC_B = -7.22 pcm/ppm
	Design Value (Design Conditions)	αC_B = -7.20 ± 0.72 pcm/ppm
	Reference	Technical Report NE-1119, Rev. 0
V Acceptance Criteria	FSAR/Tech Spec	Not Applicable
	Reference	Not Applicable
VI Comments	Design Tolerance is met : ✓ YES ____ NO Acceptance Criteria is met : ✓ YES ____ NO	

Prepared By: Pamela D Banning

Reviewed By: Thomas S. [illegible]

SURRY POWER STATION UNIT 1 CYCLE 15
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Isothermal Temperature Coefficient - ARO Proc No / Section: 1-NPT-RX-008	Sequence Step No:
II Test Conditions (Design)	Bank Positions (Steps) SDA: 227 SDB: 227 CA: 227 CB: 227 CC: 227 CD: 227	RCS Temperature (^{O}F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 227 SDB: 227 CA: 227 CB: 227 CC: 227 CD: 208	RCS Temperature (^{O}F): 547.4 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 4/28/97, 18:22	
	Measured Parameter (Description)	$(\alpha_T^{ISO})_{ARO}$: Isothermal Temperature Coefficient - ARO
	Measured Value	$(\alpha_T^{ISO})_{ARO}$ = -0.85 pcm/^{O}F (C_B= 1955 ppm)
	Design Value (Actual Conditions)	$(\alpha_T^{ISO})_{ARO}$ = -1.38 ±3.0 pcm/^{O}F (C_B= 1955 ppm)
	Design Value (Design Conditions)	$(\alpha_T^{ISO})_{ARO}$ = -1.20±3.0 pcm/^{O}F (C_B= 1974 ppm)
	Reference	Technical Report NE-1119, Rev. 0
V Acceptance Criteria	FSAR/COLR	$\alpha_T^{ISO} \leq 3.81^*$ pcm/^{O}F α_T^{DOP} = -1.69 pcm/^{O}F
	Reference	COLR 2.1.1, Technical Report NE-1119, 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: Paula D Banning

Reviewed By: Thomas S. [illegible]

SURRY POWER STATION UNIT 1 CYCLE 15
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Control Bank B Worth Measurement, Rod Swap Ref. Bank Proc No / Section: 1-NPT-RX-008 Sequence Step No:	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 227 SDB: 227 CA: 227 CB: moving CC: 227 CD: 227	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 227 SDB: 227 CA: 227 CB: moving CC: 227 CD: 227	RCS Temperature (°F): 547.7 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 4/28/97, 1927	
	Measured Parameter (Description)	I_B^{REF}: Integral Worth Of Control Bank B, All Other Rods Out
	Measured Value	I_B^{REF} = 1392.5 pcm
	Design Value (Design Conditions)	I_B^{REF} = 1404 ± 140 pcm
	Reference	Technical Report NE-1119, 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: Thomas S. Smith

Reviewed By: Pamela D.

SURRY POWER STATION UNIT 1 CYCLE 15
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

<table>
<tr><td>I
Reference</td><td colspan="3">Test Description: Critical Boron Concentration - B Bank In
Proc No / Section: 1-NPT-RX-008 Sequence Step No:</td></tr>
<tr><td>II
Test
Conditions
(Design)</td><td colspan="2">Bank Positions (Steps)
SDA: 227 SDB: 227 CA: 227
CB: 0 CC: 227 CD: 227</td><td>RCS Temperature (°F): 547
Power Level (% F.P.): 0
Other (specify):
Below Nuclear Heating</td></tr>
<tr><td>III
Test
Conditions
(Actual)</td><td colspan="2">Bank Positions (Steps)
SDA: 227 SDB: 227 CA: 227
CB: 0 CC: 227 CD: 227</td><td>RCS Temperature (°F): 547.8
Power Level (% F.P.): 0
Other (specify):
Below Nuclear Heating</td></tr>
<tr><td rowspan="5">IV
Test
Results</td><td colspan="2">Date/Time Test Performed:
4/28/97 22:50</td><td></td></tr>
<tr><td>Measured Parameter
(Description)</td><td colspan="2">$(C_B)^M_B$: Critical Boron Concentration, B Bank In</td></tr>
<tr><td>Measured Value
(Design Conditions)</td><td colspan="2">$(C_B)^M_B$= 1767 ppm</td></tr>
<tr><td>Design Value
(Design Conditions)</td><td colspan="2">$C_B = 1779 + \Delta C_B^{Prev} \pm (10 + 140.4/|\alpha C_B|)$ ppm
C_B= 1765 ± 30 ppm</td></tr>
<tr><td>Reference</td><td colspan="2">Technical Report NE-1119, Rev. 0</td></tr>
<tr><td rowspan="2">V
Acceptance
Criteria</td><td>FSAR/Tech Spec</td><td colspan="2">Not Applicable</td></tr>
<tr><td>Reference</td><td colspan="2">Not Applicable</td></tr>
<tr><td rowspan="2">VI
Comments</td><td colspan="3">Design Tolerance is met : ✓ YES ____ NO
Acceptance Criteria is met : ✓ YES ____ NO</td></tr>
<tr><td colspan="3">αC_B = -7.20 pcm/ppm
ΔC_B^{Prev} = $(C_B)^M_{ARO}$ - 1974 ppm</td></tr>
</table>

Prepared By: Pamela D. Banning

Reviewed By: Thomas S. [illegible]

Second Test.

SURRY POWER STATION UNIT 1 CYCLE 15
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Reactivity Computer Checkout Proc No / Section: 1-NPT-RX-008	Sequence Step No:
II Test Conditions (Design)	Bank Positions (Steps) SDA: 227 SDB: 227 CA: 227 CB: 227 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: 227 SDB: 227 CA: 227 CB: 227 CC: CD:	RCS Temperature (^{o}F): 545.5 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 5/1/97 1115	
	Measured Parameter (Description)	ρ_c= Measured Reactivity using ρ-computer ρ_t= Predicted Reactivity
	Measured Value	ρ_c= -48.0, +51.0 ρ_t= -49.0, +51.4 %D= -2.0%, -0.8%
	Design Value	%D= $\{(\rho_c - \rho_t)/\rho_t\} \times 100\% \leq 4.0\%$
	Reference	WCAP 7905, Rev. 1, Table 3.6
V Acceptance Criteria	FSAR/Tech Spec	Not Applicable
	Reference	Not Applicable
VI Comments	Design Tolerance is met : ✓ YES ____ NO Acceptance Criteria is met : ✓ YES ____ NO	
	* At The Just Critical Position The allowable range will be set based on the above results, as well as results from the benchmark test. Allowable Range =	

Prepared By: ____________ Reviewed By: Ted Wheeler

SURRY POWER STATION UNIT 1 CYCLE 15
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Shutdown Bank A Worth Measurement, Rod Swap Proc No / Section: 1-NPT-RX-008 Sequence Step No:	
II Test Conditions (Design)	Bank Positions (Steps) SDA: moving SDB: 227 CA: 227 CB: moving CC: 227 CD: 227	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: moving SDB: 227 CA: 227 CB: moving CC: 227 CD: 227	RCS Temperature (°F): 545.7 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 5/1/97 1445	
	Measured Parameter (Description)	I_{SA}^{RS}: Integral Worth of Shutdown Bank A, Rod Swap
	Measured Value	I_{SA}^{RS}= 1169.8 (Adjusted Measured Critical Reference Bank Position = 174 steps)
	Design Value (Actual Conditions)	I_{SA}^{RS}= 1163.9 (Adjusted Measured Critical Reference Bank Position = 174 steps)
	Design Value (Design Conditions)	I_{SA}^{RS}= 1160 ± 174 pcm (Critical Reference Bank Position = 177 steps)
	Reference	Technical Report NE-1119, 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: ____________

SURRY POWER STATION UNIT 1 CYCLE 15
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Shutdown Bank B Worth Measurement, Rod Swap Proc No / Section: 1-NPT-RX-008 Sequence Step No:	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 227 SDB: moving CA: 227 CB: moving CC: 227 CD: 227	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 227 SDB: moving CA: 227 CB: moving CC: 227 CD: 227	RCS Temperature (°F): 545.1 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 5/1/97 1516	
	Measured Parameter (Description)	I_{SB}^{RS}: Integral Worth of Shutdown Bank B, Rod Swap
	Measured Value	I_{SB}^{RS}= 862.2 (Adjusted Measured Critical Reference Bank Position = 120 steps)
	Design Value (Actual Conditions)	I_{SB}^{RS}= 957.7 (Adjusted Measured Critical Reference Bank Position = 120 steps)
	Design Value (Design Conditions)	I_{SB}^{RS}= 962 ± 144 pcm (Critical Reference Bank Position = 145 steps)
	Reference	Technical Report NE-1119, 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: ____________

SURRY POWER STATION UNIT 1 CYCLE 15
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Control Bank A Worth Measurement, Rod Swap Proc No / Section: 1-NPT-RX-008 Sequence Step No:	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 227 SDB: 227 CA: moving CB: moving CC: 227 CD: 227	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 227 SDB: 227 CA: moving CB: moving CC: 227 CD: 227	RCS Temperature (°F): 544.9 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 5/1/97 1554	
	Measured Parameter (Description)	I_A^{RS}: Integral Worth of Control Bank A, Rod Swap
	Measured Value	I_A^{RS}= 372.7 (Adjusted Measured Critical Reference Bank Position = 62 steps)
	Design Value (Actual Conditions)	I_A^{RS}= 378.8 (Adjusted Measured Critical Reference Bank Position = 62 steps)
	Design Value (Design Conditions)	I_A^{RS}= 389 ± 100 pcm (Critical Reference Bank Position = 74 steps)
	Reference	Technical Report NE-1119, 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
	Design Tolerance is met : Acceptance Criteria is met :	✓ YES ____ NO ✓ YES ____ NO
VI Comments		

Prepared By: ____________ Reviewed By: ____________

SURRY POWER STATION UNIT 1 CYCLE 15
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Control Bank C Worth Measurement, Rod Swap Proc No / Section: 1-NPT-RX-008 Sequence Step No:	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 227 SDB: 227 CA: 227 CB: moving CC: moving CD: 227	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 227 SDB: 227 CA: 227 CB: moving CC: moving CD: 227	RCS Temperature (°F): 544.8 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 5/1/97 1644	
	Measured Parameter (Description)	I_C^{RS}; Integral Worth of Control Bank C, Rod Swap
	Measured Value	I_C^{RS}= 595.5 pcm (Adjusted Measured Critical Reference Bank Position = ~~144~~ 84 steps) PDB 5/1/97
	Design Value (Actual Conditions)	I_C^{RS}= 684.9 pcm (Adjusted Measured Critical Reference Bank Position = ~~144~~ 84 steps) PDB 5/1/97
	Design Value (Design Conditions)	I_C^{RS}= 673 ± 101 pcm (Critical Reference Bank Position = 104 steps)
	Reference	Technical Report NE-1119, 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:

SURRY POWER STATION UNIT 1 CYCLE 15
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Control Bank D Worth Measurement, Rod Swap Proc No / Section: 1-NPT-RX-008 Sequence Step No:	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 227 SDB: 227 CA: 227 CB: moving CC: 227 CD: moving	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 227 SDB: 227 CA: 227 CB: moving CC: 227 CD: moving	RCS Temperature (°F): 544.8 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 5/1/97 1738	
	Measured Parameter (Description)	I_D^{RS}; Integral Worth of Control Bank D, Rod Swap
	Measured Value	I_D^{RS}= 1002.4 pcm (Adjusted Measured Critical Reference Bank Position = 144 steps)
	Design Value (Actual Conditions)	I_D^{RS}= 1080.0 pcm (Adjusted Measured Critical Reference Bank Position = 144 steps)
	Design Value (Design Conditions)	I_D^{RS}= 1073 ± 161 pcm (Critical Reference Bank Position = 163 steps)
	Reference	Technical Report NE-1119, Rev. 0, VEP-FRD-36A
V Acceptance Criteria	FSAR/Tech Spec	If Design Tolerance is exceeded, SNSOC shall evaluate impact of test result on safety analysis. SNSOC may specify that additional testing be performed.
	Reference	VEP-FRD-36A
VI Comments	Design Tolerance is met : ✓ YES ____ NO Acceptance Criteria is met : ✓ YES ____ NO	

Prepared By: Thomas S. Cink

Reviewed By: Pamela D Banning

SURRY POWER STATION UNIT 1 CYCLE 15
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Total Rod Worth, Rod Swap Proc No / Section: I-NPT-RX-008	Sequence Step No:
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): 547.7 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 4/28/97 19:27	
	Measured Parameter (Description)	I_{Total}: Integral Worth of All Banks, Rod Swap
	Measured Value	I_{Total}= 5395.1 pcm
	Design Value (Actual Conditions)	I_{Total}= 5669.3 pcm
	Design Value (Design Conditions)	I_{Total}= 5660 ± 566 pcm
	Reference	Technical Report NE-1119, 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: Pamela D Banning

Reviewed By: Thomas S. Paul

SURRY POWER STATION UNIT 1 CYCLE 15
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: M/D Flux Map - At Power Proc No / Section: 1-NPT-RX-008 ,002	Sequence Step No:
II Test Conditions (Design)	Bank Positions (Steps) SDA: 227 SDB: 227 CA: 227 CB: 227 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: 227 SDB: 227 CA: 227 CB: 227 CC: 227 CD: 173	RCS Temperature (°F): T_{REF} Power Level (% F.P.): 28.5% Other (specify): 41 Thimbles
IV Test Results	Date/Time Test Performed: 5/2/97 2302	

	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 $F_O(Z)$	Maximum Positive Incore Quadrant Power Tilt
IV Test Results	Measured Value	-9.2% P≥0.9 +10.5% P<0.9	1.508	2.060	1.0258 (2.58%)
	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	≤ 1.0205
	Reference	WCAP-7905, Rev. 1	None	None	WCAP-7905, Rev. 1
V Acceptance Criteria	FSAR/COLR	None	$F\Delta H(N) \leq 1.56(1+0.3(1-P))$	$F_O(Z) \leq 4.64 * K(Z)$	None
	Reference	None	COLR 2.4	COLR 2.3	None

Design Tolerance is met : ✓ YES ____ NO

Acceptance Criteria is met : ✓ YES ____ NO

VI Comments

* As required

** Must have at least 16 thimbles for quarter core maps for multi-point calibrations

Prepared By: Pamela D. Banning

Reviewed By:

SURRY POWER STATION UNIT 1 CYCLE 15
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: M/D Flux Map - At Power Proc No / Section: 1-NPT-RX-008 ,002 Sequence Step No:				
II Test Conditions (Design)	Bank Positions (Steps) SDA: 227 SDB: 227 CA: 227 CB: 227 CC: 227 CD: *		RCS Temperature (°F): T_{REF} ± 1 Power Level (% F.P.):95 ≤ P ≤ 100 Other (specify): Must have ≥ 38 thimbles**		
III Test Conditions (Actual)	Bank Positions (Steps) 225 SDA: 227 SDB: 227 CA: 227 CB: 227 CC: 227 CD: 225		RCS Temperature (°F): 573 Power Level (% F.P.): 99.96 Other (specify):		
IV Test Results	Date/Time Test Performed: 4 5/16/97 1~~0~~42				
	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	−5.5 (≥.9) 10.4 (<.9)	1.433	1.765	1.0136 mf ~~1.0148~~ 5/22/97
	Design Value (Design Conditions)	±10% for P_i ≥0.9 ±15% for P_i<0.9 (P_i = assy power)	N/A	N/A	≤ 1.0205
	Reference	WCAP-7905, Rev. 1	None	None	WCAP-7905, Rev. 1
V Acceptance Criteria	FSAR/COLR	None	FΔH(N)≤1.56(1+0.3(1-P))	$F_Q(Z)$≤2.32/P*K(Z)	None
	Reference	None	COLR 2.4	COLR 2.3	None
	Design Tolerance is met : ✓ YES ____ NO Acceptance Criteria is met : ✓ YES ____ NO				
VI Comments	* As required ** Must have at least 16 thimbles for quarter core maps for multi-point calibrations				

Prepared By: Mark Paul

Reviewed By: J. W. H