50-280 SURRY UNIT 1

SURRY 1 CYCLE 10 STARTUP TESTS REPORT

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SURRY UNIT 1, CYCLE 10

STARTUP PHYSICS TESTS REPORT

by

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PREFACE

The purpose of this report is to present the analysis and evaluation of the physics tests which were performed to verify that the Surry 1, Cycle 10 core could be operated safely, and to make 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 test 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 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 10 Startup Physics Tests Results and Evaluation Sheets have been included as an appendix to provide additional information on the startup test results. Each data sheet provides the following information: 1) test identification, 2) test conditions (design), 3) test conditions (actual), 4) test results, 5) acceptance criteria, and 6) comments concerning the test. These sheets provide a compact summary of the startup test results in a consistent format. The design test conditions and design values of the measured parameters were completed prior to the startup physics testing. The entries for the design values were based on the calculations performed by Virginia Electric and Power Company's Nuclear Analysis and Fuel Group[1]. During the tests, the data sheets were used as guidelines both to verify that the proper test conditions were met and to facilitate the preliminary comparison between measured and predicted test results, thus enabling a quick identification of possible problems occuring during the tests. The Appendix to this report contains the final completed and approved version of the Startup Physics Tests Results and Evaluation Sheets.

SECTION 1

INTRODUCTION AND SUMMARY

On April 9, 1988 Unit No. 1 of the Surry Power Station was shutdown for its ninth refueling. During this shutdown, 48 of the 157 fuel assemblies in the core were replaced with fresh fuel assemblies. The tenth cycle core consists of 18 sub-batches of fuel: eight once-burned batches, one from Cycle 6 (batch 8B7), three from Cycle 7 (batches 9A5, 9B5, and 9B7), and four from Cycle 9 (batches 11A1, 11A2, 11B2 and 11B3), four twice-burned batches, two from Cycles 7 and 9 (batches 9A4 and 9B4), one from cycles 6 and 7 (batch 8B3) and one from Cycles 8 and 9 (batch 10A3), four thrice-burned batches, three from Cycles 7,8, and 9 (batches 9A3, 9B3, and S2/9B), and one from Cycles 6, 8, and 9 (batch 8B4), and two fresh batches (batches 12A and 12B). The core loading pattern and the design parameters for each batch are shown in Figure 1.1. Fuel assembly burnups are given in Figure 1.2. The incore instrumentation locations are identified in Figure 1.3. Figure 1.4 identifies the location and number of burnable poison rods and source assemblies for Cycle 10, and Figure 1.5 identifies the location and number of control rods in the Cycle 10 core.

On July 14, 1988 at 0825, the tenth cycle core achieved initial criticality. Following criticality, startup physics tests were performed as outlined in Table 1.1. A summary of the results of these tests follows:

1. The drop time of each control rod was confirmed to be within the 2.4 second limit of the Surry Technical Specifications[2].

2. Individual control rod bank worths for the control rod banks were measured using the rod swap technique[3] and were found to be within 15.3% of the design predictions. The sum of the individual control rod bank worths was measured to be within 6.1% of the design prediction. These results are within the design tolerance of ±15% or 100 pcm, whichever is greater, 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. Critical boron concentrations for two control bank configurations were measured to be within 43 ppm of the design predictions. These results were within the design tolerances and also met the accident analysis acceptance criterion.

4. The boron worth coefficient was measured to be within 2.5% of the design prediction, which is within the design tolerance of ±10% and met the accident analysis criterion.

5. The isothermal temperature coefficient for the all-rods-out configuration was measured to be within 0.8 pcm/^{0}F of the design prediction. This result is within the design tolerance of ±3 pcm/^{0}F and also meets the accident analysis acceptance criterion.

6. Core power distributions for at-power conditions were within established design tolerances. Generally, the measured core

power distribution was within 4.4% of the predicted power distribution. The measured parameters were within the limits of the Technical Specifications and met their respective accident analysis acceptance criteria.

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

Table 1.1

SURRY 1 - CYCLE 10 STARTUP PHYSICS TESTS

CHRONOLOGY OF TESTS

Test	Date	Time	Power	Reference Procedure
Hot Rod Drop Timing Test	07/13/88	2200	HSD	1-PT-7.2
Zero Power Testing Range	07/14/88	1230	HZP	1-PT-28.11
Reactivity Computer Checkout	07/14/88	1304	HZP	1-PT-28.11
Boron Endpoint-ARO	07/15/88	0445	HZP	1-PT-28.11
Temperature Coefficient-ARO	07/15/88	0549	HZP	1-PT-28.11
Rod Worth	07/15/88	0725	HZP	1-PT-28.11
Boron Endpoint-B In	07/15/88	1315	HZP	1-PT-28.11
Bank D Worth - Rod Swap	07/15/88	1425	HZP	1-PT-28.11
Bank C Worth - Rod Swap	07/15/88	1507	HZP	1-PT-28.11
Bank A Worth - Rod Swap	07/15/88	1639	HZP	1-PT-28.11
Bank SB Worth - Rod Swap	07/15/88	1710	HZP	1-PT-28.11
Bank SA Worth - Rod Swap	07/15/88	1749	HZP	1-PT-28.11
Flux Map - Power Distribution Verification	07/16/88	0637	29%	1-OP-57, 1-PT-28.2
Flux Map - Hot Channel Factor Verification	07/18/88	2219	42%	1-OP-57, 1-PT-28.2
Flux Map - I/E Calibration	07/20/88	0112	69%	1-OP-57, 1-PT-28.2
Flux Map - I/E Calibration	07/20/88	0309	68%	1-OP-57, 1-PT-28.2
Flux Map - I/E Calibration	07/20/88	0509	68%	1-OP-57, 1-PT-28.2
Flux Map - HFP, Eq. Xenon	07/29/88	1630	100%	1-OP-57, 1-PT-28.2

ERRATA

Page 11 of the Surry Unit 1, Cycle 10 Startup Physics Tests Report incorrectly states that the Technical Specifications limit on rod drop time is 1.8 seconds. The correct Technical Specifications limit for rod drop time is 2.4 seconds. This error does not affect the conclusion in the report that all rod drop times were acceptable.

FIGURE 1.1

SURRY UNIT 1 - CYCLE 10

CORE LOADING MAP

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
						9A 2D2	10A 2E2	9A 2D4							1
				10A 2E1	8B 0C9	12B 2G5	11B 4F1	12B 3G3	8B 2C1	10A 0E2					2
			9B 4D2	12A 0G1	12B 4G8	11A 1F0	11B 2F9	11A 2F6	12B 3G9	12A 1G9	9B 4D6				3
		9A 2D5	8B 0C4	12B 3G6	11A 1F6	12A 1G3	11B 4F5	12A 0G6	11A 2F5	12B 4G5	8B 4C3	9A 1D3			4
	10A 0E7	12A 2G3	12B 4G1	11B 4F7	11A 0F3	11B 3F5	9B 3D9	11B 3F3	11A 1F1	11B 5F3	12B 3G0	12A 0G5	10A 5E5		5
	8B 0C2	12B 4G6	11A 0F4	11A 1F2	9A 0D2	12A 0G3	11A 2F7	12A 1G5	9B 3D7	11A 0F7	11A 2F3	12B 4G7	8B 3C0		6
9A 2D3	12B 2G7	11A 1F9	12A 1G6	11B 3F8	12A 2G0	9B 5D4	11B 5F5	9B 5D0	12A 2G2	9A 2D6	12A 1G1	11A 1F4	12B 3G1	8B 4C0	7
10A 1E4	11B 5F6	11B 5F0	11B 5F4	9B 5D6	11A 2F1	11B 3F2	9B 4D7	11B 4F9	11A 2F8	9B 4D4	11B 3F1	11B 4F3	11B 3F7	10A 5E1	8
9A 1D9	12B 3G2	11A 0F2	12A 0G8	11B 3F4	12A 1G0	9A 2D0	11B 5F2	9A 2D9	12A 2G1	11B 3F6	12A 1G8	11A 0F5	12B 4G2	9A 1D4	9
	8B 3C2	12B 4G0	11A 2F4	11A 1F3	9B 4D0	12A 1G7	11A 0F1	12A 0G4	9B 5D8	11A 0F6	11A 1F5	12B 3G5	8B 0C8		10
	10A 1E1	12A 1G2	12B 2G8	11B 4F4	11A 0F8	11B 3F9	9B 4D9	11B 4F2	11A 1F7	11B 3F0	12B 2G9	12A 0G2	10A 2E6		11
		S2/9B 4R0	8B 2C0	12B 4G3	11A 2F2	12A 0G7	11B 4F6	12A 1G4	11A 1F8	12B 3G8	8B 3C7	S2/9B 3R2			12
			9A 0D4	12A 2G4	12B 3G4	11A 2F0	11B 4F0	11A 0F9	12B 4G4	12A 0G9	9A 3D4				13
				10A 5E4	8B 1C3	12B 3G7	11B 4F8	12B 2G6	8B 2C5	10A 3E9					14
						8B 2C4	10A 3E5	9A 3D6							15

--> BATCH
--> ASSEMBLY ID

FUEL ASSEMBLY DESIGN PARAMETERS

	SUB-BATCH								
	8B	9A	9B	S2/9B	10A	11A	11B	12A	12B
INITIAL ENRICHMENT (W/O U-235)	3.40	3.59	3.61	3.59	3.60	3.60	3.80	3.80	3.99
BURNUP AT BOC 10 (MWD/MTU)	19454	31169	20502	34030	33055	19560	18887	0	0
ASSEMBLY TYPE	15X15	15X15	15X15	15X15	15X15	15X15	15X15	15X15	15X15
NUMBER OF ASSEMBLIES	14	14	12	2	12	28	27	24	24
FUEL RODS PER ASSEMBLY	204	204	204	204	204	204	204	204	204

FIGURE 1.2

SURRY UNIT 1 - CYCLE 10

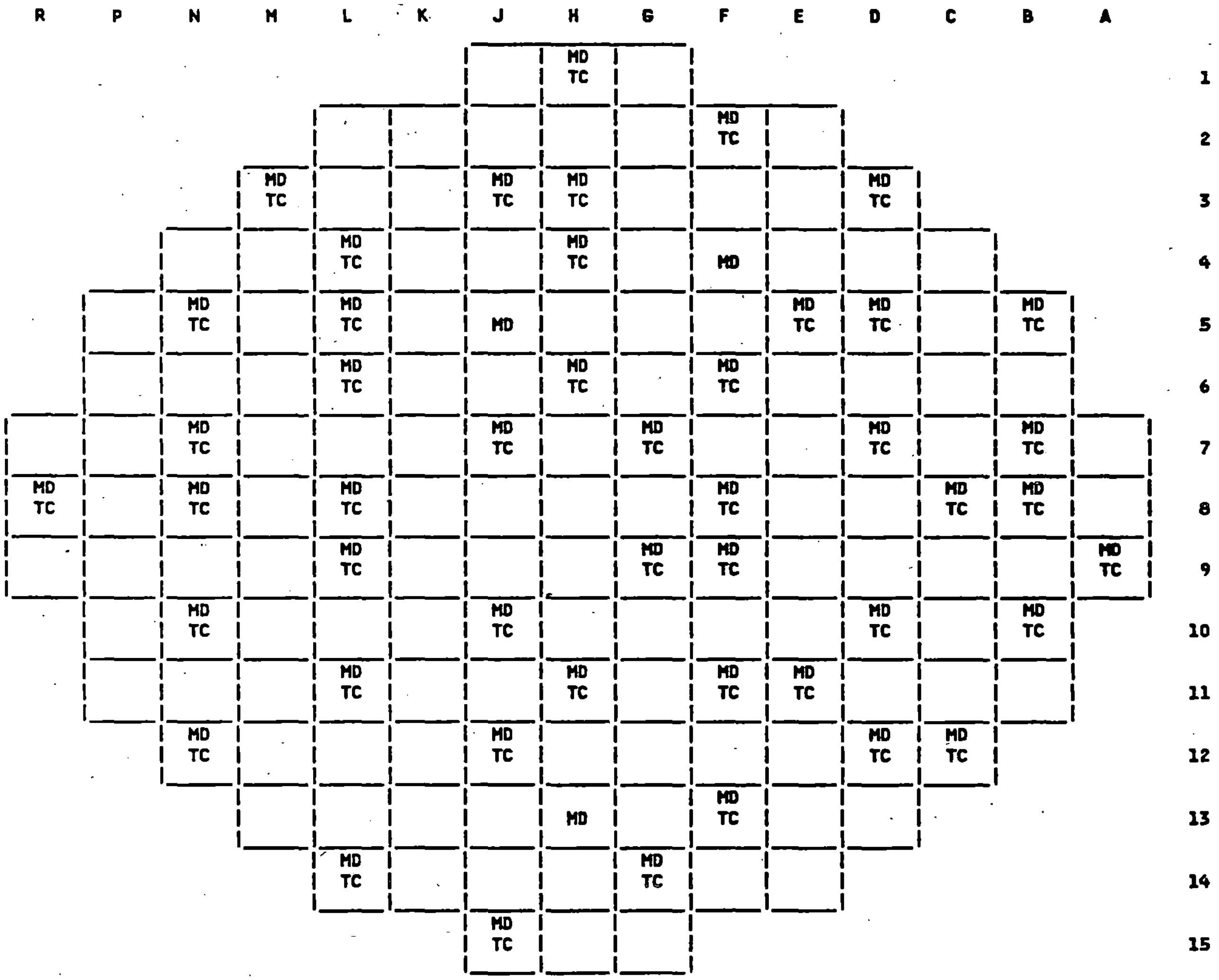
BEGINNING OF CYCLE FUEL ASSEMBLY BURNUPS

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
						2D2 34433	2E2 30465	2D4 34405							1
				2E1 34264	0C9 16045	2G5 0	4F1 19756	3G3 0	2C1 16502	0E2 34754					2
			4D2 33653	0G1 0	4G8 0	1F0 20677	2F9 16620	2F6 20861	3G9 0	1G9 0	4D6 34859				3
		2D5 34658	0C4 18931	3G6 0	1F6 20731	1G3 0	4F5 19507	0G6 0	2F5 20660	4G5 0	4C3 19560	1D3 34185			4
	0E7 34643	2G3 0	4G1 0	4F7 19956	0F3 16865	3F5 19990	3D9 14298	3F3 20242	1F1 16647	5F3 19964	3G0 0	0G5 0	5E5 34420		5
	0C2 15810	4G6 0	0F4 20593	1F2 16294	0D2 15426	0G3 0	2F7 20783	1G5 0	3D7 15228	0F7 16990	2F3 20858	4G7 0	3C0 15702		6
2D3 33747	2G7 0	1F9 20426	1G6 0	3F8 20291	2G0 0	5D4 29420	5F5 16652	5D0 29585	2G2 0	2D6 15494	1G1 0	1F4 20942	3G1 0	4C0 32333	7
1E4 30382	5F6 18829	5F0 16343	5F4 19498	5D6 14351	2F1 21429	3F2 16621	4D7 15702	4F9 16492	2F8 20812	4D4 13701	3F1 19719	4F3 16202	3F7 19389	5E1 30267	8
1D9 35118	3G2 0	0F2 20329	0G8 0	3F4 20350	1G0 0	2D0 29853	5F2 16332	2D9 29846	2G1 0	3F6 20492	1G8 0	0F5 20440	4G2 0	1D4 34888	9
	3C2 16111	4G0 0	2F4 20919	1F3 16883	4D0 15655	1G7 0	0F1 20481	0G4 0	5D8 15043	0F6 16771	1F5 20738	3G5 0	0C8 16559		10
	1E1 34468	1G2 0	2G8 0	4F4 20046	0F8 16756	3F9 20506	4D9 14591	4F2 20158	1F7 16644	3F0 20257	2G9 0	0G2 0	2E6 33976		11
		4R0 33896	2C0 19764	4G3 0	2F2 20948	0G7 0	4F6 18843	1G4 0	1F8 20285	3G8 0	3C7 19003	3R2 34164			12
			0D4 34824	2G4 0	3G4 0	2F0 20305	4F0 17297	0F9 20575	4G4 0	0G9 0	3D4 34547				13
				5E4 33968	1C3 16478	3G7 0	4F8 19608	2G6 0	2C5 16312	3E9 34189					14
						2C4 33252	3E5 30876	3D6 34852							15

|--> ASSEMBLY ID
|--> ASSEMBLY BURNUP

SURRY UNIT 1 - CYCLE 10

INCORE INSTRUMENTATION LOCATIONS



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

MD - Movable Detector
TC - Thermocouple

FIGURE 1.4

SURRY UNIT 1 - CYCLE 10

BURNABLE POISON AND SOURCE ASSEMBLY LOCATIONS

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
															1
						3P		3P							2
				4P	16P		SS1		16P	4P					3
				16P		20P		20P		16P					4
		4P	16P		4P		4P		4P		16P	4P			5
		16P		4P		20P		20P		4P		16P			6
	3P		20P		20P				20P	20P*	20P		3P		7
				4P		SS7				4P					8
	3P		20P		20P				20P		20P		3P		9
		16P		4P		20P		20P		4P		16P			10
		4P	16P		4P		4P		4P		16P	4P			11
				16P		20P		20P		16P					12
				4P	16P		SS2		16P	4P					13
						3P		3P							14
															15

3P -- 3 BURNABLE POISON ROD CLUSTER

4P -- 4 BURNABLE POISON ROD CLUSTER

16P -- 16 BURNABLE POISON ROD CLUSTER

20P -- 20 BURNABLE POISON ROD CLUSTER

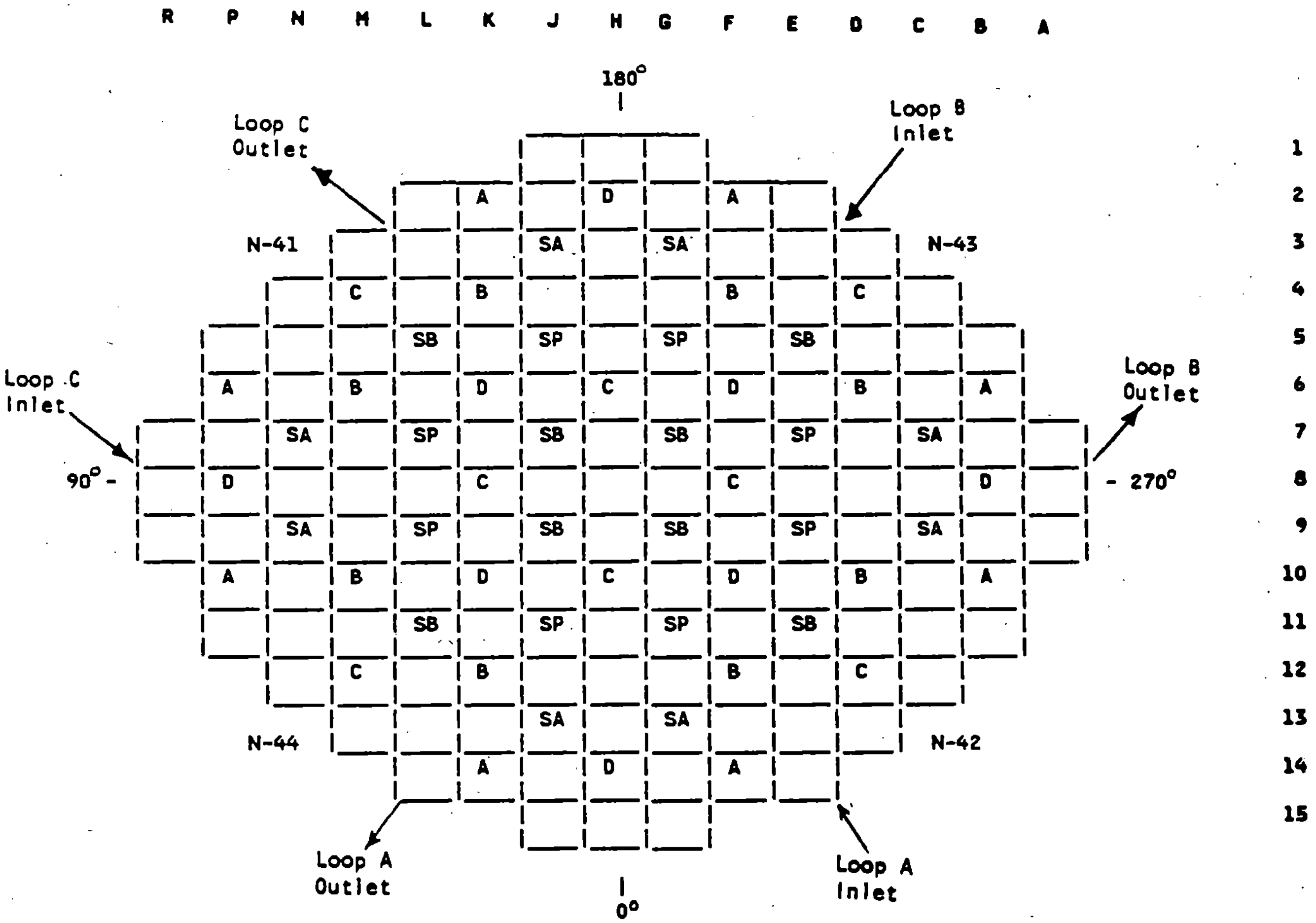
20P* -- 20 DEPLETED BURNABLE POISON ROD CLUSTER

SSX -- SECONDARY SOURCE

FIGURE 1.5

SURRY UNIT 1 - CYCLE 10

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		SP		SP		SB				
6		A		B		D		C		D		B		A	
7			SA		SP		SB		SB		SP		SA		
8		D				C				C				D	
9			SA		SP		SB		SB		SP		SA		
10		A		B		D		C		D		B		A	
11					SB		SP		SP		SB				
12			C			B				B		C			
13							SA		SA						
14						A		D		A					
15															

Absorber
Material
Ag-In-Cd

Function	Number of Clusters
Control Bank D	8
Control Bank C	8
Control Bank B	8
Control Bank A	8
Shutdown Bank SB	8
Shutdown Bank SA	8
SP (Spare Rod Locations)	8

SECTION 2

CONTROL ROD DROP TIME MEASUREMENTS

The drop time of each control rod was measured at hot full-flow RCS conditions in order to confirm satisfactory operation and to verify that the rod drop times were less than the maximum allowed by the Technical Specifications. The hot control rod drop time measurements were run with the RCS at hot, full flow conditions (547°F, 2235 psig) and are described below.

The rod drop time measurements were performed by first withdrawing a rod bank to its fully withdrawn position, and then removing the movable gripper coil fuse and stationary gripper coil fuse for the test rod. This allows the rod to drop into the core as it would in a normal plant trip. The data recorded during this test are the stationary gripper coil voltage, the LVDT (Linear Variable Differential Transformer) primary coil voltage, and a 60 Hz timing trace which are recorded via a visicorder. The rod drop time to the dashpot entry and to the bottom of the dashpot are determined from this data. Figure 2.1 provides an example of the data that is recorded during a rod drop time measurement.

As shown in Figure 2.1, the initiation of the rod drop is indicated by the decay of the stationary gripper coil voltage when the stationary coil fuse is removed. A voltage is then induced in the LVDT primary coil as the rod drops. The magnitude of this voltage is a function of the rod velocity. When the rod enters the dashpot section of its guide tube, the velocity slows causing a voltage decrease in the LVDT coil. The LVDT voltage then reaches a minimum as the rod reaches the bottom of the dashpot. Subsequent variations in the trace are caused by the rod bouncing. This procedure was repeated for each control rod.

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 1.8 seconds with the RCS at hot, full flow conditions. The test results met this limit.

Table 2.1

SURRY UNIT 1 - CYCLE 10

HOT ROD DROP TIME SUMMARY

ROD DROP TIME TO DASHPOT ENTRY

SLOWEST ROD	FASTEST ROD	AVERAGE TIME
F-14 1.24 sec.	G-7 1.16 sec.	1.20 sec.

ROD DROP TIME TO BOTTOM OF DASHPOT

SLOWEST ROD	FASTEST ROD	AVERAGE TIME
B-6 1.86 sec.	L-11,M-4 1.73 sec.	1.79 sec.

FIGURE 2.1

TYPICAL ROD DROP TRACE

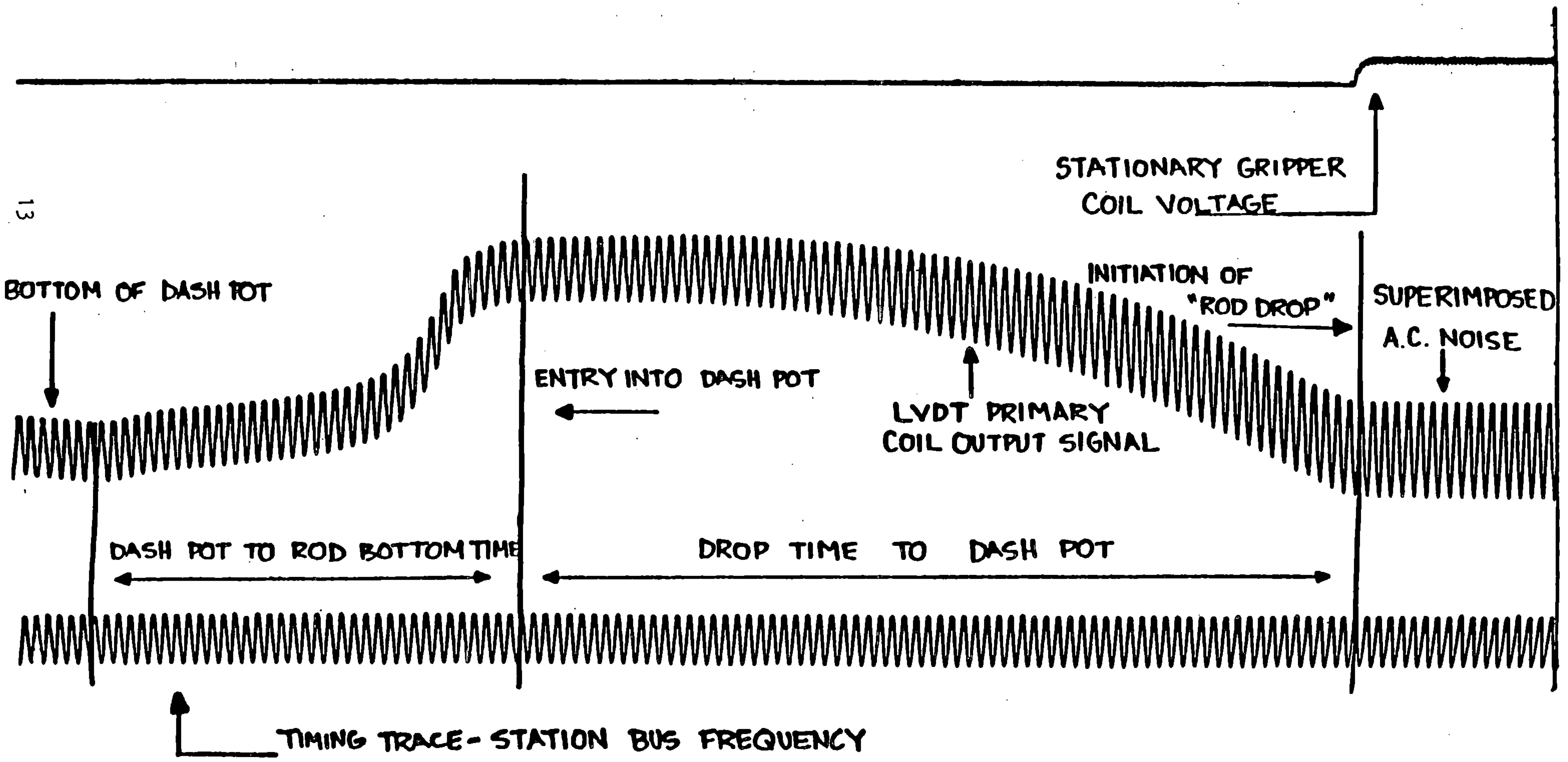


FIGURE 2.2

SURRY UNIT 1 - CYCLE 10

ROD DROP TIMES - HOT FULL FLOW CONDITIONS

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
1																1
2						1.20 1.78		1.19 1.78		1.19 1.79						2
3							1.22 1.80		1.20 1.77							3
4				1.19 1.73		1.18 1.78				1.21 1.81		1.21 1.76				4
5					1.18 1.78						1.23 1.83					5
6		1.18 1.77		1.20 1.80		1.20 1.78		1.17 1.77		1.20 1.83		1.19 1.79		1.22 1.86		6
7			1.19 1.77				1.20 1.79		1.16 1.76				1.21 1.81			7
8		1.20 1.80				1.19 1.80				1.19 1.77				1.23 1.83		8
9			1.21 1.81				1.20 1.76		1.21 1.81				1.19 1.74			9
10		1.19 1.75		1.20 1.80		1.20 1.81		1.21 1.80		1.22 1.83		1.19 1.82		1.20 1.84		10
11					1.18 1.73						1.20 1.77					11
12				1.18 1.77		1.19 1.79				1.20 1.77		1.23 1.79				12
13							1.21 1.75		1.21 1.78							13
14						1.22 1.80		1.20 1.81		1.24 1.83						14
15																15
	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	

--ROD DROP TIME TO DASHPOT ENTRY(SEC.)

--ROD DROP TIME TO BOTTOM OF DASHPOT(SEC.)

SECTION 3

CONTROL ROD BANK WORTH MEASUREMENTS

Control rod bank worth measurements were obtained for the control and shutdown banks using the rod swap technique. The first step in the rod swap procedure was to dilute the most reactive control rod bank (hereafter referred to as the reference bank) into the core and measure its reactivity worth using conventional test techniques. The reactivity changes resulting from the reference bank movements were recorded continuously by the reactivity computer[4] and were used to determine the differential and integral worth of the reference bank (Control Bank B).

At the completion of the reference bank reactivity worth measurement, the reactor coolant system temperature and boron concentration were stabilized such that the reactor was critical with the reference bank near full insertion. Initial statepoint data for the rod swap maneuver were obtained by moving the reference bank to its fully inserted position and recording the core reactivity and moderator temperature. At this point, a rod swap maneuver was performed by withdrawing the reference bank while one of the other control rod banks (i.e., a test bank) was inserted. The core was kept nominally critical throughout this rod swap and the maneuver was continued until the test bank was fully inserted and the reference bank was at the position at which the core was just critical. This measured critical position (MCP) of the reference bank with the test bank fully inserted is the major parameter of interest and was used to determine the integral reactivity worth of the test bank. Statepoint data (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 was then performed in reverse order such that the reference bank once again was near full insertion and the test bank was once again fully withdrawn from the core. The rod swap process was then repeated for all of the other control rod banks (control and shutdown).

A summary of the results for these tests is given in Table 3.1. As shown by this table and the Startup Physics Tests Results and Evaluation Sheets given in the Appendix, the individual measured bank worths for the control and shutdown banks were within the design tolerance (±10% for the reference bank and ±15% or 100 pcm, whichever is greater, for the test banks). The sum of the individual rod bank worths was measured to be within 6.1% 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 10

CONTROL ROD BANK WORTH SUMMARY

BANK	MEASURED WORTH (PCM)	PREDICTED WORTH (PCM)	PERCENT DIFFERENCE (%) (M-P)/P X 100
B-Reference Bank	1134	1242	-8.7
D	1077	1118	-3.7
C	824	824	0.0
A	299	353	-15.3
SB	979	990	-1.1
SA	879	1002	-12.3
Total Worth	5192	5529	-6.1

FIGURE 3.1

SURRY UNIT 1 - CYCLE 10
B BANK INTEGRAL ROD WORTH - HZP
B BANK WITH ALL OTHER RODS OUT

-- PREDICTED

✱ MEASURED

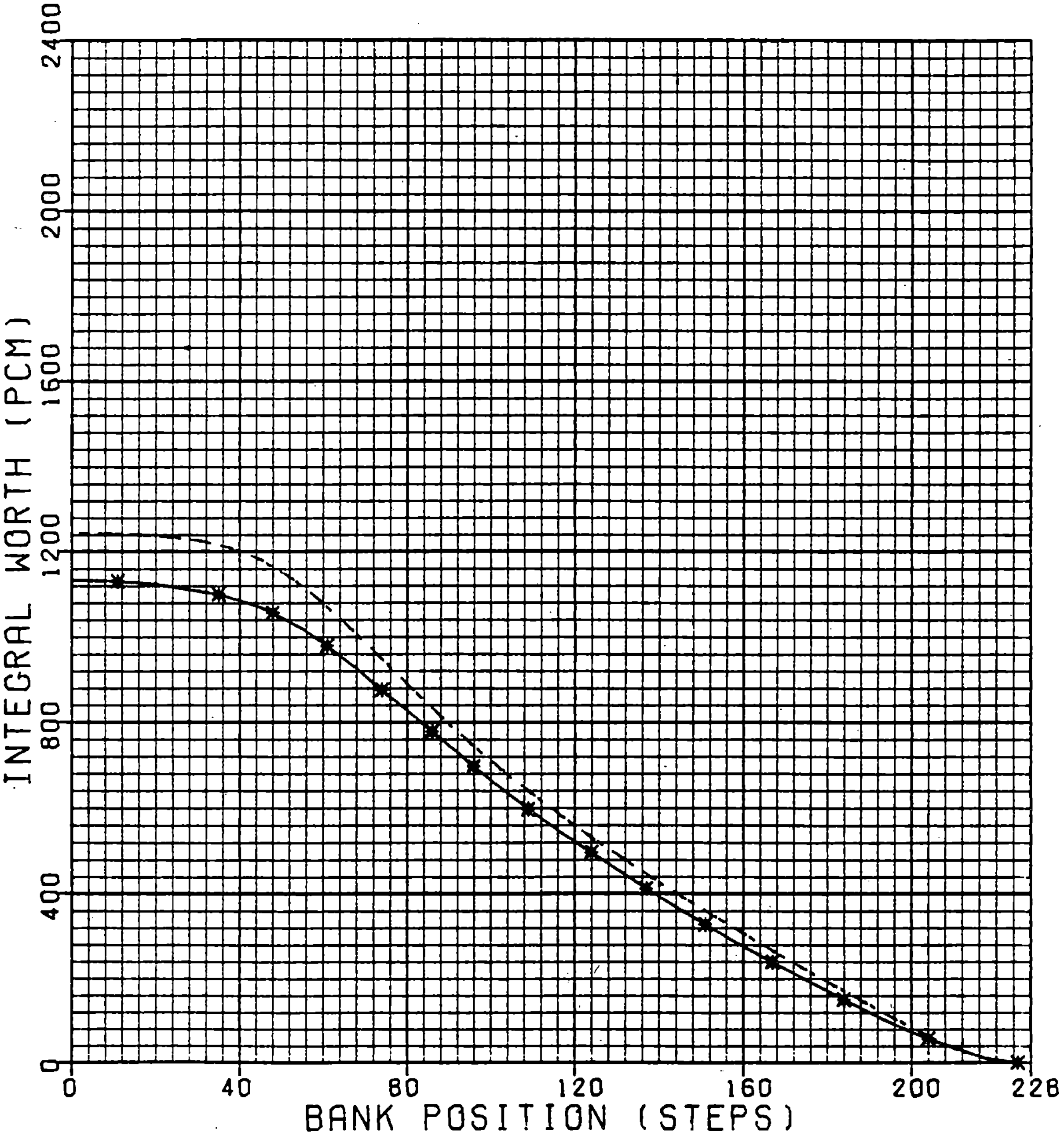
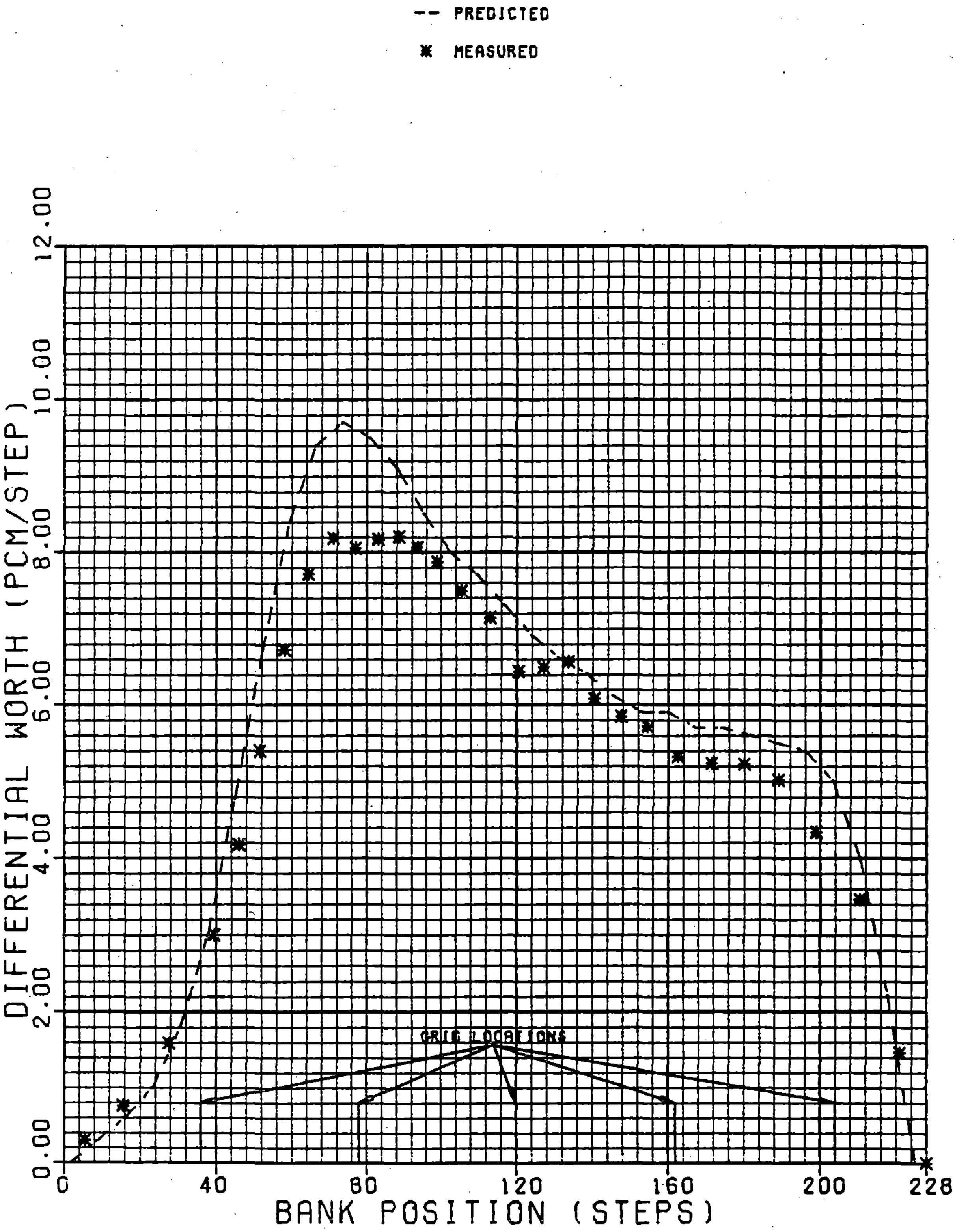


FIGURE 3.2

SURRY UNIT 1 - CYCLE 10
B BANK DIFFERENTIAL ROD WORTH - HZP
B BANK WITH ALL OTHER RODS OUT



SECTION 4

BORON ENDPOINT AND WORTH MEASUREMENTS

Boron Endpoint

With the reactor critical at hot zero power, reactor coolant system boron concentrations were measured at selected rod bank configurations to enable a direct comparison of measured boron endpoints with design predictions. For each measurement, the RCS conditions were stabilized with the control banks at or very near a selected endpoint position. The critical boron concentration was then measured. If necessary, an adjustment to the measured critical boron concentration was made to account for off-nominal core conditions; that is, for rod position and moderator temperature.

The results of these measurements are given in Table 4.1. As shown in this table and in the Startup Physics Tests Results and Evaluation Sheets given in the Appendix, the measured critical boron endpoint values were within their respective design tolerances. The measured values met the accident analysis acceptance criterion. 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 was determined. A plot of the boron concentration as a function of integrated reactivity can be constructed 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 boron coefficient, over the range of boron endpoint concentrations, is obtained directly from this plot.

The boron worth plot is shown in Figure 4.1. As indicated in this figure and in the Appendix, the boron worth coefficient of reactivity was measured to be -7.61 pcm/ppm. The measured boron worth coefficient is within 2.5% of the predicted value of -7.80 pcm/ppm and is well within the design tolerance of ±10%. The measurement result also met the accident analysis acceptance criterion. In summary, the measured boron worth was satisfactory.

Table 4.1

SURRY UNIT 1 - CYCLE 10

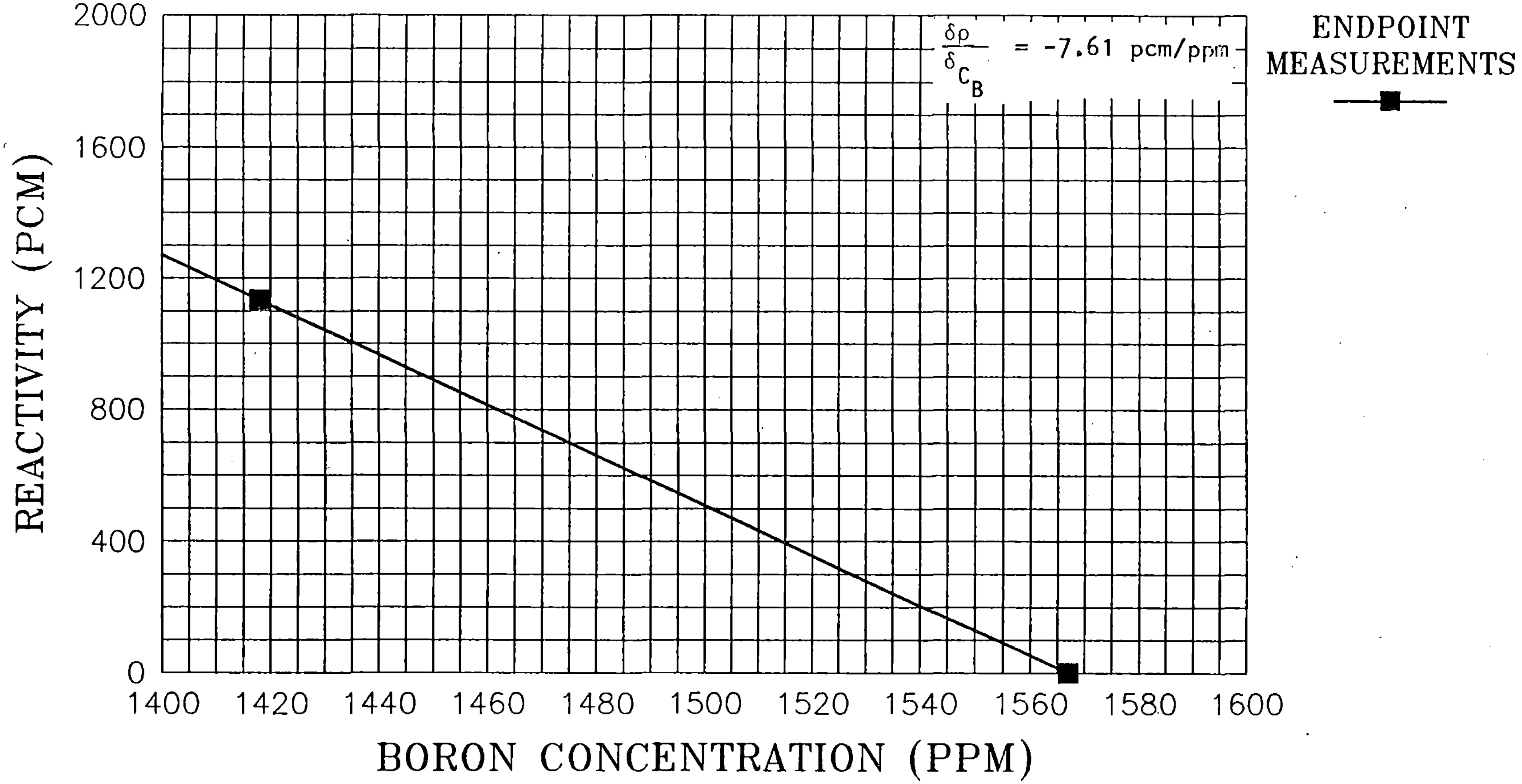
BORON ENDPOINTS SUMMARY

Control Rod Configuration	Measured Endpoint (ppm)	Predicted Endpoint (ppm)	Difference M-P (ppm)
ARO	1567	1610	-43
B Bank In	1418	1408*	10

* The predicted endpoint for the B Bank in configuration has been 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 Sheets in the Appendix.

FIGURE 4.1

SURRY UNIT 1, CYCLE 10
BORON WORTH COEFFICIENT



SECTION 5

TEMPERATURE COEFFICIENT MEASUREMENTS

The isothermal temperature coefficient measurement was accomplished by controlling the RCS heat gains/losses with the steam dump valves to the condenser, and/or steam generator blowdown establishing a constant and uniform heatup/cooldown rate, and then monitoring the resulting reactivity changes on the reactivity computer. This measurement was performed at a very low power level in order to minimize the effects of non-uniform nuclear heating, thus, the moderator and fuel were approximately at the same temperature (between 542-547°F) during the measurement. To eliminate the boron reactivity effect of outflow from the pressurizer, the pressurizer level was maintained constant or slightly increasing during the measurement.

An isothermal temperature coefficient measurement was performed at the all-rods-out configuration. Reactivity measurements were taken during both RCS heatup and cooldown ramps during which the RCS temperature varied approximately 3°F. Reactivity was determined using the reactivity computer and was plotted against the RCS temperature on an x-y recorder. The temperature coefficient was then determined from the slope of the plotted lines.

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 Sheets given in the Appendix, the measured isothermal temperature coefficient value was within the design tolerance of ±3 pcm/°F and met the accident analysis acceptance criterion. In summary, the measured temperature coefficient was satisfactory.

Table 5.1

SURRY UNIT 1 - CYCLE 10

ISOTHERMAL TEMPERATURE COEFFICIENT SUMMARY

BANK POSITION	TEMPERATURE RANGE (°F)	BORON CONCENTRATION (ppm)	ISOTHERMAL TEMPERATURE COEFFICIENT (PCM/°F)				
			HEATUP	COOL DOWN	AVER.	PRED.	DIFFER. (M-P)
ARO	546.3 to 543.3	1566	---	-3.67	---	-4.01	0.34
ARO	545.5 to 542.4	1566	---	-2.77	* -3.22	-4.01	1.24

* This is the average of the two cooldowns used in the Isothermal Temperature Coefficient calculations.

SECTION 6

POWER DISTRIBUTION MEASUREMENTS

The core power distributions were measured using the incore movable detector flux mapping system. This system consists of five fission detectors which traverse fuel assembly instrumentation thimbles in 50 core locations (see Figure 1.3). For each traverse, the detector output is continuously monitored on a strip chart recorder. The output is also scanned for 61 discrete axial points by the PRODAC P-250 process computer. Full core, three-dimensional power distributions are then determined by analyzing this data using the Westinghouse computer program, INCORE[5]. INCORE couples the measured flux map data 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 test program together with a list of the measured values of the important power distribution parameters is given in Table 6.1. The measured power distribution parameter values are compared with their Technical Specifications limits in Table 6.2. Flux Map 1 was taken at slightly less than 30% power to verify radial power symmetry according to the American National Standards Institute standard on power reactor startup physics testing (ANSI/ANS-19.6.1-1985). Figure 6.1 shows the resulting radial power distribution associated with this flux map.

Flux maps 2 through 6 were taken over a wide range of power levels and control rod configurations. These flux maps were taken to check the at-power design predictions and to measure core power distributions at various operating conditions. These maps also provide a cross-calibration between the incore and excore nuclear instrumentation systems. The radial power distributions for maps 2 and 6 are given in Figures 6.2 and 6.3. These figures show that the measured relative assembly power values are generally within 4.4% of the predicted values.

In conclusion, the power distribution measurement results were considered to be acceptable with respect to the design tolerances, the accident analysis acceptance criteria, and the Technical Specification limits. It is therefore anticipated that the core will continue to operate as designed throughout Cycle 10.

TABLE 6.1

SURRY UNIT 1 - CYCLE 10 STARTUP PHYSICS TESTS

INCORE FLUX MAP SUMMARY

MAP DESCRIPTION	MAP NO.	DATE	BURN UP MWD/ MTU	PWR (%)	BANK D STEPS	F-Q(T) HOT CHANNEL FACTOR[1]				F-DH(N) HOT CHNL.FACTOR[2]			CORE F(Z) MAX		F(XY)[3]	QPTR[4]		AXIAL OFF SET (%)	NO. OF THIMBLES
						ASSY	PIN	AXIAL POINT	F-Q(T)	ASSY	PIN	F-DH(N)	AXIAL POINT	F(Z)		MAX	LOC		
POWER DISTRIBUTION	1	7-18-88	10	29	158	K06	DE	32	2.152	H05	DE	1.498	32	1.403	1.422	1.007	NW	-5.399	42
HOT CHANNEL FACTOR VERIFICATION	2	7-18-88	12	42	171	J14	KL	31	2.036	H05	DE	1.484	30	1.308	1.443	1.007	SE	-0.119	42
HFP (5)	6	7-29-88	238	100	225	H08	MG	32	1.822	H08	MG	1.488	34	1.189	1.421	1.006	SE	-0.194	45

NOTES: HOT SPOT LOCATIONS ARE SPECIFIED BY GIVING ASSEMBLY LOCATIONS (E.G. H-8 IS THE CENTER-OF-CORE ASSEMBLY), FOLLOWED BY THE PIN LOCATION (DENOTED BY THE "Y" COORDINATE WITH THE FIFTEEN ROWS OF FUEL RODS LETTERED A THROUGH R AND THE "X" COORDINATE DESIGNATED IN A SIMILAR MANNER).
IN THE "Z" DIRECTION THE CORE IS DIVIDED IN TO 61 AXIAL POINTS STARTING FROM THE TOP OF THE CORE.

1. F-Q(T) INCLUDES A TOTAL UNCERTAINTY OF 1.08
2. F-DH(N) INCLUDES A MEASUREMENT UNCERTAINTY OF 1.04
3. F(XY) IS EVALUATED AT THE MIDPLANE OF THE CORE.
4. QPTR - QUADRANT POWER TILT RATIO.
5. MAPS 3, 4 AND 5 WERE QUARTER-CORE MAPS TAKEN FOR INCORE/EXCORE DETECTOR CALIBRATION AT 69% POWER.

Table 6.2

SURRY UNIT 1 - CYCLE 10

COMPARISION OF MEASURED POWER DISTRIBUTION PARAMETERS WITH THEIR TECHNICAL SPECIFICATIONS LIMITS

MAP NO.	F-Q(T) HOT CHANNEL FACTOR*			F-DH(N) HOT CHANNEL FACTOR+		
	MEAS	LIMIT	MARGIN (%)	MEAS	LIMIT	MARGIN (%)
1	2.152	4.64	53.6	1.498	1.880	20.3
2	2.036	4.64	56.1	1.484	1.820	18.5
6	1.822	2.32	20.7	1.488	1.550	4.0

* The Technical Specification's limit for the heat flux hot channel factor, F-Q(T), is a function of core height. The value for F-Q(T) listed above is the maximum value of F-Q(T) in the core. The Technical Specification's limit listed above is evaluated at the plane of maximum F-Q(T). The minimum margin values listed above are the minimum percent difference between the measured values of F-Q(T) and the Technical Specification's limit for each map. The measured F-Q(T) hot channel factors include 8% total uncertainty.

\+ The measured values for the enthalpy rise hot channel factor, F-dH(N), include 4% measurement uncertainty.

FIGURE 6.1

SURRY UNIT 1 - CYCLE 10

ASSEMBLYWISE POWER DISTRIBUTION
29% POWER

PREDICTED
MEASURED
PCT DIFFERENCE

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
						0.26 0.26 -0.3	0.31 0.30 -0.4	0.26 0.26 -0.8							1
				0.33 0.33 2.0	0.64 0.63 -1.1	1.09 1.07 -1.9	0.88 0.86 -2.1	1.10 1.08 -2.0	0.65 0.64 -1.6	0.33 0.32 -0.3					2
			0.35 0.35 1.6	1.09 1.10 0.4	1.22 1.20 -1.1	1.19 1.17 -1.6	1.25 1.20 -4.0	1.20 1.16 -3.4	1.22 1.20 -1.6	1.09 1.09 0.4	0.34 0.35 1.6				3
		0.35 0.36 2.0	0.79 0.79 0.4	1.25 1.24 -0.9	1.22 1.21 -1.1	1.27 1.24 -2.5	1.32 1.28 -3.2	1.26 1.20 -4.6	1.21 1.16 -4.2	1.23 1.21 -1.8	0.76 0.76 -1.0	0.34 0.34 -0.1			4
	0.33 0.34 2.0	1.11 1.13 2.0	1.25 1.26 0.4	1.23 1.22 -0.7	1.20 1.20 -0.2	1.30 1.34 3.1	1.28 1.22 -4.6	1.29 1.32 2.3	1.18 1.17 -1.0	1.21 1.17 -3.2	1.23 1.21 -1.9	1.09 1.08 -0.9	0.33 0.33 -0.2		5
	0.66 0.66 -0.2	1.23 1.23 -0.3	1.23 1.23 0.2	1.20 1.22 1.4	1.20 1.21 1.3	1.20 1.23 3.0	1.20 1.26 4.6	1.19 1.23 4.1	1.18 1.20 1.4	1.18 1.17 -0.6	1.21 1.19 -1.2	1.22 1.21 -0.5	0.65 0.64 -0.7		6
0.26 0.27 2.1	1.11 1.11 -0.2	1.21 1.18 -2.1	1.28 1.28 -0.0	1.30 1.32 1.4	1.20 1.22 2.1	1.01 1.04 3.1	1.23 1.29 4.6	1.00 1.05 5.7	1.18 1.22 4.1	1.22 1.24 1.5	1.25 1.26 0.8	1.20 1.19 -0.5	1.10 1.09 -1.2	0.26 0.25 -1.2	7
0.31 0.31 1.9	0.89 0.89 0.6	1.26 1.27 0.6	1.34 1.34 0.2	1.29 1.30 1.0	1.21 1.22 1.4	1.23 1.27 3.1	1.23 1.29 4.7	1.23 1.29 4.9	1.19 1.25 4.5	1.28 1.31 2.3	1.32 1.32 -0.0	1.25 1.24 -1.0	0.88 0.88 -0.1	0.31 0.31 1.5	8
0.26 0.27 2.1	1.11 1.12 0.7	1.21 1.21 -0.2	1.27 1.28 0.2	1.30 1.30 0.2	1.19 1.20 0.3	1.00 1.01 0.4	1.23 1.27 3.0	1.01 1.05 4.5	1.19 1.23 3.5	1.29 1.31 1.9	1.26 1.25 -0.7	1.20 1.19 -0.8	1.10 1.11 0.7	0.26 0.27 2.8	9
	0.66 0.65 -1.6	1.23 1.21 -1.7	1.22 1.21 -1.1	1.20 1.19 -0.7	1.19 1.18 -0.7	1.19 1.20 0.3	1.21 1.23 1.5	1.20 1.23 2.9	1.19 1.22 2.2	1.19 1.20 0.7	1.22 1.22 -0.5	1.23 1.22 -0.6	0.65 0.65 -0.2		10
	0.33 0.33 -0.1	1.10 1.10 -0.1	1.24 1.24 -0.6	1.22 1.20 -1.4	1.19 1.18 -0.9	1.30 1.30 -0.1	1.29 1.30 0.4	1.31 1.32 1.4	1.20 1.22 1.7	1.23 1.23 -0.3	1.25 1.24 -0.7	1.10 1.09 -0.7	0.33 0.33 -0.7		11
		0.35 0.35 1.6	0.77 0.77 0.4	1.24 1.22 -1.4	1.22 1.21 -1.2	1.27 1.26 -0.9	1.33 1.33 -0.3	1.28 1.28 0.1	1.23 1.23 -0.3	1.26 1.25 -0.5	0.80 0.79 -0.8	0.35 0.35 -0.8			12
			0.34 0.35 1.1	1.09 1.09 0.6	1.22 1.22 -0.2	1.21 1.20 -1.1	1.27 1.22 -3.7	1.21 1.16 -4.4	1.24 1.20 -2.9	1.11 1.09 -1.8	0.35 0.35 -0.8				13
				0.32 0.32 0.7	0.65 0.66 1.1	1.12 1.14 1.5	0.89 0.86 -3.3	1.11 1.04 -5.9	0.66 0.63 -4.4	0.33 0.32 -2.5					14
						0.26 0.27 1.5	0.31 0.31 -1.6	0.26 0.24 -6.3							15

STANDARD
DEVIATION
=1.405

AVERAGE
PCT DIFFERENCE
= 1.6

SUMMARY

MAP NO: S1-10-01	DATE: 7/18/88	POWER: 29%
CONTROL ROD POSITIONS:	F-Q(T) = 2.152	QPTR:
D BANK AT 158 STEPS	F-DH(N) = 1.498	NW 1.007 | NE 0.991
	F(Z) = 1.403	SW 0.998 | SE 1.005
	F(XY) = 1.422	
	BURNUP = 10 MWD/MTU	A.O = -5.399(%)

FIGURE 6.2

SURRY UNIT 1 - CYCLE 10

ASSEMBLYWISE POWER DISTRIBUTION
42% POWER

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

       ...............                    ......................                    ...............
       .  PREDICTED  .                    . 0.26 . 0.31 . 0.26 .                    .  PREDICTED  .
       .  MEASURED   .                    . 0.27 . 0.32 . 0.27 .                    .  MEASURED   .             1
       .PCT DIFFERENCE.                   .  3.0 .  2.9 .  2.2 .                    .PCT DIFFERENCE.
       ...............      ..................................................      ...............
                            . 0.33 . 0.64 . 1.10 . 0.90 . 1.11 . 0.66 . 0.33 .
                            . 0.34 . 0.64 . 1.10 . 0.90 . 1.11 . 0.66 . 0.33 .                                  2
                            .  4.2 .  0.3 . -0.2 . -0.4 . -0.1 .  0.8 .  1.4 .
                     ................................................................
                     . 0.35 . 1.08 . 1.21 . 1.19 . 1.25 . 1.19 . 1.21 . 1.08 . 0.34 .
                     . 0.36 . 1.10 . 1.20 . 1.18 . 1.20 . 1.16 . 1.22 . 1.10 . 0.35 .                           3
                     .  3.6 .  1.4 . -0.4 . -0.4 . -3.9 . -2.5 .  0.8 .  1.8 .  2.4 .
              ..............................................................................
              . 0.35 . 0.78 . 1.24 . 1.21 . 1.26 . 1.32 . 1.25 . 1.20 . 1.22 . 0.76 . 0.34 .
              . 0.37 . 0.79 . 1.23 . 1.20 . 1.24 . 1.28 . 1.19 . 1.17 . 1.22 . 0.76 . 0.35 .                    4
              .  4.2 .  0.6 . -1.0 . -1.0 . -1.6 . -2.7 . -4.7 . -2.5 . -0.7 . -0.1 .  0.8 .
       ............................................................................................
       . 0.33 . 1.10 . 1.24 . 1.23 . 1.20 . 1.30 . 1.28 . 1.29 . 1.19 . 1.21 . 1.22 . 1.08 . 0.33 .
       . 0.33 . 1.08 . 1.23 . 1.21 . 1.19 . 1.33 . 1.22 . 1.31 . 1.18 . 1.18 . 1.21 . 1.08 . 0.33 .             5
       . -2.0 . -1.8 . -0.9 . -1.3 . -0.8 .  2.4 . -4.7 .  1.5 . -0.4 . -1.9 . -1.1 .  0.1 .  1.1 .
       ............................................................................................
       . 0.66 . 1.22 . 1.22 . 1.20 . 1.22 . 1.20 . 1.21 . 1.19 . 1.20 . 1.18 . 1.20 . 1.21 . 0.65 .
       . 0.65 . 1.20 . 1.21 . 1.21 . 1.23 . 1.23 . 1.25 . 1.23 . 1.22 . 1.18 . 1.19 . 1.20 . 0.65 .             6
       . -2.0 . -2.0 . -0.7 .  0.5 .  0.5 .  2.2 .  3.9 .  3.4 .  1.0 . -0.4 . -1.0 . -0.4 . -0.4 .
..........................................................................................................
. 0.27 . 1.11 . 1.20 . 1.27 . 1.30 . 1.20 . 1.02 . 1.24 . 1.00 . 1.18 . 1.22 . 1.24 . 1.19 . 1.11 . 0.26 .
. 0.27 . 1.11 . 1.18 . 1.26 . 1.30 . 1.22 . 1.04 . 1.28 . 1.06 . 1.23 . 1.24 . 1.24 . 1.18 . 1.09 . 0.26 .      7
.  2.7 . -0.3 . -1.9 . -0.7 .  0.4 .  1.1 .  2.3 .  3.9 .  5.1 .  3.9 .  1.7 . -0.4 . -1.4 . -1.7 . -1.6 .
..........................................................................................................
. 0.32 . 0.91 . 1.27 . 1.33 . 1.29 . 1.21 . 1.24 . 1.24 . 1.23 . 1.20 . 1.28 . 1.31 . 1.25 . 0.90 . 0.32 .
. 0.33 . 0.91 . 1.25 . 1.32 . 1.28 . 1.21 . 1.27 . 1.29 . 1.29 . 1.25 . 1.31 . 1.30 . 1.23 . 0.90 . 0.32 .      8
.  2.5 .  0.1 . -1.1 . -0.9 . -0.2 .  0.3 .  2.4 .  3.9 .  4.2 .  4.5 .  2.6 . -1.1 . -1.9 . -0.3 .  2.2 .
..........................................................................................................
. 0.27 . 1.12 . 1.21 . 1.26 . 1.30 . 1.20 . 1.01 . 1.24 . 1.02 . 1.19 . 1.29 . 1.25 . 1.19 . 1.11 . 0.26 .
. 0.27 . 1.12 . 1.19 . 1.25 . 1.29 . 1.19 . 1.02 . 1.27 . 1.05 . 1.22 . 1.31 . 1.25 . 1.18 . 1.12 . 0.27 .      9
.  2.7 .  0.2 . -1.2 . -0.9 . -0.8 . -0.3 .  0.8 .  2.7 .  3.6 .  2.2 .  2.1 . -0.7 . -1.1 .  0.9 .  4.1 .
..........................................................................................................
       . 0.66 . 1.22 . 1.22 . 1.20 . 1.22 . 1.20 . 1.21 . 1.20 . 1.22 . 1.20 . 1.21 . 1.22 . 0.65 .
       . 0.65 . 1.20 . 1.20 . 1.18 . 1.21 . 1.21 . 1.23 . 1.23 . 1.23 . 1.20 . 1.21 . 1.21 . 0.65 .             10
       . -1.5 . -1.6 . -1.4 . -1.4 . -0.9 .  0.7 .  1.7 .  2.1 .  1.2 .  0.4 .  0.0 . -0.4 . -0.4 .
       ............................................................................................
       . 0.33 . 1.09 . 1.23 . 1.22 . 1.20 . 1.29 . 1.29 . 1.30 . 1.20 . 1.23 . 1.24 . 1.09 . 0.33 .
       . 0.33 . 1.10 . 1.23 . 1.20 . 1.18 . 1.29 . 1.30 . 1.32 . 1.22 . 1.22 . 1.24 . 1.09 . 0.33 .             11
       .  0.9 .  0.9 . -0.2 . -1.7 . -1.2 . -0.1 .  0.8 .  1.2 .  1.0 . -0.4 . -0.2 . -0.2 . -1.0 .
       ............................................................................................
              . 0.35 . 0.77 . 1.23 . 1.21 . 1.26 . 1.33 . 1.27 . 1.22 . 1.25 . 0.79 . 0.35 .
              . 0.36 . 0.78 . 1.21 . 1.19 . 1.24 . 1.32 . 1.27 . 1.22 . 1.24 . 0.79 . 0.35 .                    12
              .  3.4 .  1.4 . -1.6 . -2.0 . -1.9 . -0.6 . -0.0 . -0.7 . -0.4 .  0.1 .  0.2 .
              ..............................................................................
                     . 0.34 . 1.08 . 1.21 . 1.21 . 1.27 . 1.20 . 1.23 . 1.10 . 0.35 .
                     . 0.35 . 1.10 . 1.21 . 1.18 . 1.23 . 1.17 . 1.19 . 1.08 . 0.35 .                           13
                     .  2.7 .  2.1 . -0.0 . -2.3 . -3.0 . -3.1 . -2.7 . -1.5 .  0.2 .
                     ................................................................
                            . 0.32 . 0.66 . 1.13 . 0.91 . 1.12 . 0.66 . 0.33 .
                            . 0.33 . 0.67 . 1.16 . 0.90 . 1.08 . 0.64 . 0.32 .                                  14
                            .  2.1 .  2.7 .  3.3 . -1.1 . -3.6 . -3.1 . -2.6 .
       ...............      ..................................................      ...............
       .   STANDARD  .                    . 0.27 . 0.32 . 0.27 .                    .   AVERAGE   .
       .  DEVIATION  .                    . 0.28 . 0.32 . 0.26 .                    .PCT DIFFERENCE.             15
       .   =1.241    .                    .  3.3 .  0.5 . -3.8 .                    .    = 1.6    .
       ...............                    ......................                    ...............
```

```
                                   SUMMARY
                                   -------

MAP NO: S1-10-02              DATE: 7/18/88               POWER: 42%

CONTROL ROD POSITIONS:        F-Q(T)   = 2.036            QPTR:

D BANK AT 171 STEPS           F-DH(N)  = 1.484            NW  1.000 | NE  0.989
                                                          ----------|----------
                              F(Z)     = 1.308            SW  1.005 | SE  1.007

                              F(XY)    = 1.443

                              BURNUP   = 12 MWD/MTU       A.O = -0.119(%)
```

FIGURE 6.3

SURRY UNIT 1 - CYCLE 10

ASSEMBLYWISE POWER DISTRIBUTION
HFP

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

       ................                   ......................                    ................
       .   PREDICTED  .                   . 0.30 . 0.36 . 0.30 .                    .   PREDICTED  .
       .   MEASURED   .                   . 0.30 . 0.37 . 0.30 .                    .   MEASURED   .          1
       .PCT DIFFERENCE.                   .  1.3 .  1.3 . -0.1 .                    .PCT DIFFERENCE.
       ................     ..................................................      ................
                            . 0.34 . 0.66 . 1.13 . 0.99 . 1.14 . 0.68 . 0.34 .
                            . 0.34 . 0.66 . 1.12 . 0.98 . 1.12 . 0.66 . 0.34 .                                2
                            .  0.7 . -0.4 . -0.9 . -1.1 . -1.8 . -2.4 . -1.4 .
                     ................................................................
                     . 0.36 . 1.06 . 1.17 . 1.18 . 1.26 . 1.18 . 1.18 . 1.06 . 0.36 .
                     . 0.36 . 1.05 . 1.15 . 1.17 . 1.21 . 1.14 . 1.15 . 1.05 . 0.36 .                         3
                     .  0.3 . -1.1 . -1.4 . -0.9 . -3.4 . -3.3 . -2.4 . -0.8 .  0.2 .
              ..............................................................................
              . 0.36 . 0.78 . 1.20 . 1.18 . 1.22 . 1.28 . 1.22 . 1.18 . 1.19 . 0.77 . 0.36 .
              . 0.36 . 0.78 . 1.17 . 1.17 . 1.20 . 1.25 . 1.17 . 1.16 . 1.17 . 0.76 . 0.36 .                  4
              . -0.5 . -0.8 . -2.2 . -1.3 . -1.8 . -2.5 . -3.9 . -1.9 . -1.3 . -1.1 . -0.8 .
       ............................................................................................
       . 0.35 . 1.06 . 1.19 . 1.21 . 1.21 . 1.28 . 1.26 . 1.27 . 1.20 . 1.20 . 1.19 . 1.06 . 0.34 .
       . 0.34 . 1.05 . 1.19 . 1.21 . 1.20 . 1.32 . 1.21 . 1.28 . 1.19 . 1.18 . 1.16 . 1.04 . 0.34 .           5
       . -1.2 . -1.2 . -0.5 .  0.1 . -0.2 .  3.1 . -3.9 .  0.8 . -0.5 . -1.7 . -1.9 . -1.2 . -0.6 .
       ............................................................................................
       . 0.68 . 1.18 . 1.18 . 1.20 . 1.30 . 1.21 . 1.21 . 1.21 . 1.29 . 1.19 . 1.17 . 1.17 . 0.67 .
       . 0.67 . 1.16 . 1.18 . 1.22 . 1.32 . 1.25 . 1.26 . 1.24 . 1.30 . 1.18 . 1.16 . 1.15 . 0.66 .           6
       . -1.4 . -1.4 .  0.0 .  1.5 .  1.7 .  3.1 .  4.3 .  3.1 .  1.0 . -0.8 . -1.4 . -1.6 . -2.0 .
..........................................................................................................
. 0.30 . 1.14 . 1.18 . 1.22 . 1.28 . 1.21 . 1.05 . 1.26 . 1.04 . 1.20 . 1.21 . 1.21 . 1.18 . 1.14 . 0.30 .
. 0.30 . 1.13 . 1.17 . 1.22 . 1.29 . 1.24 . 1.08 . 1.31 . 1.09 . 1.24 . 1.23 . 1.20 . 1.16 . 1.10 . 0.29 .    7
.  1.5 . -0.4 . -1.5 . -0.1 .  1.2 .  2.0 .  3.1 .  4.3 .  4.9 .  3.5 .  1.1 . -0.8 . -2.1 . -3.1 . -2.8 .
..........................................................................................................
. 0.36 . 0.99 . 1.26 . 1.29 . 1.26 . 1.21 . 1.26 . 1.26 . 1.26 . 1.20 . 1.27 . 1.28 . 1.26 . 0.99 . 0.36 .
. 0.37 . 0.99 . 1.25 . 1.29 . 1.27 . 1.23 . 1.29 . 1.33 . 1.31 . 1.25 . 1.29 . 1.26 . 1.23 . 0.97 . 0.36 .    8
.  1.5 .  0.0 . -0.5 . -0.1 .  0.7 .  1.4 .  3.1 .  4.9 .  4.7 .  4.1 .  2.2 . -1.5 . -2.2 . -1.8 . -0.8 .
..........................................................................................................
. 0.30 . 1.14 . 1.19 . 1.22 . 1.28 . 1.21 . 1.04 . 1.26 . 1.05 . 1.21 . 1.27 . 1.22 . 1.18 . 1.13 . 0.30 .
. 0.30 . 1.13 . 1.17 . 1.22 . 1.29 . 1.22 . 1.06 . 1.31 . 1.10 . 1.24 . 1.30 . 1.21 . 1.16 . 1.13 . 0.30 .    9
.  1.5 . -0.5 . -1.5 . -0.2 .  0.8 .  1.0 .  1.6 .  4.4 .  5.5 .  2.8 .  2.0 . -0.9 . -1.4 . -0.7 .  1.4 .
..........................................................................................................
       . 0.68 . 1.18 . 1.18 . 1.20 . 1.29 . 1.21 . 1.21 . 1.21 . 1.29 . 1.20 . 1.18 . 1.18 . 0.67 .
       . 0.66 . 1.15 . 1.17 . 1.20 . 1.30 . 1.23 . 1.25 . 1.25 . 1.33 . 1.21 . 1.18 . 1.17 . 0.67 .          10
       . -2.6 . -2.6 . -1.2 . -0.1 .  0.6 .  1.7 .  3.0 .  3.5 .  2.5 .  0.9 . -0.0 . -0.6 . -0.8 .
       ............................................................................................
       . 0.34 . 1.06 . 1.19 . 1.20 . 1.20 . 1.27 . 1.26 . 1.28 . 1.20 . 1.20 . 1.19 . 1.06 . 0.34 .
       . 0.35 . 1.06 . 1.18 . 1.18 . 1.20 . 1.29 . 1.29 . 1.31 . 1.23 . 1.21 . 1.20 . 1.06 . 0.34 .          11
       .  0.4 .  0.4 . -0.2 . -1.1 . -0.1 .  1.2 .  2.1 .  2.2 .  1.8 .  0.4 .  0.3 .  0.1 . -0.3 .
       ............................................................................................
              . 0.36 . 0.77 . 1.18 . 1.18 . 1.22 . 1.29 . 1.22 . 1.18 . 1.20 . 0.79 . 0.36 .
              . 0.37 . 0.78 . 1.17 . 1.17 . 1.22 . 1.30 . 1.23 . 1.18 . 1.20 . 0.79 . 0.37 .                 12
              .  3.4 .  1.7 . -1.1 . -0.6 . -0.0 .  1.0 .  0.5 . -0.3 . -0.1 .  0.2 .  0.8 .
              ..............................................................................
                     . 0.36 . 1.05 . 1.17 . 1.19 . 1.26 . 1.18 . 1.18 . 1.07 . 0.37 .
                     . 0.36 . 1.04 . 1.16 . 1.18 . 1.24 . 1.14 . 1.14 . 1.05 . 0.37 .                        13
                     .  1.3 . -0.9 . -0.6 . -0.3 . -1.8 . -3.2 . -3.1 . -1.8 .  0.4 .
                     ................................................................
                            . 0.34 . 0.67 . 1.15 . 0.99 . 1.14 . 0.67 . 0.35 .
                            . 0.34 . 0.67 . 1.17 . 0.98 . 1.10 . 0.65 . 0.34 .                               14
                            . -0.9 .  0.1 .  1.6 . -1.4 . -3.3 . -3.2 . -3.1 .
       ................     ..................................................      ................
       .   STANDARD   .                   . 0.30 . 0.37 . 0.30 .                    .    AVERAGE   .
       .   DEVIATION  .                   . 0.31 . 0.36 . 0.29 .                    .PCT DIFFERENCE.         15
       .    =1.215    .                   .  1.6 . -0.4 . -3.4 .                    .     =  1.6   .
       ................                   ......................                    ................

                                          SUMMARY
                                          -------

   MAP NO: S1-10-06               DATE: 7/29/88                 POWER: 100%

   CONTROL ROD POSITIONS:         F-Q(T)   = 1.822              QPTR:

   D BANK AT 225 STEPS            F-DH(N)  = 1.488              NW  1.002 | NE  0.990
                                                                ----------|----------
                                  F(Z)     = 1.189              SW  1.002 | SE  1.006

                                  F(XY)    = 1.421

                                  BURNUP   = 238 MWD/MTU        A.O = -0.194(%)
```

SECTION 7

REFERENCES

1. C. B. Laroe, A. H. Nicholson, "Surry Unit 1, Cycle 10 Design Report," NE Technical Report No. 633, Virginia Power, May 1988.

2. Surry Power Station Technical Specifications, Sections 3.12.C.1 and 3.12.B.1.

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

4. "Technical Manual for Westinghouse Solid State Reactivity Computer," Westinghouse Electric Corporation.

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

APPENDIX

STARTUP PHYSICS TESTS RESULTS AND EVALUATION SHEETS

JUL 4 1988

SURRY POWER STATION UNIT 1 CYCLE 10
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Reactivity Computer Checkout Proc No /Section: 1-PT-28.11 Sequence Step No: 3	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: 225 CC: 225 CD: *	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: 225 CC: 225 CD: 194	RCS Temperature (°F): 544.3 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 7/14/88 @ 1304	
IV Test Results	Measured Parameter (Description)	ρ_c = Meas. Reactivty using ρ-computer ρ_t = Inferred React from react period
	Measured Value	ρ_c = +44 pcm -40 pcm ρ_t = +44 pcm -40 pcm %D = 0.0% 0.0%
	Design Value (Actual Conditions)	$\%D = \{(\rho_c - \rho_t)/\rho_t\} \times 100\% \leq 4.0\%$
	Design Value (Design Conditions)	$\%D = \{(\rho_c - \rho_t)/\rho_t\} \times 100\% \leq 4.0\%$
	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 Allowable Range = ± 40 pcm	

Completed By: ____________
Test Engineer

Evaluated By: ____________

Recommended for Approval By : ____________
NFO Engineer

JUL 4 1988

SURRY POWER STATION UNIT 1 CYCLE 10
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Critical Boron Concentration - ARO Proc No /Section: 1-PT-28.11 Sequence Step No: 4	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: 225 CC: 225 CD: 225	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: 225 CC: 225 CD: 225	RCS Temperature (°F): 546.0 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 7/15/88 0445	
	Meas Parameter (Description)	$(C_B)^{M}_{ARO}$; Critical Boron Conc - ARO
	Measured Value	$(C_B)^{M}_{ARO}$ = 1567 ppm
	Design Value (Actual Cond)	C_B = 1610 ± 50 ppm
	Design Value (Design Cond)	C_B =1610 ± 50 ppm
	Reference	NE Technical Report No. 633
V Acceptance Criteria	FSAR/Tech Spec	$\alpha C_B \times C_B \leq 15{,}115$ pcm
	Reference	UFSAR Section 14.2.5
	Design Tolerance is met : ✓YES ___NO Acceptance Criteria is met : ✓YES ___NO	
VI Comments	$\alpha C_B = -7.80$ pcm/ppm for preliminary analysis $\alpha C_B = -7.61$ pcm/ppm for final analysis	

Completed By: __________
Test Engineer

Evaluated By: __________

Recommended for Approval By : __________
NFO Engineer

JUL 4 1988

SURRY POWER STATION UNIT 1 CYCLE 10
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Isothermal Temperature Coefficient - ARO Proc No /Section: 1-PT-28.11 Sequence Step No: 5	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: 225 CC: 225 CD: 225	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: 225 CC: 225 CD: 225	RCS Temperature (°F): 546.3 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 7-15-88 / 0549	
	Meas Parameter (Description)	$(\alpha_T^{ISO})_{ARO}$ Isothermal Temp Coeff - ARO
	Measured Value	$(\alpha_T^{ISO})_{ARO} = -3.22$ pcm/°F (C_B = 1566 ppm)
	Design Value (Actual Cond)	$(\alpha_T^{ISO})_{ARO} = -4.01 \pm 3.0$ pcm/°F (C_B = 1566 ppm)
	Design Value (Design Cond)	$(\alpha_T^{ISO})_{ARO} = -3.57 \pm 3.0$ pcm/°F (C_B = 1610 ppm)
	Reference	NE Technical Report No. 633
V Acceptance Criteria	FSAR/Tech Spec	$\alpha_T^{ISO} \leq 0.80^*$ pcm/°F $\alpha_T^{Dop} = -1.70$ pcm/°F
	Reference	TS 3.1, NE Technical Report No. 633
VI	Design Tolerance is met : ✓YES ___NO Acceptance Criteria is met : ✓YES ___NO	
Comments	* Uncertainty on αT_{MOD} = 0.5 pcm/°F (Reference: memorandum from C. T. Snow to E. J. Lozito dated June 27, 1980).	

Completed By: J.W. Henderson
Test Engineer

Evaluated By: Tom A. Brookman

Recommended for Approval By : C A Ford
NFO Engineer

JUL 4 1988

SURRY POWER STATION UNIT 1 CYCLE 10
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Cntl Bank B Worth Meas.,Rod Swap Ref. Bank Proc No /Section: 1-PT-28.11 Sequence Step No:6	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB:Moving CC: 225 CD: 225	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB:Moving CC: 225 CD: 225	RCS Temperature (°F): 545.2 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 7/15/88 0725	
IV Test Results	Measured Parameter (Description)	I_B^{REF} ; Integral Worth of Cntl Bank B, All Other Rods Out
	Measured Value	I_B^{REF} = 1134.4 pcm
	Design Value (Actual Conditions)	I_B^{REF} = 1242 ± 124 pcm
	Design Value (Design Conditions)	I_B^{REF} = 1242 ± 124 pcm
	Reference	NE Technical Report No. 633
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	

Completed By: ______________
Test Engineer

Evaluated By: ______________

Recommended for
Approval By : ______________
NFO Engineer

JUL 4 1988

SURRY POWER STATION UNIT 1 CYCLE 10
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Critical Boron Concentration - B Bank In Proc No /Section: 1-PT-28.11 Sequence Step No:7	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: 0 CC: 225 CD: 225	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB: 0 CC: 225 CD: 225	RCS Temperature (°F): 545.3 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 7/15/88 1315	
IV Test Results	Meas Parameter (Description)	$(C_B)^M_D$; Critical Boron Conc - B Bank In
	Measured Value	$(C_B)^M_D$ = 1418 ppm
	Design Value (Actual Cond)	C_B = 1408 ± 29 ppm
	Design Value (Design Cond)	$C_B = 1451 + \Delta C_B^{Prev} \pm (10 + 145.1/\lvert\alpha C_B\rvert)$ppm
	Reference	NE Technical Report No. 633
V Acceptance Criteria	FSAR/Tech Spec	$\alpha C_B \times C_B \leq 15{,}115$ pcm
	Reference	UFSAR Section 14.2.5
	Design Tolerance is met : [✓ YES] __NO Acceptance Criteria is met : [✓ YES] __NO	
VI Comments	αC_B = -7.80 pcm/ppm for preliminary analysis $\Delta C_B^{Prev} = (C_B)^M_{ARO} - 1610$ αC_B = -7.61 pcm/ppm for final analysis	

Completed By: M Paul
Test Engineer

Evaluated By: Pierce

Recommended for Approval By :
NFO Engineer

JUL 4 1988

SURRY POWER STATION UNIT 1 CYCLE 10
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: HZP Boron Worth Coefficent Measurement Proc No /Section: 1-PT-28.11 Sequence Step No: 7	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB:Moving CC: 225 CD: 225	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB:Moving CC: 225 CD: 225	RCS Temperature (°F): 545.3 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 7/15/88 1345	
	Measured Parameter (Description)	αC_B, Boron Worth Coefficient
	Measured Value	αC_B = -7.61 pcm/ppm
	Design Value (Actual Conditions)	αC_B = -7.80 ± 0.78 pcm/ppm
	Design Value (Design Conditions)	αC_B = -7.80 ± 0.78 pcm/ppm
	Reference	NE Technical Report No. 633
V Acceptance Criteria	FSAR/Tech Spec	$\alpha C_B \times C_B \leq 15{,}115$ pcm
	Reference	UFSAR Section 14.2.5
VI Comments	Design Tolerance is met : ✓ YES ___NO Acceptance Criteria is met : ✓ YES ___NO	

Completed By: ____________
Test Engineer

Evaluated By: K.S. Prince

Recommended for Approval By: ____________
NFO Engineer

JUL 4 1988

SURRY POWER STATION UNIT 1 CYCLE 10
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Cntl Bank D Worth Measurement-Rod Swap Proc No /Section: 1-PT-28.11 Sequence Step No:9	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB:Moving CC: 225 CD:Moving	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB:Moving CC: 225 CD:Moving	RCS Temperature (°F): 545.3 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 7/15/88 1425	
	Meas Parameter (Description)	I_D^{RS} ; Int Worth of Cntl Bank D-Rod Swap
	Measured Value	I_D^{RS} = 1077 (Adj. Meas. Crit. Ref Bank Position = 204 steps)
	Design Value (Actual Cond)	I_D^{RS} = 1118 (Adj. Meas. Crit. Ref Bank Position = 194 steps)
	Design Value (Design Cond)	I_D^{RS} = 1120 ± 168 pcm (Critical Ref Bank Position = 194 steps)
	Reference	NE Technical Report No. 633, VEP-FRD-36A, NFO-TI-2.2A
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	

Completed By: Test Engineer

Evaluated By: Pierce

Recommended for Approval By : NFO Engineer

JUL 4 1988

SURRY POWER STATION UNIT 1 CYCLE 10
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Cntl Bank C Worth Measurement-Rod Swap Proc No /Section: 1-PT-28.11 Sequence Step No:10	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB:Moving CC:Moving CD: 225	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB:Moving CC:Moving CD: 225	RCS Temperature (°F): 544.8 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 7/15/88 1507	
	Meas Parameter (Description)	I_C^{RS}; Int Worth of Cntl Bank C-Rod Swap
	Measured Value	I_C^{RS} = 824 (Adj. Meas. Crit. Ref Bank Position = 154 steps)
	Design Value (Actual Cond)	I_C^{RS} = 824 (Adj. Meas. Crit. Ref Bank Position = 143 steps)
	Design Value (Design Cond)	I_C^{RS} = 831 ± 125 pcm (Critical Ref Bank Position = 143 steps)
	Reference	NE Technical Report No. 633, VEP-FRD-36A, NFO-TI-2.2A
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	

Completed By: J Raymo
Test Engineer

Evaluated By: K.L. Pierce

Recommended for Approval By :
NFO Engineer

JUL 4 1988

SURRY POWER STATION UNIT 1 CYCLE 10
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Cntl Bank A Worth Measurement-Rod Swap Proc No /Section: 1-PT-28.11 Sequence Step No: 11	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 225 SDB: 225 CA:Moving CB:Moving CC: 225 CD: 225	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 225 SDB: 225 CA:Moving CB:Moving CC: 225 CD: 225	RCS Temperature (°F): 546.0 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 7/15/88 1639	
	Meas Parameter (Description)	I_A^{RS} ; Int Worth of Cntl Bank A - Rod Swap
	Measured Value	I_A^{RS} = 299 (Adj. Meas. Crit. Ref Bank Position = 79 steps)
	Design Value (Actual Cond)	I_A^{RS} = 353 (Adj. Meas. Crit. Ref Bank Position = 80 steps)
	Design Value (Design Cond)	I_A^{RS} = 352 ± 100 pcm (Critical Ref Bank Position = 80 steps)
	Reference	NE Technical Report No. 633, VEP-FRD-36A, NFO-TI-2.2A
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	

Completed By: __________
Test Engineer

Evaluated By: N.S. Pierce

Recommended for Approval By : __________
NFO Engineer

JUL 4 1987

SURRY POWER STATION UNIT 1 CYCLE 10
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Shutdown Bank B Worth Meas. - Rod Swap Proc No /Section: 1-PT-28.11 Sequence Step No: 12	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 225 SDB:Moving CA: 225 CB:Moving CC: 225 CD: 225	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 225 SDB:Moving CA: 225 CB:Moving CC: 225 CD: 225	RCS Temperature (°F): 5455 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 7/15/88 1710	
	Meas Parameter (Description)	I_{SB}^{RS}; Int Worth of Shutdown Bank B-Rod Swap
	Measured Value	$I_{SB}^{RS} = 979$ (Adj. Meas. Crit. Ref Bank Position = 183 steps)
	Design Value (Actual Cond)	$I_{SB}^{RS} = 990$ (Adj. Meas. Crit. Ref Bank Position = 170 steps)
	Design Value (Design Cond)	$I_{SB}^{RS} = 988 \pm 148$ pcm (Critical Ref Bank Position = 170 steps)
	Reference	NE Technical Report No. 633, VEP-FRD-36A, NFO-TI-2.2A
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	

Completed By: J Rayno
Test Engineer

Evaluated By: N. S. Pierce

Recommended for Approval By : BO Mann
NFO Engineer

JUL 4 1988

SURRY POWER STATION UNIT 1 CYCLE 10
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Shutdown Bank A Worth Meas. - Rod Swap Proc No /Section: 1-PT-28.11 Sequence Step No: 13	
II Test Conditions (Design)	Bank Positions (Steps) SDA:Moving SDB: 225 CA: 225 CB:Moving CC: 225 CD: 225	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA:Moving SDB: 225 CA: 225 CB:Moving CC: 225 CD: 225	RCS Temperature (°F): 545.5 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 7/15/88 1749	
	Meas Parameter (Description)	I_{SA}^{RS}; Int Worth of Shutdown Bank A-Rod Swap
	Measured Value	I_{SA}^{RS} = 879 (Adj. Meas. Crit. Ref Bank Position = 164 steps)
	Design Value (Actual Cond)	I_{SA}^{RS} = 1002 (Adj. Meas. Crit. Ref Bank Position = 172 steps)
	Design Value (Design Cond)	I_{SA}^{RS} = 999 ± 150 pcm (Critical Ref Bank Position = 172 steps)
	Reference	NE Technical Report No. 633, VEP-FRD-36A, NFO-TI-2.2A
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	

Completed By: J Rayno
Test Engineer

Evaluated By: N.S. Pierce

Recommended for Approval By :
NFO Engineer

JUL 4 1988

SURRY POWER STATION UNIT 1 CYCLE 10
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Total Rod Worth - Rod Swap Proc No /Section: 1-PT-28.11 Sequence Step No: 13	
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): 545.3 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: [illegible] 7/15/88 07/15/88 ~~0720~~ 0725	
	Meas Parameter (Description)	I_{Total}; Int Worth of All Banks - Rod Swap
	Measured Value	I_{Total} = 5192
	Design Value (Actual Cond)	I_{Total} = 5529
	Design Value (Design Cond)	I_{Total} = 5532 ± 553 pcm
	Reference	NE Technical Report No. 633, VEP-FRD-36A, NFO-TI-2.2A
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	

Completed By: J Rayno
Test Engineer

Evaluated By: N L Pierce

Recommended for Approval By : [illegible]
NFO Engineer

JUL 4 1988

SURRY POWER STATION UNIT 1 CYCLE 10
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference

Test Description: M/D Flux Map - Low power
Proc No / Section: 1-PT-28.2, 1-OP-57 Sequence Step No: 41

II Test Conditions (Design)

Bank Positions (Steps)

SDA: 225 SDB: 225 CA: 225
CB : 225 CC : 225 CD: *

RCS Temperature (°F): T_{REF} ±1
Power Level (% F.P.): <30
Other (specify)
Must have ≥ 38 thimbles

III Test Conditions (Actual)

Bank Positions (Steps)

SDA: 225 SDB: 225 CA: 225
CB : 225 CC : 225 CD: 158

RCS Temperature(°F): 552 °F
Power Level (% F.P.): 29 %
Other (Specify):
42 Thimbles obtained

Date/Time Test Performed: 7/18/88 @ 0637

IV Test Results	Meas Parameter (Description)	MAX. REL ASSY PWR % DIFF (M-P)/P	NUC ENTHAL RISE HOT CHAN FACT F-dH(N)	TOTAL HEAT FLUX HOT CHAN FACT F-Q(T)	QUADRANT POWER TILT RATIO QPTR
	Measured Value	+5.9% in loc. G-14 for $P_i \geq 0.9$ -6.3% in loc. G-15 for $P_i < 0.9$	1.498	2.152	1.0071
	Design Value (Design Conds)	± 10% for $P_i \geq 0.9$ ± 15% for $P_i < 0.9$ (P_i = Assy. Pwr.)	NA	NA	≤ 1.024 **
	Reference	WCAP-7905 REV.1	NONE	NONE	WCAP-7905 REV.1
V Acceptance Criteria	FSAR/Tech Spec	NONE	$F^N_{\Delta H} \leq 1.55(1+.3(1-P))$	$F^T_Q(Z) \leq 4.64/P \times K(Z)$	NA
	Reference	NONE	TS 3.12	TS 3.12	TS 3.12

VI Comments

Design Tolerance is met : ✓ YES ___ NO
Acceptance Criteria is met : ✓ YES ___ NO

* As Required
**The design value of QPTR is the sum of the .004 design prediction tilt and the 1.02 uncertainty identified in WCAP-7905.

Completed By: ____________
Test Engineer

Evaluated By: ____________

Recommended for Approval By : ____________
NFO Engineer

JUL 4 1988

SURRY POWER STATION UNIT 1 CYCLE 10
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference

Test Description: M/D Flux Map-At Power
Proc No / Section: 1-PT-28.2, 1-OP-57 Sequence Step No: 43

II Test Conditions (Design)

Bank Positions (Steps)
SDA: 225 SDB: 225 CA: 225
CB : 225 CC : 225 CD: *

RCS Temperature (°F): T_{REF} ±1
Power Level (% F.P.): ~ 50
Other (specify)
Must have ≥ 38 thimbles

III Test Conditions (Actual)

Bank Positions (Steps)
SDA: 225 SDB: 225 CA: 225
CB : 225 CC : 225 CD: 171

RCS Temperature(°F): 556°F
Power Level (% F.P.): 42%
Other (Specify):
42 Thimbles Obtained

Date/Time Test Performed: 7/18/88 @ 2219

IV Test Results

Meas Parameter (Description)	MAX. REL ASSY PWR % DIFF (M-P)/P	NUC ENTHAL RISE HOT CHAN FACT F-dH(N)	TOTAL HEAT FLUX HOT CHAN FACT F-Q(T)	QUADRANT POWER TILT RATIO QPTR
Measured Value	5.1% for Pi ≥ 0.9 @ location G7 4.2% for Pi < 0.9 @ location L2	1.484	2.036	1.0066
Design Value (Design Conds)	± 10% for $P_i \geq 0.9$ ± 15% for $P_i < 0.9$ (P_i = Assy. Pwr.)	NA	NA	≤ 1.02
Reference	WCAP-7905 REV. 1	NONE	NONE	WCAP-7905 REV. 1

V Acceptance Criteria

FSAR/Tech Spec	NONE	$F^N_{\Delta H} \leq 1.55(1+.3(1-P))$	$F_Q(Z) \leq 4.64 \times K(Z)$ For $P \leq 0.5$ $F_Q(Z) \leq 2.32/P \times K(Z)$ For $P > 0.5$	NA
Reference	NONE	TS 3.12	TS 3.12	TS 3.12

VI Comments

Design Tolerance is met : ✓ YES ___ NO
Acceptance Criteria is met : ✓ YES ___ NO

* As Required

Completed By: John W. Henderson
Test Engineer

Evaluated By: Tom A.

Recommended for Approval By :
NFO Engineer

JUL 4 1988

SURRY POWER STATION UNIT 1 CYCLE 10
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Descri6tion: M/D Flux Map-At Power,NI Calibration Proc No / Section: 1-PT-28.2, 1-OP-57 Sequence Step No: 44	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB : 225 CC : 225 CD: **	RCS Temperature (°F): T_{REF} ±1 Power Level (% F.P.): ~ 70 Other (specify): *
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB : 225 CC : 225 CD: 189	RCS Temperature(°F): 565 °F Power Level (% F.P.): 68.5% Other (Specify): 1/4-core map - 21 Thimbles
	Date/Time Test: 7/20/88 Performed: @ 0112	

IV Test Results	Meas Parameter (Description)	MAX. REL ASSY PWR % DIFF (M-P)/P	NUC ENTHAL RISE HOT CHAN FACT F-dH(N)	TOTAL HEAT FLUX HOT CHAN FACT F-Q(T)	QUADRANT POWER TILT RATIO QPTR
	Measured Value	N/A	N/A	N/A	N/A
	Design Value (Design Conds)	± 10% for $P_i \ge 0.9$ ± 15% for $P_i < 0.9$ (P_i = Assy. Pwr.)	NA	NA	≤ 1.02
	Reference	WCAP-7905 REV.1	NONE	NONE	WCAP-7905 REV.1
V Acceptance Criteria	FSAR/Tech Spec	NONE	$F^N_{\Delta H} \le 1.55(1+.3(1-P))$	$F^T_Q(Z) \le 2.32/P \times K(Z)$	NA
	Reference	NONE	TS 3.12	TS 3.12	TS 3.12

VI Comments

Design Tolerance is met : ✓YES ___NO
Acceptance Criteria is met : ✓YES ___NO

* Must have at least 38 thimbles for a full-core flux map, or at least 16 thimbles for a quarter-core flux map.
** As Required

Completed By: ______________
Test Engineer

Evaluated By: Tom A. Brookmire

Recommended for Approval By : C. A. Ford
NFO Engineer

SURRY POWER STATION UNIT 1 CYCLE 10
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

JUL 4 [illegible]

I Reference	Test Description: M/D Flux Map-At Power,NI Calibration Proc No / Section: 1-PT-28.2, 1-OP-57 Sequence Step No: 45	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB : 225 CC : 225 CD: **	RCS Temperature (°F):T_{REF} ±1 Power Level (% F.P.): ~ 70 Other (specify): *
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB : 225 CC : 225 CD: 180	RCS Temperature(°F): 565 °F Power Level (% F.P.): 68.4% Other (Specify): 1/4-core map - 21 Thimbles
	Date/Time Test: 7/20/88 Performed: @ 0309	

IV	Meas Parameter (Description)	MAX. REL ASSY PWR % DIFF (M-P)/P	NUC ENTHAL RISE HOT CHAN FACT F-dH(N)	TOTAL HEAT FLUX HOT CHAN FACT F-Q(T)	QUADRANT POWER TILT RATIO QPTR
Test Results	Measured Value	N/A	N/A	N/A	N/A
	Design Value (Design Conds)	± 10% for $P_i \ge 0.9$ ± 15% for $P_i < 0.9$ (P_i = Assy. Pwr.)	NA	NA	≤ 1.02
	Reference	WCAP-7905 REV.1	NONE	NONE	WCAP-7905 REV.1
V Acceptance Criteria	FSAR/Tech Spec	NONE	$F^N_{\Delta H} \le 1.55(1+.3(1-P))$	$F^T_Q(Z) \le 2.32/P \times K(Z)$	NA
	Reference	NONE	TS 3.12	TS 3.12	TS 3.12

VI Comments

Design Tolerance is met : ✓ YES __NO
Acceptance Criteria is met : ✓ YES __NO

*** Must have at least 38 thimbles for a full-core flux map, or at least 16 thimbles for a quarter-core flux map.**
**** As Required**

Completed By: J.W. Hench
Test Engineer

Evaluated By: Tom A Brookmire

Recommended for Approval By : P C Ford
NFO Engineer

JUL 4 1988

SURRY POWER STATION UNIT 1 CYCLE 10
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference

Test Description: M/D Flux Map-At Power,NI Calibration
Proc No / Section: 1-PT-28.2, 1-OP-57 Sequence Step No: 46

II Test Conditions (Design)

Bank Positions (Steps)
SDA: 225 SDB: 225 CA: 225
CB : 225 CC : 225 CD: **

RCS Temperature (°F): T_{REF} ±1
Power Level (% F.P.): ~ 70
Other (specify): *

III Test Conditions (Actual)

Bank Positions (Steps)
SDA: 225 SDB: 225 CA: 225
CB : 225 CC : 225 CD: 208

RCS Temperature(°F): 565 °F
Power Level (% F.P.): 68.1 %
Other (Specify):
1/4-Core map - 20 Thimbles

Date/Time Test Performed: 7/20/88 @ 0509

IV Test Results	Meas Parameter (Description)	MAX. REL ASSY PWR % DIFF (M-P)/P	NUC ENTHAL RISE HOT CHAN FACT F-dH(N)	TOTAL HEAT FLUX HOT CHAN FACT F-Q(T)	QUADRANT POWER TILT RATIO QPTR
	Measured Value	N/A	N/A	N/A	N/A
	Design Value (Design Conds)	± 10% for $P_i \geq 0.9$ ± 15% for $P_i < 0.9$ (P_i = Assy. Pwr.)	NA	NA	≤ 1.02
	Reference	WCAP-7905 REV. 1	NONE	NONE	WCAP-7905 REV. 1
V Acceptance Criteria	FSAR/Tech Spec	NONE	$F^N_{\Delta H} \leq 1.55(1+.3(1-P))$	$F^T_Q(Z) \leq 2.32/P \times K(Z)$	NA
	Reference	NONE	TS 3.12	TS 3.12	TS 3.12

VI Comments

Design Tolerance is met : ✓YES ___NO
Acceptance Criteria is met : ✓YES ___NO

* Must have at least 38 thimbles for a full-core flux map, or at least 16 thimbles for a quarter-core flux map.
** As Required

Completed By: J.W. Henderson
Test Engineer

Evaluated By: Tom A Brookman

Recommended for Approval By : C.C. Ford
NFO Engineer

JUL 4 1988

SURRY POWER STATION UNIT 1 CYCLE 10
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: M/D Flux Map - HFP, ARO, Eq. Xe Proc No / Section: 1-PT-28.2, 1-OP-57 Sequence Step No: 47	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB : 225 CC : 225 CD: *	RCS Temperature (°F): T_{REF} ±1 Power Level (% F.P.): 95 ± 5 Other (specify): Eq. Xe. Must have ≥ 38 thimbles
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 225 SDB: 225 CA: 225 CB : 225 CC : 225 CD: 225	RCS Temperature (°F): 574°F Power Level (% F.P.): 100 % Other (Specify): 45 Thimbles obtained
	Date/Time Test Performed: 07/29/88 @ 16:30	

IV	Meas Parameter (Description)	MAX. REL ASSY PWR % DIFF (M-P)/P	NUC ENTHAL RISE HOT CHAN FACT F-dH(N)	TOTAL HEAT FLUX HOT CHAN FACT F-Q(T)	QUADRANT POWER TILT RATIO QPTR
Test Results	Measured Value	5.5% for $P_i \geq 0.9$ in location G9 3.4% for $P_i < 0.9$ in location N12	1.488	1.822	1.0060
	Design Value (Design Conds)	± 10% for $P_i \geq 0.9$ ± 15% for $P_i < 0.9$ (P_i = Assy. Pwr.)	NA	NA	≤ 1.02
	Reference	WCAP-7905 REV. 1	NONE	NONE	WCAP-7905 REV. 1
V Acceptance Criteria	FSAR/Tech Spec	NONE	$F^N_{\Delta H} \leq 1.55(1+.3(1-P))$	$F^T_Q(Z) \leq 2.32/P \times K(Z)$	NA
	Reference	NONE	TS 3.12	TS 3.12	TS 3.12

VI
Comments

Design Tolerance is met : ✓YES ___NO
Acceptance Criteria is met : ✓YES ___NO

* As Required

Completed By: Test Engineer

Evaluated By:

Recommended for Approval By : NFO Engineer

VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

October 28, 1988

U. S. Nuclear Regulatory Commission		Serial No.	88-649
Attn: Document Control Desk		NO/BDM:vlh	R1
Washington, D.C. 20555		Docket Nos.	50-280
			50-281
		License Nos.	DPR-32
			DPR-37

Gentlemen:

VIRGINIA ELECTRIC AND POWER COMPANY
SURRY POWER STATION UNITS 1 AND 2
SURRY UNIT 1, CYCLE 10 STARTUP PHYSICS TESTS REPORT

For your information, enclosed are five copies of the Virginia Electric and Power Company Topical Report VP-NOS-41, "Surry Unit 1, Cycle 10 Startup Physics Tests Report" with an errata sheet. This report was due October 12, 1988, per Technical Specification 6.6. As discussed with the NRC Project Manager, we inadvertently missed the date due to an administrative oversight in the tracking process. This oversight has been corrected by discussing the reporting requirements of this type report with the affected personnel.

Very truly yours,

W. R. Cartwright
Vice President - Nuclear

Attachments

cc: U. S. Nuclear Regulatory Commission
Region II
101 Marietta Street, N.W.
Suite 2900
Atlanta, Georgia 30323

Mr. W. E. Holland
NRC Senior Resident Inspector
Surry Power Station

Mr. Chandu P. Patel
NRC Surry Project Manager
Project Directorate II-2
Division of Reactor Projects - I/II

IE26
1/1

ATTACHMENT 1