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SURRY UNIT 2, CYCLE 7 STARTUP PHYSICS TEST REPORT

NUCLEAR OPERATIONS DEPARTMENT

Virginia Electric and Power Company

VEP-NOS-7

SURRY UNIT 2, CYCLE 7

STARTUP PHYSICS TEST REPORT

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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 2, Cycle 7 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 2, Cycle 7 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 startup physics testing. The entries for the design values were based on the calculations performed by Vepco's Nuclear Fuel Engineering 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 June 30, 1983 Unit No. 2 of the Surry Power Station was shutdown for its seventh refueling. During this shutdown, 61 of the 157 fuel assemblies in the core were replaced with fresh fuel assemblies. The seventh cycle core consists of 6 sub-batches of fuel: one once-burned batch from Cycle 6 (sub-batch 8A), two twice burned sub-batches that were carried over from Cycle 5 (sub-batches 7A2 and 7B2), one thrice burned sub-batch that was carried over from Cycle 4 (sub-batch 6B5), and two fresh sub-batches (sub-batch 9A and sub-batch S1/9C). 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 7. Figure 1.5 identifies the location and number of control rods in the Cycle 7 core.

On September 25, 1983 at 1902, the seventh 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 1.8 second limit of the Surry Technical Specifications[2].

2. Individual control rod bank worths for all control rod banks were measured using the rod swap technique and were found to be within 5.6% of the design predictions. The sum of the individual control

rod bank worths was measured to be within 0.9% of the design prediction. These results are within the design tolerance of ±15% for individual bank worths (±10% for the rod swap reference bank worth) and the design tolerance of ±10% for the sum of the individual control rod bank worths.

3. Critical boron concentrations for two control bank configurations were measured to be within 24 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 ARO configuration was measured to be within 0.55 pcm/°F of design predictions. This is within the design tolerance of ±3 pcm/°F and met the accident analysis acceptance criterion.

6. Core power distributions at HZP indicated measured assemblywise power values to be somewhat larger than the established design tolerance. These higher-than-expected power values were accompanied by a quadrant power tilt ratio (QPTR) which at hot-zero-power, was measured to be approximately 2.9%, but decreased to 0.7% at full power. Core power distributions for various at-power conditions were generally within 8% of the predicted power distributions. These deviations of power

distribution at HZP had no adverse consequences since, for all maps, the hot channel factors were measured to be within the limits of the Technical Specifications.

In summary, all 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 2 - BOL CYCLE 7 PHYSICS TESTS

CHRONOLOGY OF TESTS

Test	Date	Time	Power	Reference Procedure
Hot Rod Drop-Hot Full Flow	9/21/83	0830	HSD	PT-7
Reactivity Computer Checkout	9/25/83	2200	HZP	PT28.11(B)
Boron Endpoint-ARO	9/26/83	0958	HZP	PT28.11(C)
Temperature Coefficient-ARO	9/26/83	1021	HZP	PT28.11(D)
Flux Map-ARO	9/26/83	1547	HZP	OP-57, PT28.2
Bank B Worth	9/26/83	2330	HZP	PT28.11(E)
Boron Endpoint-B In	9/27/83	0716	HZP	PT28.11(C)
Bank D Worth - Rod Swap	9/27/83	0811	HZP	PT28.11(F)
Bank C Worth - Rod Swap	9/27/83	0849	HZP	PT28.11(F)
Bank A Worth - Rod Swap	9/27/83	0920	HZP	PT28.11(F)
Bank SB Worth - Rod Swap	9/27/83	0947	HZP	PT28.11(F)
Bank SA Worth - Rod Swap	9/27/83	1020	HZP	PT28.11(F)
Flux Map - NI Calibration	9/29/83	0912	46.5%	OP-57, PT28.2
Flux Map - NI Calibration	9/29/83	1458	53.9%	OP-57, PT28.2
Flux Map - NI Calibration	9/29/83	2054	66.0%	OP-57, PT28.2
Flux Map - HFP, Eq. Xenon	10/5/83	1210	100%	OP-57, PT28.2

Figure 1.1

SURRY UNIT 2 - CYCLE 7

CORE LOADING MAP

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							8 1P2	*9C 6R4	8 2P6						
2					7B2 3N0	8 2P7	9 5R8	8 5P2	9 2R0	8 4P0	7B2 0N8				
3				8 5P3	9 3R9	9 3R1	8 0P9	8 4P8	8 2P3	9 5R7	9 1R7	8 2P0			
4			8 4P2	8 4P4	9 4R5	8 1P0	9 0R6	8 3P9	9 2R5	8 5P1	9 4R8	8 6P5	8 2P4		
5		7B2 3N2	9 5R6	9 2R6	7A2 0L7	9 1R0	6B5 W41	8 2P8	6B5 W11	9 5R4	7A2 0L4	9 2R1	9 5R2	7B2 0N6	
6		8 1P7	9 4R2	8 4P1	9 5R3	7A2 1L2	9 2R4	8 1P3	9 3R3	7A2 1L0	9 4R6	8 6P4	9 0R1	8 4P5	
7	8 2P2	9 5R1	8 3P8	9 0R2	6B5 W29	9 2R8	7B2 1N2	8 4P7	7B2 2N8	9 0R9	6B5 W20	9 1R8	8 0P7	9 3R6	8 1P8
8	*9C 6R2	8 5P5	8 1P6	8 0P4	8 6P6	8 2P5	8 3P3	9 1R3	8 5P6	8 6P0	8 1P4	8 0P3	8 0P2	8 3P0	*9C 6R3
9	8 4P6	9 3R5	8 4P9	9 1R9	6B5 W32	9 4R9	7B2 4N0	8 6P1	7B2 5N0	9 3R0	6B5 W04	9 2R9	8 3P6	9 4R1	8 3P4
10		8 1P1	9 5R5	8 0P6	9 3R4	7A2 1L1	9 1R5	8 2P9	9 0R3	7A2 0L2	9 6R0	8 3P7	9 3R8	8 5P0	
11		7B2 0N1	9 0R8	9 3R7	7A2 0L6	9 2R3	6B5 W05	8 1P9	6B5 W48	9 1R6	7A2 0L5	9 2R2	9 5R9	7B2 1N7	
12			8 0P5	8 5P4	9 4R7	8 6P2	9 2R7	8 6P7	9 4R3	8 6P8	9 0R4	8 0P1	8 5P8		
13				8 2P1	9 0R5	9 4R4	8 1P5	8 3P5	8 5P9	9 5R0	9 6R1	8 3P1			
14					7B2 0N4	8 6P3	9 1R1	8 3P2	9 0R7	8 5P7	7B2 2N3				
15							8 4P3	*9C 6R5	8 0P8						

--> BATCH
--> ASSEMBLY ID

FUEL ASSEMBLY DESIGN PARAMETERS

	SUB-BATCH					
	6B5	7A2	7B2	8A	9A	S1/9C
INITIAL ENRICHMENT (w/o U235)	3.20	3.13	3.41	3.61	3.59	3.59
BURNUP AT BOC 7 (MWD/MTU)	24,415	24,135	25,610	17,681	0	0
ASSEMBLY TYPE	15X15	15X15	15X15	15X15	15X15	15X15
NUMBER OF ASSEMBLIES	8	8	12	68	57	4
FUEL RODS PER ASSEMBLY	204	204	204	204	204	204

Figure 1.2

SURRY UNIT 2 - CYCLE 7

BEGINNING OF CYCLE FUEL ASSEMBLY BURNUPS

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
						1P2 16583	6R4 0	2P6 17365							1
				3N0 25523	2P7 14693	5R8 0	5P2 15408	2R0 0	4P0 15364	0N8 25916					2
			5P3 18842	3R9 0	3R1 0	0P9 19742	4P8 19597	2P3 19598	5R7 0	1R7 0	2P0 19061				3
		4P2 18777	4P4 19101	4R5 0	1P0 20061	0R6 0	3P9 19158	2R5 0	5P1 19549	4R8 0	6P5 19166	2P4 18718			4
	3N2 25400	5R6 0	2R6 0	0L7 23965	1R0 0	W41 24402	2P8 10944	W11 24270	5R4 0	0L4 24398	2R1 0	5R2 0	0N6 25634		5
	1P7 14774	4R2 0	4P1 19945	5R3 0	1L2 24309	2R4 0	1P3 19722	3R3 0	1L0 24394	4R6 0	6P4 19872	0R1 0	4P5 14871		6
2P2 16704	5R1 0	3P8 20237	0R2 0	W29 24336	2R8 0	1N2 25411	4P7 15626	2N8 25876	0R9 0	W20 24544	1R8 0	0P7 20055	3R6 0	1P8 16876	7
6R2 0	5P5 15424	1P6 19706	0P4 19704	6P6 10563	2P5 19285	3P3 15843	1R3 0	5P6 15289	6P0 19731	1P4 11428	0P3 19096	0P2 19297	3P0 15973	6R3 0	8
4P6 16854	3R5 0	4P9 19934	1R9 0	W32 23903	4R9 0	4N0 25799	6P1 15681	5N0 25894	3R0 0	W04 24670	2R9 0	3P6 19929	4R1 0	3P4 16239	9
	1P1 15216	5R5 0	0P6 19792	3R4 0	1L1 24193	1R5 0	2P9 19623	0R3 0	0L2 23972	6R0 0	3P7 20202	3R8 0	5P0 14690		10
	0N1 25721	0R8 0	3R7 0	0L6 23830	2R3 0	W05 24671	1P9 11479	W48 24521	1R6 0	0L5 24020	2R2 0	5R9 0	1N7 25239		11
		0P5 18917	5P4 19189	4R7 0	6P2 19886	2R7 0	6P7 19527	4R3 0	6P8 20167	0R4 0	0P1 19138	5P8 18566			12
			2P1 18903	0R5 0	4R4 0	1P5 20123	3P5 19236	5P9 20007	5R0 0	6R1 0	3P1 18578				13
				0N4 25450	6P3 14760	1R1 0	3P2 15870	0R7 0	5P7 14753	2N3 25456					14
						4P3 16807	6R5 0	0P8 16488							15

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

Figure 1.3

SURRY UNIT 2 - CYCLE 7
INCORE INSTRUMENTATION LOCATIONS

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

MD - MOVABLE DETECTOR
TC - THERMOCOUPLE

Figure 1.4

SURRY UNIT 2 - CYCLE 7

BURNABLE POISON AND SOURCE ASSEMBLY LOCATIONS

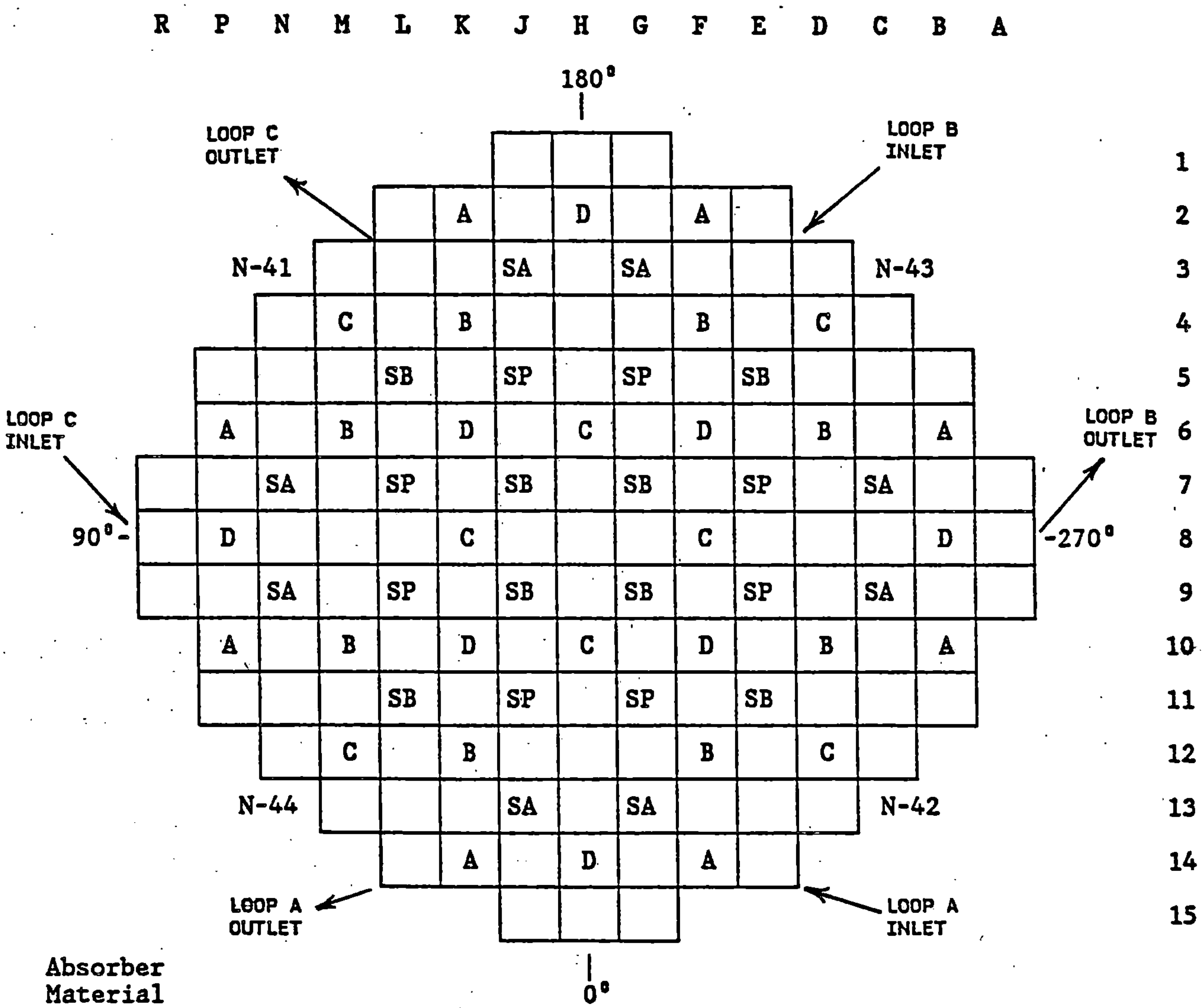
R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
															1
						12P		12P							2
				8P	16P		SS		16P	8P					3
				16P		20P	4P	20P		16P					4
		8P	16P		16P		4P		16P		16P	8P			5
		16P		16P		16P		16P		16P		16P			6
	12P		20P		16P		4P		16P		20P		12P		7
SS			4P	4P		4P	20P	4P		4P	4P				8
	12P		20P		16P		4P		16P		20P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

900 -- FRESH BURNABLE POISON RODS
SS -- SECONDARY SOURCE

Figure 1.5

SURRY UNIT 2 - CYCLE 7

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
SP (Spare Rod Locations)	8

SECTION 2

CONTROL ROD DROP TIME MEASUREMENTS

The drop time of each control rod was measured at cold and at hot 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 60Hz 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[2] 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. All test results met this limit.

Table 2.1

SURRY UNIT 2 - CYCLE 7 BOL PHYSICS TEST

HOT ROD DROP TIME SUMMARY

ROD DROP TIME TO DASHPOT ENTRY

SLOWEST ROD	FASTEST ROD	AVERAGE TIME
K-6, 1.29 sec.	P-6, 1.20 sec.	1.25 sec.

ROD DROP TIME TO BOTTOM OF DASHPOT

SLOWEST ROD	FASTEST ROD	AVERAGE TIME
G-9, 2.04 sec.	M-12, 1.87 sec.	1.97 sec.

Figure 2.1

SURRY UNIT 2 - CYCLE 7 BOL PHYSICS TEST

TYPICAL ROD DROP TRACE

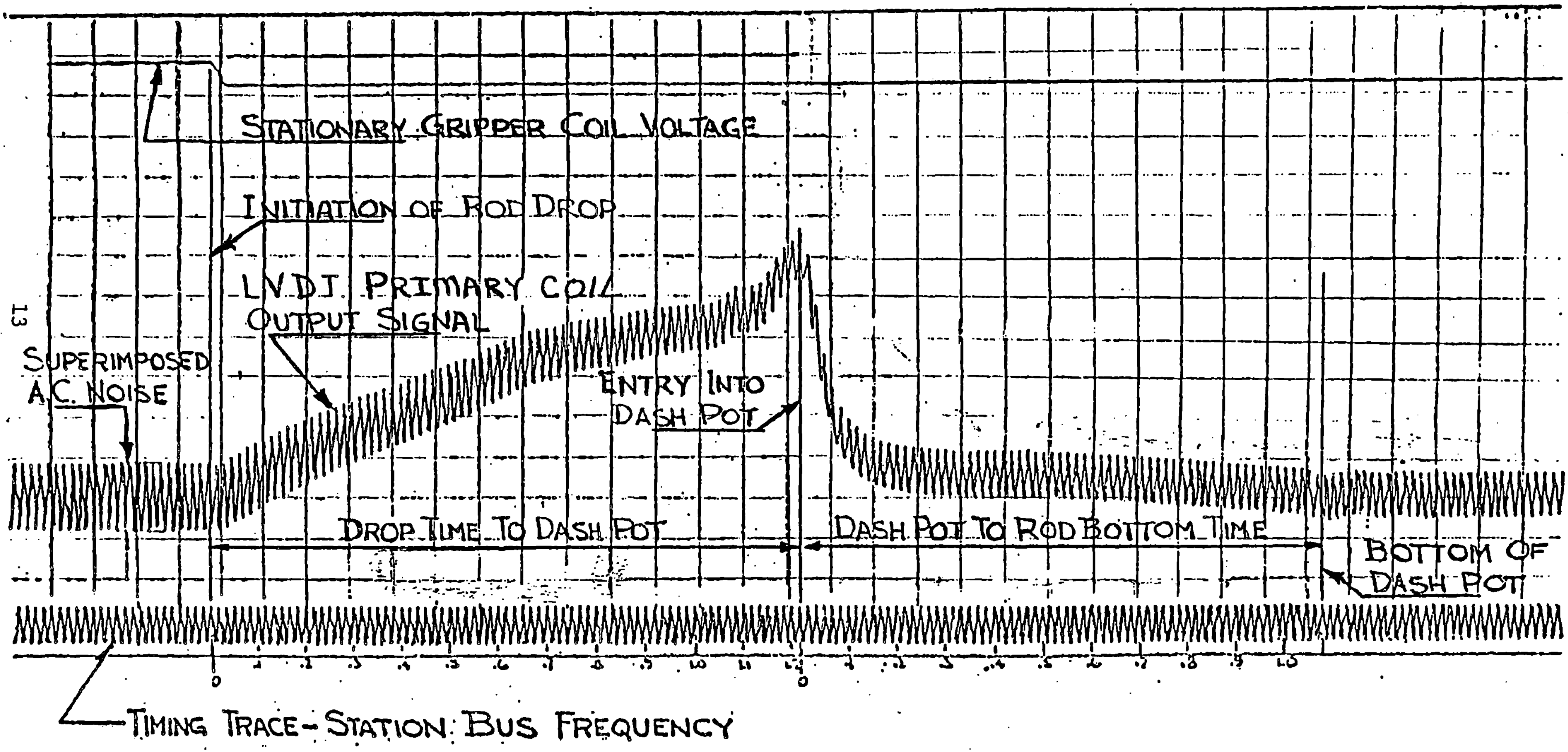


Figure 2.2

SURRY UNIT 2 - CYCLE 7 BOL PHYSICS TEST

ROD DROP TIME - HOT FULL FLOW CONDITIONS

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
1																1
2						1.24 / 1.94		1.26 / 1.98		1.25 / 1.94						2
3							1.23 / 2.01		1.25 / 1.93							3
4				1.22 / 1.90		1.22 / 1.94				1.23 / 1.95		1.28 / 2.01				4
5					1.25 / 1.98						1.28 / 1.98					5
6		1.20 / 1.96		1.21 / 1.94		1.29 / 2.01		1.27 / 1.99		1.25 / 1.96		1.24 / 1.97		1.28 / 2.01		6
7			1.22 / 1.99				1.25 / 1.93		1.26 / 2.02				1.26 / 1.99			7
8		1.24 / 2.03				1.28 / 1.96				1.24 / 1.97				1.28 / 2.03		8
9			1.25 / 1.93				1.25 / 1.96		1.26 / 2.04				1.23 / 1.96			9
10		1.21 / 1.89		1.24 / 2.04		1.28 / 2.01		1.25 / 2.01		1.29 / 1.99		1.23 / 1.94		1.22 / 1.93		10
11					1.26 / 1.97						1.29 / 1.99					11
12				1.23 / 1.87		1.22 / 1.97				1.26 / 1.97		1.24 / 1.94				12
13							1.23 / 1.93		1.26 / 1.94							13
14						1.27 / 2.02		1.28 / 1.98		1.23 / 1.97						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 all control and shutdown banks using the rod swap[3] 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 all of the control and shutdown banks were within the design tolerance (±10% for the reference bank and ±15% for the test banks). The sum of the individual rod bank worths was measured to be within -0.9% of the design prediction. This is well within the design tolerance of ±10% for the sum of the individual control rod bank worths.

The integral and differential reactivity worths of the reference bank (Control Bank B) are shown in Figures 3.1 and 3.2, respectively. The design predictions and the measured data are plotted together in order to illustrate their agreement. Figure 3.2 indicates that the measured differential rod worth for Control Bank B is somewhat different from the predicted differential rod worth. However, the measured integral rod worth demonstrates good agreement with the design prediction (-3.3%), therefore this test met the acceptance criteria and design tolerance. In summary, all measured rod worth values were satisfactory.

Table 3.1

SURRY UNIT 2 - CYCLE 7 BOL PHYSICS TEST
CONTROL ROD BANK WORTH SUMMARY

BANK	MEASURED WORTH (PCM)	PREDICTED WORTH (PCM)	PERCENT DIFFERENCE (M-P)/P X 100
B-Reference Bank	1254	1297	-3.3%
D	1121	1146	-2.2%
C	776	794	-2.3%
A	469	444	5.6% (25 pcm)
SB	799	830	-3.7%
SA	1116	1077	3.6%
Total Worth	5535	5588	-0.9%

Figure 3.1

SURRY UNIT 2 - CYCLE 7 BOL PHYSICS TEST
BANK B INTEGRAL ROD WORTH - HZP
B BANK WITH ALL OTHER RODS OUT

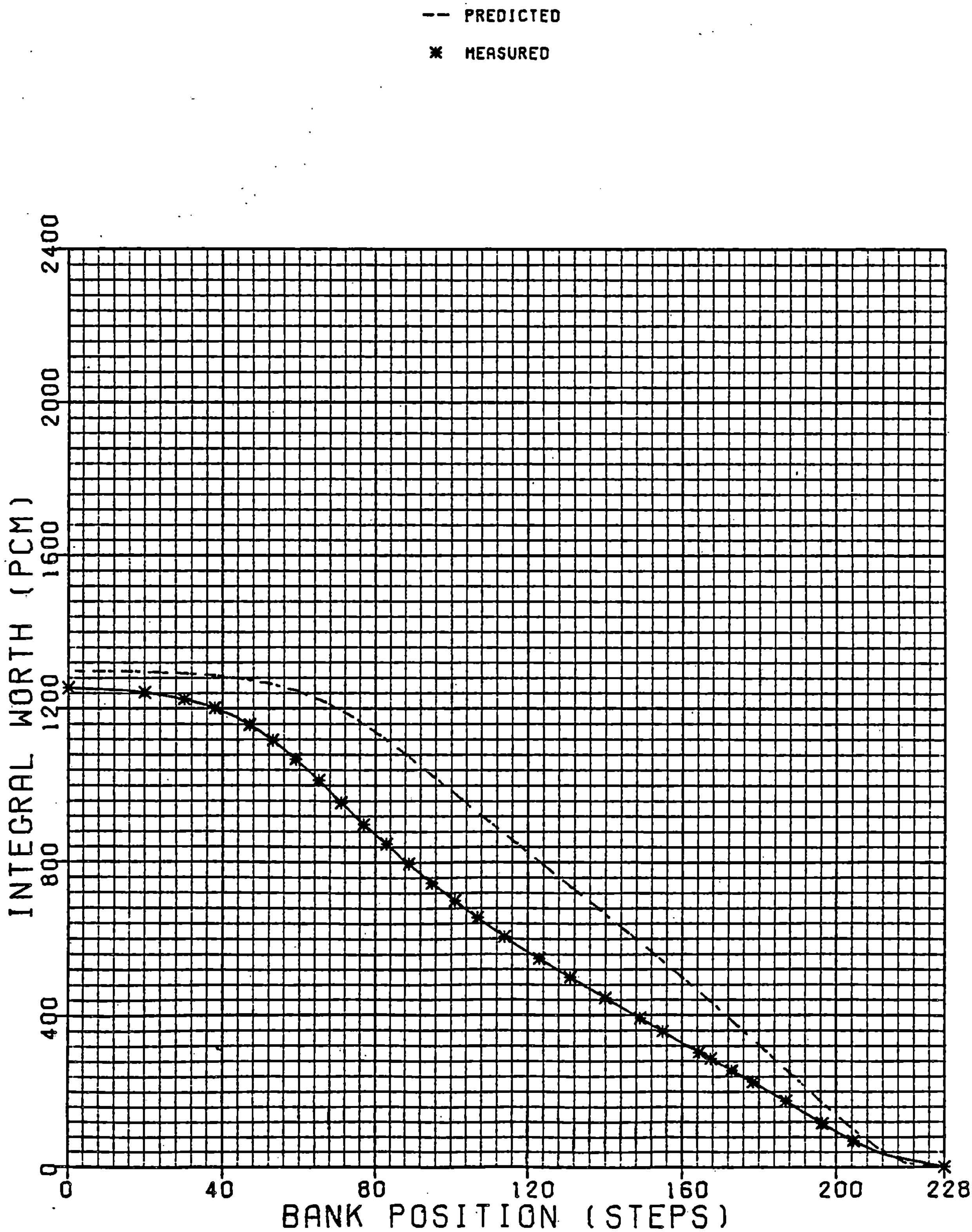
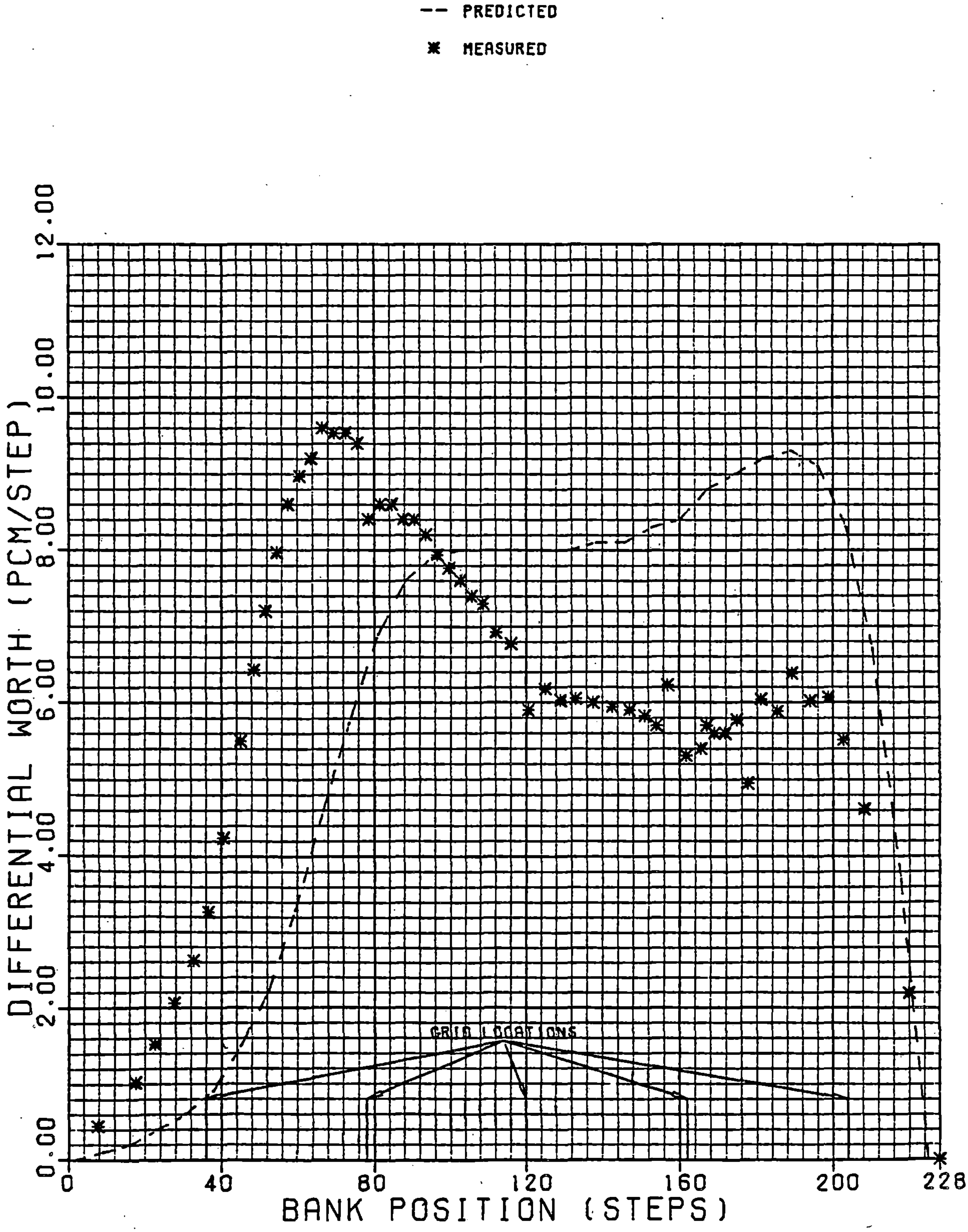


Figure 3.2

SURRY UNIT 2 - CYCLE 7 BOL PHYSICS TEST
BANK B 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, i.e., 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 Test Results and Evaluation Sheets given in the Appendix, all measured critical boron endpoint values were within their respective design tolerances. All measured values met the accident analysis acceptance criterion. In summary, all 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 -8.09 pcm/ppm. The measured boron worth coefficient is within 2.5% of the predicted value of -8.30 pcm/ppm and is well within the design tolerance of ±10%. The measurement result also met the accident analysis acceptance criterion. In summary, this result was satisfactory.

Table 4.1

SURRY UNIT 2 - CYCLE 7 BOL PHYSICS TEST

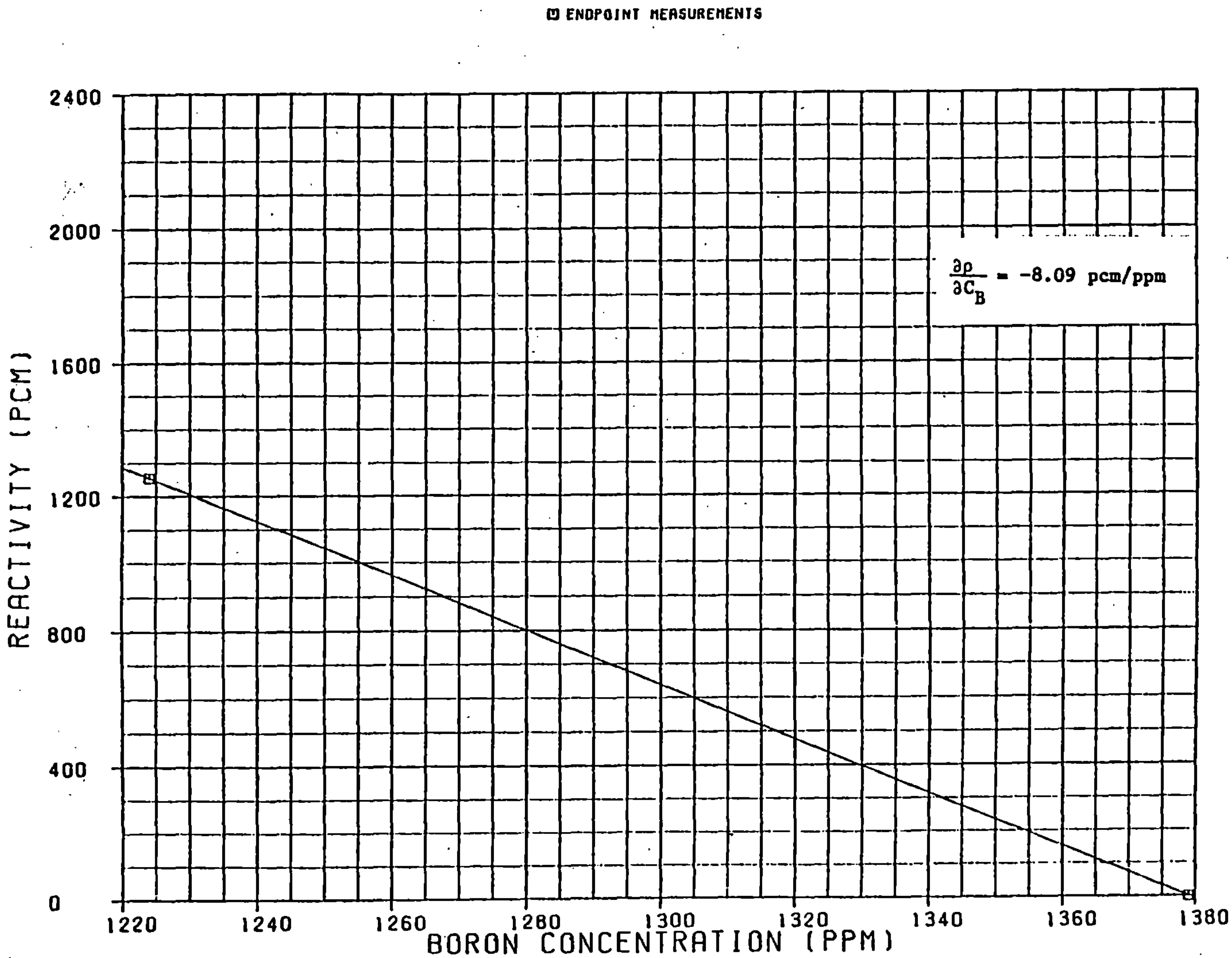
BORON ENDPOINTS SUMMARY

Control Rod Configuration	Measured Endpoint (ppm)	Predicted Endpoint (ppm)	Difference M-P (ppm)
ARO	1379	1403	-24
B Bank In	1224	1220*	4

* 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 2 - CYCLE 7 BOL PHYSICS TEST
BORON WORTH COEFFICIENT



SECTION 5

TEMPERATURE COEFFICIENT MEASUREMENT

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 542-546 °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 ARO configuration. Reactivity measurements were taken during both RCS heatup and cooldown ramps during which the RCS temperature varied approximately 4°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 x-y recorder plots of reactivity changes versus RCS temperature for each measurement are shown in Figure 5.1.

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 results were satisfactory.

Table 5.1

SURRY UNIT 2 - CYCLE 7 BOL PHYSICS TESTS

ISOTHERMAL TEMPERATURE COEFFICIENT SUMMARY

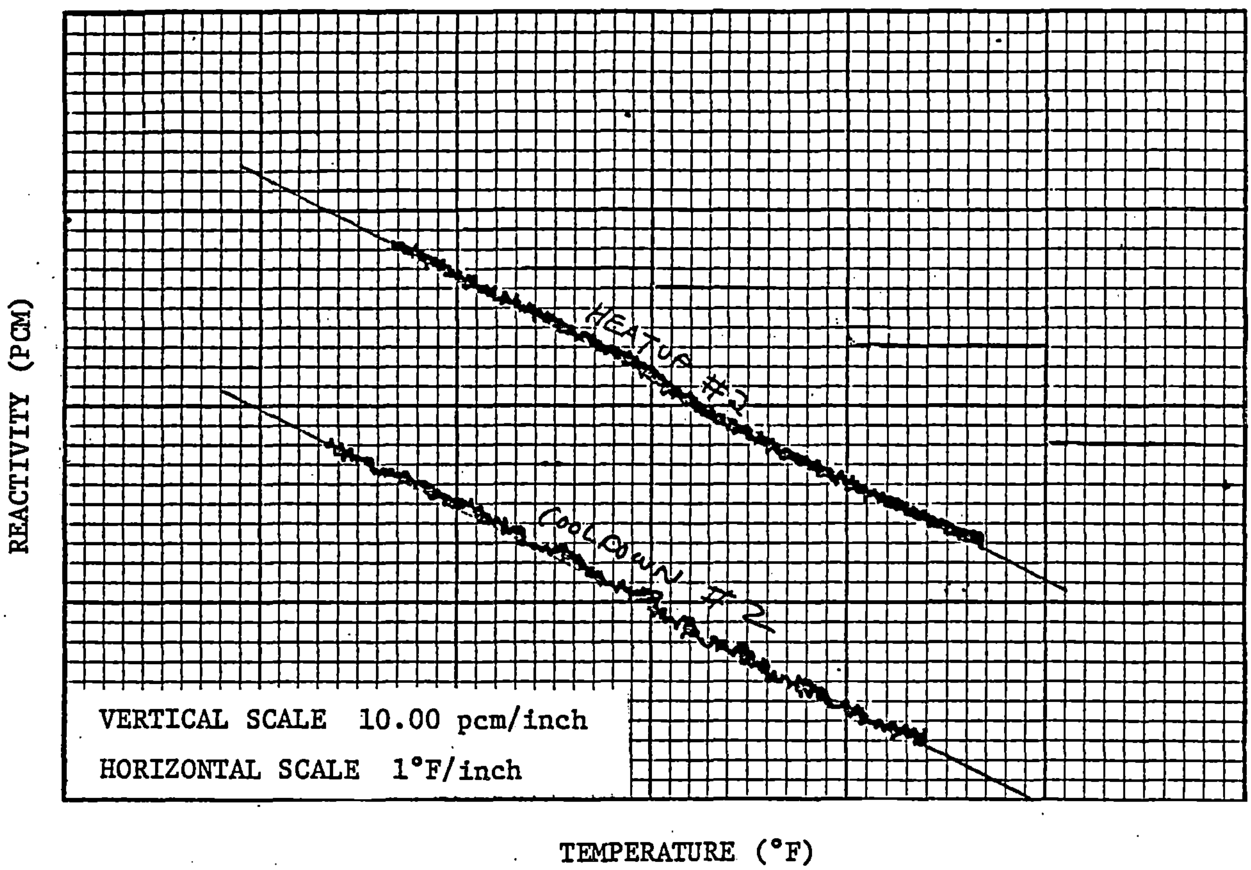
BANK POSITION	TEMPERATURE RANGE (°F)	BORON CONCENTRATION (ppm)	ISOTHERMAL TEMPERATURE COEFFICIENT (PCM/°F)				
			HEATUP	COOL DOWN	AVER.	PRED.	DIFFER. (M-P)
ALL RODS OUT	542.3 to 545.7	1380	-5.23	-5.03	-5.13	-5.68	0.55

Figure 5.1

SURRY UNIT 2 - CYCLE 7 BOL PHYSICS TESTS

ISOTHERMAL TEMPERATURE COEFFICIENT

HZP, ARO



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 all 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 zero power. This flux map serves as the base case design check. Figure 6.1 shows the resulting radial power distribution associated with this flux map. This map indicated the presence of a quadrant power tilt (2.9%) and some assemblywise relative power values in excess of the design tolerance, but all measured hot channel factor values were within the Technical Specifications limits. Flux Maps 2 and 5 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 incore/excore calibration data for the nuclear instrumentation system. The radial power distributions for these maps are given in Figures 6.2 and 6.3. These figures show that the measured relative assembly power values are generally within 8% of the predicted values, and that the quadrant power tilt ratio decreased significantly during power ascension.

In conclusion, all 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 safely throughout Cycle 7.

TABLE 6.1

SURRY UNIT 2 - CYCLE 7 BOL 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		
ARO	1	9-26-83	0	0	211	E10	IH	14	2.439	E10	IH	1.519	14	1.562	1.491	1.029	NE	31.52	38
46.5% POWER	2	9-29-83	10	47	178	C10	GH	31	1.943	L13	MN	1.459	24	1.275	1.424	1.011	NE	0.16	38
HFP, EQ. XENON[5]	5	10- 5-83	198	100	228	E10	IH	33	1.761	L10	GH	1.420	34	1.177	1.378	1.007	NE	-1.35	38

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 SEVENTEEN 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 INTO 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 AND 4 WERE QUARTER-CORE FLUX MAPS TAKEN FOR INCORE/EXCORE DETECTOR CALIBRATION.

Table 6.2

SURRY UNIT 2 - CYCLE 7 BOL PHYSICS TESTS
COMPARISION OF MEASURED POWER DISTRIBUTION PARAMETERS
WITH THEIR TECHNICAL SPECIFICATION LIMITS

MAP NO.	F-Q(T) HOT CHANNEL FACTOR*			F-DH(N) HOT CHANNEL FACTOR+		
	MEAS	LIMIT	MARGIN (%)	MEAS	LIMIT	MARGIN (%)
1	2.44	4.18	41.6	1.52	1.86	18.3
2	1.94	4.36	54.9	1.46	1.72	15.0
5	1.76	2.18	19.2	1.42	1.55	8.4

* The Technical Specification 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 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 Specifications limit for each map. All 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 2 - CYCLE 7 BOL PHYSICS TESTS

ASSEMBLYWISE POWER DISTRIBUTION

HZP, ARO

PREDICTED / MEASURED / PCT DIFFERENCE

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							0.50 0.53 6.3	0.84 0.90 6.2	0.50 0.53 6.3						
2					0.37 0.36 -3.5	0.73 0.74 1.0	1.09 1.15 5.5	1.15 1.23 6.7	1.09 1.19 9.0	0.73 0.73 -0.2	0.37 0.36 -3.8				
3				0.47 0.46 -3.5	1.03 0.99 -3.5	1.19 1.18 -0.7	1.21 1.24 2.3	1.23 1.33 8.6	1.21 1.27 4.8	1.19 1.19 -0.2	1.03 1.01 -2.4	0.47 0.45 -3.9			
4			0.47 0.46 -2.9	0.84 0.81 -2.9	1.16 1.12 -3.2	1.23 1.20 -2.4	1.23 1.24 0.8	1.17 1.18 0.6	1.23 1.26 2.5	1.23 1.23 -0.1	1.16 1.17 1.0	0.84 0.85 1.7	0.47 0.47 -0.2		
5		0.37 0.36 -2.9	1.02 0.99 -2.9	1.15 1.13 -1.7	0.98 0.97 -1.5	1.25 1.22 -2.3	1.03 0.98 -4.7	1.25 1.20 -4.1	1.03 1.00 -2.5	1.25 1.25 0.4	0.98 1.00 1.8	1.15 1.23 6.7	1.02 1.04 1.7	0.37 0.35 -4.4	
6		0.72 0.72 -0.9	1.17 1.16 -0.9	1.21 1.21 -0.1	1.24 1.25 1.6	0.98 0.96 -1.5	1.22 1.16 -4.9	1.19 1.12 -5.8	1.22 1.17 -4.6	0.98 0.97 -0.7	1.24 1.28 3.3	1.21 1.26 4.0	1.17 1.20 1.9	0.72 0.69 -4.3	
7	0.49 0.45 -9.9	1.08 1.04 -3.4	1.19 1.20 1.0	1.22 1.23 1.5	1.01 1.04 2.1	1.21 1.19 -1.1	0.99 0.96 -3.5	1.13 1.08 -4.2	0.99 0.96 -3.2	1.21 1.17 -2.8	1.01 1.04 2.4	1.22 1.24 2.3	1.19 1.25 4.9	1.08 1.17 8.6	0.49 0.54 8.5
8	0.83 0.75 -10.0	1.14 1.07 -5.9	1.21 1.22 0.9	1.16 1.17 0.6	1.23 1.23 0.3	1.17 1.16 -1.4	1.11 1.08 -3.2	1.14 1.11 -2.8	1.11 1.09 -2.6	1.17 1.14 -2.6	1.23 1.26 2.3	1.16 1.19 2.3	1.21 1.28 6.2	1.14 1.22 7.8	0.83 0.89 6.6
9	0.49 0.45 -9.9	1.08 1.02 -4.9	1.19 1.19 0.1	1.22 1.22 0.2	1.01 1.02 0.3	1.21 1.18 -2.2	0.99 0.93 -6.0	1.13 1.08 -3.8	0.99 0.97 -2.4	1.21 1.18 -2.4	1.01 1.12 10.2	1.22 1.24 2.3	1.19 1.22 2.6	1.08 1.11 3.3	0.49 0.52 4.4
10		0.72 0.72 0.1	1.17 1.17 0.1	1.21 1.21 0.2	1.24 1.24 0.3	0.98 0.94 -3.7	1.22 1.15 -5.6	1.19 1.15 -3.6	1.22 1.19 -2.5	0.98 0.98 0.8	1.24 1.30 5.0	1.21 1.33 10.2	1.17 1.13 -3.6	0.72 0.70 -2.7	
11		0.37 0.35 -4.0	1.02 0.98 -4.0	1.15 1.11 -4.0	0.98 0.99 0.3	1.25 1.20 -3.9	1.03 0.99 -3.3	1.25 1.22 -2.4	1.03 1.00 -2.6	1.25 1.23 -1.2	0.98 1.06 7.7	1.15 1.19 3.5	1.02 1.00 -2.4	0.37 0.35 -3.9	
12			0.47 0.43 -8.0	0.84 0.77 -8.0	1.16 1.15 -0.6	1.23 1.21 -1.8	1.23 1.21 -1.8	1.17 1.15 -2.1	1.23 1.20 -2.6	1.23 1.25 2.1	1.16 1.21 3.8	0.84 0.85 1.8	0.47 0.45 -3.5		
13				0.47 0.45 -4.3	1.03 1.02 -0.6	1.19 1.18 -1.2	1.21 1.18 -2.1	1.23 1.20 -2.0	1.21 1.21 0.1	1.19 1.22 2.8	1.03 1.05 1.9	0.47 0.47 -0.6			
14					0.37 0.37 -0.6	0.73 0.71 -2.5	1.09 1.05 -4.4	1.15 1.14 -1.6	1.09 1.12 2.0	0.73 0.75 2.7	0.37 0.38 2.8				
15							0.50 0.47 -5.8	0.84 0.82 -2.6	0.50 0.51 2.5						

STANDARD DEVIATION =2.402

AVERAGE PCT DIFFERENCE = 3.2

SUMMARY

MAP NO: S2-7- 1	DATE: 9/26/83	POWER: 0%
CONTROL ROD POSITIONS:	F-Q(T) = 2.439	QPTR:
D BANK AT 211 STEPS	F-DH(N) = 1.519	NW 0.984 | NE 1.029
	F(Z) = 1.562	SW 0.968 | SE 1.019
	F(XY) = 1.491	
	BURNUP = 0 MWD/MTU	A.O = 31.52(%)

Figure 6.2

SURRY UNIT 2 - CYCLE 7 BOL PHYSICS TESTS

ASSEMBLYWISE POWER DISTRIBUTION

46.5% POWER

Key (each cell): PREDICTED / MEASURED / PCT DIFFERENCE

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							0.50 0.52 4.4	0.82 0.86 4.2	0.50 0.52 4.4						
2					0.39 0.38 -0.5	0.74 0.74 -0.1	1.07 1.08 0.9	1.08 1.09 1.0	1.07 1.09 1.8	0.74 0.74 0.3	0.39 0.40 4.5				
3				0.50 0.49 -0.6	1.05 1.04 -0.5	1.19 1.18 -0.2	1.19 1.19 -0.5	1.20 1.19 -1.1	1.19 1.18 -1.1	1.19 1.19 0.2	1.05 1.08 2.8	0.50 0.52 4.4			
4			0.49 0.49 -1.5	0.87 0.85 -1.4	1.17 1.16 -0.8	1.23 1.21 -0.9	1.22 1.21 -1.3	1.17 1.14 -2.3	1.22 1.21 -1.2	1.23 1.23 0.2	1.17 1.18 1.0	0.87 0.88 1.8	0.49 0.51 3.7		
5		0.38 0.38 -1.5	1.04 1.02 -1.5	1.16 1.14 -2.0	0.99 0.97 -2.3	1.23 1.21 -2.1	1.03 0.99 -4.3	1.25 1.20 -4.2	1.03 1.00 -2.7	1.23 1.23 0.0	0.99 0.99 -0.1	1.16 1.17 0.6	1.04 1.07 3.4	0.38 0.41 6.1	
6		0.73 0.73 -0.7	1.18 1.17 -0.7	1.21 1.19 -2.1	1.22 1.18 -3.5	0.94 0.91 -2.9	1.22 1.17 -3.9	1.20 1.14 -4.9	1.22 1.17 -3.6	0.94 0.93 -1.0	1.22 1.23 0.8	1.21 1.22 1.0	1.18 1.22 3.4	0.73 0.77 5.3	
7	0.49 0.49 -0.2	1.06 1.06 -0.2	1.18 1.18 -0.1	1.21 1.19 -1.5	1.02 0.98 -3.6	1.21 1.17 -2.7	1.01 0.99 -2.3	1.15 1.11 -3.0	1.01 0.99 -1.9	1.21 1.19 -1.5	1.02 1.04 2.1	1.21 1.24 2.1	1.18 1.22 3.5	1.06 1.10 4.3	0.49 0.51 4.1
8	0.81 0.81 -0.3	1.07 1.07 -0.5	1.19 1.19 -0.2	1.16 1.15 -0.7	1.23 1.22 -1.3	1.19 1.17 -1.6	1.14 1.12 -1.8	1.16 1.14 -2.0	1.14 1.11 -2.2	1.19 1.16 -2.2	1.23 1.26 2.1	1.16 1.18 2.1	1.19 1.23 3.6	1.07 1.11 3.9	0.81 0.85 4.9
9	0.49 0.49 -0.2	1.06 1.07 1.6	1.18 1.22 3.3	1.21 1.22 0.5	1.02 1.01 -1.3	1.21 1.17 -2.7	1.01 0.96 -4.8	1.15 1.11 -3.7	1.01 0.98 -3.1	1.21 1.17 -3.2	1.02 1.04 1.9	1.21 1.24 2.1	1.18 1.24 4.6	1.06 1.11 5.2	0.49 0.52 6.1
10		0.73 0.76 3.3	1.18 1.21 3.3	1.21 1.23 1.5	1.22 1.21 -1.3	0.94 0.90 -3.7	1.22 1.16 -5.1	1.20 1.14 -5.2	1.22 1.17 -4.1	0.94 0.92 -1.4	1.22 1.23 0.3	1.21 1.23 1.8	1.18 1.24 5.1	0.73 0.77 5.3	
11		0.38 0.40 4.2	1.04 1.08 4.2	1.16 1.21 4.2	0.99 0.98 -1.3	1.23 1.19 -3.7	1.03 0.98 -4.8	1.25 1.17 -6.5	1.03 0.98 -4.7	1.23 1.21 -1.6	0.99 1.01 1.4	1.16 1.20 2.9	1.04 1.08 4.1	0.38 0.40 4.7	
12			0.49 0.52 5.1	0.87 0.91 5.1	1.17 1.23 4.9	1.23 1.19 -2.6	1.22 1.19 -3.0	1.17 1.12 -4.0	1.22 1.18 -3.9	1.23 1.22 -0.7	1.17 1.19 1.3	0.87 0.89 3.1	0.49 0.51 3.9		
13				0.50 0.52 4.9	1.05 1.10 4.9	1.19 1.20 1.1	1.19 1.16 -2.5	1.20 1.18 -2.0	1.19 1.19 -0.0	1.19 1.21 2.2	1.05 1.08 3.2	0.50 0.51 3.5			
14					0.39 0.41 4.9	0.74 0.78 4.8	1.07 1.09 1.8	1.08 1.09 1.1	1.07 1.09 1.9	0.74 0.76 2.2	0.39 0.39 2.2				
15							0.50 0.52 4.4	0.82 0.85 3.6	0.50 0.51 2.4						

STANDARD DEVIATION =1.635

AVERAGE PCT DIFFERENCE. = 2.6

SUMMARY

MAP NO: S2-7- 2	DATE: 9/29/83	POWER: 47%
CONTROL ROD POSITIONS:	F-Q(T) = 1.943	QPTR:
D BANK AT 178 STEPS	F-DH(N) = 1.459	NW 0.984 | NE 1.011
	F(Z) = 1.275	SW 0.994 | SE 1.011
	F(XY) = 1.424	
	BURNUP = 10 MWD/MTU	A.O = 0.16(%)

Figure 6.3

SURRY UNIT 2 - CYCLE 7 BOL PHYSICS TESTS
ASSEMBLYWISE POWER DISTRIBUTION
HFP, EQUILIBRIUM XENON

PREDICTED
MEASURED
PCT DIFFERENCE.

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							0.53 0.55 2.8	0.88 0.90 2.8	0.53 0.55 2.8						
2					0.40 0.39 -0.7	0.75 0.75 -0.2	1.09 1.09 0.3	1.16 1.17 0.5	1.09 1.09 0.7	0.75 0.74 -0.9	0.40 0.41 4.5				
3				0.50 0.50 -0.7	1.02 1.01 -0.7	1.15 1.14 -0.4	1.18 1.17 -0.5	1.21 1.19 -1.3	1.18 1.16 -1.3	1.15 1.14 -0.9	1.02 1.04 2.4	0.50 0.53 4.5			
4			0.50 0.49 -2.2	0.86 0.85 -1.2	1.13 1.12 -0.8	1.19 1.18 -0.7	1.19 1.18 -1.0	1.15 1.13 -1.5	1.19 1.17 -1.3	1.19 1.18 -0.8	1.13 1.14 0.7	0.86 0.88 2.1	0.50 0.52 3.2		
5		0.39 0.39 -2.2	1.01 0.99 -2.2	1.13 1.11 -1.9	0.99 0.97 -1.4	1.22 1.20 -1.7	1.03 1.01 -2.5	1.23 1.20 -2.5	1.03 1.01 -1.9	1.22 1.21 -0.6	0.99 0.98 -0.2	1.13 1.14 0.9	1.01 1.04 2.5	0.39 0.41 3.9	
6		0.74 0.74 -0.2	1.14 1.14 -0.2	1.18 1.16 -1.6	1.21 1.17 -3.3	1.01 0.99 -2.1	1.22 1.20 -1.9	1.20 1.17 -2.7	1.22 1.21 -1.5	1.01 1.01 0.1	1.21 1.22 0.7	1.18 1.19 1.0	1.14 1.17 2.4	0.74 0.77 3.4	
7	0.53 0.51 -3.7	1.08 1.08 -0.4	1.17 1.19 1.8	1.18 1.18 -0.4	1.03 0.99 -3.7	1.21 1.19 -1.8	1.03 1.02 -0.8	1.15 1.14 -1.1	1.03 1.03 0.0	1.21 1.22 0.4	1.03 1.04 1.7	1.18 1.20 1.7	1.17 1.20 2.3	1.08 1.11 2.8	0.53 0.55 2.6
8	0.88 0.84 -3.7	1.16 1.14 -1.5	1.20 1.22 1.8	1.14 1.16 1.4	1.23 1.24 1.0	1.19 1.19 0.3	1.14 1.14 -0.5	1.15 1.15 -0.2	1.14 1.14 -0.0	1.19 1.19 -0.0	1.23 1.25 1.7	1.14 1.16 1.7	1.20 1.23 2.3	1.16 1.19 2.9	0.88 0.92 4.6
9	0.53 0.51 -3.7	1.08 1.06 -1.8	1.17 1.17 0.1	1.18 1.19 0.7	1.03 1.04 1.0	1.21 1.21 -0.4	1.03 1.00 -2.7	1.15 1.14 -1.3	1.03 1.02 -0.5	1.21 1.21 -0.5	1.03 1.03 0.3	1.18 1.20 1.7	1.17 1.21 2.8	1.08 1.13 4.5	0.53 0.57 7.0
10		0.74 0.75 0.1	1.14 1.14 0.1	1.18 1.18 0.5	1.21 1.23 1.0	1.01 1.00 -1.2	1.22 1.19 -2.9	1.20 1.17 -3.0	1.22 1.20 -1.8	1.01 1.00 -0.4	1.21 1.21 -0.2	1.18 1.18 0.3	1.14 1.18 3.2	0.74 0.77 3.7	
11		0.39 0.40 1.5	1.01 1.03 1.5	1.13 1.14 1.5	0.99 1.00 1.0	1.22 1.20 -1.4	1.03 1.01 -2.6	1.23 1.18 -4.2	1.03 1.00 -2.8	1.22 1.21 -0.7	0.99 0.99 0.3	1.13 1.15 1.9	1.01 1.04 3.1	0.39 0.41 3.3	
12			0.50 0.52 2.9	0.86 0.88 2.9	1.13 1.16 2.1	1.19 1.19 -0.1	1.19 1.18 -0.9	1.15 1.12 -2.8	1.19 1.15 -3.1	1.19 1.18 -0.4	1.13 1.14 0.8	0.86 0.88 2.4	0.50 0.52 3.3		
13				0.50 0.52 2.5	1.02 1.04 2.1	1.15 1.16 1.0	1.18 1.16 -1.8	1.21 1.17 -2.8	1.18 1.17 -1.0	1.15 1.17 1.5	1.02 1.04 2.5	0.50 0.52 2.9			
14					0.40 0.40 2.1	0.75 0.77 2.4	1.09 1.09 0.3	1.16 1.16 -0.1	1.09 1.10 1.0	0.75 0.76 1.5	0.40 0.40 1.5				
15							0.53 0.55 2.7	0.88 0.90 2.3	0.53 0.54 1.5						

STANDARD DEVIATION =1.228

AVERAGE PCT DIFFERENCE = 1.7

SUMMARY

MAP NO: S2-7- 5	DATE: 10/ 5/83	POWER: 100%
CONTROL ROD POSITIONS:	F-Q(T) = 1.761	QPTR:
D BANK AT 228 STEPS	F-DH(N) = 1.420	NW 0.989 | NE 1.007
	F(Z) = 1.177	SW 0.997 | SE 1.007
	F(XY) = 1.378	
	BURNUP = 198 MWD/MTU	A.O = -1.35(%)

SECTION 7

REFERENCES

1. M. E Paul and A.P. Main, "Surry Unit 2, Cycle 7, Design Report," NFE Technical Report No. 290, Vepco, July, 1983.

2. Surry Power Station Technical Specifications, Section 3.1.E, 3.12.C.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 TEST RESULTS AND EVALUATION SHEETS

SURRY POWER STATION UNIT 2 CYCLE 7
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Reactivity Computer Checkout Proc No /Section: 2-PT-28.11/APP.B Sequence Step No: 6	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB: 228 CC: 228 CD: *	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB: 228 CC: 228 CD: 108	RCS Temperature (°F): 543.8 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 9/25/83 2200	
	Measured Parameter (Description)	ρ_c = Meas. Reactivity using ρ-computer ρ_t = Inferred ρ from reactor period
	Measured Value	ρ_c = -55.0 -40.0 -30.0 25.5 41.5 66.5 ρ_t = -57.2 -40.4 -30.0 26.1 41.7 67.0 %D = -3.8 -1.0 0.0 -2.3 -0.5 -0.7
	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 = ± 55 pcm	

Completed By: [signature] Test Engineer

Evaluated By: [signature]

Recommended for Approval By: C. J. Snow
NFO Engineer

SURRY POWER STATION UNIT 2 CYCLE 7
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Critical Boron Concentration - ARO Proc No /Section: 2-PT-28.11/APP.C Sequence Step No: 7		
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB: 228 CC: 228 CD: 228	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating	
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB: 228 CC: 228 CD: 228	RCS Temperature (°F): 543.6 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating	
	Date/Time Test Performed: 9/26/83 0958		
IV	Meas Parameter (Description)	$(C_B)^M_{ARO}$; Critical Boron Concentration - ARO	
Test Results	Measured Value	$(C_B)^M_{ARO}$ = 1379 ppm	
	Design Value (Actual Cond)	C_B = 1403 ± 50 ppm	
	Design Value (Design Cond)	C_B =1403 ± 50 ppm	
	Reference	VEP-PSE-NFE-290	
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 : X YES ___NO		
	α_{C_B} = -8.30 pcm/ppm for preliminary analysis αC_B = -8.09 pcm/ppm for final analysis		

Completed By: [signature]
Test Engineer

Evaluated By: E. J. Hal

Recommended for Approval By: C. J. Snow
NFO Engineer

SEP 1 7 1983

SURRY POWER STATION UNIT 2 CYCLE 7
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Isothermal Temperature Coefficient - ARO Proc No /Section: 2-PT-28.11/APP.D Sequence Step No: 8	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB: 228 CC: 228 CD: 228	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB: 228 CC: 228 CD: 228	RCS Temperature (°F): 544.1 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 9/26/83 1021	
IV	Meas Parameter (Description)	$(\alpha_T^{ISO})_{ARO}$ Isothermal Temp Coeff - ARO
Test Results	Measured Value	$(\alpha_T^{ISO})_{ARO}$ = -5.13 pcm/°F (C_B = 1380 ppm)
	Design Value (Actual Cond)	$(\alpha_T^{ISO})_{ARO}$ = -5.68 ±3.0 pcm/°F (C_B = 1380 ppm)
	Design Value (Design Cond)	$(\alpha_T^{ISO})_{ARO} = -5.41 \pm 3.0$ pcm/°F (C_B = 1403 ppm)
	Reference	VEP-PSE-NFE-290
V Acceptance Criteria	FSAR/Tech Spec	$\alpha_T^{ISO} \leq 0.43^*$ pcm/°F α_T^{Dop} = -2.07 pcm/°F
	Reference	TS 3.1, VEP-FRD-NFE-290
VI Comments	Design Tolerance is met : X YES ___NO Acceptance Criteria is met : X YES ___NO	
	* Uncertainty on $\alpha_{T_{MOD}}$ = 0.5 pcm/°F (Reference: memorandum from C. T. Snow to E. J. Lozito dated June 27, 1980).	

Completed By: [signature] Test Engineer

Evaluated By: [signature]

Recommended for Approval By: [signature: C. T. Snow] NFO Engineer

SEP 1 7 1983

SURRY POWER STATION UNIT 2 CYCLE 7
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description : M/D Flux Map - Hot Zero Power, All Rods Out Proc No / Section: 2-PT-28.2, OP-57 Sequence Step No: 9	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB : 228 CC : 228 CD: *	RCS Temperature (°F): T_{REF} ±1 Power Level (% Full Power): ~ 0 Other (specify) Must have ≥ 38 thimbles
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB : 228 CC : 228 CD: 211	RCS Temperature(°F): 547.1 Power Level (% Full Power): 2% Other (Specify): 38 thimbles
	Date/Time Test Performed: 9/26/83 1547	

IV	Measured Parameter	MAXIMUM REL. ASSEMBLYWISE PERCENT DIFF. (M-P)/P	NUCLEAR ENTHALPY RISE HOT CHANNEL FACTOR $F^N_{\Delta H}$	TOTAL HEAT FLUX HOT CHANNEL FACTOR F^T_Q	QUADRANT POWER TILT RATIO QPTR
Test Results	Measured Value	10.2% for P_{E9} = 1.12 + 10.2% for P_{O10} = 1.33 + 10.0% for P_{R8} = 0.75	1.520	2.439	1.029 +
	Design Value	±10% For P_i≥0.9 ±15% For P_i<0.9	$F^N_{\Delta H} \leq 1.55[1+0.2(1-P)]$	$F^T_Q \leq (4.36) \times K(z)$	≤ 1.02
	Reference	WCAP-7905 REV.1	NONE	NONE	WCAP-7905 REV.1
V Acceptance Criteria	FSAR/ Tech Spec	NONE	NA	NA	NA
	Reference	NONE	Tech Spec 3.12	Tech Spec 3.12	TS 3.12

VI Comments

The Minimum $F^T_Q(z)$ Margin is 41.6 %

Design Tolerance is met : ___YES ✓ NO

Acceptance Criteria is met : ✓ YES ___NO

* As Required

\+ Design tolerance not met but test results are acceptable per Surry Power Station Deviation Report S2-83-301.

Completed By: R. J. Cuffman
Test Engineer

Evaluated By: B D Mann

Recommended for Approval By: C. J. Snow
NFO Engineer

SURRY POWER STATION UNIT 2 CYCLE 7
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Cntl Bank B Worth Meas., Rod Swap Ref. Bank Proc No /Section: 2-PT-28.11/APP.E Sequence Step No: 10	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB:Moving CC: 228 CD: 228	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB:Moving CC: 228 CD: 228	RCS Temperature (°F): 545.9 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 9/26/83 2330	
IV Test Results	Measured Parameter (Description)	I_B^{REF}; Integral Worth of Cntl Bank B, All Other Rods Out
	Measured Value	I_B^{REF} = 1254 pcm
	Design Value (Actual Conditions)	I_B^{REF} = 1297 ± 130 pcm
	Design Value (Design Conditions)	I_B^{REF} = 1297 ± 130 pcm
	Reference	VEP-PSE-NFE-290
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: R. J. Cuyman (signature)
Test Engineer

Evaluated By: Tom A. Brookman (signature)

Recommended for Approval By: C. T. Snow (signature)
NFO Engineer

SEP 17 1983

SURRY POWER STATION UNIT 2 CYCLE 7
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Critical Boron Concentration - B Bank In Proc No /Section: 2-PT-28.11/APP.C Sequence Step No: 11	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB: 0 CC: 228 CD: 228	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB: 0 CC: 228 CD: 228	RCS Temperature (°F): 545.8 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 9/27/83 0716	
IV Test Results	Meas Parameter (Description)	$(C_B)_B^M$; Critical Boron Conc - B Bank In
	Measured Value	$(C_B)_B^M$ = 1224 ppm
	Design Value (Actual Cond)	C_B = 1220 ± 26 ppm
	Design Value (Design Cond)	$C_B = 1244 + \Delta C_B^{Prev} \pm (10 + 129.7/\lvert\alpha_{C_B}\rvert)$ppm
	Reference	VEP-PSE-NFE-290
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	
	α_{C_B} = -8.30 pcm/ppm for preliminary analysis $\Delta C_B^{Prev} = (C_B)_{ARO}^M - 1403$ α_{C_B} = -8.09 pcm/ppm for final analysis	

Completed By: L. J. Cuffman
Test Engineer

Evaluated By: Tom A. Brookmire

Recommended for Approval By: C. J. Snow
NFO Engineer

SEP 1 7 1983

SURRY POWER STATION UNIT 2 CYCLE 7
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: HZP Boron Worth Coefficent Measurement Proc No /Section: 2-PT-28.11/APP.E Sequence Step No: N/A	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB:Moving CC: 228 CD: 228	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB:Moving CC: 228 CD: 228	RCS Temperature (°F): 543.7 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 9/26/83 0958	
	Measured Parameter (Description)	α_{C_B} , Boron Worth Coefficient
	Measured Value	α_{C_B} = -8.09 pcm/ppm
	Design Value (Actual Conditions)	α_{C_B} = -8.30 ± 0.83 pcm/ppm
	Design Value (Design Conditions)	α_{C_B} = -8.30 ± 0.83 pcm/ppm
	Reference	VEP-PSE-NFE-290
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: [signature] Test Engineer

Evaluated By: Tom A. Brookmire

Recommended for Approval By: C. T. Snow
NFO Engineer

SEP 17 1983

SURRY POWER STATION UNIT 2 CYCLE 7
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Cntl Bank D Worth Measurement-Rod Swap Proc No /Section: 2-PT-28.11/APP.F Sequence Step No: 13	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB:Moving CC: 228 CD:Moving	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB:Moving CC: 228 CD:Moving	RCS Temperature (°F): 545.5 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 9/27/83 0811	
IV Test Results	Meas Parameter (Description)	I_D^{RS};Int Worth of Cntl Bank D-Rod Swap
	Measured Value	I_D^{RS}= 1121 pcm (Adj. Meas. Crit. Ref Bank Position = 194 steps)
	Design Value (Actual Cond)	I_D^{RS}= 1146 ± 172 pcm (Adj. Meas. Crit. Ref Bank Position = 194 steps)
	Design Value (Design Cond)	I_D^{RS}= 1141 ± 171 pcm (Critical Ref Bank Position = 198 steps)
	Reference	VEP-PSE-NFE-290, 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: [signature] Test Engineer

Evaluated By: [signature]

Recommended for Approval By : C. J. Snow
NFO Engineer

SURRY POWER STATION UNIT 2 CYCLE 7
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Cntl Bank C Worth Measurement-Rod Swap Proc No /Section: 2-PT-28.11/APP.F Sequence Step No: 14	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB:Moving CC:Moving CD: 228	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB:Moving CC:Moving CD: 228	RCS Temperature (°F): 545.4 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 9/27/83 0849	
IV Test Results	Meas Parameter (Description)	I_C^{RS};Int Worth of Cntl Bank C-Rod Swap
	Measured Value	I_C^{RS}= 776 pcm (Adj. Meas. Crit. Ref Bank Position = 135 steps)
	Design Value (Actual Cond)	I_C^{RS}= 794 ± 119 pcm (Adj. Meas. Crit. Ref Bank Position = 135 steps)
	Design Value (Design Cond)	I_C^{RS}= 799 ± 120 pcm (Critical Ref Bank Position = 160 steps)
	Reference	VEP-PSE-NFE-290, 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: L. J. Cuyman (signature)
Test Engineer

Evaluated By: H. C. Hatfield (signature)

Recommended for Approval By: C. J. Snow (signature)
NFO Engineer

SEP 1 7 1983

SURRY POWER STATION UNIT 2 CYCLE 7
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Cntl Bank A Worth Measurement-Rod Swap Proc No /Section: 2-PT-28.11/APP.F Sequence Step No: 15	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA:Moving CB:Moving CC: 228 CD: 228	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA:Moving CB:Moving CC: 228 CD: 228	RCS Temperature (°F): 545.3 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 9/27/83 0920	

IV Test Results	Meas Parameter (Description)	I_A^{RS};Int Worth of Cntl Bank A - Rod Swap
	Measured Value	I_A^{RS}= 469 pcm (Adj. Meas. Crit. Ref Bank Position = 90 steps)
	Design Value (Actual Cond)	I_A^{RS}= 444 ± 100 pcm (Adj. Meas. Crit. Ref Bank Position = 90 steps)
	Design Value (Design Cond)	I_A^{RS}= 464 ± 100 pcm (Critical Ref Bank Position = 119 steps)
	Reference	VEP-PSE-NFE-290, 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 : X YES __NO Acceptance Criteria is met : X YES __NO	

Completed By: L. J. Cuyman (signature)
Test Engineer

Evaluated By: E. S. Hal (signature)

Recommended for Approval By : C. J. Snow (signature)
NFO Engineer

SURRY POWER STATION UNIT 2 CYCLE 7
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Shutdown Bank B Worth Meas. - Rod Swap Proc No /Section: 2-PT-28.11/APP.F Sequence Step No: 16	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB:Moving CA: 228 CB:Moving CC: 228 CD: 228	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB:Moving CA: 228 CB:Moving CC: 228 CD: 228	RCS Temperature (°F): 544.9 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 9/27/83 0947	
IV Test Results	Meas Parameter (Description)	I_{SB}^{RS};Int Worth of Shutdown Bank B-Rod Swap
	Measured Value	I_{SB}^{RS}= 799 pcm (Adj. Meas. Crit. Ref Bank Position = 138 steps)
	Design Value (Actual Cond)	I_{SB}^{RS}= 830 ± 125 pcm (Adj. Meas. Crit. Ref Bank Position = 138 steps)
	Design Value (Design Cond)	I_{SB}^{RS}= 841 ± 126 pcm (Critical Ref Bank Position = 165 steps)
	Reference	VEP-PSE-NFE-290, 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: [signature] Test Engineer

Evaluated By: [signature]

Recommended for Approval By: C. J. Snow, NFO Engineer

SURRY POWER STATION UNIT 2 CYCLE 7
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Shutdown Bank A Worth Meas. - Rod Swap Proc No /Section: 2-PT-28.11/APP.F Sequence Step No: 17	
II Test Conditions (Design)	Bank Positions (Steps) SDA:Moving SDB: 228 CA: 228 CB:Moving CC: 228 CD: 228	RCS Temperature (°F): 547 Power Level (% F.P.): 0 Other (specify): Below Nuclear Heating
III Test Conditions (Actual)	Bank Positions (Steps) SDA:Moving SDB: 228 CA: 228 CB:Moving CC: 228 CD: 228	RCS Temperature (°F): 544.4 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
IV Test Results	Date/Time Test Performed: 9/27/83 1020	
	Meas Parameter (Description)	I_{SA}^{RS};Int Worth of Shutdown Bank A-Rod Swap
	Measured Value	I_{SA}^{RS}= 1116 pcm (Adj. Meas. Crit. Ref Bank Position = 193 steps)
	Design Value (Actual Cond)	I_{SA}^{RS}= 1077 ± 162 pcm (Adj. Meas. Crit. Ref Bank Position = 193 steps)
	Design Value (Design Cond)	I_{SA}^{RS}= 1076 ± 161 pcm (Critical Ref Bank Position = 191 steps)
	Reference	VEP-PSE-NFE-290, 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: [signature] Test Engineer

Evaluated By: [signature]

Recommended for Approval By: C. J. Snow
NFO Engineer

SURRY POWER STATION UNIT 2 CYCLE 7
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description: Total Rod Worth - Rod Swap Proc No /Section: 2-PT-28.11/APP.F Sequence Step No: N/A	
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): 545.5 Power Level (% F.P.): 0 Other (Specify): Below Nuclear Heating
	Date/Time Test Performed: 9/27/83 0811	
IV Test Results	Meas Parameter (Description)	I_{Total};Int Worth of All Banks - Rod Swap
	Measured Value	I_{Total} = 5535 pcm
	Design Value (Actual Cond)	I_{Total} = 5588 ± 559 pcm
	Design Value (Design Cond)	I_{Total} = 5618 ± 562 pcm
	Reference	VEP-PSE-NFE-290, 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: L. J. Guzman
Test Engineer

Evaluated By: H. C. Hartsfield

Recommended for Approval By: C. J. Snow
NFO Engineer

SURRY POWER STATION UNIT 2 CYCLE 7
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description : M/D Flux Map - At Power, NI Calibration, FCFM Proc No / Section: 2-PT-28.2, OP-57 Sequence Step No: 45	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB : 228 CC : 228 CD: *	RCS Temperature (°F): T_{REF} ±1 Power Level (% Full Power): ~ 50 Other (specify) Must have ≥ 38 thimbles
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB : 228 CC : 228 CD: 178	RCS Temperature(°F): 558 Power Level (% Full Power): 46.5 % Other (Specify): 38 thimbles
	Date/Time Test Performed: 9/29/83 0912	

IV	Measured Parameter	MAXIMUM REL. ASSEMBLYWISE PERCENT DIFF. (M-P)/P	NUCLEAR ENTHALPY RISE HOT CHANNEL FACTOR $F^N_{\Delta H}$	TOTAL HEAT FLUX HOT CHANNEL FACTOR F^T_Q	QUADRANT POWER TILT RATIO QPTR
Test Results	Measured Value	-6.5% for P_{H-11} = 1.17 6.1% for P_{A-9} = 0.52	1.459	1.943	1.0112
	Design Value	±10% For P_i≥0.9 ±15% For P_i<0.9	NA	NA	≤ 1.02
	Reference	WCAP-7905 REV. 1	NONE	NONE	WCAP-7905 REV.1
V Acceptance Criteria	FSAR/ Tech Spec	NONE	$F^N_{\Delta H} \leq 1.55[1+0.2(1-P)]$	For P > 0.5 $F^T_Q \leq (2.18/P) \times K(z)$ $F^T_Q \leq (4.36) \times K(z)$ For P ≤ 0.5	NA
	Reference	NONE	Tech Spec 3.12	Tech Spec 3.12	TS 3.12

VI - Comments	The Minimum $F^T_Q(z)$ Margin is 54.9 % Design Tolerance is met : X YES __NO Acceptance Criteria is met : X YES __NO
	* As Required

Completed By: [signature] Test Engineer

Evaluated By: [signature]

Recommended for Approval By: C. J. Snow NFO Engineer

SURRY POWER STATION UNIT 2 CYCLE 7
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description :M/D Flux Map-At Power,NI Calibration, QCFM Proc No / Section: 2-PT-28.2, OP-57 Sequence Step No: 46	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB : 228 CC : 228 CD: *	RCS Temperature (°F): T_{REF} ±1 Power Level (% F.P.): ~ 60 Other (specify) Must have ≥ 16 thimbles
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB : 228 CC : 228 CD: 184	RCS Temperature(°F): 559 Power Level (% F.P.): 53.9 Other (Specify): 19 thimbles
	Date/Time Test Performed: 9/29/83 1458	

IV Test Results	Measured Parameter (Description)	MAXIMUM RELATIVE ASSEMBLYWISE POWER PERCENT DIFFERENCE [(Measured - Predicted)/Predicted]
	Measured Value	-3.0 % for P_{H-5} = 1.21 4.9% for P_{B-11} = 0.40
	Design Value (Design Conditions)	± 10% For $P_i \geq 0.9$ ± 15% For $P_i < 0.9$
	Reference	WCAP-7905 REV.1
V Comments	Design Tolerance is met : X YES ___NO	
	* As Required	

Completed By: [signature] Test Engineer

Evaluated By: [signature]

Recommended for Approval By: C. J. Snow
NFO Engineer

SURRY POWER STATION UNIT 2 CYCLE 7
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description :M/D Flux Map-At Power,NI Calibration, QCFM Proc No / Section: 2-PT-28.2, OP-57 Sequence Step No: 47	
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB : 228 CC : 228 CD: *	RCS Temperature (°F): T_{REF} ±1 Power Level (% F.P.): ~ 70 Other (specify) Must have ≥ 16 thimbles
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB : 228 CC : 228 CD: 183	RCS Temperature(°F): 563 Power Level (% F.P.): 66.0 Other (Specify): 19 thimbles
	Date/Time Test Performed: 9/29/83 2054	
IV Test Results	Measured Parameter (Description)	MAXIMUM RELATIVE ASSEMBLYWISE POWER PERCENT DIFFERENCE [(Measured - Predicted)/Predicted]
	Measured Value	−2.8% for P_{H-5} = 1.21 4.1% for P_{B-11} = 0.40
	Design Value (Design Conditions)	± 10% For $P_i \geq 0.9$ ± 15% For $P_i < 0.9$
	Reference	WCAP-7905 REV.1
V Comments	Design Tolerance is met : X YES ___ NO	
	* As Required	

Completed By: [signature] Test Engineer

Evaluated By: [signature]

Recommended for Approval By: C. J. Snow
NFO Engineer

SURRY POWER STATION UNIT 2 CYCLE 7
STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEET

I Reference	Test Description : M/D Flux Map - Full Power Equilibrium Xenon Proc No / Section: 2-PT-28.2, OP-57 Sequence Step No: 48				
II Test Conditions (Design)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB : 228 CC : 228 CD: *		RCS Temperature (°F): T_{REF} ±1 Power Level (% Full Power): 95 +5/-0 Other (specify) Must have ≥ 38 thimbles		
III Test Conditions (Actual)	Bank Positions (Steps) SDA: 228 SDB: 228 CA: 228 CB : 228 CC : 228 CD: 228 Date/Time Test Performed: 10/5/83 12:10		RCS Temperature(°F): 573 Power Level (% Full Power): 100 Other (Specify): 38 thimbles		
IV Test Results	Measured Parameter	MAXIMUM REL. ASSEMBLYWISE PERCENT DIFF. (M-P)/P	NUCLEAR ENTHALPY RISE HOT CHANNEL FACTOR $F^N_{\Delta H}$	TOTAL HEAT FLUX HOT CHANNEL FACTOR F^T_Q	QUADRANT POWER TILT RATIO QPTR
	Measured Value	4.6% for P_{A-8} = 0.92 7.0% for P_{A-9} = 0.57	1.420	1.761	1.0071
	Design Value	±10% For P_i≥0.9 ±15% For P_i<0.9	NA	NA	≤ 1.02
	Reference	WCAP-7905 REV. 1	NONE	NONE	WCAP-7905 REV.1
V Acceptance Criteria	FSAR/ Tech Spec	NONE	$F^N_{\Delta H} \leq 1.55[1+0.2(1-P)]$	$F^T_Q \leq (2.18/P) \times K(z)$	NA
	Reference	NONE	Tech Spec 3.12	Tech Spec 3.12	TS 3.12
VI Comments	The Minimum $F^T_Q(z)$ Margin is 19.2 % Design Tolerance is met : X YES ___NO Acceptance Criteria is met : X YES ___NO				
	* As Required				

Completed By: [signature] Test Engineer

Evaluated By: [signature]

Recommended for Approval By: [signature] NFO Engineer