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Original

VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

August 17, 2006

United States Nuclear Regulatory Commission
Regional Administrator – Region II
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VIRGINIA ELECTRIC AND POWER COMPANY (DOMINION)
SURRY POWER STATION UNIT 1
CYCLE 21 STARTUP PHYSICS TESTS REPORT

As required by Surry Technical Specification 6.6.A.1, enclosed is the Virginia Electric and Power Company (Dominion) Technical Report NE-1487, Revision 0, entitled "Surry Unit 1, Cycle 21 Startup Physics Tests Report." This report summarizes the results of the physics testing program performed after the initial criticality of Cycle 21 on May 25, 2006. The results of the physics tests were within the applicable Technical Specification limits.

Please note that although this report is for Surry, the reference to an issue during "N1C19" startup testing on page 23 of the enclosure refers to North Anna Unit 1 Cycle 19. If you have any questions or require additional information, please contact Mr. Gary Miller at (804) 273-2771.

Very truly yours,

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Enclosure

Commitments made in this letter: None

IE26

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TECHNICAL REPORT No. NE-1487

SURRY UNIT 1, CYCLE 21
STARTUP PHYSICS TESTS REPORT

NUCLEAR ANALYSIS AND FUEL

NUCLEAR ENGINEERING
DOMINION

JULY 2006

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QA Category: Nuclear Safety Related

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PREFACE

This report presents the analysis and evaluation of the physics tests that were performed to verify that the Surry Unit 1, Cycle 21 core could be operated safely, and makes an initial evaluation of the performance of the core. It is not the intent of this report to discuss the particular methods of testing or to present the detailed data taken. Standard testing techniques and methods of data analysis were used. The test data, results and evaluations, together with the detailed startup procedures, are on file at the 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 Unit 1, Cycle 21 startup physics tests results and evaluation sheets are included as an appendix to provide additional information on the startup test results. These are the revised and condensed evaluation sheets introduced last year. Each data sheet provides the following information: 1) test identification, 2) test conditions (design), 3) test conditions (actual), 4) test results, 5) acceptance criteria, and 6) comments concerning the test. These sheets provide a compact summary of the startup test results in a consistent format. The design test conditions and design values (at design conditions) of the measured parameters were completed prior to the startup physics testing. The entries for the design values were based on calculations performed by Dominion's Nuclear Analysis and Fuel Group. During the tests, the data sheets were used as guidelines both to verify that the proper test conditions were met and to facilitate the preliminary comparison between measured and predicted test results, thus enabling a quick identification of possible problems occurring during the tests.

SECTION 1 — INTRODUCTION AND SUMMARY

On 23 April 2006, Unit No. 1 of the Surry Power Station shut down for its twentieth refueling [Ref. 1]. During this shutdown, 62 of the 157 fuel assemblies in the core were replaced with 60 fresh Batch 23 assemblies and two Batch 18 assemblies last irradiated in S2C17 [Ref. 8]. The Cycle 21 core consists of 11 sub-batches of fuel: five fresh batches (S1/23A, S1/23B, S1/23C, S1/23D, and S1/23E), two once-burned batches (S1/22A and S1/22B), and four twice-burned batches (S1/21A, S1/21B, S2/18B, and S2/18C). Batches S1/21, S1/22, and S1/23 are of the SIF/P+ZIRLO+2 fuel type. Batch S2/18 is of the SIF/P+ZIRLO design [Ref. 1].

Both Westinghouse SIF/P+ZIRLO and SIF/P+ZIRLO+2 fuel assembly designs incorporate ZIRLO fuel cladding, intermediate grids, guide tubes, instrumentation tubes, and debris resistance features that are part of the Westinghouse PERFORMANCE+ design [Ref. 1]. The SIF/P+ZIRLO+2 design used in batches S1/23A, S1/23B, S1/23C, S1/23D, S1/23E, S1/22A, S1/22B, S1/21A, and S1/21B is similar to the SIF/P+ZIRLO design used in batches S2/18B and S2/18C. The differences in the P+ZIRLO+2 design include the following [Ref. 13]: the overall assembly length has increased by 0.2 inches, the fuel rod length has increased by 0.2 inches, the top Inconel grid elevation increases by 0.2 inches, the fuel holddown spring height is slightly decreased, the fuel rod top end plug length has decreased by 0.1 inch, and the bottom end plug is longer by 0.2 inches. These dimensional changes result in a small net increase in the fission gas plenum volume of the fuel rod. The bottom of the active fuel region for both the SIF/P+ZIRLO and SIF/P+ZIRLO+2 fuel is the same.

This is the first Surry cycle to use Westinghouse's IFBA fuel product. All physical changes for IFBA are internal to the fuel rod cladding, with no apparent difference from existing fuel assemblies in any external features. The IFBA design involves the application of a thin (0.0003125 inch) coating of ZrB_2 on the fuel pellet surface during fabrication. Pellets with the IFBA coating are placed in specific symmetric patterns in each fresh assembly, typically affecting from 16 to 148 rods per assembly. The top and bottom 6 inches of the fuel pellet stack in the IFBA rods will contain pellets that have no IFBA coating, and have a hole in the center (annular).

This additional void space helps accommodate the helium gas that accumulates from neutron absorption in ZrB_2. IFBA rods generate more internal gas during operation because neutron absorption in the ZrB_2 coating creates helium gas in addition to the fission gas created during irradiation of the fuel. Therefore, the initial pressure is set lower so the internal pressure early in lifetime may be lower [Ref. 8].

In addition to the IFBA rods, several discrete burnable poison rod assemblies were also used for S1C21. The burnable poison (BP) rod design for this cycle is B_4C in Alumina which is available in various B_4C enrichments [Ref. 1]. Flux suppression inserts (FSIs) have been removed from Surry 1 for this cycle (the last eight Surry 1 cycles had FSIs to reduce neutron fluence at specific reactor vessel weld locations) [Ref. 8]. In conjunction with the FSI removal, the active burnable absorber length for Surry 1 was changed from the 135.5 inch design (which was compatible with the FSIs) to the 127.1 inch design similar to the BP product currently in use at Surry 2 [Ref. 5].

The S1C21 full core loading plan [Ref. 12] is given in Figure 1.1 and the beginning of cycle fuel assembly burnups [Ref. 6] are given in Figure 1.2. The available incore moveable detector locations used for the flux map analyses [Ref. 7] are identified in Figure 1.3 and the Cycle 21 burnable poison locations are detailed in Figure 1.4. Figure 1.5 identifies the location and number of control rods in the Cycle 21 core [Ref. 1].

According to the Startup Physics logs, the Cycle 21 core achieved initial criticality on 25 May 2006 at 02:04. Prior to and following criticality, startup physics tests were performed as outlined in Table 1.1. This cycle used the FTI Reactivity Measurement and Analysis System (RMAS) to perform startup physics testing. Note that RMAS v.6 was used for S1C21 Startup Physics Testing. The tests performed are the same as in previous cycles. A summary of the test results follows.

The measured drop time of each control rod was within the 2.4 second Technical Specification [Ref. 4] limit, as well as the 1.93 second administrative limit [Ref. 11].

Individual control rod bank worths were measured using the rod swap technique [Ref. 2], [Ref. 16], incorporating the recommendations of [Ref 10]. The sum of the individual measured control rod bank worths was within –2.2% of the design prediction. The reference bank (Control Bank D) worth was within –2.6% of its design prediction (corresponding to 31.7 pcm). The other control rod banks were within ±3.2% (-3.2% was recorded for Bank B, which corresponds to a difference of 38.1 pcm) of the design predictions, which was the greatest percent difference of all control rod banks with design predictions greater than 600 pcm. For individual banks worth 600 pcm or less (only Control Bank A fits this category), the difference was within –9.8 pcm of the design prediction. These results are within the design tolerances of ±15% for individual banks worth more than 600 pcm (±10% for the rod swap reference bank worth), ±100 pcm for individual banks worth 600 pcm or less, and ±10% for the sum of the individual control rod bank worths.

Measured critical boron concentrations for two control bank configurations (ARO and D-bank in) were within 7.3 ppm of the design predictions. These results were within the design tolerances and also met the Technical Specification [Ref. 4] criterion that the overall core reactivity balance shall be within ±1% Δk/k of the design prediction. The boron worth coefficient measurement was within +1.75% of the design prediction, which is within the design tolerance of ±10%.

The measured isothermal temperature coefficient (ITC) for the all-rods-out (ARO) configuration was within –0.416 pcm/°F of the design prediction. This result is within the design tolerance of ±2.0 pcm/°F.

Core power distributions, as measured by startup flux mapping, were within established design tolerances. The measured core power distributions were within ±5.6% of the design predictions, where a -5.6% maximum difference occurred in the 28.2% power map. The heat flux hot channel factors, $F_Q(Z)$, and enthalpy rise hot channel factors, $F^N_{\Delta H}$, were within the limits of COLR Sections 3.3 and 3.4, respectively. All power flux maps were within the maximum incore power tilt design tolerance of 2% (QPTR $\leq$ 1.02).

The total RCS Flow was successfully verified as being greater than 273000 gpm as required by Technical Specification 3.12.F.1. The total RCS Flow was measured as 286074 gpm.

In summary, all startup physics test results were acceptable. Detailed results, specific design tolerances and acceptance criteria for each measurement are presented in the following sections of this report. The screening (PRC, CDS, and ASC) for this technical report will be included in the engineering transmittal that implements and distributes the report.

Table 1.1

SURRY UNIT 1 – CYCLE 21
CHRONOLOGY OF TESTS

Test	Date	Time	Power	Reference Procedure
Hot Rod Drop-Hot Full Flow	05/23/06	1446	HSD	1-NPT-RX-014
Reactivity Computer Checkout	05/25/06	0249	HZP	1-NPT-RX-008
Boron Endpoint – ARO	05/25/06	0249	HZP	1-NPT-RX-008
Zero Power Testing Range	05/25/06	0249	HZP	1-NPT-RX-008
Boron Worth Coefficient	05/25/06	0249	HZP	1-NPT-RX-008
Temperature Coefficient – ARO	05/25/06	0325	HZP	1-NPT-RX-008
Bank D Worth	05/25/06	0419	HZP	1-NPT-RX-008
Boron Endpoint - D in	05/25/06	0541	HZP	1-NPT-RX-008
Bank A Worth - Rod Swap	05/25/06	0552	HZP	1-NPT-RX-008
Bank C Worth - Rod Swap	05/25/06	0559	HZP	1-NPT-RX-008
Bank SA Worth - Rod Swap	05/25/06	0613	HZP	1-NPT-RX-008
Bank B Worth - Rod Swap	05/25/06	0638	HZP	1-NPT-RX-008
Bank SB Worth - Rod Swap	05/25/06	0626	HZP	1-NPT-RX-008
Total Rod Worth	05/25/06	0419	HZP	1-NPT-RX-008
Flux Map – less than 30% Power Peaking Factor Verification & Power Range Calibration	05/27/06	0211	28.2%	1-NPT-RX-002 1-NPT-RX-008 1-NPT-RX-005
Flux Map – 65% - 75% Power Peaking Factor Verification & Power Range Calibration	05/27/06	2111	69.7%	1-NPT-RX-002 1-NPT-RX-008 1-NPT-RX-005
Flux Map – 95% - 100% Power Peaking Factor Verification & Power Range Calibration	06/02/06	0859	99.97%	1-NPT-RX-002 1-NPT-RX-008 1-NPT-RX-005
RCS Flow Measurement	06/05/06	1400	HFP	1-NPT-RX-009

Figure 1.1

SURRY UNIT 1 – CYCLE 21
CORE LOADING MAP

SURRY UNIT 1 - CYCLE 21
FULL CORE LOADING PLAN
REVISION NO. 1

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VEP-NES-NAF

NORTH ↑

A	B	C	D	E	F	G	H	J	K	L	M	N	P	R	
						20F	45F	06F							15
				29F	RCC 43F	5P 55H	RCC 43G	5P 51H	RCC 28F	39F					14
			22F	3P 49H	10H	RCC 05H	20P 38H	RCC 04H	13H	3P 47H	55F				13
		26F	RCC 41H	17H	RCC 32G	19G	15G	12G	RCC 42G	22H	RCC 44H	40F			12
	51F	3P 56H	20H	RCC 07G	49G	23G	20P 35H	16G	58G	RCC 26G	24H	3P 60H	33F		11
	RCC 48F	11H	RCC 52G	51G	RCC 40G	29H	RCC 29G	30H	RCC 37G	60G	RCC 36G	12H	RCC 42F		10
25F	5P 53H	RCC 06H	20G	11G	32H	RCC 02G	44G	RCC 03G	26H	28G	18G	RCC 01H	5P 54H	37F	9
270° 31F	RCC 39G	20P 37H	25G	20P 33H	RCC 38G	59G	27N	31G	RCC 34G	20P 36H	08G	20P 39H	RCC 56G	52F	8
38F	5P 58H	RCC 02H	10G	05G	27H	RCC 24G	54G	RCC 22G	25H	27G	17G	RCC 08H	5P 48H	23F	7
	RCC 27F	16H	RCC 35G	46G	RCC 45G	31H	RCC 50G	28H	RCC 48G	53G	RCC 47G	15H	RCC 57N		6
	56F	3P 46H	23H	RCC 21G	57G	09G	20P 40H	06G	30G	RCC 01G	21H	3P 59H	49F		5
		35F	RCC 43H	19H	RCC 41G	13G	14G	04G	RCC 33G	18H	RCC 42H	46F			4
			54F	3P 52H	14H	RCC 03H	20P 34H	RCC 07H	09H	3P 57H	41F				3
				34F	RCC 47F	5P 45H	RCC 55G	5P 50H	RCC 36F	44F					2
						05F	32F	09F							1

180°

INCORE DEVICE DESCRIPTIONS:
RCC- FULL LENGTH CONTROL ROD
3P- 3 BURNABLE POISON ROD CLUSTER
5P- 5 BURNABLE POISON ROD CLUSTER
20P- 20 BURNABLE POISON ROD CLUSTER

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Figure 1.2

SURRY UNIT 1 – CYCLE 21
BEGINNING OF CYCLE FUEL ASSEMBLY BURNUPS

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

                                              ----------------------                           -------------
 1                                            | 41.44| 33.82| 41.50|                           |  MEASURED |    1
                                              | 41.69| 33.71| 41.70|                           | PREDICTED |
                                --------------------------------------------------             -------------
 2                              | 34.52| 38.79|  0.00| 17.71|  0.00| 38.73| 34.12|                              2
                                | 34.47| 38.73|  0.00| 17.82|  0.00| 38.75| 34.45|
                         ----------------------------------------------------------------
 3                       | 43.02|  0.00|  0.00|  0.00|  0.00|  0.00|  0.00|  0.00| 43.03|                       3
                         | 43.05|  0.00|  0.00|  0.00|  0.00|  0.00|  0.00|  0.00| 43.05|
                  ------------------------------------------------------------------------------
 4                | 43.07|  0.00|  0.00| 22.11| 22.40| 22.20| 22.51| 22.39|  0.00|  0.00| 43.07|                4
                  | 43.04|  0.00|  0.00| 22.11| 22.40| 21.94| 22.41| 22.13|  0.00|  0.00| 43.04|
           --------------------------------------------------------------------------------------------
 5         | 37.82|  0.00|  0.00| 22.05| 17.92| 23.21|  0.00| 23.17| 17.74| 21.95|  0.00|  0.00| 38.02|         5
           | 38.13|  0.00|  0.00| 22.11| 17.88| 23.24|  0.00| 23.22| 17.83| 22.12|  0.00|  0.00| 38.12|
           --------------------------------------------------------------------------------------------
 6         | 37.81|  0.00| 22.50| 17.89| 20.46|  0.00| 20.51|  0.00| 20.54| 17.85| 22.30|  0.00| 38.86|         6
           | 37.96|  0.00| 22.11| 17.81| 20.47|  0.00| 20.55|  0.00| 20.53| 17.83| 22.10|  0.00| 38.78|
    ----------------------------------------------------------------------------------------------------------
 7  | 43.40|  0.00|  0.00| 22.50| 23.20|  0.00| 22.03| 17.78| 22.10|  0.00| 23.30| 22.39|  0.00|  0.00| 42.98|  7
    | 42.92|  0.00|  0.00| 22.42| 23.23|  0.00| 22.15| 17.77| 22.15|  0.00| 23.25| 22.42|  0.00|  0.00| 42.92|
    ----------------------------------------------------------------------------------------------------------
 8  | 33.72| 17.70|  0.00| 21.95|  0.00| 20.62| 17.51| 38.22| 17.67| 20.54|  0.00| 22.04|  0.00| 18.21| 34.04|  8
    | 33.71| 17.77|  0.00| 21.91|  0.00| 20.49| 17.71| 37.74| 17.71| 20.48|  0.00| 21.91|  0.00| 17.77| 33.71|
    ----------------------------------------------------------------------------------------------------------
 9  | 43.17|  0.00|  0.00| 22.50| 23.25|  0.00| 22.06| 17.81| 22.42|  0.00| 23.27| 22.63|  0.00|  0.00| 43.34|  9
    | 42.92|  0.00|  0.00| 22.42| 23.25|  0.00| 22.14| 17.77| 22.16|  0.00| 23.23| 22.42|  0.00|  0.00| 42.92|
    ----------------------------------------------------------------------------------------------------------
10         | 38.93|  0.00| 22.37| 18.01| 20.60|  0.00| 20.43|  0.00| 20.57| 18.06| 22.10|  0.00| 38.38|         10
           | 38.78|  0.00| 22.10| 17.83| 20.53|  0.00| 20.55|  0.00| 20.47| 17.81| 22.10|  0.00| 38.80|
           --------------------------------------------------------------------------------------------
11         | 38.18|  0.00|  0.00| 22.00| 17.84| 23.24|  0.00| 23.35| 17.92| 21.95|  0.00|  0.00| 38.04|         11
           | 38.17|  0.00|  0.00| 22.11| 17.83| 23.22|  0.00| 23.25| 17.88| 22.11|  0.00|  0.00| 38.16|
           --------------------------------------------------------------------------------------------
12                | 43.09|  0.00|  0.00| 22.43| 22.26| 22.13| 22.36| 22.19|  0.00|  0.00| 43.11|                12
                  | 43.04|  0.00|  0.00| 22.12| 22.41| 21.94| 22.40| 22.11|  0.00|  0.00| 43.04|
                  ------------------------------------------------------------------------------
13                       | 43.09|  0.00|  0.00|  0.00|  0.00|  0.00|  0.00|  0.00| 43.21|                       13
                         | 43.05|  0.00|  0.00|  0.00|  0.00|  0.00|  0.00|  0.00| 43.05|
                         ----------------------------------------------------------------
14                              | 34.33| 38.92|  0.00| 17.80|  0.00| 38.56| 34.31|                              14
                                | 34.45| 38.75|  0.00| 17.82|  0.00| 38.73| 34.47|
                                --------------------------------------------------
15                                            | 41.55| 33.71| 41.44|                                            15
                                              | 41.70| 33.71| 41.70|
                                              ----------------------

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

Figure 1.3

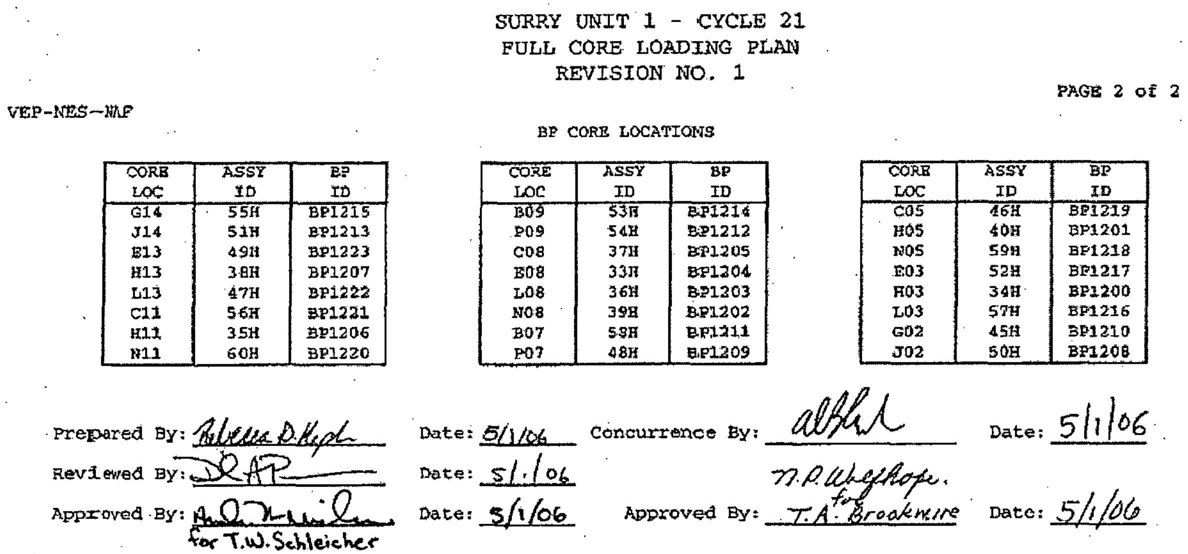
SURRY UNIT 1 – CYCLE 21
AVAILABLE INCORE MOVEABLE DETECTOR LOCATIONS

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

MD - Moveable Detector
** - Locations Not Used For Flux Map 1 for S1C21
* - Locations Not Used For Flux Map 1, 2, or 3 for S1C21

Figure 1.4

SURRY UNIT 1 – CYCLE 21
BURNABLE POISON LOCATIONS



SURRY UNIT 1 - CYCLE 21
FULL CORE LOADING PLAN
REVISION NO. 1

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VEP-NES-NAF

BP CORE LOCATIONS

CORE LOC	ASSY ID	BP ID
G14	55H	BP1215
J14	51H	BP1213
E13	49H	BP1223
H13	38H	BP1207
L13	47H	BP1222
C11	56H	BP1221
H11	35H	BP1206
N11	60H	BP1220

CORE LOC	ASSY ID	BP ID
B09	53H	BP1214
P09	54H	BP1212
C08	37H	BP1205
E08	33H	BP1204
L08	36H	BP1203
N08	39H	BP1202
B07	58H	BP1211
P07	48H	BP1209

CORE LOC	ASSY ID	BP ID
C05	46H	BP1219
H05	40H	BP1201
N05	59H	BP1218
E03	52H	BP1217
H03	34H	BP1200
L03	57H	BP1216
G02	45H	BP1210
J02	50H	BP1208

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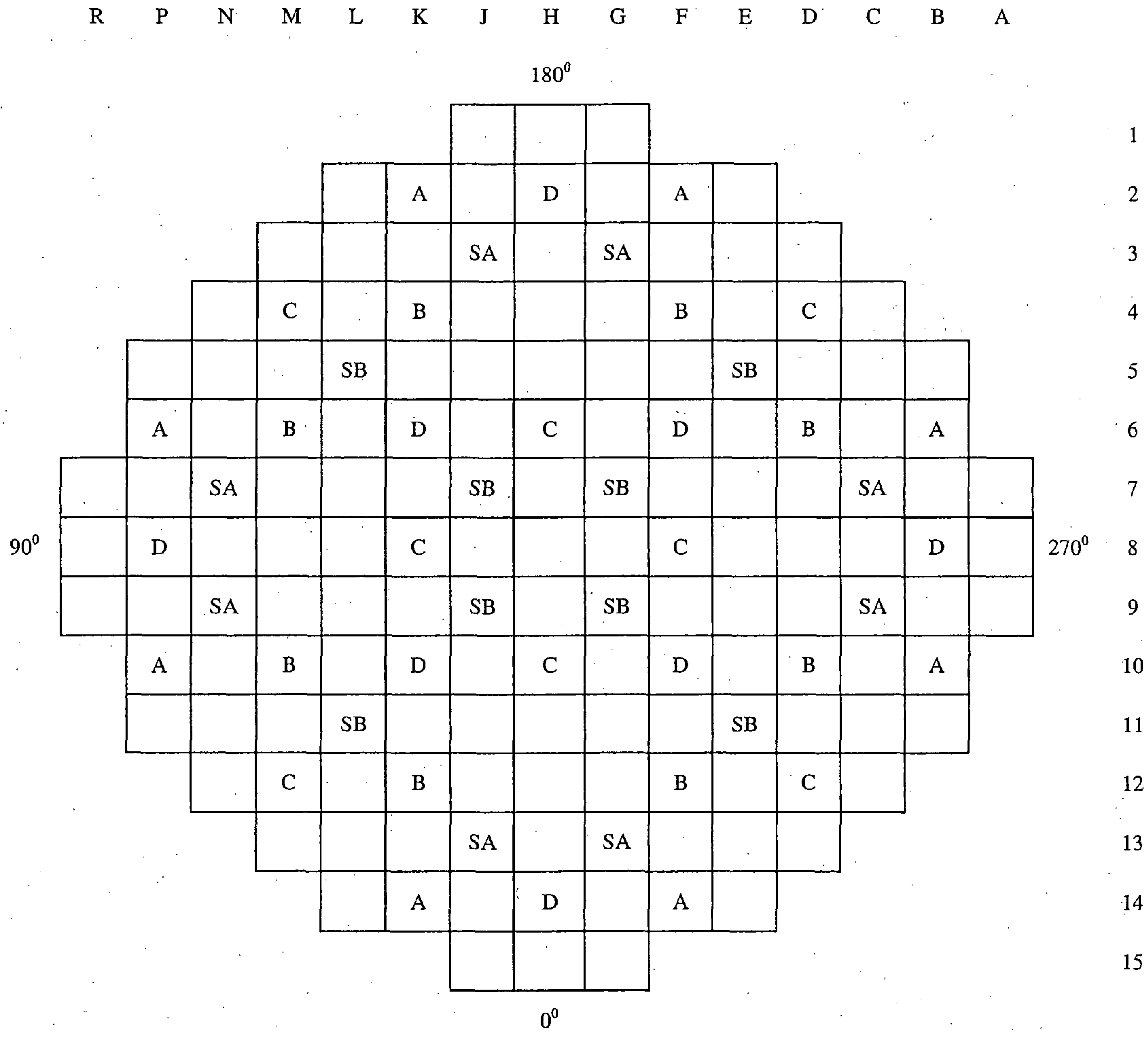
Figure 1.5

SURRY UNIT 1 – CYCLE 21 CONTROL ROD LOCATIONS



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

D = Control Bank D
C = Control Bank C
B = Control Bank B
A = Control Bank A

SB = Shutdown Bank SB
SA = Shutdown Bank SA

SECTION 2 — CONTROL ROD DROP TIME MEASUREMENTS

The drop time of each control rod was measured in hot shutdown with three RCPs in operation (full flow) and with T_{ave} greater than 530 F as per 1-NPT-RX-014. This verified that the time to the entry of the rod into the dashpot was less than or equal to the maximum allowed Technical Specification 3.12.C.1 [Ref. 4].

Surry Unit 1 Cycle 21 used the rod drop test computer (RDTC) in conjunction with the Computer Enhanced Rod Position Indication (CERPI) system. The CERPI system equipment replaced the Individual Rod Position Indication (IRPI) system. The rod drop times were measured by withdrawing all banks to their fully withdrawn position and dropping all of the 48 control rods into the core by opening the reactor trip breakers. This allowed the rods to drop into the core as they would during a plant trip.

Data prior to S1C20 was previously acquired using the primary RPI coil terminals (/1 & /2) for each rod. Traces that printed from the Yokogawas were used to determine initial quality, while binary output was saved to diskette for further analysis using ACRAWin32 software. The new methodology acquires data using the secondary RPI coil terminals (/3 & /4) on the CERPI racks for each rod. Data is immediately saved to the rod drop test computer (RDTC) which computes the rod drop time automatically. Original data is also saved as an ASCII file and burned to CD-R. Further details about the RDTC can be found in [Ref. 14].

As shown on the typical rod drop trace in Figure 2.1, the initiation of the rod drop is indicated by quick increase of voltage. The magnitude of this voltage is a function of control rod velocity. As the rod enters the dashpot region of the guide tube, its velocity slows causing a sharp voltage decrease. This voltage reaches a minimum when the rod reaches the bottom of the dashpot. In each trace, there should be an evident oscillation in the voltage curve after it has reached that bottom of the dashpot. This "bounce" indicates that the rod has not gotten stuck in the dashpot. Subsequent variations in rod drop traces are caused by rod bouncing.

The measured drop times for each control rod are recorded on Figure 2.2 in accordance with station procedure 1-NPT-RX-014. The slowest, fastest, and average drop times are summarized in Table 2.1. Technical Specification 3.12.C.1 [Ref. 4] specifies a maximum rod drop time from loss of stationary gripper coil voltage to dashpot entry of 2.4 seconds for all rods. These test results satisfied this technical limit as well as the administrative limit [Ref. 11] of 1.93 seconds. In addition, rod bounce was observed at the end of each trace demonstrating that no control rod stuck in the dashpot region.

Table 2.1

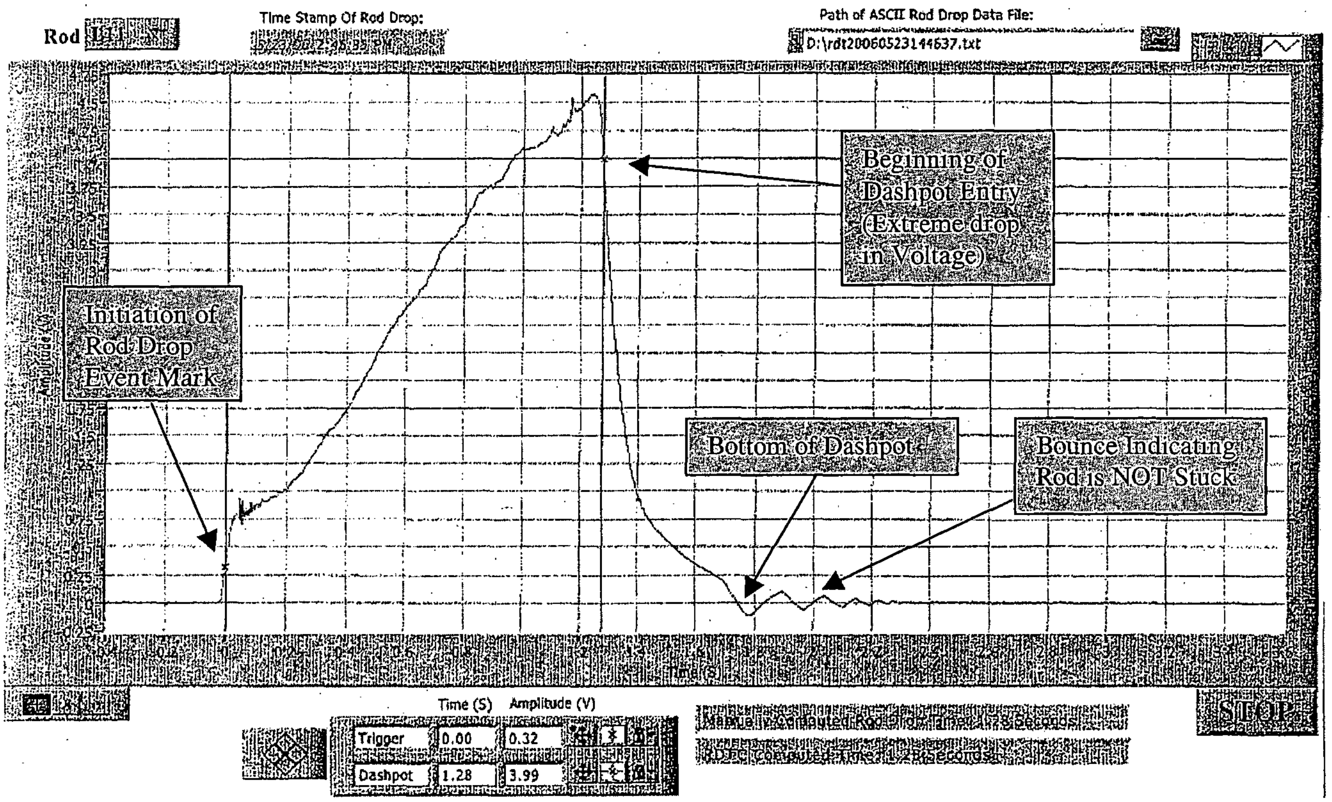
SURRY UNIT 1 – CYCLE 21 STARTUP PHYSICS TESTS
HOT ROD DROP TIME SUMMARY

ROD DROP TIME TO DASHPOT ENTRY

SLOWEST ROD	FASTEST ROD	AVERAGE TIME
P-08 1.39 sec.	L-05 & M-12 1.25 sec	1.30 sec.

Figure 2.1

SURRY UNIT 1 – CYCLE 21 STARTUP PHYSICS TESTS
TYPICAL ROD DROP TRACE



D:\rdt20060523144637.txt

Beginning of Dashpot Entry (Extreme drop in Voltage)

Initiation of Rod Drop Event Mark

Bottom of Dashpot

Bounce Indicating Rod is NOT Stuck

	Time (S)	Amplitude (V)
Trigger	0.00	0.32
Dashpot	1.28	3.99

Manually Computed Rod Drop Time: 1.28 Seconds

RDPC Computed Time: 1.28 Seconds

Figure 2.2

SURRY UNIT 1 – CYCLE 21 STARTUP PHYSICS TESTS ROD DROP TIME – HOT FULL FLOW CONDITIONS

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
															1
					1.29		1.28		1.28						2
						1.30		1.32							3
			1.29		1.26				1.28		1.31				4
				1.25						1.28					5
	1.27		1.26		1.29		1.30		1.28		1.27		1.36		6
		1.28				1.31		1.29				1.30			7
	1.39				1.31				1.38				1.30		8
		1.34				1.29		1.32				1.30			9
	1.29		1.29		1.27		1.29		1.31		1.29		1.31		10
				1.28						1.29					11
			1.25		1.26				1.28		1.32				12
						1.30		1.31							13
					1.32		1.27		1.36						14
															15

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

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SECTION 3 — CONTROL ROD BANK WORTH MEASUREMENTS

Control rod bank worths were measured for the control and shutdown banks using the rod swap technique [Ref. 2]. The initial step of the rod swap method diluted the predicted most reactive control rod bank (hereafter referred to as the reference bank) into the core and measured its reactivity worth using conventional test techniques. The reactivity changes resulting from the reference bank movements were recorded continuously by the reactivity computer and were used to determine the differential and integral worth of the reference bank. Surry 1 used a dilution rate of 1100 pcm/hr for the reference bank measurement. For Cycle 21, Control Bank D was used as the reference bank.

During the N1C19 startup physics testing campaign, a control rod became stuck on bottom eventually forcing a reactor trip to fix the issue. A theorized potential cause of the stuck rod issue was the presence of debris near the upper core plate interfering with the rod grippers when the control rods were manually inserted to the fully inserted position (0 steps withdrawn). A possible solution to this theory for startup physics testing was to avoid requiring control rods to be manually inserted to 0 steps. To accomplish this, an evaluation of the startup physics testing process was performed [Ref. 15], concluding that the definition of fully inserted for control rod positions used in startup physics testing could be changed from 0 steps withdrawn to a range of 0 to 2 steps withdrawn. The S1C21 startup physics testing campaign used 2 steps withdrawn for all conditions requiring control rods to be manually fully inserted.

After completion of the reference bank reactivity worth measurement, the reactor coolant system temperature and boron concentration were allowed to stabilize with the reactor near critical and the reference bank near its full insertion. Initial statepoint data (core reactivity and moderator temperature) for the rod swap maneuver were next obtained with the reference bank at its fully inserted position and all other banks fully withdrawn.

Test bank swaps proceed in sequential order from the bank with the smallest worth to the bank with the largest worth. The second test bank should have a predicted worth higher than the first bank in order to ensure the first bank will be moved fully out. The rod swap maneuver was performed by withdrawing the previous test bank (or reference bank for the first maneuver) several steps and then inserting the next test bank to balance the reactivity of the reference bank withdrawal. This sequence was repeated until the previous test bank was fully withdrawn and the test bank was nearly inserted. The next step was to swap the rest of the test bank in by balancing the reactivity with the withdrawal of the reference bank, until the test bank was fully inserted and the reference bank was positioned such that the core was just critical or near the initial statepoint condition. This measured critical position (MCP) of the reference bank with the test bank fully inserted was used to determine the integral reactivity worth of the test bank.

The core reactivity, moderator temperature, and differential worth of the reference bank were recorded with the reference bank at the MCP. The rod swap maneuver was repeated for all test banks. Note that after the final test bank was fully inserted, the test bank was swapped with the reference bank until the reference bank was fully inserted and the last test bank was fully withdrawn. Here the final statepoint data for the rod swap maneuver was obtained (core reactivity and moderator temperature) in order to verify the reactivity drift for the rod swap test.

A summary of the test results is given in Table 3.1. As shown in this table and the Startup Physics Test Results and Evaluation Sheets given in the Appendix, the individual measured bank worths for the control and shutdown banks were within the design tolerance of ±10% for the reference bank, ±15% for test banks of worth greater than 600 pcm, and ±100 pcm for test banks of worth less than or equal to 600 pcm. The sum of the individual measured rod bank worths was within –2.2% 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 D) are shown in Figures 3.1 and 3.2, respectively. The design predictions [Ref. 1] and the measured data from station procedure 1-NPT-RX-008 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 21 STARTUP PHYSICS TESTS CONTROL ROD BANK WORTH SUMMARY

BANK	MEASURED WORTH (PCM)	PREDICTED WORTH (PCM)	PERCENT DIFFERENCE (%) (M-P)/P X 100
D - Reference	1198.3	1230.0	-2.6
B	1159.3	1197.4	-3.2
C	815.9	816.6	-0.1
A	277.0	286.8	-3.4 (a)
SB	1004.1	1025.5	-2.1
SA	979.3	997.4	-1.8
Total Bank Worth	5433.9	5553.6	-2.2

(a). M – P = -9.8 pcm

Figure 3.1

SURRY UNIT 1 – CYCLE 21 STARTUP PHYSICS TESTS CONTROL BANK D INTEGRAL ROD WORTH - HZP ALL OTHER RODS WITHDRAWN

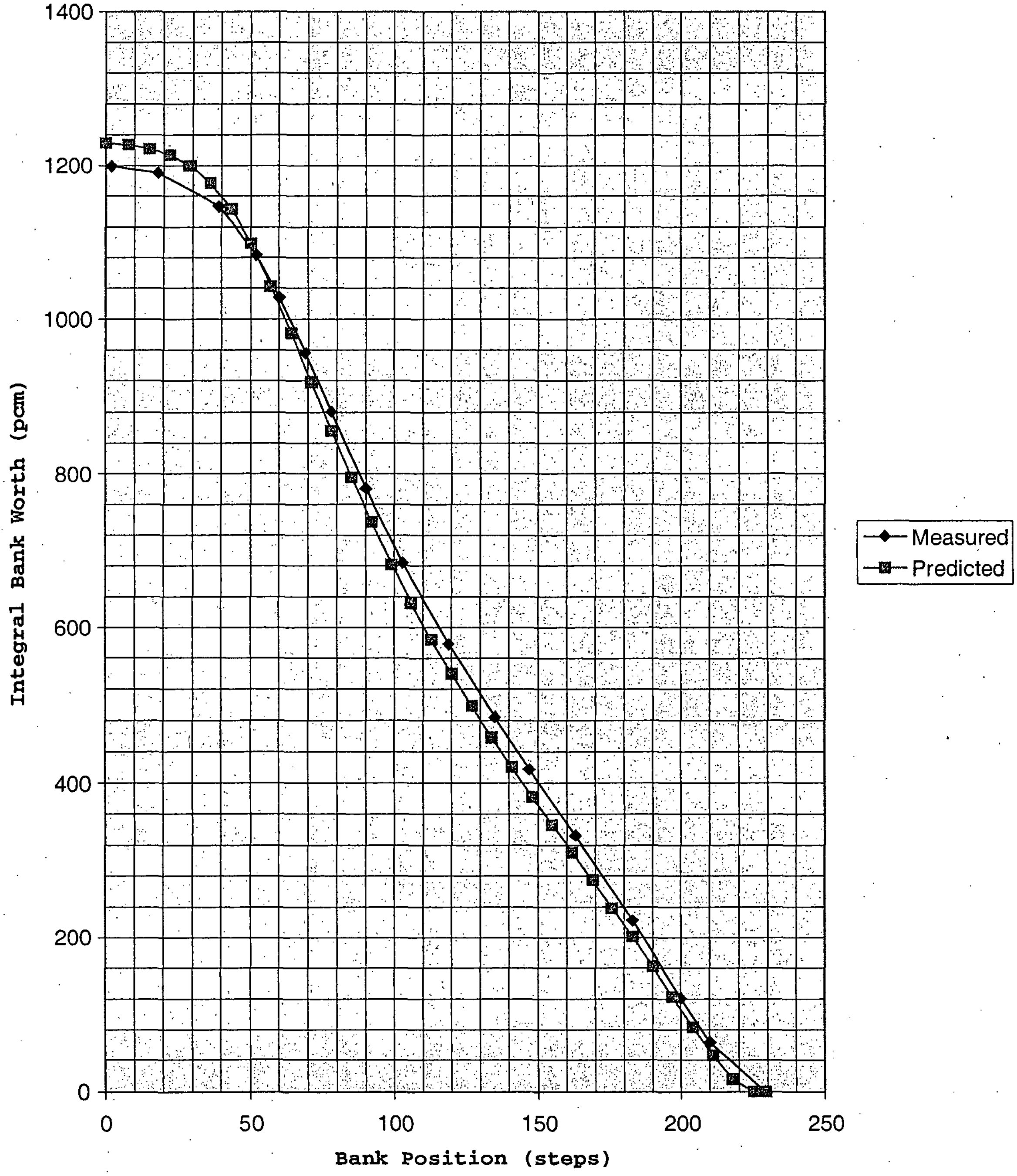
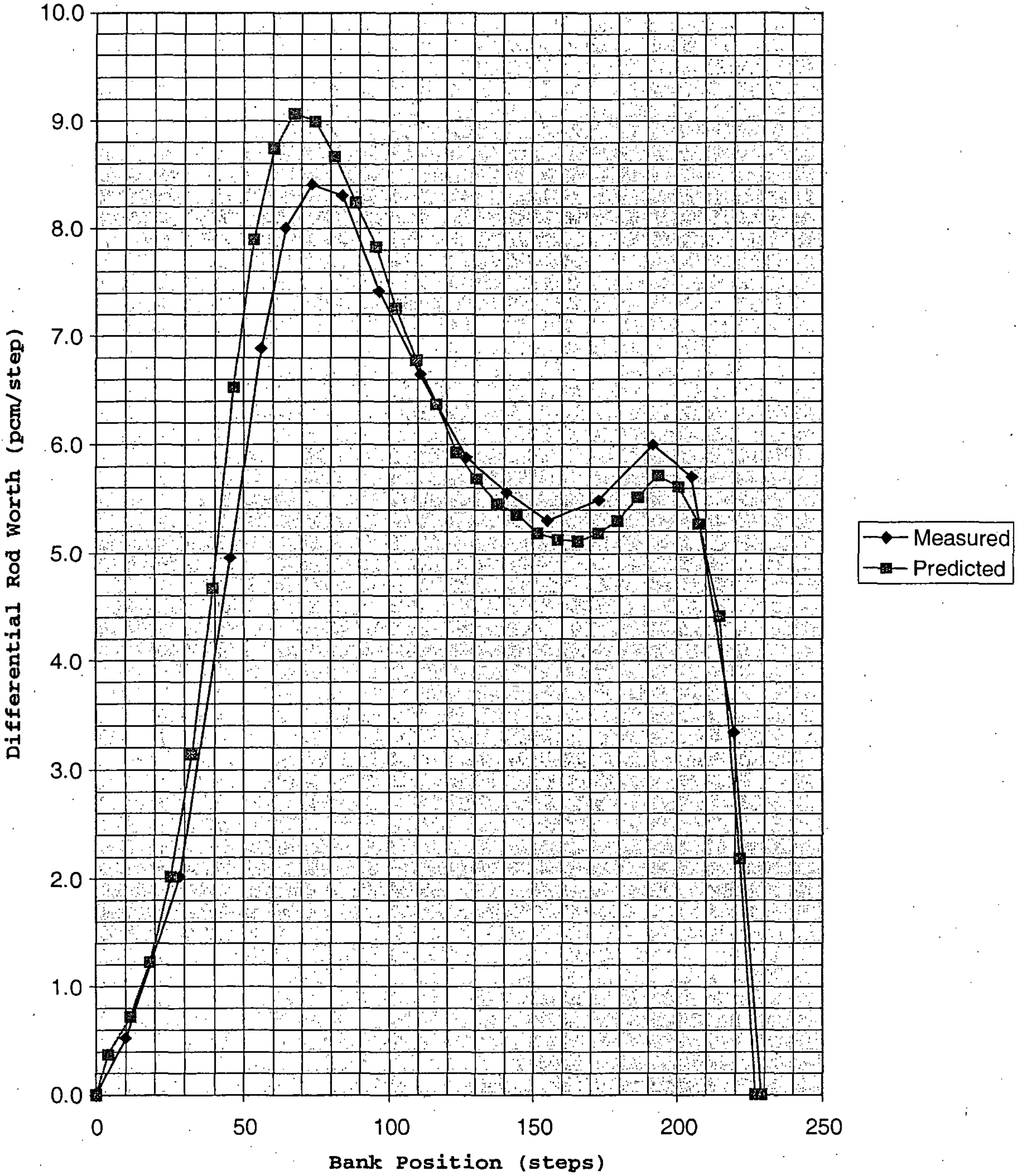


Figure 3.2

SURRY UNIT 1 – CYCLE 21 STARTUP PHYSICS TESTS
CONTROL BANK D DIFFERENTIAL ROD WORTH - HZP
ALL OTHER RODS WITHDRAWN



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SECTION 4 — BORON ENDPOINT AND WORTH MEASUREMENTS

Boron Endpoint

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

The results of these measurements are given in Table 4.1. As shown in this table and in the Startup Physics Test Results and Evaluation Sheets given in the Appendix, the measured critical boron endpoint values were within their respective design tolerances. The ARO endpoint comparison to the predicted value met the requirements of Technical Specification 4.10.A [Ref. 4] regarding core reactivity balance. In summary, the boron endpoint results were satisfactory.

Boron Worth Coefficient

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

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

Table 4.1

SURRY UNIT 1 – CYCLE 21 STARTUP PHYSICS TESTS
BORON ENDPOINTS SUMMARY

Control Rod Configuration	Measured Endpoint (ppm)	Predicted Endpoint (ppm)	Difference M-P (ppm)
ARO	1692	1693	-1
D Bank In	1533	1526*	+7

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

Table 4.2

SURRY UNIT 1 – CYCLE 21 STARTUP PHYSICS TESTS
BORON WORTH COEFFICIENT

Measured Boron Worth (pcm/ppm)	Predicted Boron Worth (pcm/ppm)	Percent Difference (%) (M-P)/P x 100
-7.54	-7.41	-1.75

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SECTION 5 — TEMPERATURE COEFFICIENT MEASUREMENT

The isothermal temperature coefficient (ITC) at the all-rods-out condition is measured by controlling the reactor coolant system (RCS) temperature with the steam dump valves to the condenser, establishing a constant heatup or cooldown rate, and monitoring the resulting reactivity changes on the reactivity computer.

Reactivity was measured during the RCS heatup of +3.04°F, followed by the RCS cooldown of -3.03°F. Reactivity and temperature data were taken from the reactivity computer. Using the statepoint method, the temperature coefficient was determined by dividing the change in reactivity by the change in RCS temperature. Plots of reactivity versus temperature confirmed the statepoint method in calculating the measured ITC.

The predicted and measured isothermal temperature coefficient values are compared in Table 5.1. As can be seen from this summary and from the Startup Physics Test Results and Evaluation Sheet given in the Appendix, the measured isothermal temperature coefficient value was within the design tolerance of ±2 pcm/°F. The measured ITC of –2.009 pcm/°F meets the Core Operating Limits Report (COLR) 3.1.1 criterion [Ref. 9] that the moderator temperature coefficient (MTC) be less than or equal to +6.0 pcm/°F. When the Doppler temperature coefficient [Ref. 1] of –1.81 pcm/°F and a 0.5 pcm/°F uncertainty are accounted for with the MTC limit, the MTC requirement is satisfied as long as the ITC is less than or equal to +3.69 pcm/ °F.

Table 5.1

SURRY UNIT 1 – CYCLE 21 STARTUP PHYSICS TESTS
ISOTHERMAL TEMPERATURE COEFFICIENT SUMMARY

BANK POSITION (STEPS)	TEMPERATURE RANGE (°F)		BORON CONCENTRATION (ppm)	ISOTHERMAL TEMPERATURE COEFFICIENT (PCM/°F)				
	LOWER LIMIT	UPPER LIMIT		HEAT-UP	COOL-DOWN	AVG. MEAS	PRED	DIFFER (M-P)
D/210	546.63	550.08	1684	-2.022	-1.996	-2.009	-1.593	-0.416

SECTION 6 — POWER DISTRIBUTION MEASUREMENTS

The core power distributions were measured using the moveable incore detector flux mapping system. This system consists of five fission chamber detectors which traverse fuel assembly instrumentation thimbles in up to 50 core locations. Figure 1.3 shows the available locations monitored by the moveable detectors for the ramp to full power flux maps for Cycle 21. For each traverse, the detector voltage output is continuously monitored on a recorder, and scanned for 610 discrete axial points. Full core, three-dimensional power distributions are determined from this data using a Dominion-modified version of the Combustion Engineering computer program, CECOR [Ref. 3]. CECOR couples the measured voltages with predetermined analytic power-to-flux ratios in order to determine the power distribution for the whole core.

A list of the full-core flux maps [Ref. 7] taken during the startup test program and the measured values of the important power distribution parameters are given in Table 6.1. A comparison of these measured values with their COLR limits is given in Table 6.2. Flux map 1 was taken at 28.2% power to verify the radial power distribution (RPD) predictions at low power. Figure 6.1 shows the measured RPDs from this flux map. Flux maps 2 and 3 were taken at 69.7% and 99.97% power, respectively, with different control rod configurations. These flux maps were taken to check at-power design predictions and to measure core power distributions at various operating conditions. The radial power distributions for these maps are given in Figures 6.2 and 6.3.

The radial power distributions for the maps given in Figures 6.1, 6.2, and 6.3 show that the measured relative assembly power values deviated from the design predictions by at most –5.6% in the 28.2% power map, -5.4% in the 69.7% power map, and –4.3% in the 99.97% power map. The maximum quadrant power tilts for 28.2%, 69.7%, and 99.97% power maps were +1.29 % (1.0129), +0.46 % (1.0046), and +0.46% (1.0046), respectively. These power tilts were within the design tolerance of 2% (1.02).

The measured $F_Q(Z)$ and $F_{\Delta H}^N$ peaking factor values for the at-power flux maps were within the limits of COLR Sections 3.3 and 3.4 [Ref. 9], respectively. Flux Maps 1, 2, and 3 were used for power range detector calibration or were used to confirm existing calibrations. The flux map analyses are documented in [Ref. 7].

In conclusion, the power distribution measurement results were considered to be acceptable with respect to the design tolerances, the accident analysis acceptance criteria, and the COLR [Ref. 9]. It is therefore anticipated that the core will continue to operate safely throughout Cycle 21.

Table 6.1

SURRY UNIT 1 – CYCLE 21 STARTUP PHYSICS TESTS INCORE FLUX MAP SUMMARY

Map Description	Map No.	Date	Burn up MWD/MTU	Power (%)	Bank D Steps	Peak $F_Q(Z)$ Hot Channel Factor (1)			$F^N_{\Delta H}$ Hot Channel Factor		Core F_Z Max		Core Tilt (2)		Axial Offset (%)	No. Of Thimbles
						Assy	Axial Point	$F_Q(Z)$	Assy	$F^N_{\Delta H}$	Axial Point	F_Z	Max	Loc		
Low Power	1	05/27/06	3	28.20	172	H13	30	2.202	H13	1.551	30	1.319	1.0129	NE	+2.686	41
Int. Power (3)	2	05/27/06	17	69.70	194	C8	25	1.919	C8	1.511	23	1.179	1.0046	NE	+2.626	42
Hot Full Power	3	06/02/06	155	99.97	228	H11	32	1.778	H11	1.466	30	1.134	1.0046	NE	+1.660	42

NOTES: Hot spot locations are specified by giving assembly locations (e.g. H-8 is the center-of-core assembly) and core height (in the "Z" direction the core is divided into 61 axial points starting from the top of the core). Flux Maps 1, 2, and 3 were used for power range detector calibration or were used to confirm existing calibrations.

(1) $F_Q(Z)$ includes a total uncertainty of 1.08

(2) CORE TILT - defined as the average quadrant power tilt from CECOR. "Max" refers to the maximum positive core tilt (QPTR > 1.0000).

(3) Int. Power – intermediate power flux map.

Table 6.2

SURRY UNIT 1 – CYCLE 21 STARTUP PHYSICS TESTS
COMPARISION OF MEASURED POWER DISTRIBUTION PARAMETERS WITH THEIR CORE OPERATING LIMITS

Map	Peak $F_Q(Z)$ Hot Channel Factor*			$F_Q(Z)$ Hot Channel Factor** (At Node of Minimum Margin)				$F_{\Delta H}^N$ Hot Channel Factor		
No.	Meas.	Limit	Node	Meas.	Limit	Node	Margin (%)	Meas.	Limit	Margin (%)
1	2.202	4.628	30	2.183	4.582	26	52.36	1.551	1.896	18.20
2	1.919	3.279	25	1.907	3.254	22	41.40	1.511	1.702	11.22
3	1.778	2.321	32	1.770	2.257	20	21.58	1.466	1.560	6.03

*The Core Operating Limit for the heat flux hot channel factor, $F_Q(Z)$, is a function of core height and power level. The value for $F_Q(Z)$ listed above is the maximum value of $F_Q(Z)$ in the core. The COLR [Ref. 9] limit listed above is evaluated at the plane of maximum $F_Q(Z)$.

**The value for $F_Q(Z)$ listed above is the value at the plane of minimum margin. The minimum margin values listed above are the minimum percent difference between the measured values of $F_Q(Z)$ and the COLR limit for each map.

The measured $F_Q(Z)$ hot channel factors include 8% total uncertainty.

Figure 6.1

SURRY UNIT 1 – CYCLE 21 STARTUP PHYSICS TESTS
ASSEMBLYWISE POWER DISTRIBUTION
28.2% POWER

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

        .......................                 .........................                 .......................
        .      PREDICTED      .                 .  .285 .  .374 .  .285 .                 .      PREDICTED      .
        .      MEASURED       .                 .  .283 .  .360 .  .283 .                 .      MEASURED       .           1
        .   PCT DIFFERENCE    .                 .   -.8 .  -3.6 .   -.7 .                 .   PCT DIFFERENCE    .
        ....................... ......................................................... .......................
                                .  .334 .  .527 . 1.162 .  .992 . 1.157 .  .527 .  .329 .
                                .  .334 .  .527 . 1.163 .  .991 . 1.160 .  .526 .  .330 .                                   2
                                .   -.1 .    .0 .    .1 .   -.1 .    .3 .   -.1 .    .6 .
                        .........................................................................
                        .  .352 . 1.079 . 1.087 . 1.306 . 1.318 . 1.303 . 1.084 . 1.072 .  .351 .
                        .  .345 . 1.078 . 1.087 . 1.310 . 1.331 . 1.313 . 1.092 . 1.082 .  .351 .                           3
                        .  -2.1 .   -.1 .    .0 .    .3 .    .9 .    .8 .    .8 .   1.0 .    .1 .
                .........................................................................................
                .  .344 .  .845 . 1.096 . 1.232 . 1.254 . 1.284 . 1.253 . 1.230 . 1.096 .  .849 .  .348 .
                .  .343 .  .841 . 1.099 . 1.229 . 1.257 . 1.309 . 1.268 . 1.244 . 1.110 .  .864 .  .354 .                   4
                .   -.2 .   -.5 .    .2 .   -.2 .    .2 .   2.0 .   1.2 .   1.1 .   1.3 .   1.8 .   1.8 .
        .........................................................................................................
        .  .296 . 1.038 . 1.082 . 1.152 . 1.319 . 1.227 . 1.322 . 1.226 . 1.319 . 1.156 . 1.091 . 1.056 .  .305 .
        .  .296 . 1.041 . 1.072 . 1.125 . 1.304 . 1.210 . 1.321 . 1.234 . 1.334 . 1.175 . 1.121 . 1.077 .  .297 .           5
        .   -.1 .    .2 .   -.9 .  -2.3 .  -1.2 .  -1.4 .    .0 .    .6 .   1.2 .   1.7 .   2.7 .   2.0 .  -2.7 .
        .........................................................................................................
        .  .492 . 1.052 . 1.213 . 1.312 . 1.195 . 1.190 . 1.283 . 1.188 . 1.196 . 1.319 . 1.225 . 1.073 .  .517 .
        .  .489 . 1.048 . 1.205 . 1.302 . 1.182 . 1.177 . 1.269 . 1.189 . 1.207 . 1.342 . 1.255 . 1.099 .  .530 .           6
        .   -.6 .   -.4 .   -.6 .   -.8 .  -1.1 .  -1.1 .  -1.1 .    .1 .   1.0 .   1.7 .   2.4 .   2.4 .   2.6 .
.........................................................................................................................
.  .284 . 1.132 . 1.279 . 1.239 . 1.220 . 1.188 . 1.188 . 1.300 . 1.185 . 1.189 . 1.225 . 1.250 . 1.298 . 1.156 .  .287 .
.  .277 . 1.121 . 1.273 . 1.232 . 1.213 . 1.178 . 1.179 . 1.291 . 1.184 . 1.199 . 1.245 . 1.283 . 1.336 . 1.204 .  .297 .   7
.  -2.1 .  -1.0 .   -.4 .   -.6 .   -.5 .   -.8 .   -.7 .   -.6 .   -.1 .    .8 .   1.6 .   2.7 .   2.9 .   4.1 .   3.5 .
.........................................................................................................................
.  .370 .  .979 . 1.302 . 1.273 . 1.316 . 1.285 . 1.307 . 1.020 . 1.300 . 1.284 . 1.320 . 1.280 . 1.313 .  .990 .  .374 .
.  .349 .  .962 . 1.288 . 1.263 . 1.315 . 1.275 . 1.296 . 1.011 . 1.295 . 1.294 . 1.336 . 1.304 . 1.344 . 1.010 .  .380 .   8
.  -5.6 .  -1.8 .  -1.1 .   -.7 .   -.1 .   -.8 .   -.9 .   -.8 .   -.4 .    .7 .   1.2 .   1.9 .   2.4 .   2.1 .   1.6 .
.........................................................................................................................
.  .285 . 1.147 . 1.290 . 1.245 . 1.224 . 1.191 . 1.192 . 1.306 . 1.189 . 1.190 . 1.226 . 1.250 . 1.296 . 1.151 .  .288 .
.  .278 . 1.129 . 1.273 . 1.227 . 1.195 . 1.172 . 1.175 . 1.291 . 1.169 . 1.205 . 1.237 . 1.263 . 1.310 . 1.159 .  .282 .   9
.  -2.6 .  -1.6 .  -1.4 .  -1.4 .  -2.3 .  -1.6 .  -1.4 .  -1.2 .  -1.7 .   1.3 .    .9 .   1.1 .   1.1 .    .6 .  -2.3 .
.........................................................................................................................
        .  .514 . 1.069 . 1.223 . 1.318 . 1.197 . 1.192 . 1.287 . 1.193 . 1.200 . 1.320 . 1.226 . 1.073 .  .516 .
        .  .507 . 1.054 . 1.204 . 1.297 . 1.177 . 1.166 . 1.277 . 1.184 . 1.196 . 1.321 . 1.230 . 1.074 .  .505 .           10
        .  -1.5 .  -1.4 .  -1.5 .  -1.6 .  -1.7 .  -2.1 .   -.8 .   -.8 .   -.3 .    .0 .    .3 .    .1 .  -2.3 .
        .........................................................................................................
        .  .304 . 1.053 . 1.090 . 1.156 . 1.320 . 1.229 . 1.325 . 1.231 . 1.325 . 1.160 . 1.094 . 1.057 .  .305 .
        .  .299 . 1.035 . 1.073 . 1.142 . 1.308 . 1.222 . 1.333 . 1.229 . 1.310 . 1.148 . 1.093 . 1.054 .  .302 .           11
        .  -1.7 .  -1.7 .  -1.5 .  -1.2 .   -.9 .   -.5 .    .6 .   -.1 .  -1.1 .  -1.0 .    .0 .   -.3 .   -.9 .
        .........................................................................................................
                .  .347 .  .848 . 1.096 . 1.231 . 1.256 . 1.287 . 1.258 . 1.237 . 1.102 .  .853 .  .349 .
                .  .334 .  .835 . 1.085 . 1.225 . 1.258 . 1.299 . 1.266 . 1.239 . 1.104 .  .864 .  .342 .                   12
                .  -3.8 .  -1.6 .  -1.1 .   -.5 .    .2 .    .9 .    .6 .    .2 .    .2 .   1.3 .  -2.0 .
                .........................................................................................
                        .  .351 . 1.073 . 1.085 . 1.305 . 1.321 . 1.310 . 1.091 . 1.084 .  .355 .
                        .  .346 . 1.063 . 1.083 . 1.314 . 1.349 . 1.326 . 1.104 . 1.093 .  .358 .                           13
                        .  -1.3 .   -.9 .   -.3 .    .6 .   2.1 .   1.3 .   1.1 .    .8 .   1.0 .
                        .........................................................................
                                .  .329 .  .527 . 1.159 .  .994 . 1.165 .  .529 .  .336 .
                                .  .319 .  .526 . 1.164 . 1.004 . 1.179 .  .535 .  .338 .                                   14
                                .  -3.0 .   -.3 .    .4 .   1.0 .   1.2 .   1.1 .    .9 .
        ....................... .........................................................                 .......................
        .      STANDARD       .                 .  .286 .  .375 .  .286 .                 .       AVERAGE       .
        .      DEVIATION      .                 .  .280 .  .376 .  .288 .                 .   PCT DIFFERENCE    .           15
        .       = .913        .                 .  -2.2 .    .5 .   1.0 .                 .        = 1.2        .
        .......................                 .........................                 .......................

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

Summary:

Map No: S1-21-01

Date: 05/27/2006

Power: 28.2%

Control Rod Position:

D Bank at 172 Steps

$F_Q(Z)$ = 2.202

$F_{\Delta H}^{N}$ = 1.551

F_Z = 1.319

Burnup = 3 MWD/MTU

QPTR:

0.9907	1.0129
0.9899	1.0065

Axial Offset (%) = +2.686

Figure 6.2

SURRY UNIT 1 – CYCLE 21 STARTUP PHYSICS TESTS
ASSEMBLYWISE POWER DISTRIBUTION
69.7% POWER

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

        ................                        .........................               ................
        .  PREDICTED   .                        .  .301 .  .396 .  .301 .               .  PREDICTED   .
        .  MEASURED    .                        .  .300 .  .389 .  .299 .               .  MEASURED    .                       1
        .PCT DIFFERENCE.                        .   -.3 .  -1.9 .   -.6 .               .PCT DIFFERENCE.
        ................        .........................................................................
                                .  .348 .  .541 . 1.160 . 1.022 . 1.156 .  .540 .  .342 .
                                .  .349 .  .543 . 1.164 . 1.023 . 1.154 .  .530 .  .340 .                                       2
                                .    .4 .    .3 .    .3 .    .1 .   -.1 .  -1.9 .   -.6 .
                        .........................................................................
                        .  .367 . 1.080 . 1.083 . 1.285 . 1.292 . 1.282 . 1.080 . 1.072 .  .365 .
                        .  .361 . 1.084 . 1.087 . 1.291 . 1.303 . 1.286 . 1.079 . 1.072 .  .361 .                               3
                        .  -1.6 .    .4 .    .4 .    .5 .    .9 .    .3 .   -.1 .    .0 .   -.9 .
                .........................................................................................
                .  .359 .  .861 . 1.097 . 1.220 . 1.235 . 1.257 . 1.233 . 1.218 . 1.096 .  .862 .  .362 .
                .  .361 .  .863 . 1.108 . 1.224 . 1.240 . 1.275 . 1.241 . 1.222 . 1.100 .  .868 .  .365 .                       4
                .    .4 .    .2 .    .9 .    .3 .    .4 .   1.5 .    .6 .    .4 .    .4 .    .7 .    .8 .
        .........................................................................................................
        .  .311 . 1.046 . 1.087 . 1.155 . 1.315 . 1.217 . 1.293 . 1.215 . 1.313 . 1.156 . 1.092 . 1.058 .  .318 .
        .  .313 . 1.054 . 1.086 . 1.147 . 1.310 . 1.209 . 1.295 . 1.218 . 1.318 . 1.164 . 1.108 . 1.068 .  .310 .               5
        .    .5 .    .7 .   -.1 .   -.7 .   -.4 .   -.7 .    .2 .    .3 .    .4 .    .7 .   1.5 .   1.0 .  -2.7 .
        .........................................................................................................
        .  .512 . 1.056 . 1.207 . 1.310 . 1.235 . 1.194 . 1.269 . 1.192 . 1.234 . 1.314 . 1.214 . 1.071 .  .532 .
        .  .513 . 1.060 . 1.205 . 1.298 . 1.228 . 1.189 . 1.269 . 1.189 . 1.234 . 1.322 . 1.228 . 1.085 .  .539 .               6
        .    .2 .    .4 .   -.2 .   -.9 .   -.6 .   -.4 .    .0 .   -.2 .    .0 .    .6 .   1.1 .   1.4 .   1.4 .
.........................................................................................................................
.  .302 . 1.141 . 1.267 . 1.225 . 1.212 . 1.193 . 1.188 . 1.290 . 1.184 . 1.193 . 1.215 . 1.230 . 1.278 . 1.156 .  .304 .
.  .298 . 1.141 . 1.278 . 1.225 . 1.208 . 1.187 . 1.184 . 1.285 . 1.174 . 1.191 . 1.221 . 1.243 . 1.304 . 1.187 .  .309 .       7
.  -1.4 .    .0 .    .9 .    .0 .   -.3 .   -.5 .   -.3 .   -.4 .   -.9 .   -.1 .    .5 .   1.1 .   2.0 .   2.7 .   1.7 .
.........................................................................................................................
.  .395 . 1.016 . 1.283 . 1.251 . 1.291 . 1.272 . 1.297 . 1.025 . 1.289 . 1.270 . 1.291 . 1.254 . 1.289 . 1.021 .  .397 .
.  .374 . 1.007 . 1.280 . 1.248 . 1.289 . 1.267 . 1.292 . 1.021 . 1.285 . 1.270 . 1.297 . 1.270 . 1.326 . 1.007 .  .393 .       8
.  -5.4 .   -.9 .   -.3 .   -.3 .   -.1 .   -.4 .   -.4 .   -.4 .   -.4 .    .0 .    .4 .   1.3 .   2.9 .  -1.4 .  -1.1 .
.........................................................................................................................
.  .303 . 1.152 . 1.276 . 1.229 . 1.215 . 1.195 . 1.190 . 1.294 . 1.187 . 1.193 . 1.214 . 1.230 . 1.277 . 1.152 .  .305 .
.  .296 . 1.142 . 1.266 . 1.218 . 1.194 . 1.184 . 1.185 . 1.291 . 1.182 . 1.193 . 1.216 . 1.236 . 1.284 . 1.141 .  .295 .       9
.  -2.1 .   -.9 .   -.7 .   -.9 .  -1.7 .   -.9 .   -.5 .   -.2 .   -.4 .    .0 .    .2 .    .5 .    .6 .   -.9 .  -3.1 .
.........................................................................................................................
        .  .531 . 1.069 . 1.214 . 1.315 . 1.235 . 1.194 . 1.272 . 1.195 . 1.237 . 1.314 . 1.214 . 1.070 .  .531 .
        .  .526 . 1.061 . 1.200 . 1.297 . 1.224 . 1.188 . 1.273 . 1.194 . 1.233 . 1.309 . 1.213 . 1.066 .  .516 .              10
        .   -.9 .   -.7 .  -1.1 .  -1.3 .   -.9 .   -.5 .    .1 .   -.1 .   -.3 .   -.4 .   -.1 .   -.3 .  -2.7 .
        .........................................................................................................
        .  .318 . 1.057 . 1.092 . 1.157 . 1.315 . 1.217 . 1.294 . 1.218 . 1.317 . 1.159 . 1.093 . 1.058 .  .318 .
        .  .314 . 1.043 . 1.076 . 1.137 . 1.306 . 1.219 . 1.310 . 1.222 . 1.308 . 1.142 . 1.091 . 1.052 .  .314 .              11
        .  -1.2 .  -1.3 .  -1.5 .  -1.7 .   -.7 .    .2 .   1.2 .    .4 .   -.7 .  -1.4 .   -.1 .   -.5 .  -1.3 .
        .........................................................................................................
                .  .362 .  .862 . 1.096 . 1.219 . 1.234 . 1.258 . 1.236 . 1.222 . 1.100 .  .865 .  .362 .
                .  .350 .  .848 . 1.082 . 1.214 . 1.240 . 1.275 . 1.247 . 1.226 . 1.104 .  .883 .  .354 .                      12
                .  -3.2 .  -1.6 .  -1.2 .   -.4 .    .5 .   1.3 .    .9 .    .4 .    .3 .   2.2 .  -2.2 .
                .........................................................................................
                        .  .365 . 1.072 . 1.080 . 1.283 . 1.293 . 1.286 . 1.085 . 1.082 .  .368 .
                        .  .360 . 1.059 . 1.077 . 1.293 . 1.324 . 1.304 . 1.096 . 1.091 .  .373 .                              13
                        .  -1.4 .  -1.3 .   -.3 .    .8 .   2.4 .   1.4 .   1.0 .    .9 .   1.4 .
                        .........................................................................
                                .  .342 .  .541 . 1.157 . 1.023 . 1.161 .  .542 .  .348 .
                                .  .326 .  .538 . 1.161 . 1.035 . 1.177 .  .548 .  .351 .                                      14
                                .  -4.7 .   -.6 .    .4 .   1.3 .   1.4 .   1.2 .   1.0 .
        ................        .........................................................       ................
        .   STANDARD   .                        .  .301 .  .397 .  .301 .               .   AVERAGE    .
        .  DEVIATION   .                        .  .292 .  .398 .  .304 .               .PCT DIFFERENCE.                      15
        .   = .842     .                        .  -3.1 .    .4 .   1.1 .               .   =    .9    .
        ................                        .........................               ................

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

Summary:

Map No: S1-21-02
Control Rod Position:
D Bank at 194 Steps

Date: 05/27/2006
$F_Q(Z) = 1.919$
$F^N_{\Delta H} = 1.511$
$F_Z = 1.179$
Burnup = 17 MWD/MTU

Power: 69.7%

QPTR:

0.9977	1.0046
0.9938	1.0039

Axial Offset (%) = +2.626

Figure 6.3

SURRY UNIT 1 – CYCLE 21 STARTUP PHYSICS TESTS
ASSEMBLYWISE POWER DISTRIBUTION
99.97% POWER

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

        ................                        .........................                 ................
        .   PREDICTED  .                        .  .307 .  .408 .  .307 .                 .   PREDICTED  .
        .   MEASURED   .                        .  .307 .  .405 .  .306 .                 .   MEASURED   .                  1
        .PCT DIFFERENCE.                        .    .1 .   -.7 .   -.3 .                 .PCT DIFFERENCE.
        ................        ......................................................... ................
                                .  .347 .  .541 . 1.144 . 1.048 . 1.140 .  .540 .  .342 .
                                .  .349 .  .543 . 1.149 . 1.050 . 1.139 .  .530 .  .340 .                                   2
                                .    .6 .    .4 .    .4 .    .2 .   -.1 .  -1.8 .   -.4 .
                        .........................................................................
                        .  .367 . 1.056 . 1.069 . 1.265 . 1.268 . 1.262 . 1.066 . 1.049 .  .364 .
                        .  .365 . 1.065 . 1.074 . 1.271 . 1.275 . 1.265 . 1.066 . 1.053 .  .366 .                           3
                        .   -.5 .    .8 .    .5 .    .5 .    .5 .    .3 .    .0 .    .4 .    .5 .
                ..........................................................................................
                .  .360 .  .854 . 1.088 . 1.210 . 1.224 . 1.242 . 1.222 . 1.207 . 1.086 .  .854 .  .362 .
                .  .362 .  .858 . 1.102 . 1.215 . 1.229 . 1.257 . 1.229 . 1.213 . 1.093 .  .864 .  .366 .                   4
                .    .3 .    .4 .   1.3 .    .5 .    .4 .   1.2 .    .6 .    .5 .    .7 .   1.1 .   1.1 .
        .........................................................................................................
        .  .314 . 1.028 . 1.079 . 1.159 . 1.324 . 1.222 . 1.280 . 1.220 . 1.322 . 1.159 . 1.082 . 1.036 .  .319 .
        .  .314 . 1.032 . 1.078 . 1.150 . 1.321 . 1.215 . 1.282 . 1.224 . 1.329 . 1.169 . 1.103 . 1.048 .  .312 .           5
        .    .1 .    .4 .   -.1 .   -.8 .   -.2 .   -.5 .    .1 .    .3 .    .5 .    .9 .   1.9 .   1.1 .  -2.2 .
        .........................................................................................................
        .  .518 . 1.047 . 1.200 . 1.320 . 1.302 . 1.220 . 1.278 . 1.217 . 1.300 . 1.323 . 1.204 . 1.057 .  .531 .
        .  .516 . 1.046 . 1.198 . 1.318 . 1.299 . 1.217 . 1.277 . 1.218 . 1.303 . 1.332 . 1.217 . 1.069 .  .538 .           6
        .   -.3 .   -.1 .   -.2 .   -.2 .   -.2 .   -.3 .   -.1 .    .0 .    .2 .    .7 .   1.1 .   1.2 .   1.2 .
.........................................................................................................................
.  .309 . 1.130 . 1.251 . 1.216 . 1.218 . 1.219 . 1.210 . 1.305 . 1.207 . 1.219 . 1.219 . 1.220 . 1.259 . 1.140 .  .310 .
.  .304 . 1.123 . 1.248 . 1.213 . 1.215 . 1.216 . 1.209 . 1.304 . 1.205 . 1.221 . 1.226 . 1.228 . 1.276 . 1.167 .  .314 .   7
.  -1.6 .   -.6 .   -.2 .   -.3 .   -.2 .   -.3 .   -.1 .   -.1 .   -.2 .    .2 .    .5 .    .7 .   1.3 .   2.3 .   1.3 .
.........................................................................................................................
.  .408 . 1.045 . 1.262 . 1.238 . 1.279 . 1.281 . 1.312 . 1.052 . 1.305 . 1.279 . 1.279 . 1.240 . 1.265 . 1.048 .  .409 .
.  .390 . 1.034 . 1.254 . 1.232 . 1.276 . 1.276 . 1.309 . 1.050 . 1.302 . 1.283 . 1.284 . 1.249 . 1.282 . 1.032 .  .404 .   8
.  -4.3 .  -1.1 .   -.7 .   -.5 .   -.2 .   -.4 .   -.3 .   -.3 .   -.2 .    .3 .    .4 .    .7 .   1.3 .  -1.6 .  -1.2 .
.........................................................................................................................
.  .309 . 1.138 . 1.258 . 1.219 . 1.220 . 1.221 . 1.213 . 1.309 . 1.209 . 1.219 . 1.219 . 1.219 . 1.257 . 1.137 .  .311 .
.  .304 . 1.128 . 1.248 . 1.207 . 1.198 . 1.210 . 1.207 . 1.305 . 1.199 . 1.229 . 1.224 . 1.223 . 1.258 . 1.124 .  .304 .   9
.  -1.8 .   -.9 .   -.7 .   -.9 .  -1.8 .   -.9 .   -.5 .   -.3 .   -.9 .    .8 .    .4 .    .3 .    .0 .  -1.1 .  -2.2 .
.........................................................................................................................
        .  .531 . 1.056 . 1.204 . 1.323 . 1.302 . 1.220 . 1.280 . 1.221 . 1.303 . 1.323 . 1.204 . 1.056 .  .531 .
        .  .527 . 1.053 . 1.194 . 1.310 . 1.293 . 1.214 . 1.282 . 1.219 . 1.304 . 1.323 . 1.204 . 1.052 .  .516 .          10
        .   -.7 .   -.3 .   -.8 .  -1.0 .   -.7 .   -.5 .    .1 .   -.1 .    .1 .    .0 .    .0 .   -.5 .  -2.8 .
        .........................................................................................................
        .  .318 . 1.036 . 1.082 . 1.160 . 1.323 . 1.221 . 1.282 . 1.223 . 1.326 . 1.161 . 1.083 . 1.036 .  .318 .
        .  .316 . 1.027 . 1.072 . 1.148 . 1.317 . 1.223 . 1.298 . 1.227 . 1.319 . 1.154 . 1.085 . 1.033 .  .315 .          11
        .   -.8 .   -.8 .  -1.0 .  -1.0 .   -.4 .    .2 .   1.3 .    .3 .   -.5 .   -.6 .    .2 .   -.3 .  -1.2 .
        .........................................................................................................
                .  .362 .  .854 . 1.086 . 1.208 . 1.223 . 1.243 . 1.225 . 1.211 . 1.090 .  .857 .  .362 .
                .  .353 .  .844 . 1.076 . 1.203 . 1.225 . 1.252 . 1.232 . 1.216 . 1.096 .  .875 .  .359 .                  12
                .  -2.4 .  -1.2 .   -.9 .   -.4 .    .2 .    .7 .    .6 .    .4 .    .6 .   2.1 .  -1.1 .
                ..........................................................................................
                        .  .365 . 1.050 . 1.066 . 1.263 . 1.269 . 1.266 . 1.070 . 1.058 .  .368 .
                        .  .360 . 1.038 . 1.061 . 1.263 . 1.279 . 1.276 . 1.083 . 1.069 .  .373 .                          13
                        .  -1.2 .  -1.1 .   -.5 .    .1 .    .8 .    .8 .   1.2 .   1.0 .   1.5 .
                        .........................................................................
                                .  .342 .  .540 . 1.141 . 1.049 . 1.145 .  .541 .  .347 .
                                .  .328 .  .535 . 1.138 . 1.053 . 1.153 .  .546 .  .351 .                                  14
                                .  -3.9 .   -.9 .   -.2 .    .4 .    .7 .    .9 .   1.0 .
        ................        ......................................................... ................
        . STANDARD     .                        .  .307 .  .408 .  .307 .                 .    AVERAGE   .
        . DEVIATION    .                        .  .299 .  .407 .  .308 .                 .PCT DIFFERENCE.                 15
        .  = .686      .                        .  -2.8 .   -.2 .    .4 .                 .   =    .7    .
        ................                        .........................                 ................

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

Summary:

Map No: S1-21-03

Control Rod Position:

D Bank at 228 Steps

Date: 06/02/2006

$F_Q(Z)$ = 1.778

$F^N_{\Delta H}$ = 1.466

F_Z = 1.134

Burnup = 155 MWD/MTU

Power: 99.97%

QPTR:

0.9986	1.0046
0.9939	1.0029

Axial Offset (%) = +1.660

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SECTION 7 — REFERENCES

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16. R. W. Twitchell, "Control Rod Reactivity Worth Determination By The Rod Swap Technique," Technical Report NE-1378, Rev. 1, September 2004

APPENDIX — STARTUP PHYSICS TEST RESULTS AND EVALUATION SHEETS

Surry Power Station Unit 1 Cycle 21 Startup Physics Test Summary Sheet - Formal Tests (Page 1 of 6)

Measured Value	Design Criteria	Acceptance Criteria	Design Criteria Met	Acceptance Criteria Met	Date/ Time of Test	Preparer/ Reviewer
Zero Power Testing Range Determination						
ZPTR= 2E-9 to 1E-7 amps	background < ZPTR < POAH background = 8.32E-12 amps POAH= >2E-7 amps	N/A	✓ Yes ___ No	N/A	02:49 5/25/06	RDK DAP
Reactivity Computer Checkout						
ρ_o= +63.50, -35.76 pcm (measured reactivity) ρ_t= +64.27, -35.98 pcm (predicted reactivity) %D = [(ρo - ρt)/ρt] x 100% %D = -1.18%, -0.63%	$\lvert((\rho_o - \rho_t)/\rho_t)\rvert \times 100\% \le 4.0\%^3$ The allowable range is set to the larger of the measured results or the pre-critical bench test. Pre-critical Bench Test Results ±120 pcm Allowable range ±100 pcm	N/A	✓ Yes ___ No	N/A	02:49 5/25/06	RDK DAP
Critical Boron Concentration - ARO						
$(C_B)^M_{ARO}$= 1692 ppm (Adj. To design conds.)	$(C_B)_{ARO}=^1$ 1693 ± 50 ppm $\Delta(C_B)_{ARO}=(C_B)^M_{ARO} - (C_B)_{ARO}$ = -1 ppm	$\lvert\alpha C_B \times \Delta(C_B)_{ARO}\rvert \le 1000$ pcm [T.S. 4.10.A] $\alpha C_B=^1$ -7.4 pcm/ppm	✓ Yes ___ No	✓ Yes ___ No	02:49 5/25/06	RDK DAP
Isothermal Temperature Coefficient - ARO						
$(\alpha_T^{ISO})^M_{ARO}$ = -2.009 pcm/F	$(\alpha_T^{ISO})_{ARO}=^1$ -1.593 ± 2 pcm/F $(\alpha_T^{ISO})^M_{ARO} - (\alpha_T^{ISO})_{ARO}$ = 0.416 pcm/F	$\alpha_T^{ISO} \le \alpha_M^{lim} - \alpha_T^{mod} + \alpha_T^{DOP}$ $\alpha_T^{ISO} \le 5.69$ pcm/F where: (α_M^{lim}); 6.0 pcm/F [COLR 3.1.1] $(\alpha_T^{mod})^2$; 0.5 pcm/F $(\alpha_T^{DOP})^1$; -1.81 pcm/F	✓ Yes ___ No	✓ Yes ___ No	03:25 5/25/06	RDK DAP
Control Bank D Worth Measurement / Rod Swap Reference Bank						
$I_D^{REF,M}$= 1198.32 pcm	$I_D^{REF}=^1$ 1230 ± 123 pcm 100x(Meas. - Des.)/Des. = -2.6 %	N/A	✓ Yes ___ No	N/A	04:19 5/25/06	RDK AN

References 1.) NE-1480, Rev. 0
2.) Memorandum from C.T. Snow to E.J. Lozito, dated June 27, 1980
3.) WCAP-7905, Rev. 1
4.) ET NAF-06-0053, Rev. 0

Surry Power Station Unit 1 Cycle 21 Startup Physics Test Summary Sheet - Formal Tests (Page 2 of 6)

Measured Value	Design Criteria	Acceptance Criteria	Design Criteria Met	Acceptance Criteria Met	Date/ Time of Test	Preparer/ Reviewer
Critical Boron Concentration - D Bank In						
$(C_B)^M_D=$ 1533.3 ppm	$(C_B)_D=$[1] $1527+\Delta(C_B)_{ARO} \pm 27$ ppm $\Delta(C_B)_{ARO}=$ -1 ppm (from above) $(C_B)_D=$ 1526 ± 27 ppm $(C_B)^M_D - (C_B)_D=$ 7.3 ppm	N/A	✓ Yes ___ No	N/A	5/25/06 AN ~~02:49~~ 05:41	AN RDK
HZP Boron Worth Coefficient Measurement						
$(\alpha C_B)^M=$ -7.54 pcm/ppm	$\alpha C_B=$[1] -7.41 ± 0.74 pcm/ppm $\Delta\alpha C_B=(\alpha C_B)^M - (\alpha C_B)=$ -0.13 pcm/ppm	N/A	✓ Yes ___ No	N/A	5/25/06 02:49	AN RDK
Control Bank A Worth Measurement, Rod Swap						
$I_A^{RS}=$ 277.0 pcm	(I_A^{RS})[4] $=$ 286.8 ± 100 pcm Meas. - Des. = -9.8 pcm	N/A	✓ Yes ___ No	N/A	5/25/06 05:52	AN RDK
Control Bank C Worth Measurement, Rod Swap						
$I_C^{RS}=$ 815.9 pcm	(I_C^{RS})[4] $=$ 816.6 ± 15% 100x(Meas. - Des.)/Des. = -0.1 %	N/A	✓ Yes ___ No	N/A	5/25/06 05:59	AN RDK
Shutdown Bank A Worth Measurement, Rod Swap						
$I_{SA}^{RS}=$ 979.3 pcm	(I_{SA}^{RS})[4] $=$ 997.4 ± 15% 100x(Meas. - Des.)/Des. = -1.8 %	N/A	✓ Yes ___ No	N/A	5/25/06 06:13	AN RDK
Shut Down Bank B Worth Measurement, Rod Swap						
$I_{SB}^{RS}=$ 1004.1 pcm	(I_{SB}^{RS})[4] $=$ 1025.5 ± 15% 100x(Meas. - Des.)/Des. = -2.1 %	N/A	✓ Yes ___ No	N/A	5/25/06 06:26	AN RDK
Control Bank B Worth Measurement, Rod Swap						
$I_B^{RS}=$ 1159.3 pcm	(I_B^{RS})[4] $=$ 1197.4 ± 15% 100x(Meas. - Des.)/Des. = -3.2 %	N/A	✓ Yes ___ No	N/A	5/25/06 06:38	AN RDK
Total Rod Worth, Rod Swap						
$I_{Total}=$ 5433.9 pcm	(I_{total})[4] $=$ 5553.6 ± 10% 100x(Meas. - Des.)/Des. = -2.2 %	N/A	✓ Yes ___ No	N/A	5/25/06 04:19	AN RDK

References 1.) NE-1480, Rev. 0
2.) Memorandum from C.T. Snow to E.J. Lozito, dated June 27, 1980
3.) WCAP-7905, Rev. 1
4.) ET NAF-06-0053, Rev. 0

Surry Power Station Unit 1 Cycle 21 Startup Physics Test Summary Sheet - Formal Tests (Page 3 of 6)

Measured Value	Design Criteria	Acceptance Criteria	Design Criteria Met	Acceptance Criteria Met	Date/ Time of Test	Preparer/ Reviewer
M/D Flux Map - Power ≤ 30%						
Map Power Level (% Full Power) = 28.2						
Max Relative Assembly Power, %DIFF (M-P)/P					5/27/06 02:11	DAP RAH
%DIFF= 4.1 % for Pi ≥0.9 -5.6 % for Pi<0.9	±10% for P_i ~~<~~ $\geq$ 0.9 DAP 5/27/06 ±15% for P_i<0.9 (P_i = assy power)^{1,3}	N/A	✓ Yes No	N/A		
Nuclear Enthalpy Rise Hot Channel Factor, FΔH(N)						
FΔH(N)= 1.551	N/A	FΔH(N)≤1.56(1+0.3(1-P)) [COLR 3.4]	N/A	✓ Yes No		
Total Heat Flux Hot Channel Factor, FQ(Z)						
$F_Q(Z)$= 2.202	N/A	$F_Q(Z)$≤4.64*K(Z) [COLR 3.3] Margin to COLR Limit=	N/A	✓ Yes No		
Maximum Positive Incore Quadrant Power Tilt						
Tilt= 1.0129	≤ 1.02^3	N/A	✓ Yes No	N/A		
Most Positive Measured To Predicted FDH Difference, Core Location H11 (or any of it's eighth core partners)					5/27/06 02:11	DAP RAH
%DIFF= 1.2 %	N/A	≤ 14.9% Note that if this criteria is not met, a flux map must be taken at ≤30% power, with the control rods at the rod insertion limits.	N/A	✓ Yes No		

References
1.) NE-1480, Rev. 0
2.) Memorandum from C.T. Snow to E.J. Lozito, dated June 27, 1980
3.) WCAP-7905, Rev. 1
4.) ET NAF-06-0053, Rev. 0

Surry Power Station Unit 1 Cycle 21 Startup Physics Test Summary Sheet - Formal Tests (Page 4 of 6)

Measured Value	Design Criteria	Acceptance Criteria	Design Criteria Met	Acceptance Criteria Met	Date/ Time of Test	Preparer/ Reviewer
M/D Flux Map: 65% ≤ Power ≤ 75%						
Map Power Level (% Full Power) = 69.7						
Max Relative Assembly Power, %DIFF (M-P)/P	Jwm 5/28/06				5/27/06 21:11	Jwm 5/28/06
%DIFF= 2.9 % for Pi ≥0.9 -5.4 % for Pi<0.9	±10% for P_i ~~≥~~ ≥ 0.9 ±15% for P_i<0.9 (P_i = assy power)[1,3]	N/A	X Yes ___ No	N/A		
Nuclear Enthalpy Rise Hot Channel Factor, FΔH(N)						CJW 5/28/06
FΔH(N)= 1.511	N/A	FΔH(N)≤1.56(1+0.3(1-P)) [COLR 3.4]	N/A	X Yes ___ No		
Total Heat Flux Hot Channel Factor, FQ(Z)						
(1.907 @ Min Margin) $F_Q(Z)$= 1.919	N/A	$F_Q(Z)$≤(2.32/P)*K(Z) [COLR 3.3] Margin to COLR Limit= 70.6%	N/A	X Yes ___ No		
Maximum Positive Incore Quadrant Power Tilt						
Tilt= 1.0046	≤1.02[3]	N/A	X Yes ___ No	N/A		

References 1.) NE-1480, Rev. 0
2.) Memorandum from C.T. Snow to E.J. Lozito, dated June 27, 1980
3.) WCAP-7905, Rev. 1
4.) ET NAF-06-0053, Rev. 0

Surry Power Station Unit 1 Cycle 21 Startup Physics Test Summary Sheet - Formal Tests (Page 5 of 6)

Measured Value	Design Criteria	Acceptance Criteria	Design Criteria Met	Acceptance Criteria Met	Date/ Time of Test	Preparer/ Reviewer
M/D Flux Map, 95% ≤ Power ≤ 100%						
Map Power Level (% Full Power) = 99.97						
Max Relative Assembly Power, %DIFF (M-P)/P					6/2/06 08:59	may 6/6/06 JDS
%DIFF= 2.3 % for Pi ≥0.9 -4.3 % for Pi<0.9	±10% for $P_i \geq 0.9$ ±15% for $P_i < 0.9$ (P_i = assy power)^{1,3}	N/A	X Yes ___ No	N/A		
Nuclear Enthalpy Rise Hot Channel Factor, FΔH(N)						
FΔH(N)= 1.466	N/A	FΔH(N)≤1.56(1+0.3(1-P)) [COLR 3.4]	N/A	X Yes ___ No		
Total Heat Flux Hot Channel Factor, FQ(Z)						
(1.770 at Min margin) $F_Q(Z)$= 1.778	N/A	$F_Q(Z) \leq (2.32/P)*K(Z)$ [COLR 3.3] Margin to COLR Limit=	N/A	X Yes ___ No		
Maximum Positive Incore Quadrant Power Tilt						
Tilt= 1.0046	≤ 1.02^3	N/A	X Yes ___ No	N/A		

References 1.) NE-1480, Rev. 0
2.) Memorandum from C.T. Snow to E.J. Lozito, dated June 27, 1980
3.) WCAP-7905, Rev. 1
4.) ET NAF-06-0053, Rev. 0

Surry Power Station Unit 1 Cycle 21 Startup Physics Test Summary Sheet - Formal Tests (Page 6 of 6)

Measured Value	Design Criteria	Acceptance Criteria	Design Criteria Met	Acceptance Criteria Met	Date/ Time of Test	Preparer/ Reviewer
RCS Flow Measurement						
F_{Total}= 286073.96 gpm	N/A	$F_{total} \geq 273000$ gpm [T.S. 3.12.F.1]	N/A	[✓ Yes] No	6/5/06 1400	JDS nay

References 1.) NE-1480, Rev. 0

2.) Memorandum from C.T. Snow to E.J. Lozito, dated June 27, 1980

3.) WCAP-7905, Rev. 1

4.) ET NAF-06-0053, Rev. 0