VEP-NOS-17

VIRGINIA POWER

SURRY UNIT 2, CYCLE 7 CORE PERFORMANCE REPORT

NUCLEAR OPERATIONS DEPARTMENT

A001
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VEP-NOS-17

SURRY UNIT 2, CYCLE 7
CORE PERFORMANCE REPORT

by

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INTRODUCTION AND SUMMARY

On March 20, 1985, Surry Unit 2 completed Cycle 7. Since the initial criticality of Cycle 7 on September 25, 1983, the reactor core produced approximately 87 x 10^6 MBTU (14,802 Megawatt days per metric ton of contained uranium) which has resulted in the generation of approximately 8.1 x 10^9 KWHr gross (7.7 x 10^9 KWHr net) of electrical energy. The purpose of this report is to present an analysis of the core performance for routine operation during Cycle 7. The physics tests that were performed during the startup of this cycle were covered in the Surry Unit 2, Cycle 7 Startup Physics Test Report[1] and, therefore, will not be included here.

The seventh cycle core consisted of six sub-batches of fuel: a thrice-burned sub-batch from cycles 4, 5, and 6 (6B5), two twice-burned sub-batches from cycles 5 and 6 (7A2 and 7B2), a once-burned batch from cycle 6 (8), and two fresh sub-batches (9A and S1/9C). The Surry 2, Cycle 7 core loading map specifying the fuel batch identification, fuel assembly locations, burnable poison locations and source assembly locations is shown in Figure 1.1. Movable detector locations and thermocouple locations are identified in Figure 1.2. Control rod locations are shown in Figure 1.3.

Routine core follow involves the analysis of four principal performance indicators. These are burnup distribution, reactivity depletion, power distribution, and primary coolant activity. The core burnup distribution is followed to verify both burnup symmetry and proper batch burnup sharing, thereby ensuring that the fuel held over for the next cycle will be compatible with the new fuel that is inserted. Reactivity depletion is monitored to detect the existence of any abnormal reactivity behavior, to determine if the core is depleting as designed, and to indicate at what burnup level refueling will be required. Core power distribution follow includes the monitoring of nuclear hot channel factors to verify that they are within the Technical Specifications[2] limits thereby ensuring that adequate margins to linear power density and critical heat flux thermal limits are maintained. Lastly, as part of normal core follow, the primary coolant activity is monitored to verify that the dose equivalent iodine-131 concentration is within the limits specified by the Surry Technical Specifications, and to assess the integrity of the fuel.

Each of the four performance indicators is discussed in detail for the Surry 2, Cycle 7 core in the body of this report. The results are summarized below:

1. Burnup Follow - The burnup tilt (deviation from quadrant symmetry) on the core was no greater than ±0.55% with the burnup accumulation in each batch deviating from design prediction by less than 1.2%.

2. Reactivity Depletion Follow - The critical boron concentration, used to monitor reactivity depletion, was consistently within ±0.47% $\Delta K/K$ of the design prediction which is within the ±1% $\Delta K/K$ margin allowed by Section 4.10 of the Technical Specifications.

3. Power Distribution Follow - Incore flux maps taken each month indicated that the assemblywise radial power distributions deviated from the design predictions by an average difference of less than 2%. All hot channel factors met their respective Technical Specifications limits.

4. Primary Coolant Activity Follow - The average dose equivalent iodine-131 activity level in the primary coolant during Cycle 7 was approximately 1.0×10^{-3} µCi/gm. This corresponds to much less than 1% of the operating limit for the concentration of radioiodine in the primary coolant.

In addition, the effects of fuel densification were monitored throughout the cycle. No densification effects were observed.

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							1P2	6R4	2P6						
2					3N0	2P7	5R8 12P	5P2	2R0 12P	4P0	0N8				
3				5P3	3R9 8P	3R1 16P	0P9	4P8 SS	2P3	5R7 16P	1R7 8P	2P0			
4			4P2	4P4	4R5 16P	1P0	0R6 20P	3P9 4P	2R5 20P	5P1	4R8 16P	6P5	2P4		
5		3N2	5R6 8P	2R6 16P	0L7	1R0 16P	W41	2P8 4P	W11	5R4 16P	0L4	2R1 16P	5R2 8P	0N6	
6		1P7	4R2 16P	4P1	5R3 16P	1L2	2R4 16P	1P3	3R3 16P	1L0	4R6 16P	6P4	0R1 16P	4P5	
7	2P2	5R1 12P	3P8	0R2 20P	W29	2R8 16P	1N2	4P7 4P	2N8	0R9 16P	W20	1R8 20P	0P7	3R6 12P	1P8
8	6R2 SS	5P5	1P6	0P4 4P	6P6 4P	2P5	3P3 4P	1R3 20P	5P6 4P	6P0	1P4 4P	0P3 4P	0P2	3P0	6R3
9	4P6	3R5 12P	4P9	1R9 20P	W32	4R9 16P	4N0	6P1 4P	5N0	3R0 16P	W04	2R9 20P	3P6	4R1 12P	3P4
10		1P1	5R5 16P	0P6	3R4 16P	1L1	1R5 16P	2P9	0R3 16P	0L2	6R0 16P	3P7	3R8 16P	5P0	
11		0N1	0R8 8P	3R7 16P	0L6	2R3 16P	W05	1P9 4P	W48	1R6 16P	0L5	2R2 16P	5R9 8P	1N7	
12			0P5	5P4	4R7 16P	6P2	2R7 20P	6P7 4P	4R3 20P	6P8	0R4 16P	0P1	5P8		
13				2P1	0R5 8P	4R4 16P	1P5	3P5 SS	5P9	5R0 16P	6R1 8P	3P1			
14					0N4	6P3	1R1 12P	3P2	0R7 12P	5P7	2N3				
15							4P3	6R5	0P8						

--> ASSEMBLY ID
--> ONE OF THE FOLLOWING

A. SS - SECONDARY SOURCE
B. XXP - BURNABLE POISON ASSEMBLY
(XX-NUMBER OF RODS)

FUEL ASSEMBLY DESIGN PARAMETERS

	SUB-BATCH					
	6B5	7A2	7B2	8A	9	S1/9C
INITIAL ENRICHMENT(W/O U235)	3.20	3.13	3.41	3.61	3.59	3.59
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
ASSEMBLY IDENTIFICATION	W04,W05 W11,W20 W29,W32 W41,W48	0L2,0L4 0L5-0L7 1L0-1L2	0N1,0N4 0N6,0N8 1N2,1N7 2N3,2N8 3N0,3N2 4N0,5N0	0P1-0P9 1P0-1P9 2P0-2P9 3P0-3P9 4P0-4P9 5P0-5P9 6P0-6P8	0R1-0R9 1R0,1R1 1R3,1R5 1R6-1R9 2R0-2R9 3R0,3R1 3R3-3R9 4R1-4R9 5R0-5R9 6R0,6R1	6R2-6R5

Figure 1.2

SURRY UNIT 2 - CYCLE 7

MOVABLE DETECTOR AND THERMOCOUPLE LOCATIONS

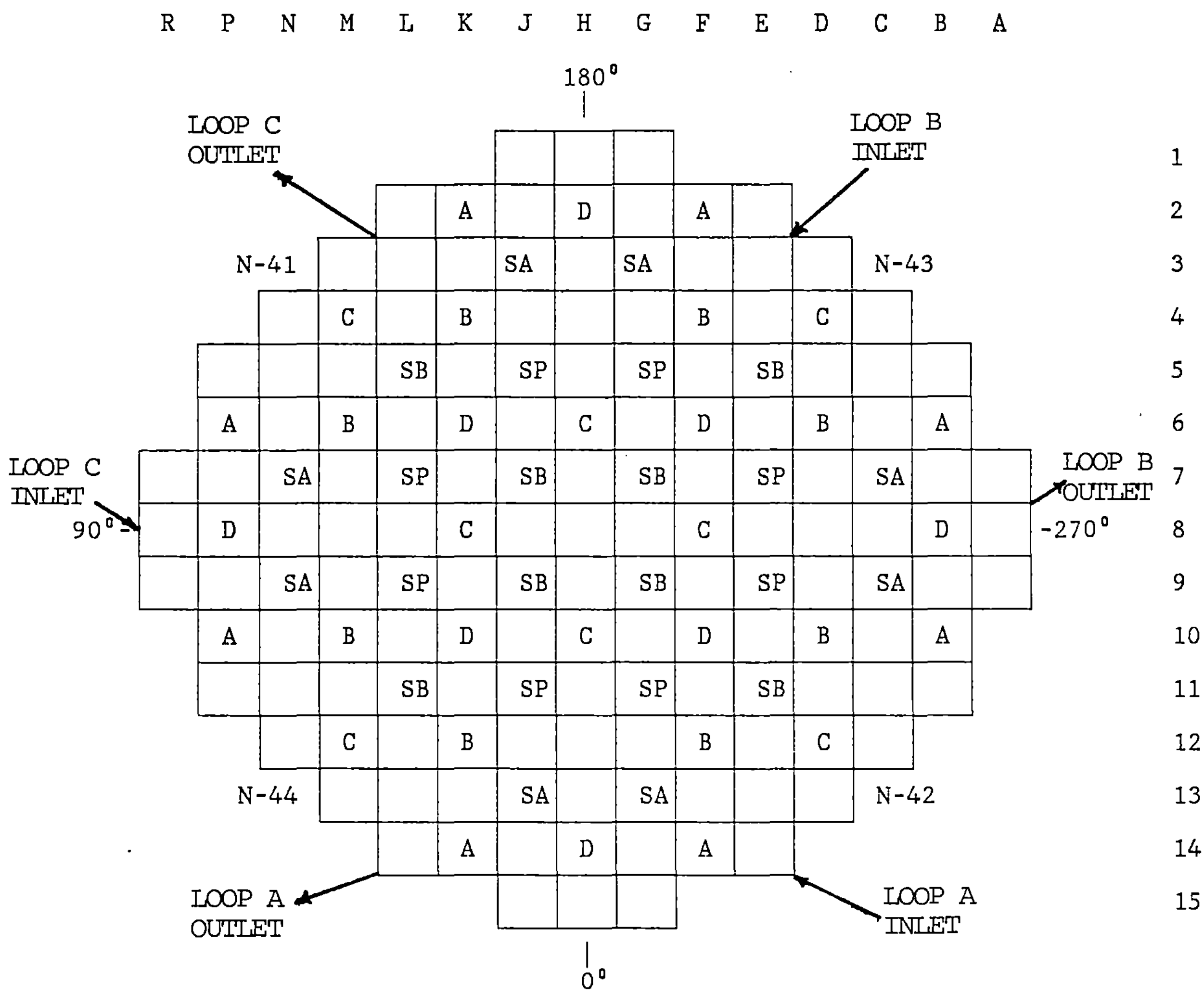
	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1								MD	TC						
2							TC		TC	MD					
3				MD TC		TC	MD	MD TC		TC		MD TC			
4			TC		MD			MD		MD	TC				
5			MD		MD	TC	MD	TC		TC	MD	MD TC		MD TC	
6			TC		MD TC			MD	TC	MD					
7	TC	TC	MD				MD		MD		TC	MD		MD	
8	MD	TC	MD TC		MD TC	TC		TC	TC	MD	TC		MD TC	MD	TC
9				TC	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 1.3

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

BURNUP FOLLOW

The burnup history for the Surry Unit 2, Cycle 7 core is graphically depicted in Figure 2.1. The Surry 2, Cycle 7 core achieved a burnup of 14,802 MWD/MTU. As shown in Figure 2.2, the average load factor for Cycle 7 was 81% when referenced to rated thermal power (2441 MW(t)).

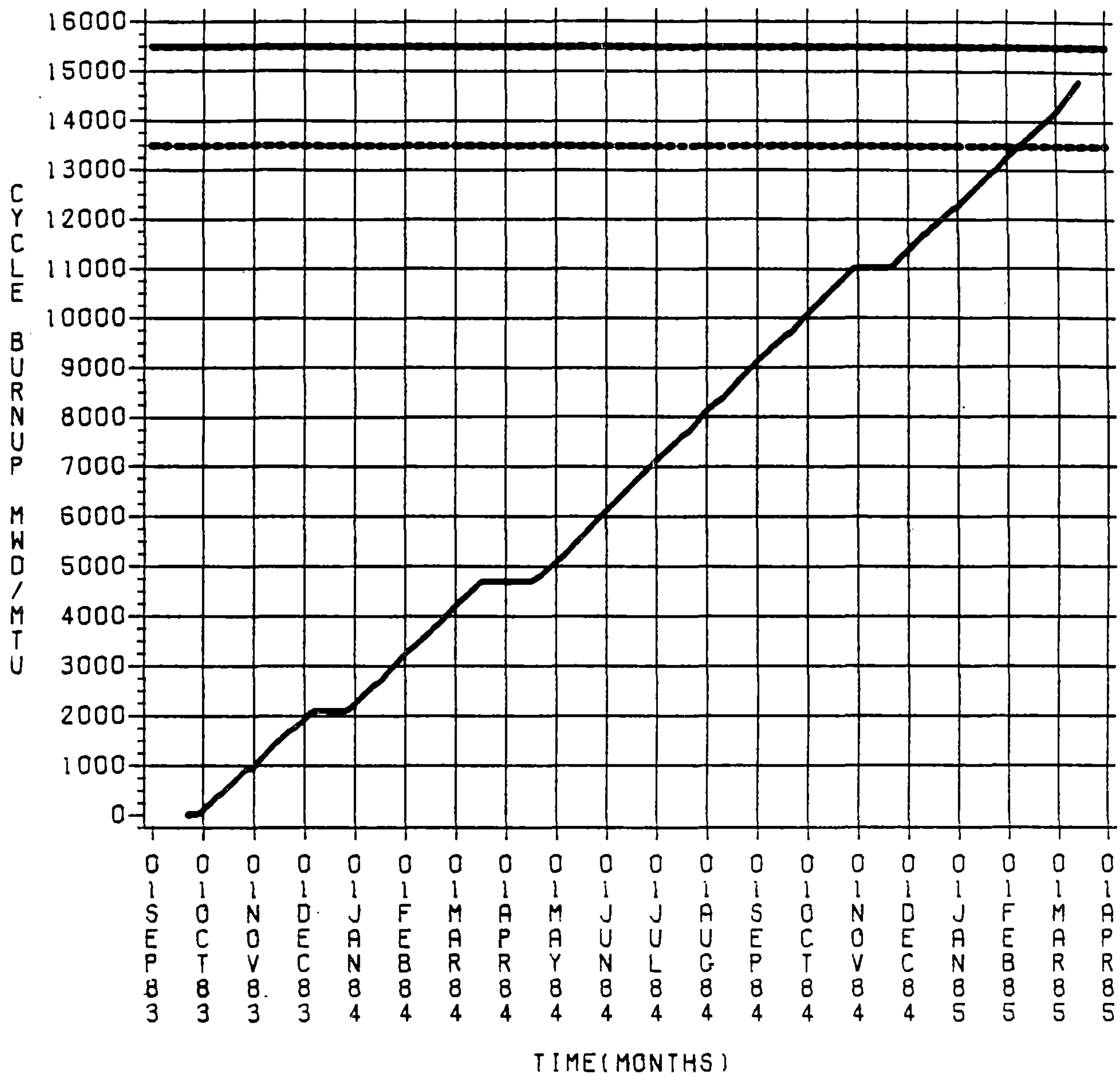
Radial (X-Y) burnup distribution maps show how the core burnup is shared among the various fuel assemblies, and thereby allow a detailed burnup distribution analysis. The NEWTOTE[3] computer code is used to calculate these assemblywise burnups. Figure 2.3 is a radial burnup distribution map in which the assemblywise burnup accumulation of the core at the end of Cycle 7 operation is given. For comparison purposes, the design values are also given. Figure 2.4 is a radial burnup distribution map in which the percentage difference comparison of measured and predicted assemblywise burnup accumulation at the end of Cycle 7 operation is also given. As can be seen from this figure, the accumulated assembly burnups were generally within ±2.9% of the predicted values. In addition, deviation from quadrant symmetry in the core, as indicated by the burnup tilt factors, was no greater than ±0.55%.

The burnup sharing on a batch basis is monitored to verify that the core is operating as designed and to enable accurate end-of-cycle batch burnup predictions to be made for use in reload fuel design studies. Batch definitions are given in Figure 1.1. As seen in Figure 2.5, the batch burnup sharing for Surry Unit 2, Cycle 7 followed design predictions closely with each batch deviating less than 1.2% from design. Symmetric burnup in conjunction with agreement between actual and predicted assemblywise burnups and batch burnup sharing indicate that the Cycle 7 core did deplete as designed.

Figure 2.1

SURRY 2 - CYCLE 7

CORE BURNUP HISTORY



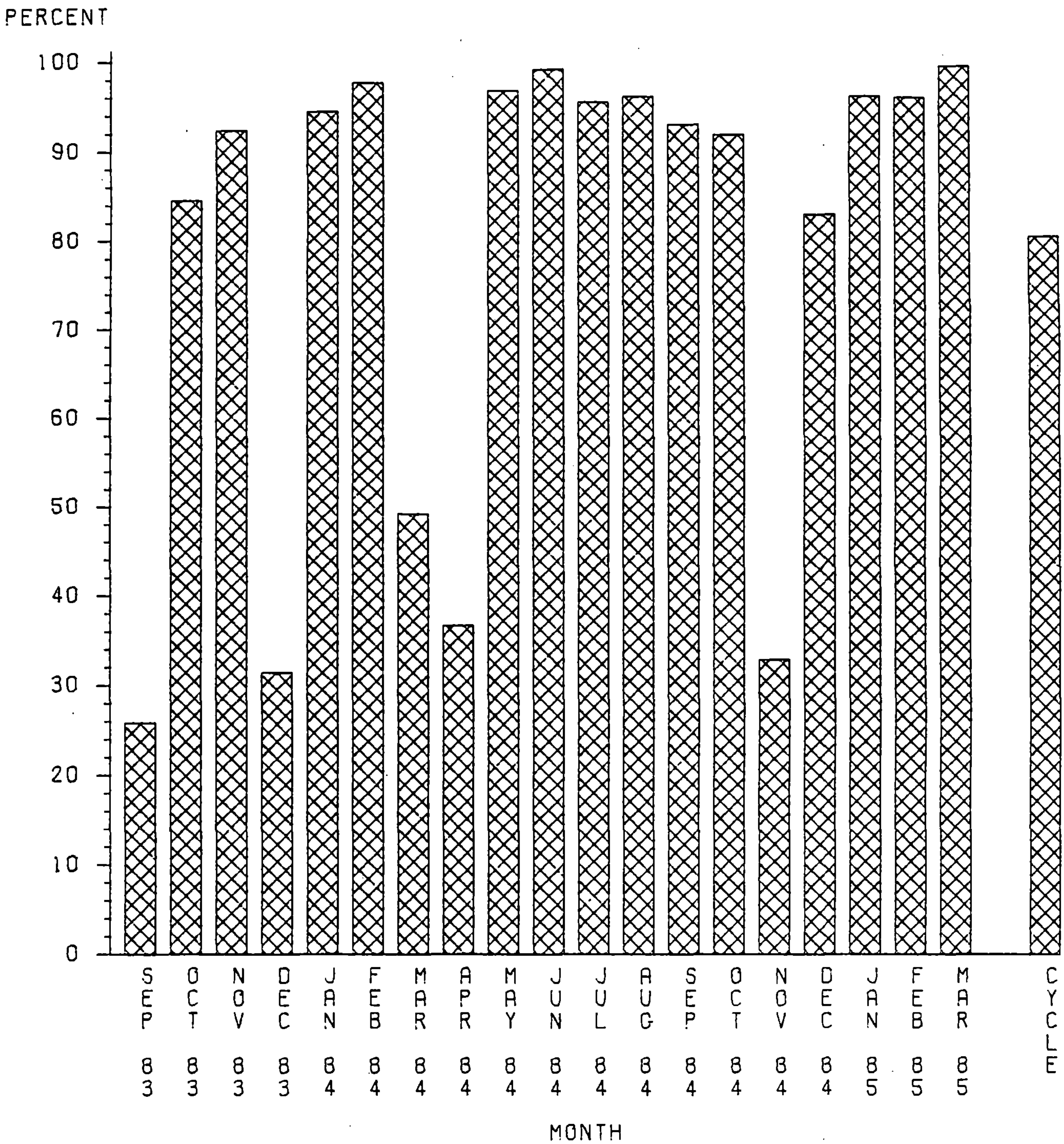
——— CYCLE 7 MAXIMUM DESIGN BURNUP - 15500 MWD/MTU

---- BURNUP WINDOW FOR CYCLE 8 DESIGN - 13500 TO 15500 MWD/MTU

Figure 2.2

SURRY 2 - CYCLE 7

MONTHLY AVERAGE LOAD FACTORS



$$\text{LOAD FACTOR} = \frac{\text{THERMAL ENERGY GENERATION IN MONTH(MWHT)}}{\text{AUTHORIZED POWER LEVEL (MWT) X HOURS IN MONTH}}$$

(EXCLUDES REFUELING OUTAGES)

Figure 2.3

SURRY 2 - CYCLE 7

ASSEMBLYWISE ACCUMULATED BURNUP

MEASURED AND PREDICTED

(1000 MWD/MTU)

MEASURED
PREDICTED

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
1							23.90	11.28	24.77							1
							24.15	11.49	24.15							
2					31.78	25.64	15.17	30.28	15.33	26.48	32.31					2
					31.72	25.80	15.38	30.90	15.38	25.80	31.72					
3				26.85	15.70	17.64	36.06	35.57	35.69	17.90	16.14	27.31				3
				26.70	15.67	17.65	36.29	35.75	36.29	17.65	15.67	26.70				
4			26.65	32.27	18.00	37.51	18.34	35.46	18.26	37.01	18.35	32.66	26.79			4
			26.58	32.32	18.04	37.39	18.54	35.95	18.54	37.39	18.04	32.32	26.58			
5		31.49	15.38	17.87	39.02	19.00	39.50	28.32	39.28	19.26	39.64	18.07	15.89	32.02		5
		31.63	15.63	17.99	39.18	19.29	39.77	29.04	39.77	19.29	39.18	17.99	15.63	31.63		
6		25.64	17.47	37.14	18.75	39.26	18.47	36.35	18.55	39.43	19.27	37.39	17.77	26.07		6
		25.78	17.60	37.35	19.22	39.47	18.88	36.78	18.88	39.47	19.22	37.35	17.60	25.78		
7	23.83	15.08	36.72	18.17	39.03	18.35	40.35	32.10	40.77	18.53	39.73	18.51	36.49	15.47	24.32	7
	24.01	15.35	36.41	18.48	39.61	18.78	40.81	32.46	40.81	18.78	39.61	18.48	36.41	15.35	24.01	
8	10.97	30.12	35.98	35.99	27.67	35.95	32.52	17.93	31.61	36.38	28.92	35.54	35.51	31.25	11.61	8
	11.49	30.94	35.77	35.96	28.76	36.50	32.27	18.06	32.27	36.50	28.76	35.96	35.77	30.94	11.49	
9	23.99	15.05	36.33	18.26	38.75	18.14	40.36	32.23	40.74	18.06	39.63	18.47	36.43	15.69	23.89	9
	24.01	15.35	36.41	18.48	39.61	18.78	40.81	32.46	40.81	18.78	39.61	18.48	36.41	15.35	24.01	
10		26.21	17.80	37.19	19.36	39.08	18.17	36.21	18.39	38.86	19.09	37.63	17.92	26.01		10
		25.78	17.60	37.35	19.22	39.47	18.88	36.78	18.88	39.47	19.22	37.35	17.60	25.78		
11		32.07	16.03	18.36	39.02	19.06	39.53	28.76	39.46	19.11	39.26	18.35	16.07	31.64		11
		31.63	15.63	17.99	39.18	19.29	39.77	29.04	39.77	19.29	39.18	17.99	15.63	31.63		
12			27.14	32.82	18.18	37.09	18.15	35.70	18.29	37.68	18.30	32.65	26.71			12
			26.58	32.32	18.04	37.39	18.54	35.95	18.54	37.39	18.04	32.32	26.58			
13				27.08	16.13	17.77	36.09	35.03	36.29	17.84	15.92	26.68				13
				26.70	15.67	17.65	36.29	35.75	36.29	17.65	15.67	26.70				
14					31.85	26.01	15.34	30.84	15.44	25.77	31.73					14
					31.72	25.80	15.38	30.90	15.38	25.80	31.72					
15							24.38	11.53	23.85							15
							24.15	11.49	24.15							
	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	

Figure 2.4

SURRY 2 - CYCLE 7
ASSEMBLYWISE ACCUMULATED BURNUP
COMPARISON OF MEASURED AND PREDICTED
(1000 MWD/MTU)

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
1							23.90 -1.04	11.28 -1.83	24.77 2.56							1
2					31.78 0.18	25.64 -0.60	15.17 -1.30	30.28 -2.00	15.33 -0.27	26.48 2.64	32.31 1.86					2
3				26.85 0.56	15.70 0.24	17.64 -0.05	36.06 -0.64	35.57 -0.50	35.69 -1.65	17.90 1.47	16.14 3.04	27.31 2.32				3
4			26.65 0.24	32.27 -0.17	18.00 -0.25	37.51 0.31	18.34 -1.04	35.46 -1.35	18.26 -1.49	37.01 -1.03	18.35 1.69	32.66 1.03	26.79 0.80			4
5		31.49 -0.44	15.38 -1.63	17.87 -0.69	39.02 -0.41	19.00 -1.49	39.50 -0.69	28.32 -2.46	39.28 -1.23	19.26 -0.16	39.64 1.17	18.07 0.41	15.89 1.65	32.02 1.23		5
6		25.64 -0.53	17.47 -0.74	37.14 -0.55	18.75 -2.47	39.26 -0.55	18.47 -2.16	36.35 -1.16	18.55 -1.78	39.43 -0.10	19.27 0.24	37.39 0.12	17.77 0.94	26.07 1.15		6
7	23.83 -0.72	15.08 -1.75	36.72 0.84	18.17 -1.65	39.03 -1.47	18.35 -2.29	40.35 -1.12	32.10 -1.10	40.77 -0.11	18.53 -1.32	39.73 0.30	18.51 0.19	36.49 0.21	15.47 0.79	24.32 1.31	7
8	10.97 -4.48	30.12 -2.64	35.98 0.57	35.99 0.08	27.67 -3.77	35.95 -1.49	32.52 0.76	17.93 -0.72	31.61 -2.05	36.38 -0.32	28.92 0.58	35.54 -1.18	35.51 -0.75	31.25 1.02	11.61 1.05	8
9	23.99 -0.05	15.05 -1.96	36.33 -0.22	18.26 -1.17	38.75 -2.18	18.14 -3.39	40.36 -1.11	32.23 -0.72	40.74 -0.17	18.06 -3.80	39.63 0.04	18.47 -0.06	36.43 0.05	15.69 2.19	23.89 -0.48	9
10		26.21 1.67	17.80 1.12	37.19 -0.43	19.36 0.70	39.08 -1.00	18.17 -3.78	36.21 -1.55	18.39 -2.58	38.86 -1.54	19.09 -0.67	37.63 0.75	17.92 1.80	26.01 0.89		10
11		32.07 1.38	16.03 2.55	18.36 2.03	39.02 -0.41	19.06 -1.15	39.53 -0.62	28.76 -0.96	39.46 -0.79	19.11 -0.91	39.26 0.20	18.35 2.00	16.07 2.78	31.64 0.04		11
12			27.14 2.09	32.82 1.55	18.18 0.74	37.09 -0.83	18.15 -2.09	35.70 -0.69	18.29 -1.35	37.68 0.77	18.30 1.41	32.65 1.00	26.71 0.46			12
13				27.08 1.44	16.13 2.98	17.77 0.68	36.09 -0.57	35.03 -2.01	36.29 -0.00	17.84 1.12	15.92 1.62	26.68 -0.07				13
14					31.85 0.41	26.01 0.83	15.34 -0.25	30.84 -0.18	15.44 0.43	25.77 -0.11	31.73 0.04					14
15							24.38 0.95	11.53 0.32	23.85 -1.23							15
	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	

MEASURED
M/P % DIFF

STANDARD DEV
= 0.89

ARITHMETIC AVG
PCT DIFF = -0.20

AVG ABS PCT
DIFF = 1.13

BURNUP SHARING
(MWD/MTU)

Batch	Cycle 4	Cycle 5	Cycle 6	Cycle 7	Total
6B5	9376	8310	6729	14949	39364
7A2	--	16441	7694	15062	39197
7B2	--	14619	10991	9147	34757
8A	--	--	17681	13632	31313
9	--	--	--	17568	17568
S1/9C	--	--	--	11348	11348
Core Average				14802	

BURNUP TILT

NW = -0.53

NE = +0.44

SW = -0.04

SE = +0.14

FIGURE 2.5A

SURRY UNIT 2 - CYCLE 7

SUB-BATCH BURNUP SHARING

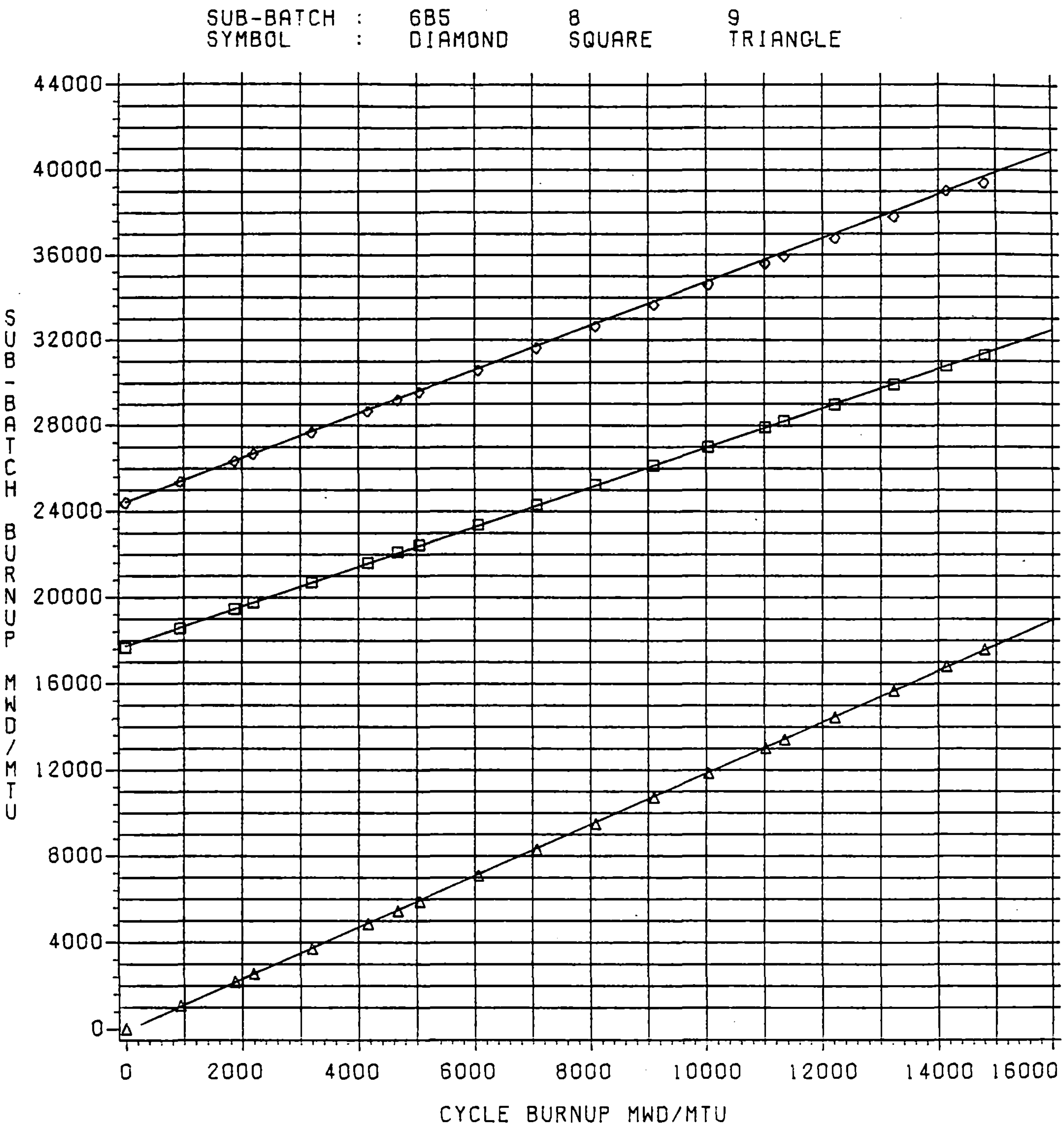
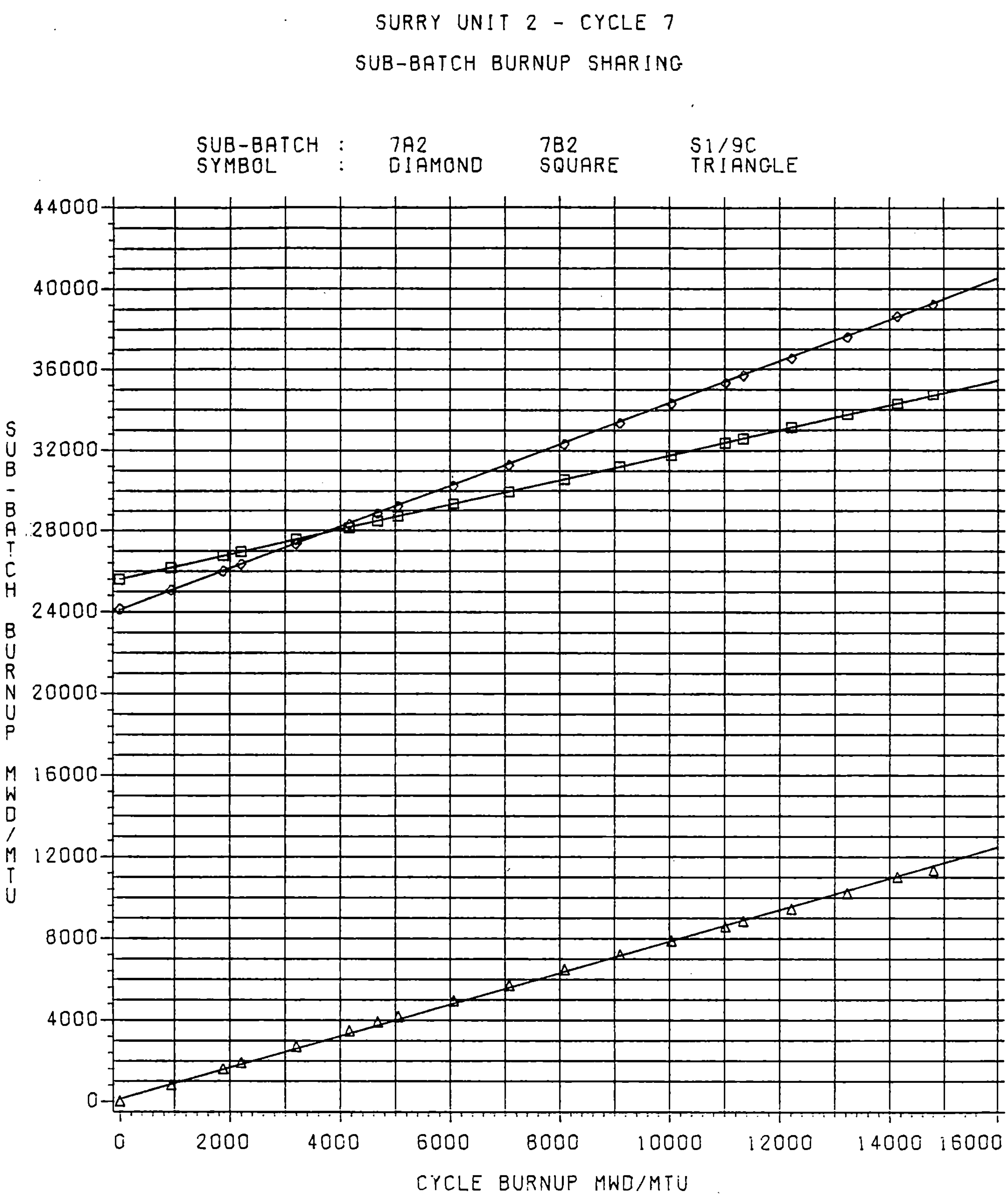


FIGURE 2.5B

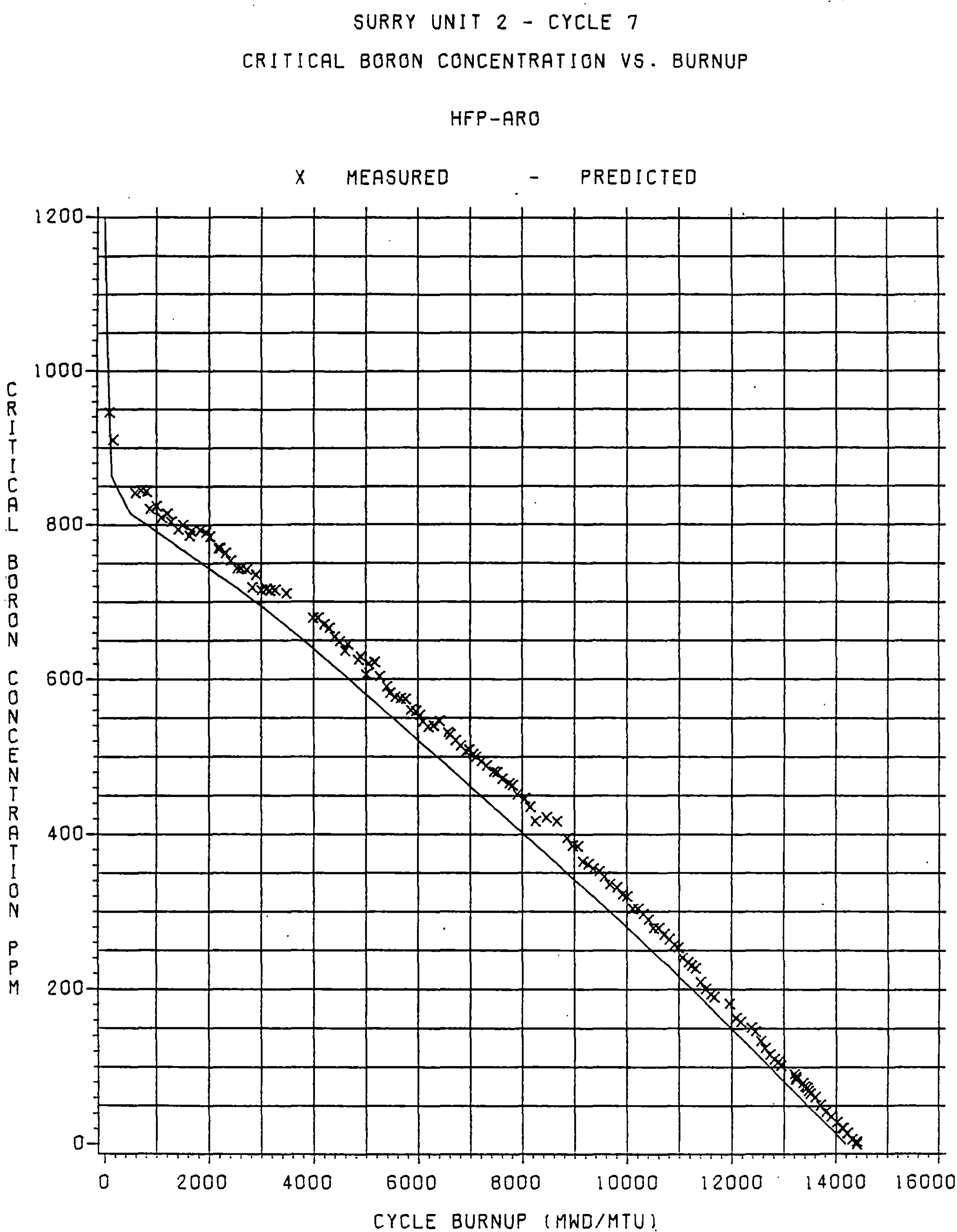

SURRY UNIT 2 - CYCLE 7
SUB-BATCH BURNUP SHARING
SUB-BATCH : 7A2 7B2 S1/9C
SYMBOL : DIAMOND SQUARE TRIANGLE
SUB-BATCH BURNUP MWD/MTU
CYCLE BURNUP MWD/MTU
0
4000
8000
12000
16000
20000
24000
28000
32000
36000
40000
44000
2000
6000
10000
14000

Section 3

REACTIVITY DEPLETION FOLLOW

The primary coolant critical boron concentration is monitored for the purposes of following core reactivity and to identify any anomalous reactivity behavior. The FOLLOW[4] computer code was used to normalize "actual" critical boron concentration measurements to design conditions taking into consideration control rod position, xenon and samarium concentrations, moderator temperature, and power level. The normalized critical boron concentration versus burnup curve for the Surry 2, Cycle 7 core is shown in Figure 3.1. It can be seen that the measured data typically compare to within 56 ppm of the design prediction. This corresponds to less than ±0.47% ΔK/K which is within the ±1% ΔK/K criterion for reactivity anomalies set forth in Section 4.10 of the Technical Specifications. In conclusion, the trend indicated by the critical boron concentration verifies that the Cycle 7 core depleted as expected without any reactivity anomalies.

Figure 3.1



SURRY UNIT 2 - CYCLE 7
CRITICAL BORON CONCENTRATION VS. BURNUP
HFP-ARO
X MEASURED - PREDICTED
CRITICAL BORON CONCENTRATION PPM
1200
1000
800
600
400
200
0
0
2000
4000
6000
8000
10000
12000
14000
16000
CYCLE BURNUP (MWD/MTU)

Section 4

POWER DISTRIBUTION FOLLOW

Analysis of core power distribution data on a routine basis is necessary to verify that the hot channel factors are within the Technical Specifications limits and to ensure that the reactor is operating without any abnormal conditions which could cause an "uneven" burnup distribution. Three-dimensional core power distributions are determined from movable detector flux map measurements using the INCORE[5] computer program. A summary of all full core flux maps taken since the completion of startup physics testing for Surry 2, Cycle 7 is given in Table 4.1. Power distribution maps were generally taken at monthly intervals with additional maps taken as needed.

Radial (X-Y) core power distributions for a representative series of incore flux maps are given in Figures 4.1 through 4.3. Figure 4.1 shows a power distribution map that was taken early in cycle life. Figure 4.2 shows a power distribution map that was taken near mid-cycle burnup. Figure 4.3 shows a map that was taken late in Cycle 7 life. The radial power distributions were taken under equilibrium operating conditions with the unit at approximately full power. In each case, the measured relative assembly powers were generally within 4.2% of the predicted values with an average percent difference of less than 2.0% which is considered good agreement. In addition, as indicated by the INCORE tilt factors, the power distributions were essentially symmetric for all cases.

An important aspect of core power distribution follow is the monitoring of nuclear hot channel factors. Verification that these factors are within Technical Specifications limits ensures that linear power density and critical heat flux limits will not be violated, thereby providing adequate thermal margins and maintaining fuel cladding integrity. The Technical Specifications limit on the axially dependent heat flux hot channel factor, $F_Q(Z)$, was 2.18 x K(Z), where K(Z) is the hot channel factor normalized operating envelope. Figure 4.4 is a plot of the K(Z) curve associated with the 2.18 $F_Q(Z)$ limit. The axially dependent heat flux hot channel factors, $F_Q(Z)$, for a representative set of flux maps are given in Figures 4.5 through 4.7. Throughout Cycle 7, the measured values of $F_Q(Z)$ were within the Technical Specifications limit. A summary of the maximum values of axially-dependent heat flux hot channel factors measured during Cycle 7 is given in Figure 4.8. Figure 4.9 shows the maximum values for the Heat Flux Hot Channel Factor measured during Cycle 7. As can be seen from the figure, there was a 20% margin to the limit at the beginning of the cycle, with the margin generally remaining unchanged throughout cycle operation.

The value of the enthalpy rise hot channel factor, F-delta H, which is the ratio of the integral of the power along the rod with the highest integrated power to that of the average rod, is routinely followed. The Technical Specifications limit for this parameter is set such that the critical heat flux (DNB) limit will not be violated. Additionally, the F-delta H limit ensures that the value of this parameter used in the LOCA-ECCS analysis is not exceeded during normal operation. The Cycle 7 limit on the enthalpy rise hot channel factor was set at 1.55(1+0.3(1-P)), where P is the fractional power level. A summary of the maximum values for the Enthalpy Rise Hot Channel Factor measured during Cycle 7 is given in Figure 4.10.

The Technical Specifications require that target delta flux* values be determined periodically. The target delta flux is the delta flux which would occur at conditions of full power, all rods out, and equilibrium xenon. Therefore, the delta flux is measured with the core at or near these conditions and the target delta flux is established at this measured point. Since the target delta flux varies as a function of burnup, the target value is updated monthly. Operational delta flux limits are then established about this target value. By maintaining the value of delta flux relatively constant, adverse axial power shapes due to xenon redistribution are avoided. The plot of the target delta flux versus burnup, given in Figure 4.11, shows the value of this parameter to have been approximately -1.5% at the beginning of Cycle 7. After approximately two-thirds of the cycle, delta flux values had shifted to -4% and then moved to -2.5% by the end of Cycle 7.

This axial power shift can also be observed in the corresponding core average axial power distribution for a representative series of maps given in Figures 4.12 through 4.14. In Map S2-7-05 (Figure 4.12), taken at approximately 200 MWD/MTU, the axial power distribution had a slightly peaked cosine shape with a peaking factor of 1.18. In Map S2-7-23 (Figure 4.13), taken at approximately 7,500 MWD/MTU, the axial power distribution had shifted toward the bottom of the core with an axial peaking factor of 1.15. Finally, in Map S2-7-45 (Figure 4.14), taken at approximately 14,150 MWD/MTU, the axial power shape was slightly concave with a peaking factor was 1.14. The history of F-Z during the cycle can be seen more clearly in a plot of F-Z versus burnup given in Figure 4.15.

In conclusion, the Surry 2, Cycle 7 core performed satisfactorily with

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$$\text{*Delta Flux} = \frac{Pt-Pb}{2441} \times 100$$

where Pt = power in top of core (MW(t))
Pb = power in bottom of core (MW(t))

power distribution analyses verifying that design predictions were accurate and that the values of the $F_Q(Z)$ and F-delta H hot channel factors were within the limits of the Technical Specifications.

TABLE 4.1

SURRY UNIT 2 - CYCLE 7

SUMMARY OF FLUX MAPS FOR ROUTINE OPERATION

MAP NO.	DATE	BURNUP 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 OFFSET (%)	NO. OF THIMBLES
					ASSY	PIN	AXIAL POINT	F-Q(T)	ASSY	PIN	F-DH(N)	AXIAL POINT	F(Z)		MAX	LOC		
5	10-05-83	198	100	228	E10	IH	33	1.761	L10	GH	1.420	34	1.177	1.378	1.007	NE	-1.35	38
(5)																		
8	10-21-83	621	100	228	E06	IH	34	1.744	E06	IH	1.421	33	1.171	1.380	1.008	SE	-1.14	38
(6)																		
11	10-26-83	825	100	214	F11	HG	35	1.784	E06	IH	1.424	43	1.192	1.386	1.010	SE	-4.51	38
13	11-23-83	1647	99	226	F11	HG	34	1.764	E06	IH	1.433	34	1.170	1.396	1.008	SE	-1.23	38
14	1-10-84	2493	100	228	F11	HG	35	1.765	F05	HI	1.432	34	1.163	1.396	1.008	NE	-1.64	43
15	2-08-84	3445	100	227	L10	GH	22	1.743	E06	IH	1.444	34	1.154	1.393	1.010	NE	-1.58	42
(7)																		
18	4-16-84	4668	75	185	L10	GH	34	1.814	L10	GH	1.444	34	1.185	1.408	1.007	NE	-3.29	41
19	5-23-84	5781	100	226	L10	GH	42	1.755	L10	GH	1.450	44	1.147	1.412	1.009	NE	-2.43	44

NOTES: HOT SPOT LOCATIONS ARE SPECIFIED BY GIVING ASSEMBLY LOCATIONS (E.G. H-8 IS THE CENTER-OF-CORE ASSEMBLY), FOLLOWED BY THE PIN LOCATION (DENOTED BY THE "Y" COORDINATE WITH THE FIFTEEN ROWS OF FUEL RODS LETTERED A THROUGH R AND THE "X" COORDINATE DESIGNATED IN A SIMILAR MANNER).
IN THE "Z" DIRECTION THE CORE IS DIVIDED 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 6 AND 7 WERE QUARTER-CORE FLUX MAPS TAKEN FOR INCORE-EXCORE DETECTOR CALIBRATION.
6. MAPS 9, 10 AND 12 WERE QUARTER-CORE FLUX MAPS TAKEN FOR INCORE-EXCORE DETECTOR CALIBRATION.
7. MAPS 16 AND 17 WERE QUARTER-CORE FLUX MAPS TAKEN FOR INCORE-EXCORE DETECTOR CALIBRATION.

TABLE 4.1 (CONTINUED)

MAP NO.	DATE	BURN UP MWD/MTU	PWR (%)	BANK D STEPS	F-Q(T) HOT CHANNEL FACTOR [1] ASSY	PIN	AXIAL POINT	F-Q(T)	F-DH(N) HOT CHNL. FACTOR [2] ASSY	PIN	F-DH(N)	CORE F(Z) MAX AXIAL POINT	F(Z)	F(XY) [3]	QPTR [4] MAX	LOC	AXIAL OFF SET (%)	NO. OF THIMBLES
20	6-06-84	6255	100	226	L10	GH	43	1.751	L10	GH	1.449	44	1.146	1.410	1.009	NE	-2.53	44
23 (8)	7-12-84	7485	100	222	F11	HG	34	1.757	F11	HG	1.466	45	1.148	1.447	1.008	SE	-3.12	40
24	8-15-84	8590	94	210	L10	GH	45	1.755	L10	GH	1.449	45	1.154	1.415	1.008	NE	-3.62	45
25	9-21-84	9702	99	205	E06	LG	48	1.755	F05	IL	1.464	47	1.136	1.421	1.009	NE	-3.94	38
28 (9)	10-04-84	10173	99	228	L10	DI	43	1.745	L10	DI	1.457	45	1.141	1.411	1.007	NE	-3.35	45
36 (10)	11-28-84	11260	100	228	L06	DG	46	1.777	L06	DG	1.465	47	1.151	1.411	1.007	NE	-4.68	47
37	12-24-84	12003	86	201	L10	DI	43	1.712	L10	DG	1.458	46	1.125	1.419	1.009	NE	-2.92	47
38	01-30-85	13122	100	223	L10	DI	52	1.719	L10	DI	1.450	53	1.132	1.414	1.008	NE	-2.53	47
45 (11)	03-01-85	14150	100	223	L10	DG	53	1.716	F05	IL	1.433	53	1.141	1.389	1.009	NE	-2.71	47

8. MAPS 21 AND 22 WERE QUARTER-CORE FLUX MAPS TAKEN FOR INCORE-EXCORE DETECTOR CALIBRATION.

9. MAPS 26 AND 27 WERE QUARTER-CORE FLUX MAPS TAKEN FOR INCORE-EXCORE DETECTOR CALIBRATION.

10. MAPS 29 THROUGH 35 WERE QUARTER-CORE FLUX MAPS TAKEN FOR INCORE-EXCORE DETECTOR CALIBRATIONS.

11. MAPS 39 THROUGH 44 WERE QUARTER-CORE FLUX MAPS TAKEN FOR INCORE-EXCORE DETECTOR CALIBRATIONS.

Figure 4.1

SURRY UNIT 2 - CYCLE 7

ASSEMBLYWISE POWER DISTRIBUTION S2-7-05

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 1.7	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 1.7	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: 10/05/83 | POWER: 100%

CONTROL ROD POSITIONS: | F-Q(T) = 1.761 | QPTR:

D BANK AT 228 STEPS | F-DH(N) = 1.420 | NW 0.9888 | NE 1.0071

F(Z) = 1.177 | SW 0.9971 | SE 1.0070

F(XY) = 1.378

BURNUP = 198 MWD/MTU   A.O. = -1.351(%)

Figure 4.2

SURRY UNIT 2 - CYCLE 7

ASSEMBLYWISE POWER DISTRIBUTION S2-7-23

PREDICTED
MEASURED
PCT DIFFERENCE

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
						0.48	0.74	0.48							1
						0.48	0.74	0.48							
						-0.5	-0.5	0.3							
				0.42	0.73	1.02	0.99	1.02	0.73	0.42					2
				0.42	0.74	1.01	0.98	1.02	0.74	0.42					
				0.9	1.0	-0.2	-0.7	0.1	1.5	1.5					
			0.53	1.06	1.19	1.09	1.07	1.09	1.19	1.06	0.53				3
			0.54	1.07	1.21	1.09	1.06	1.08	1.21	1.08	0.54				
			0.9	0.9	1.0	0.3	-1.5	-1.1	1.5	1.5	0.9				
		0.53	0.89	1.23	1.18	1.26	1.11	1.26	1.18	1.23	0.89	0.53			4
		0.53	0.89	1.24	1.18	1.25	1.08	1.23	1.20	1.25	0.91	0.54			
		-1.0	-0.2	0.5	0.6	-1.1	-2.3	-2.3	1.9	1.5	1.3	1.8			
	0.42	1.06	1.23	1.03	1.32	1.03	1.19	1.03	1.32	1.03	1.23	1.06	0.42		5
	0.41	1.04	1.21	1.03	1.30	1.00	1.16	1.01	1.33	1.05	1.24	1.08	0.43		
	-2.3	-2.3	-1.5	-0.3	-0.9	-2.9	-2.9	-2.0	0.9	1.6	1.0	1.8	2.7		
	0.73	1.19	1.17	1.31	1.03	1.28	1.14	1.28	1.03	1.31	1.17	1.19	0.73		6
	0.72	1.18	1.16	1.28	1.02	1.26	1.11	1.27	1.03	1.32	1.18	1.21	0.74		
	-0.9	-0.9	-1.3	-2.3	-1.1	-1.4	-2.3	-1.0	-0.1	0.8	1.0	1.4	2.2		
0.48	1.02	1.08	1.26	1.03	1.28	1.01	1.13	1.01	1.28	1.03	1.26	1.08	1.02	0.48	7
0.47	1.01	1.09	1.24	1.00	1.25	1.01	1.12	1.01	1.27	1.03	1.26	1.08	1.03	0.49	
-2.3	-0.6	0.5	-1.6	-3.1	-1.7	-0.2	-0.9	-0.3	-0.5	-0.3	0.1	-0.0	1.2	1.3	
0.74	0.99	1.07	1.11	1.19	1.13	1.12	1.23	1.12	1.13	1.19	1.11	1.07	0.99	0.74	8
0.73	0.97	1.07	1.09	1.15	1.11	1.12	1.23	1.11	1.12	1.17	1.10	1.05	0.99	0.76	
-2.4	-1.2	0.5	-2.0	-3.6	-2.1	0.2	0.0	-1.1	-1.5	-1.5	-1.2	-1.7	0.8	2.7	
0.48	1.02	1.08	1.26	1.03	1.28	1.01	1.13	1.01	1.28	1.03	1.26	1.08	1.02	0.48	9
0.47	1.01	1.10	1.24	0.99	1.23	1.01	1.13	1.00	1.24	1.00	1.22	1.08	1.04	0.51	
-2.3	-0.4	1.5	-1.0	-3.6	-3.6	0.1	-0.3	-0.8	-2.8	-2.7	-2.8	0.1	2.2	4.8	
	0.73	1.19	1.17	1.31	1.03	1.28	1.14	1.28	1.03	1.31	1.17	1.19	0.73		10
	0.74	1.21	1.19	1.33	1.04	1.25	1.12	1.26	1.02	1.31	1.19	1.24	0.76		
	1.5	1.5	1.4	1.3	1.3	-2.3	-1.5	-1.8	-1.1	-0.3	1.9	3.7	3.8		
	0.42	1.06	1.23	1.03	1.32	1.03	1.19	1.03	1.32	1.03	1.23	1.06	0.42		11
	0.42	1.08	1.25	1.04	1.32	1.02	1.17	1.01	1.34	1.05	1.25	1.09	0.43		
	2.1	2.1	1.7	1.3	0.4	-1.6	-2.2	-2.3	1.9	1.9	2.0	2.6	3.1		
		0.53	0.89	1.23	1.18	1.26	1.11	1.26	1.18	1.23	0.89	0.53			12
		0.55	0.91	1.25	1.18	1.24	1.09	1.25	1.20	1.26	0.91	0.55			
		2.6	2.1	1.2	-0.1	-1.2	-1.9	-1.1	1.6	1.8	2.0	2.2			
			0.53	1.06	1.19	1.09	1.07	1.09	1.19	1.06	0.53				13
			0.55	1.10	1.21	1.07	1.05	1.09	1.21	1.08	0.55				
			3.0	3.4	1.2	-1.6	-1.9	0.2	1.4	1.7	2.1				
				0.42	0.73	1.02	0.99	1.02	0.73	0.42					14
				0.43	0.75	0.99	0.98	1.03	0.74	0.42					
				3.4	3.4	-2.4	-0.6	1.0	1.4	1.4					
						0.48	0.74	0.48							15
						0.50	0.75	0.49							
						3.4	1.3	1.3							

STANDARD
DEVIATION
=0.948

AVERAGE
PCT DIFFERENCE
= 1.5

SUMMARY

MAP NO: S2-7-23	DATE: 7/12/84	POWER: 100%
CONTROL ROD POSITIONS:	F-Q(T) = 1.757	QPTR:
D BANK AT 222 STEPS	F-DH(N) = 1.466	NW 0.9859 | NE 1.0061
	F(Z) = 1.148	SW 1.0001 | SE 1.0079
	F(XY) = 1.447	
	BURNUP = 7485 MWD/MTU	A.O. = -3.117(%)

Figure 4.3

SURRY UNIT 2 - CYCLE 7

ASSEMBLYWISE POWER DISTRIBUTION S2-7-45

PREDICTED / MEASURED / PCT DIFFERENCE

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							0.49 0.49 0.5	0.73 0.73 0.5	0.49 0.50 1.3						
2					0.44 0.45 1.8	0.74 0.74 0.3	1.02 1.02 -0.1	0.95 0.95 -0.3	1.02 1.03 0.8	0.74 0.76 2.4	0.44 0.45 2.9				
3				0.56 0.57 1.4	1.08 1.08 -0.1	1.22 1.21 -0.6	1.06 1.06 -0.1	1.03 1.02 -1.2	1.06 1.05 -0.5	1.22 1.25 2.4	1.08 1.12 3.1	0.56 0.58 3.6			
4			0.56 0.55 -1.1	0.91 0.90 -0.6	1.26 1.25 -1.4	1.15 1.15 -0.4	1.28 1.28 -0.6	1.09 1.08 -1.5	1.28 1.26 -1.7	1.15 1.16 0.5	1.26 1.28 1.0	0.91 0.92 1.2	0.56 0.57 1.8		
5		0.44 0.43 -2.9	1.08 1.05 -2.9	1.26 1.24 -1.7	1.03 1.03 -0.2	1.32 1.31 -0.6	1.02 1.02 -0.0	1.15 1.14 -1.3	1.02 1.01 -1.3	1.32 1.33 0.5	1.03 1.04 0.3	1.26 1.25 -0.7	1.08 1.09 0.9	0.44 0.45 2.6	
6		0.74 0.74 -0.9	1.22 1.21 -0.9	1.15 1.14 -1.2	1.32 1.29 -2.3	1.02 1.02 -0.4	1.28 1.27 -0.2	1.09 1.08 -1.4	1.28 1.28 -0.0	1.02 1.03 0.4	1.32 1.32 -0.2	1.15 1.14 -0.8	1.22 1.23 0.6	0.74 0.76 2.3	
7	0.49 0.49 -0.6	1.02 1.03 0.5	1.06 1.07 1.1	1.28 1.27 -1.3	1.02 0.99 -3.1	1.27 1.26 -1.2	0.99 1.00 0.9	1.10 1.10 0.3	0.99 1.00 1.1	1.27 1.28 0.3	1.02 1.01 -0.9	1.28 1.27 -1.4	1.06 1.06 0.4	1.02 1.04 1.8	0.49 0.50 1.9
8	0.73 0.72 -0.6	0.95 0.95 0.0	1.03 1.04 1.1	1.09 1.07 -1.7	1.15 1.11 -3.5	1.09 1.07 -1.7	1.10 1.11 1.2	1.25 1.27 1.3	1.10 1.09 -0.4	1.09 1.08 -1.2	1.15 1.13 -2.2	1.09 1.08 -0.9	1.03 1.03 0.2	0.95 0.97 1.8	0.73 0.76 3.9
9	0.49 0.49 -0.6	1.02 1.02 -0.2	1.06 1.06 0.0	1.28 1.26 -1.7	1.02 0.98 -3.5	1.27 1.23 -3.6	0.99 0.96 -3.6	1.10 1.09 -1.0	0.99 0.99 -0.1	1.27 1.23 -3.2	1.02 0.99 -2.3	1.28 1.28 -0.3	1.06 1.07 1.0	1.02 1.06 3.4	0.49 0.52 6.5
10		0.74 0.74 0.0	1.22 1.22 0.0	1.15 1.15 0.2	1.32 1.33 0.6	1.02 1.00 -2.0	1.28 1.23 -3.4	1.09 1.07 -1.7	1.28 1.26 -1.5	1.02 1.01 -1.7	1.32 1.31 -1.2	1.15 1.15 -0.3	1.22 1.24 1.4	0.74 0.77 3.8	
11		0.44 0.45 2.3	1.08 1.11 2.3	1.26 1.28 1.5	1.03 1.04 0.6	1.32 1.30 -1.7	1.02 0.99 -2.7	1.15 1.13 -1.8	1.02 1.00 -1.9	1.32 1.30 -2.0	1.03 1.04 0.3	1.26 1.27 0.8	1.08 1.10 1.7	0.44 0.45 2.9	
12			0.56 0.58 4.6	0.91 0.94 3.0	1.26 1.27 0.5	1.15 1.13 -1.7	1.28 1.25 -3.0	1.09 1.07 -2.4	1.28 1.26 -1.8	1.15 1.14 -1.0	1.26 1.26 -0.0	0.91 0.92 1.3	0.56 0.57 2.2		
13				0.56 0.58 4.5	1.08 1.13 4.5	1.22 1.23 0.6	1.06 1.03 -2.9	1.03 1.00 -2.5	1.06 1.05 -1.0	1.22 1.21 -0.6	1.08 1.08 0.0	0.56 0.57 1.6			
14					0.44 0.46 4.5	0.74 0.78 5.2	1.02 1.05 2.6	0.95 0.96 0.6	1.02 1.02 0.0	0.74 0.74 -0.1	0.44 0.44 -0.7				
15							0.49 0.52 6.1	0.73 0.75 3.8	0.49 0.49 0.4						

STANDARD DEVIATION =1.293

AVERAGE PCT DIFFERENCE = 1.5

SUMMARY

MAP NO: S2-7-45

CONTROL ROD POSITIONS:

D BANK AT 223 STEPS

DATE: 3/01/85

F-Q(T) = 1.716

F-DH(N) = 1.433

F(Z) = 1.141

F(XY) = 1.389

BURNUP = 14150 MWD/MTU

POWER: 100%

QPTR:

NW 0.9977	NE 1.0023
SW 1.0002	SE 0.9998

A.O. = -2.712(%)

Figure 4.4

HOT CHANNEL FACTOR NORMALIZED OPERATING ENVELOPE

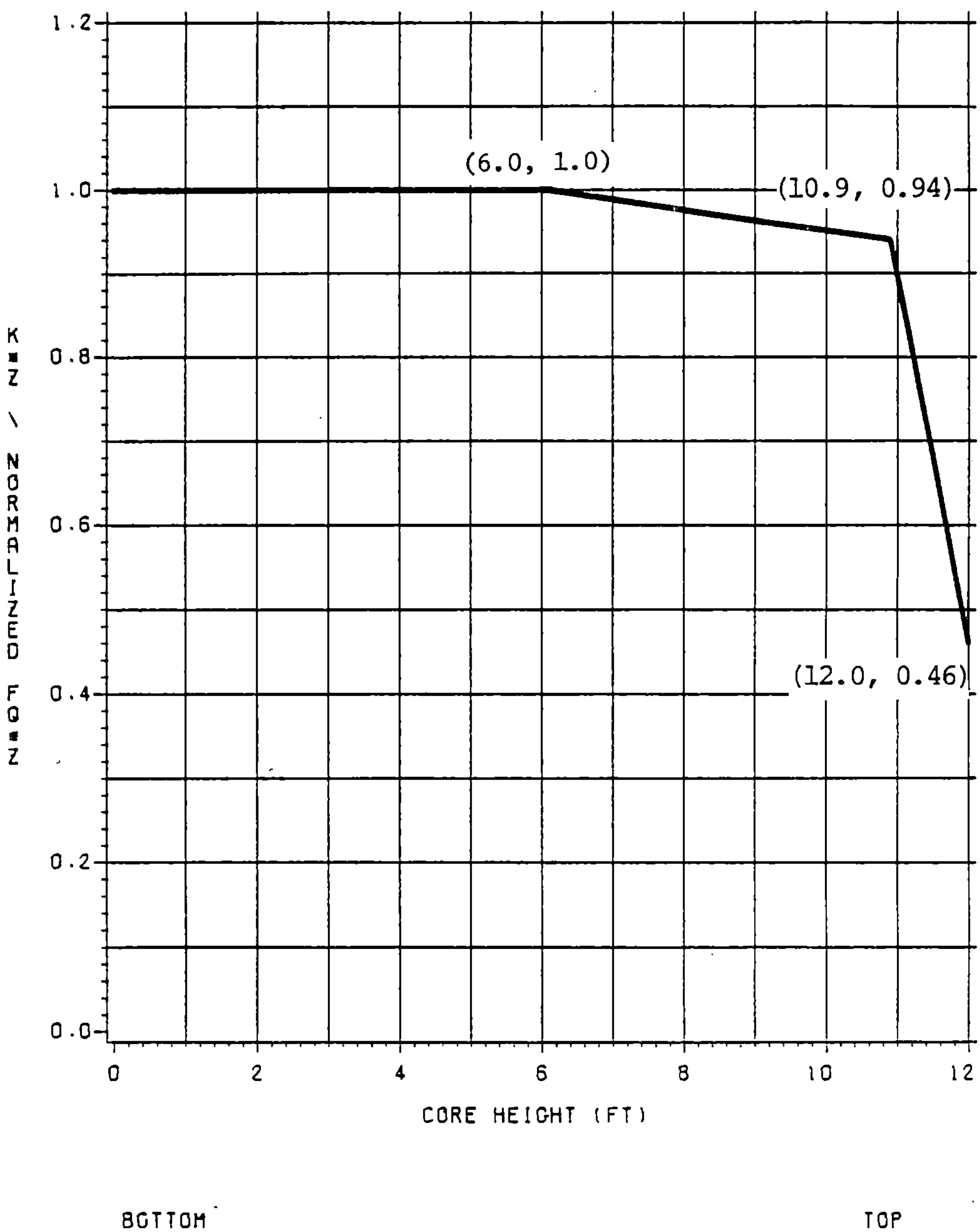


Figure 4.5

SURRY UNIT 2 - CYCLE 7

HEAT FLUX HOT CHANNEL FACTOR, $F_Q^T(Z)$

S2-7-05

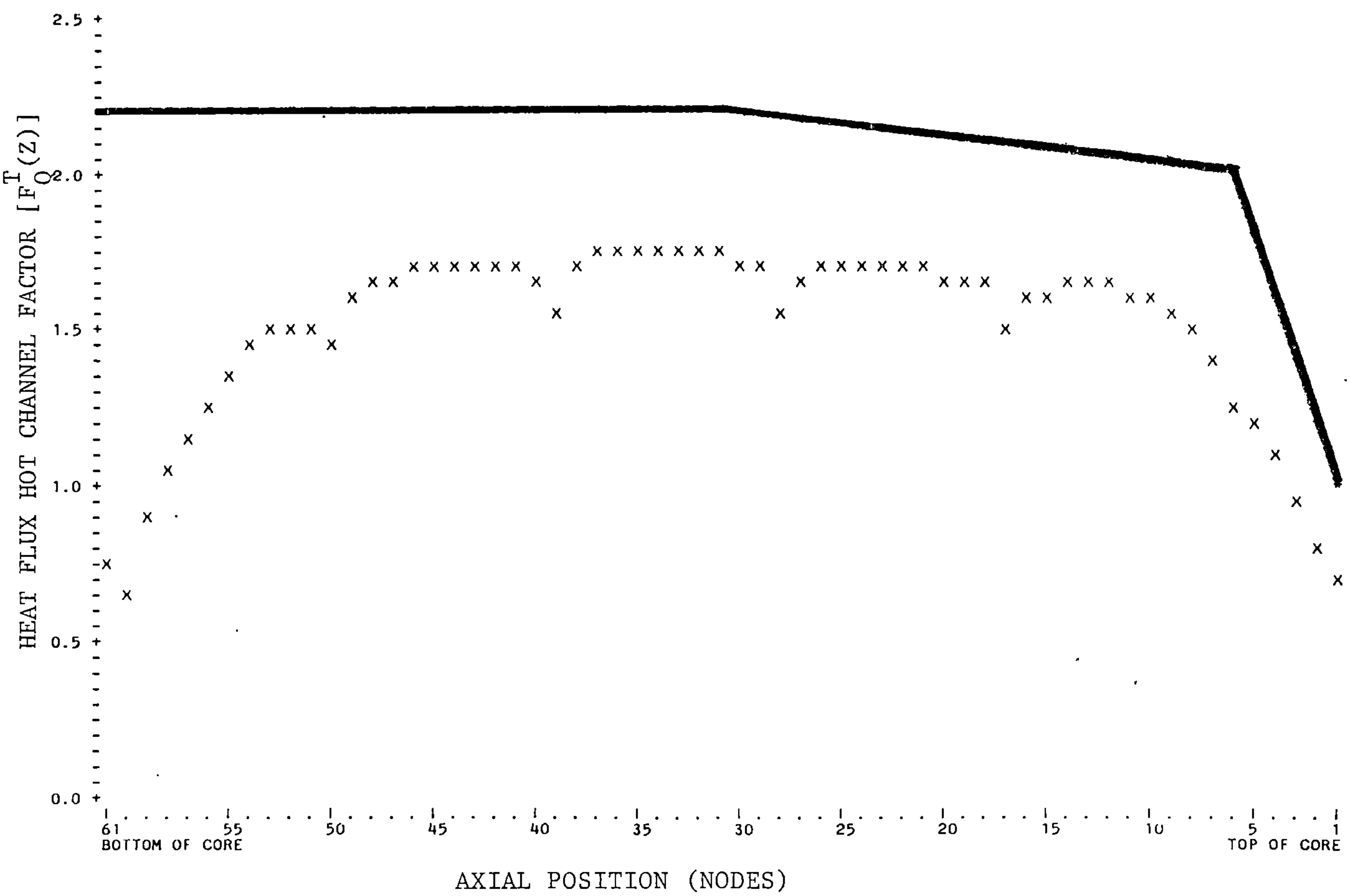


Figure 4.6

SURRY UNIT 2 - CYCLE 7

HEAT FLUX HOT CHANNEL FACTOR, $F_Q^T(Z)$

S2-7-23

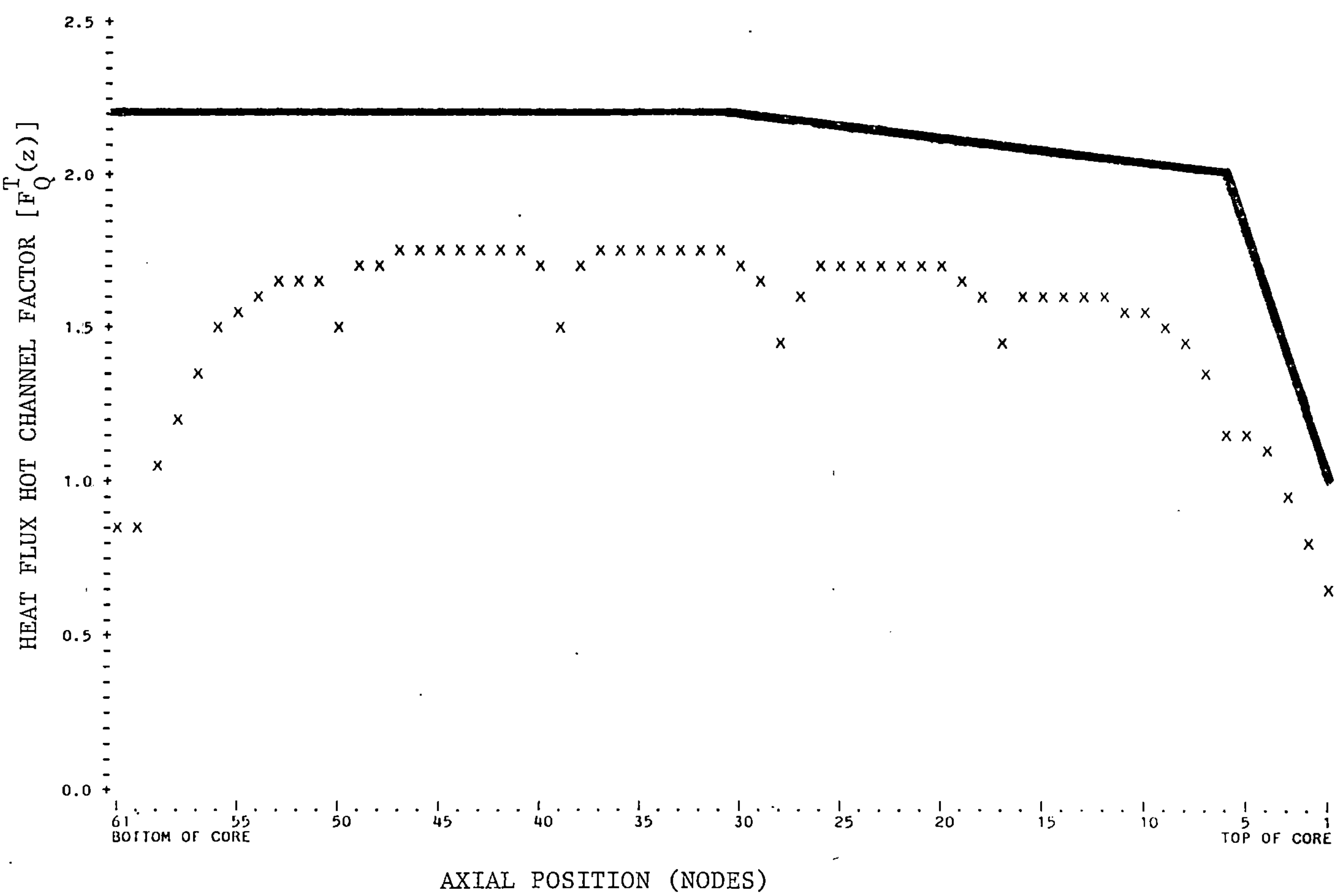


Figure 4.7

SURRY UNIT 2 - CYCLE 7

HEAT FLUX HOT CHANNEL FACTOR, $F_Q^T(Z)$

S2-7-45

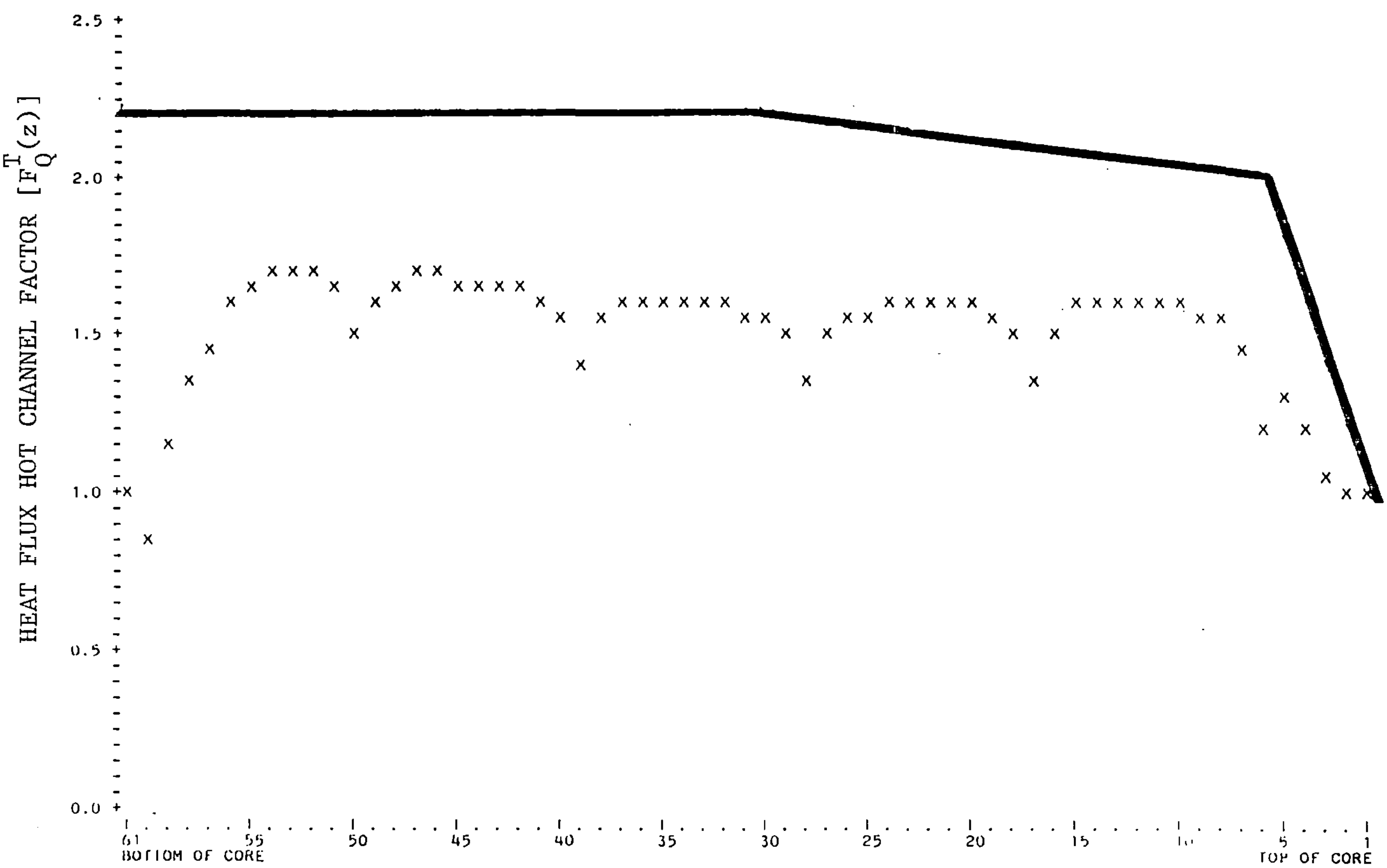


Figure 4.8

SURRY UNIT 2 - CYCLE 7

MAXIMUM HEAT FLUX HOT CHANNEL FACTOR, FQ * P VS AXIAL POSITION

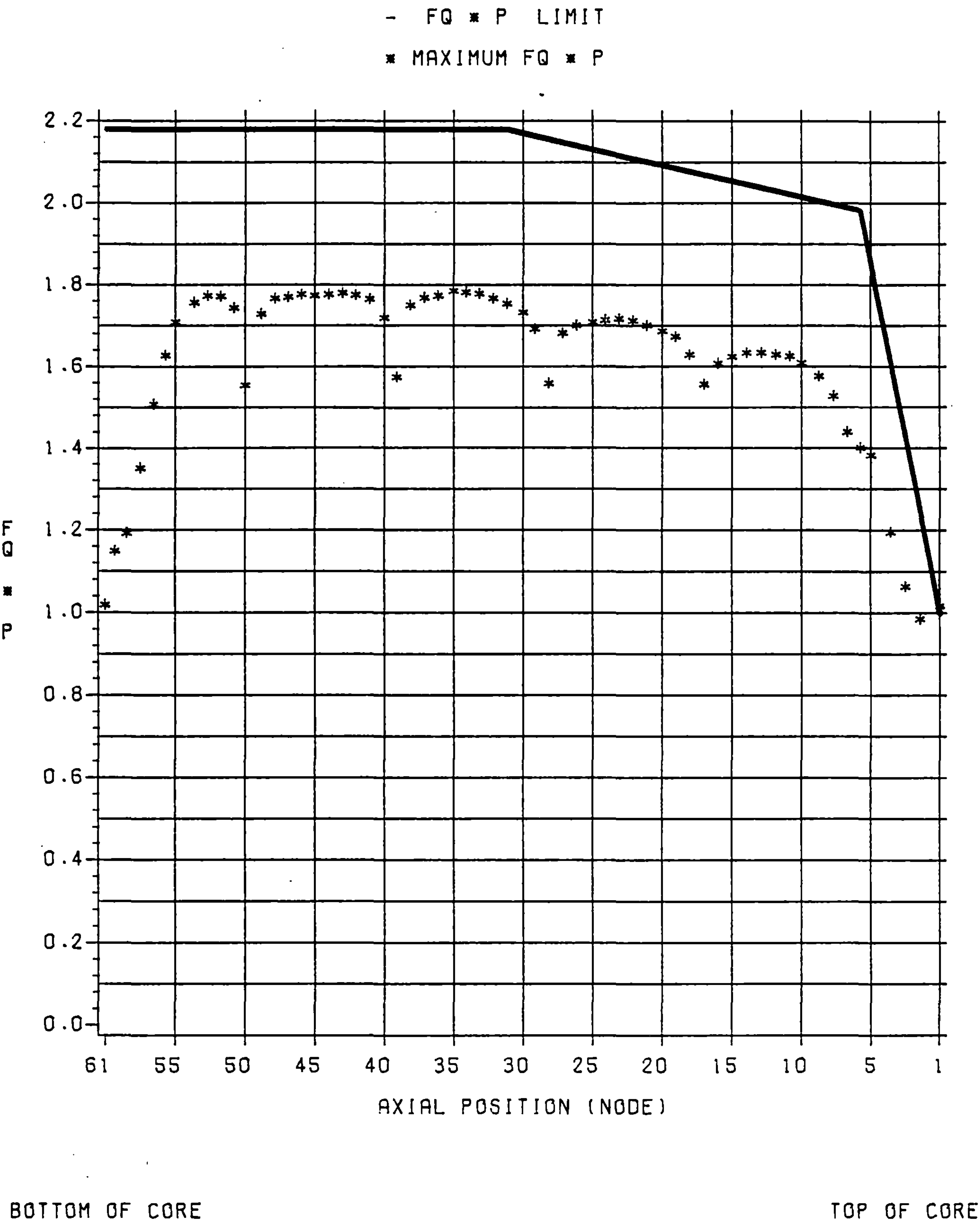


Figure 4.9

SURRY UNIT 2 - CYCLE 7

MAXIMUM HEAT FLUX HOT CHANNEL FACTOR, F-Q VS. BURNUP

- TECH SPEC LIMIT

X MEASURED VALUE

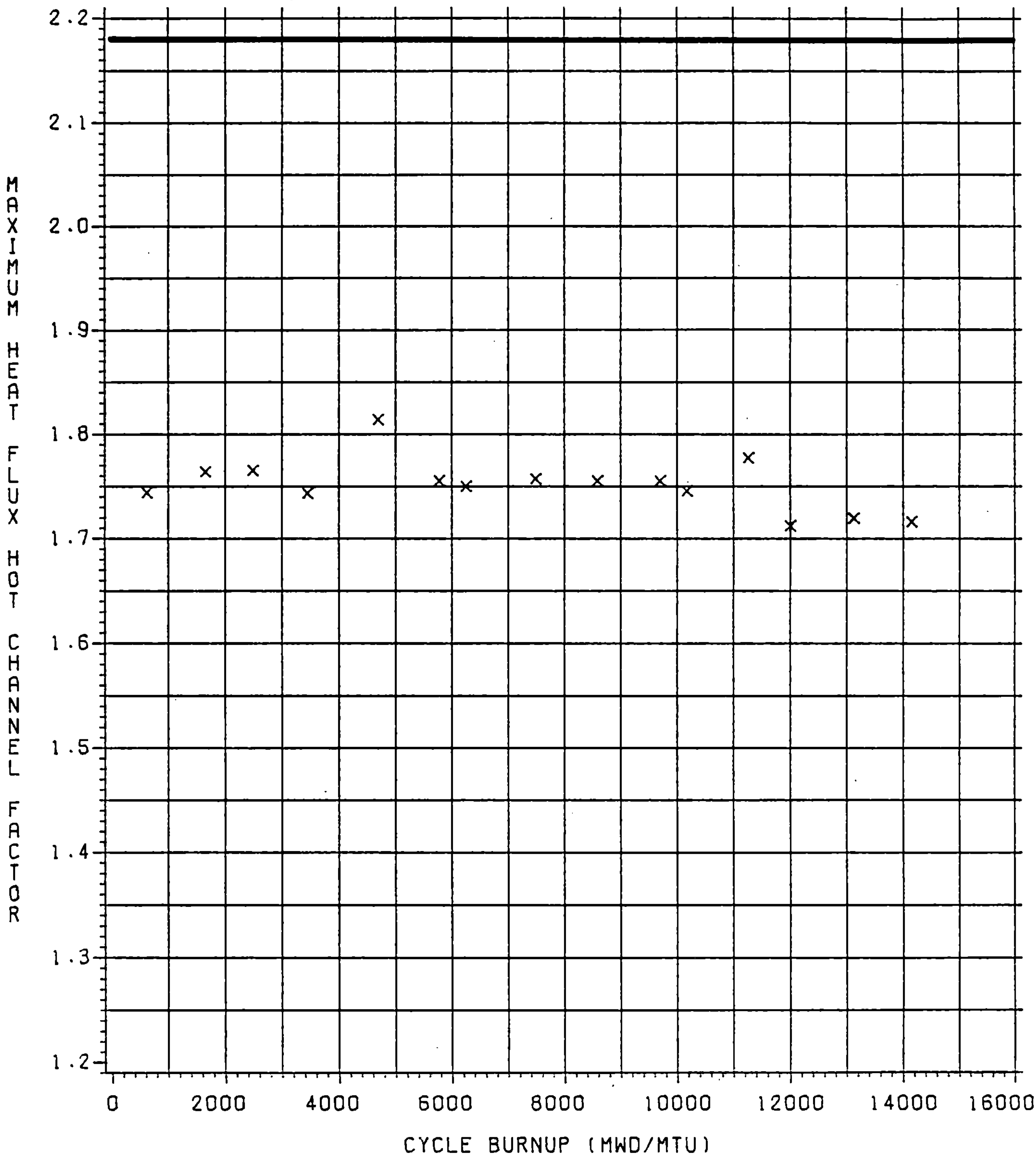


Figure 4.10

SURRY UNIT 2 - CYCLE 7

ENTHALPY RISE HOT CHANNEL FACTOR, F-DH(N) VS. BURNUP

- TECH SPEC LIMIT

X MEASURED VALUE

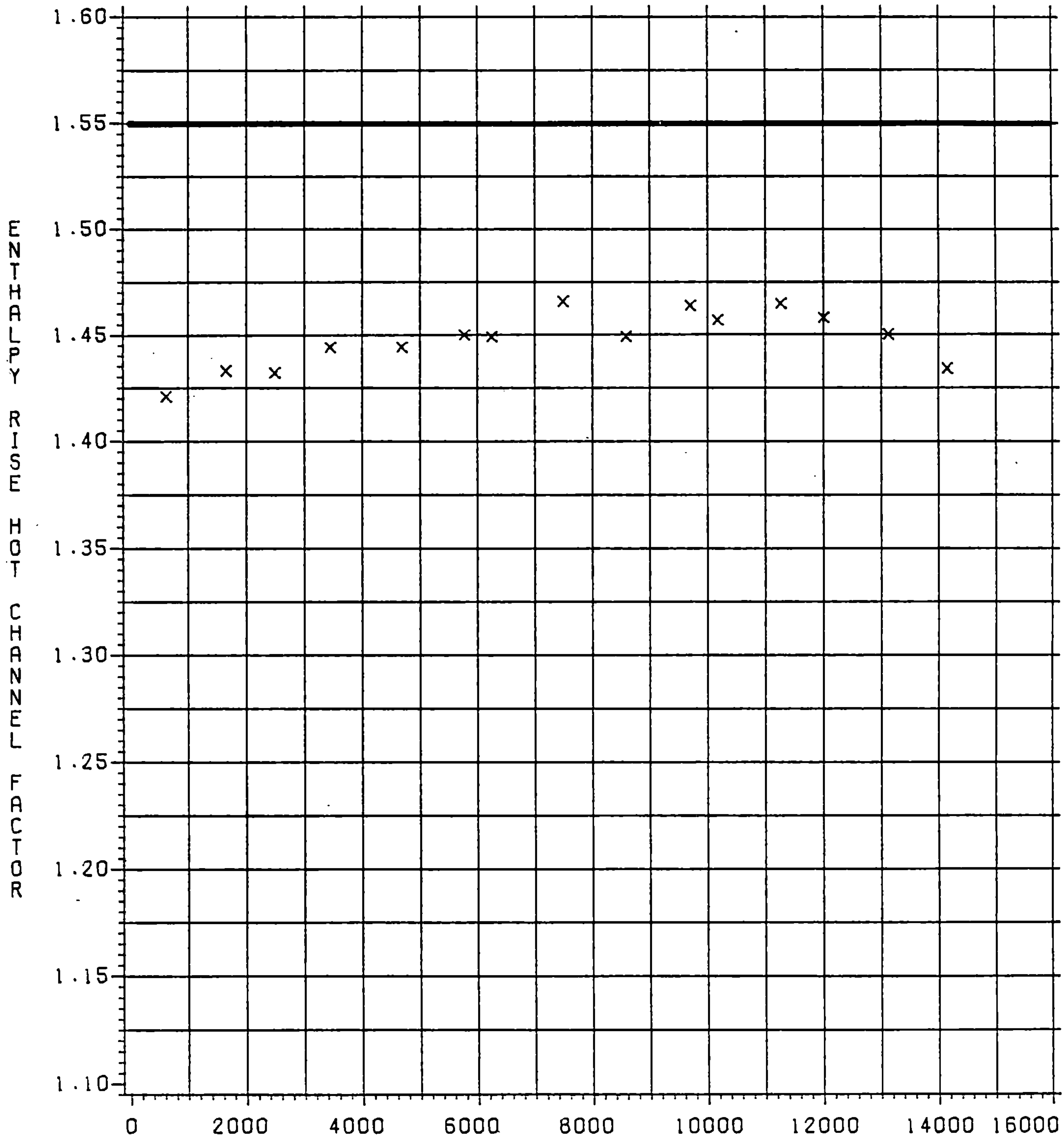


Figure 4.11

SURRY UNIT 2 - CYCLE 7

TARGET DELTA FLUX VS. BURNUP

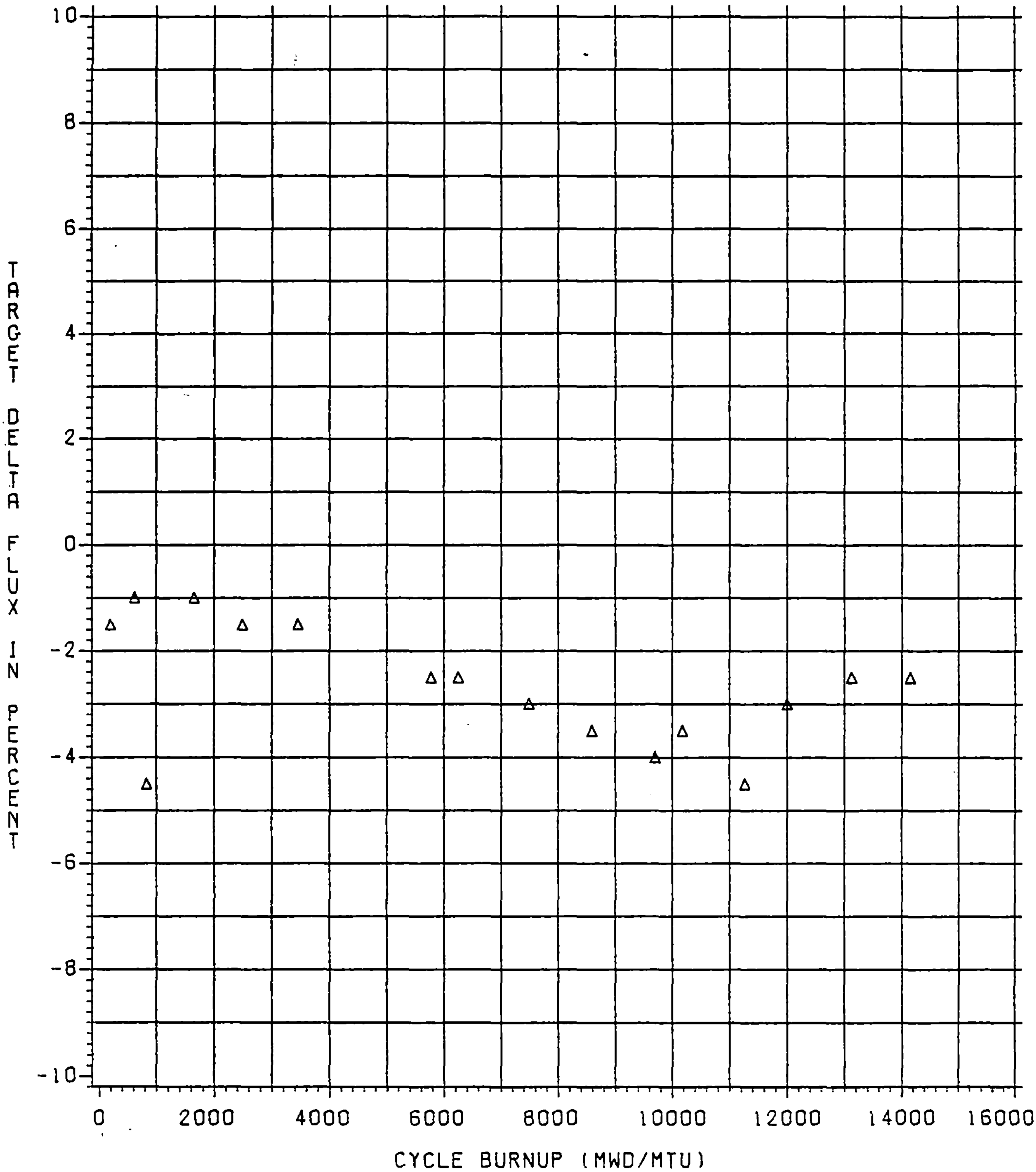


Figure 4.12

SURRY UNIT 2 - CYCLE 7

CORE AVERAGE AXIAL POWER DISTRIBUTION

S2-7-05

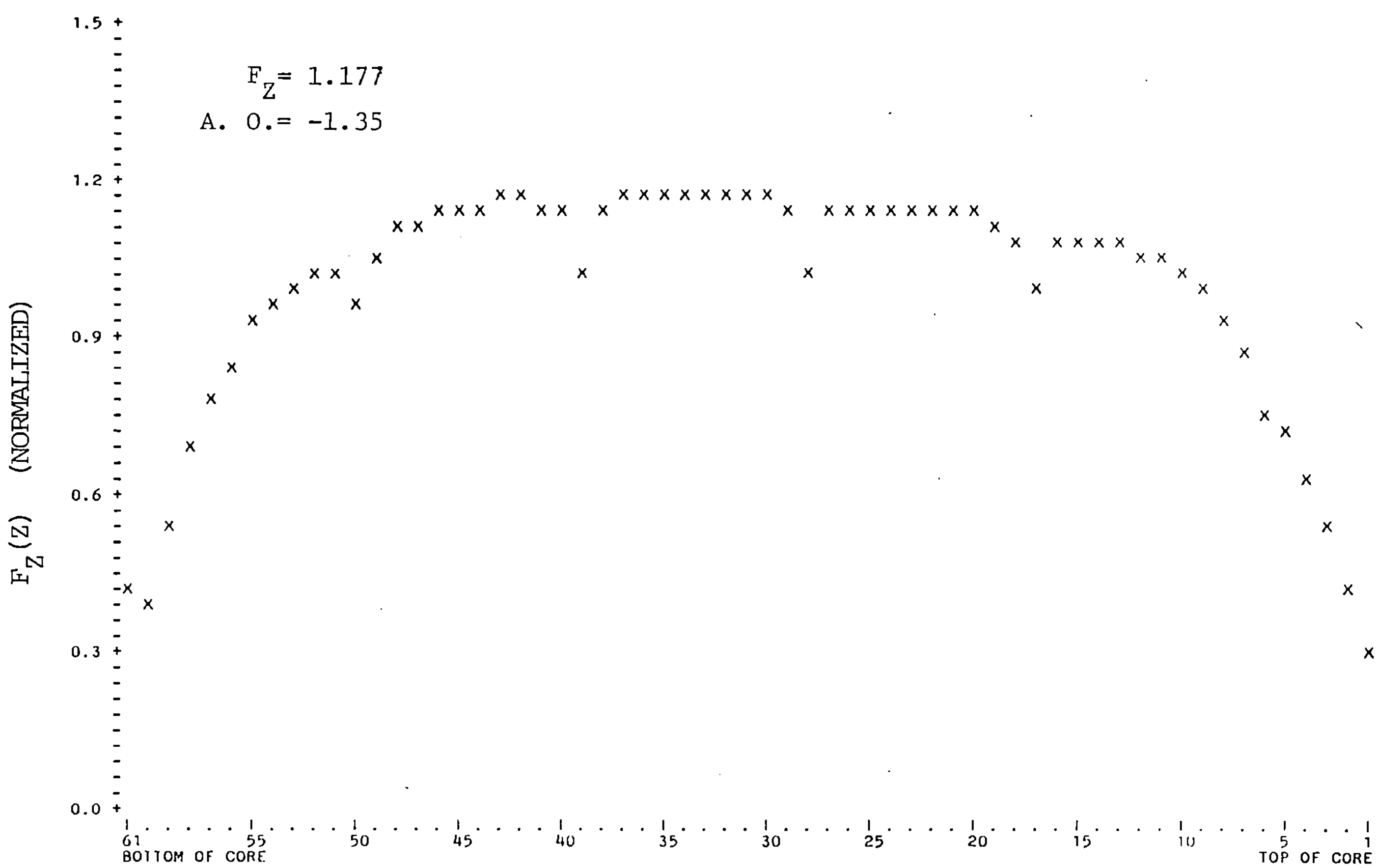


Figure 4.13

SURRY UNIT 2 - CYCLE 7

CORE AVERAGE AXIAL POWER DISTRIBUTION

S2-7-23

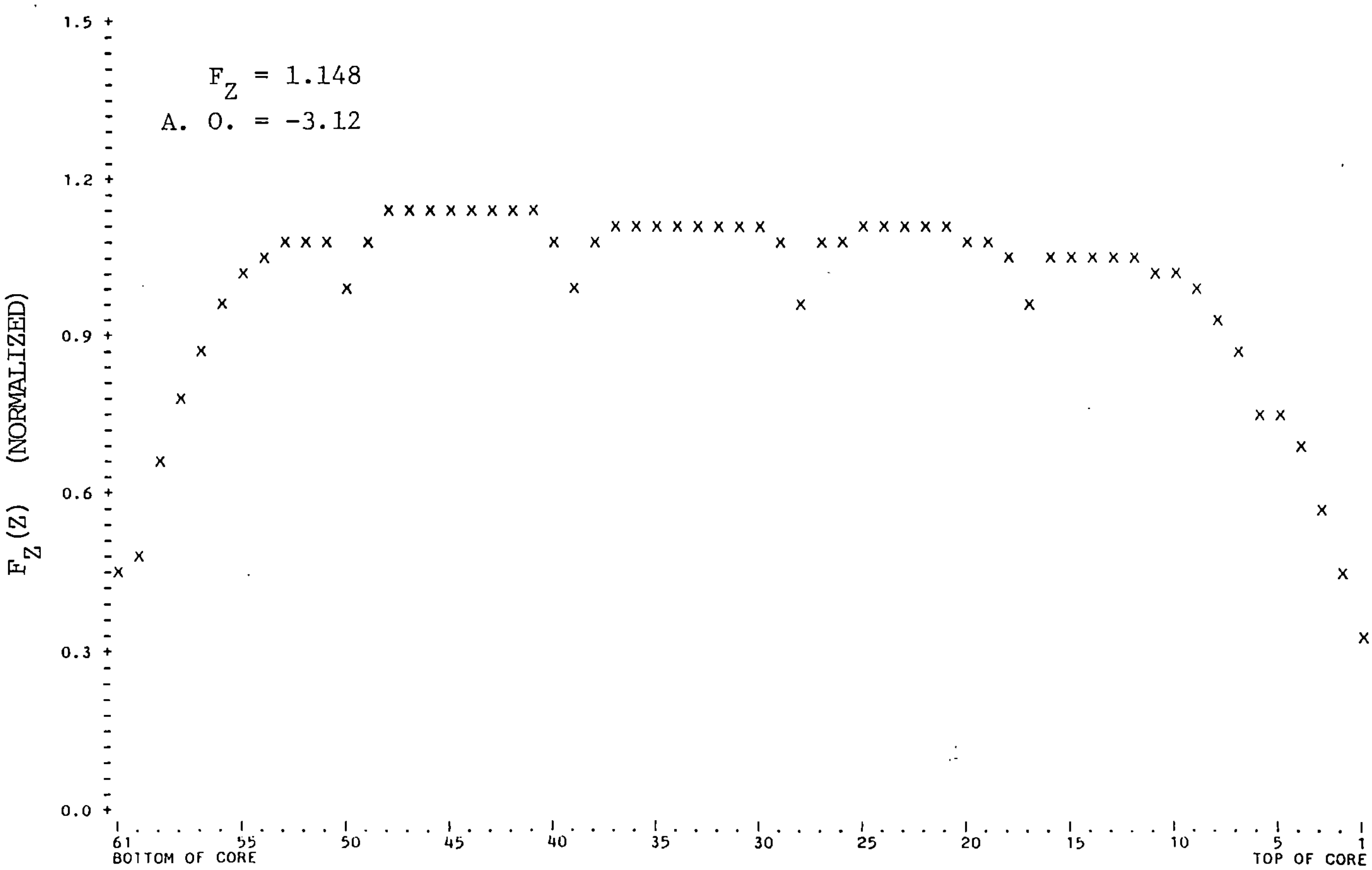


Figure 4.14

SURRY UNIT 2 - CYCLE 7

CORE AVERAGE AXIAL POWER DISTRIBUTION

S2-7-45

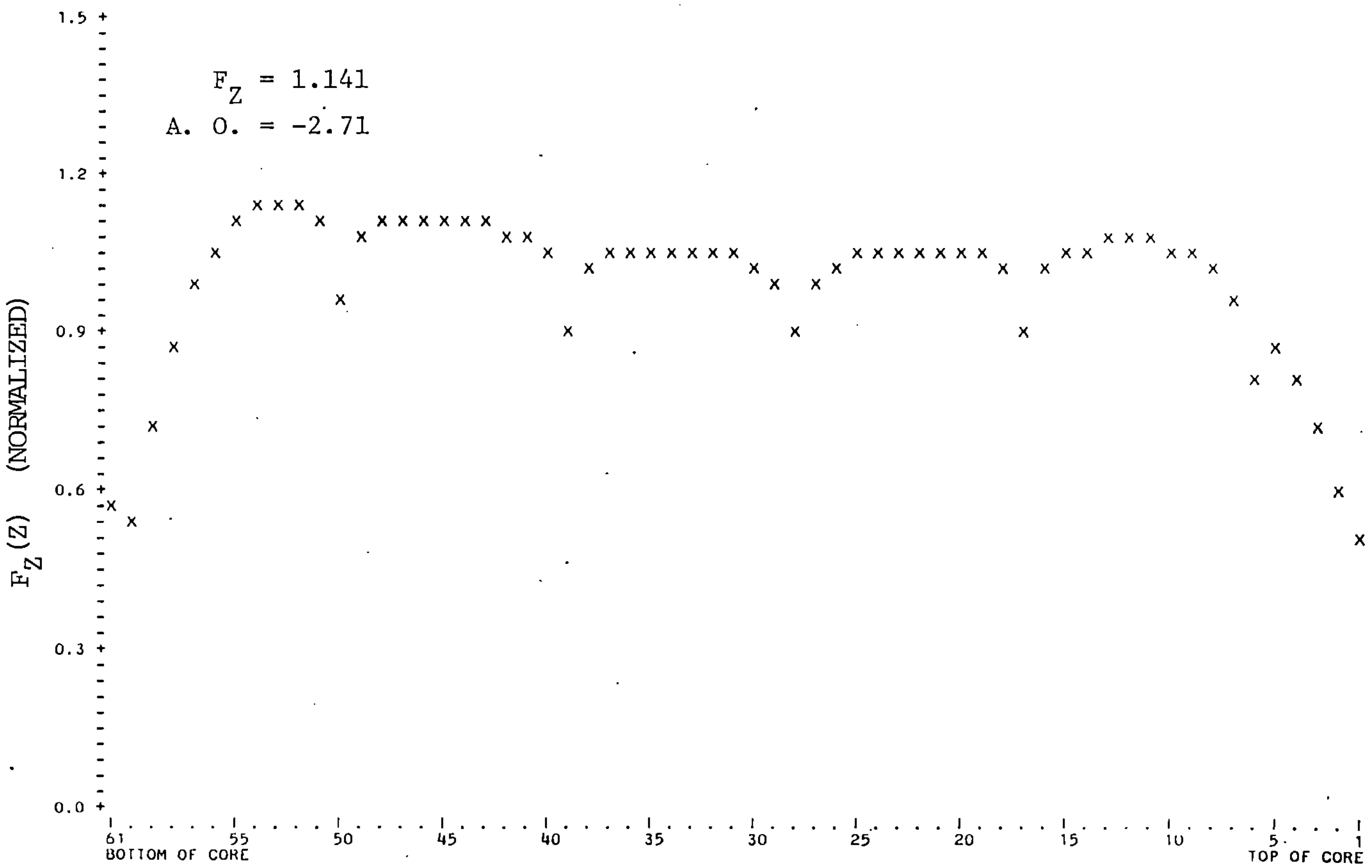
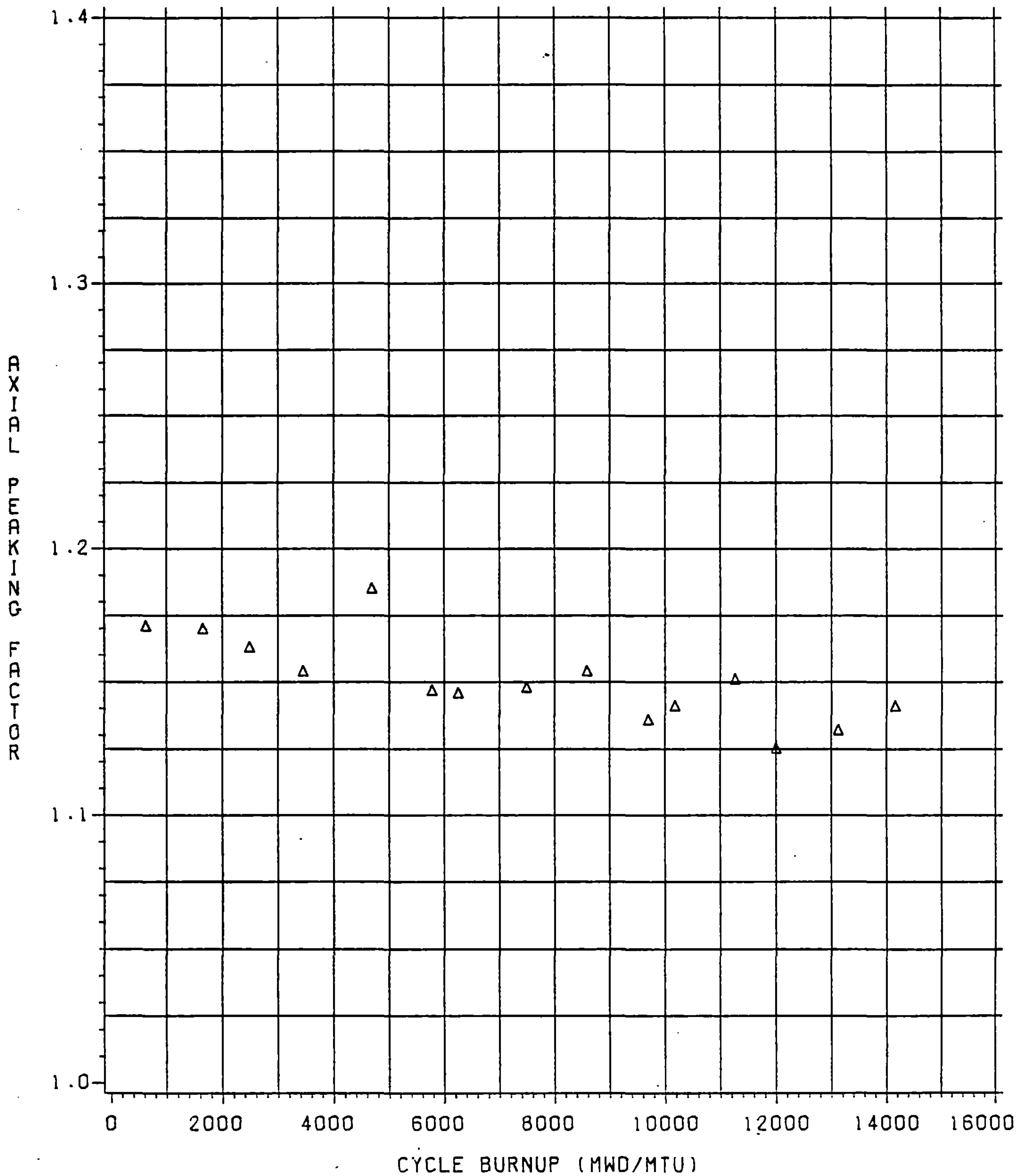


Figure 4.15

SURRY UNIT 2 - CYCLE 7

CORE AVERAGE AXIAL PEAKING FACTOR, F-Z VS. BURNUP



Section 5

PRIMARY COOLANT ACTIVITY FOLLOW

Activity levels of iodine-131 and 133 in the primary coolant are important in core performance follow analysis because they are used as indicators of defective fuel. Additionally, they are also important with respect to the offsite dose calculation values associated with accident analyses. Both I-131 and I-133 can leak into the primary coolant system throught a breach in the cladding. As indicated in the Surry Technical Specifications, the dose equivalent I-131 concentration in the primary coolant is limited to 1.0 µCi/gm for normal steady state operation. Figure 5.1 shows the dose equivalent I-131 activity level history for the Surry 2, Cycle 7 core. The demineralizer flow rate averaged 105 gpm during power operation. The data shows that during Cycle 7, the core operated substantially below the 1.0 µCi/gm limit during steady state operation (the spike data is associated with power transients and unit shutdown). Specifically, the average dose equivalent I-131 concentration of 1.0×10^{-3} µCi/gm is equal to much less than 1% of the Technical Specifications limit.

The ratio of the specific activities of I-131 to I-133 is used to characterize the type of fuel failure which may have occurred in the reactor core. Use of the ratio for this determination is feasible because I-133 has a short half-life (approximately 21 hours) compared to that of I-131 (approximately eight days). For pinhole defects, where the diffusion time through the defect is on the order of days, the I-133 decays out leaving the I-131 dominant in activity, thereby causing the ratio to be 0.5 or more. In the case of large leaks, uranium particles in the coolant, and "tramp" uranium*, where the diffusion mechanism is negligible, the I-131/I-133 ratio will generally be less than 0.1. Figure 5.2 shows the I-131/I-133 ratio data for the Surry 2, Cycle 7 core. An evaluation of the measured values for dose equivalent I-131 and the I-131/I-133 ratio indicates that there were essentially no fuel defects in the Cycle 7 core, but there was a trace of uranium in the primary coolant system.

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*"Tramp" uranium consists of small particles of uranium which adhere to the outside of the fuel during the manufacturing process.

FIGURE 5.1

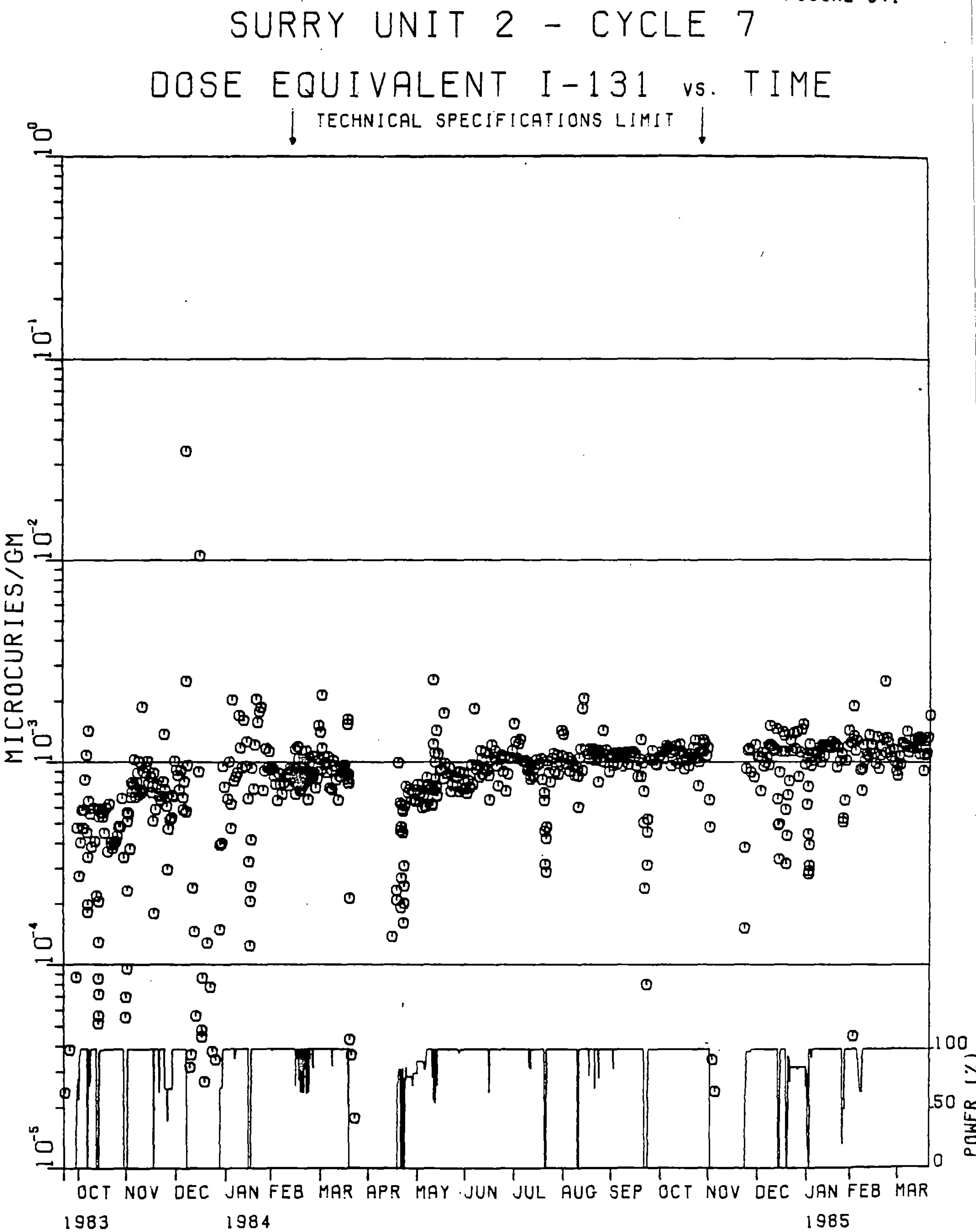
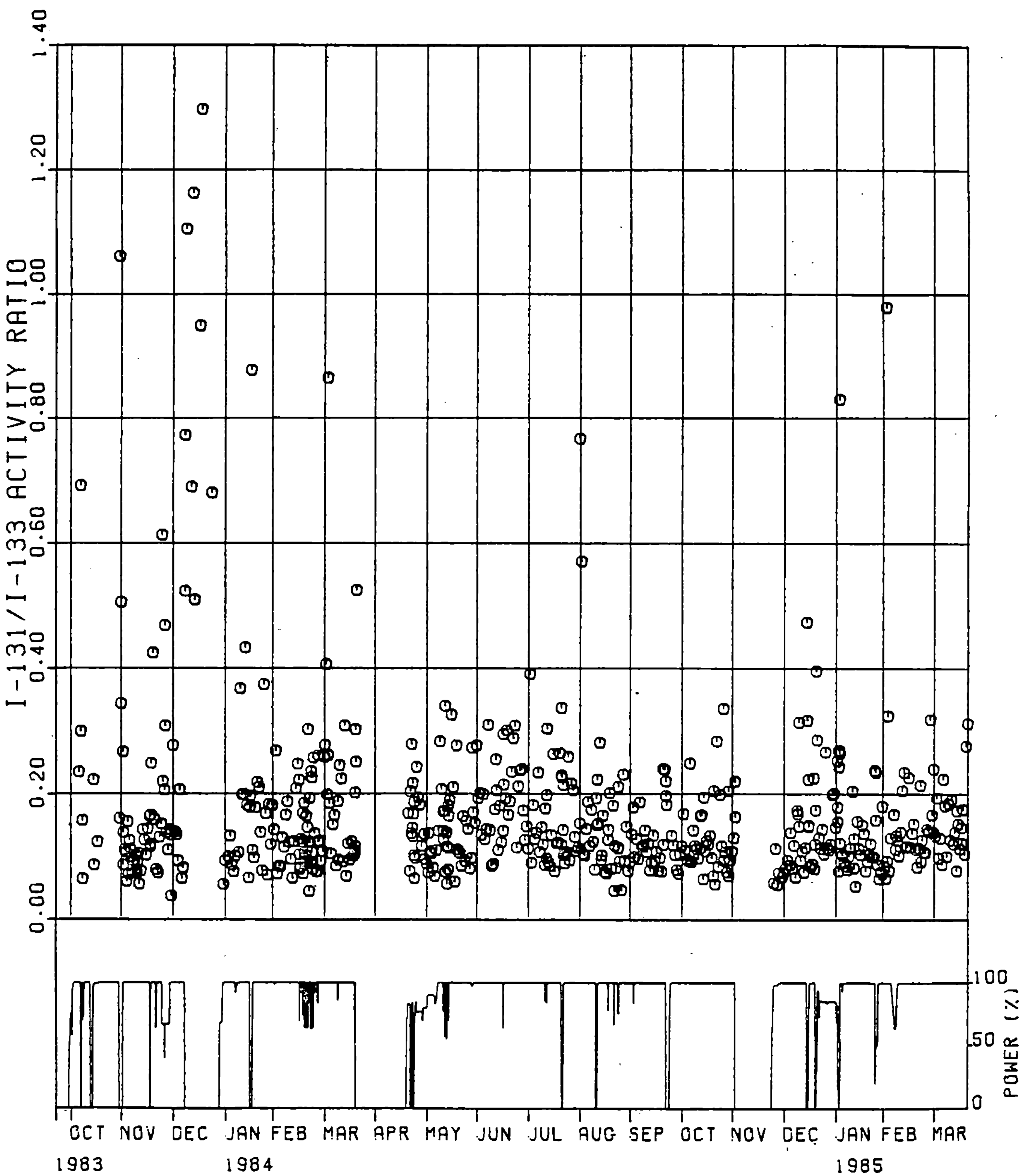

SURRY UNIT 2 - CYCLE 7
DOSE EQUIVALENT I-131 vs. TIME
TECHNICAL SPECIFICATIONS LIMIT
MICROCURIES/GM
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
POWER (%)
100
50
0
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR
1983
1984
1985

FIGURE 5.2

SURRY UNIT 2 - CYCLE 7

I-131/I-133 ACTIVITY RATIO vs. TIME



Section 6

CONCLUSIONS

The Surry 2, Cycle 7 core has completed operation. Throughout this cycle, all core performance indicators compared favorably with the design predictions and the core related Technical Specifications limits were met with significant margin. No significant abnormalities in reactivity or burnup accumulation were detected. In addition, the excellent mechanical integrity of the fuel has not changed throughout Cycle 7 as indicated by the radioiodine analysis.

Section 7

REFERENCES

1) E. S. Hendrixson, "Surry Unit 2, Cycle 7 Startup Physics Test Report," VEP-NOS-7, October, 1983

2) Surry Power Station Technical Specifications, Sections 3.1.D, 3.12.B, and 4.10.

3) T. K. Ross, "NEWTOTE Code", NFO-CCR-6, Vepco, April, 1984.

4) R. D. Klatt, W. D. Leggett, III, and L. D. Eisenhart, "FOLLOW Code," WCAP-7482, February, 1970.

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