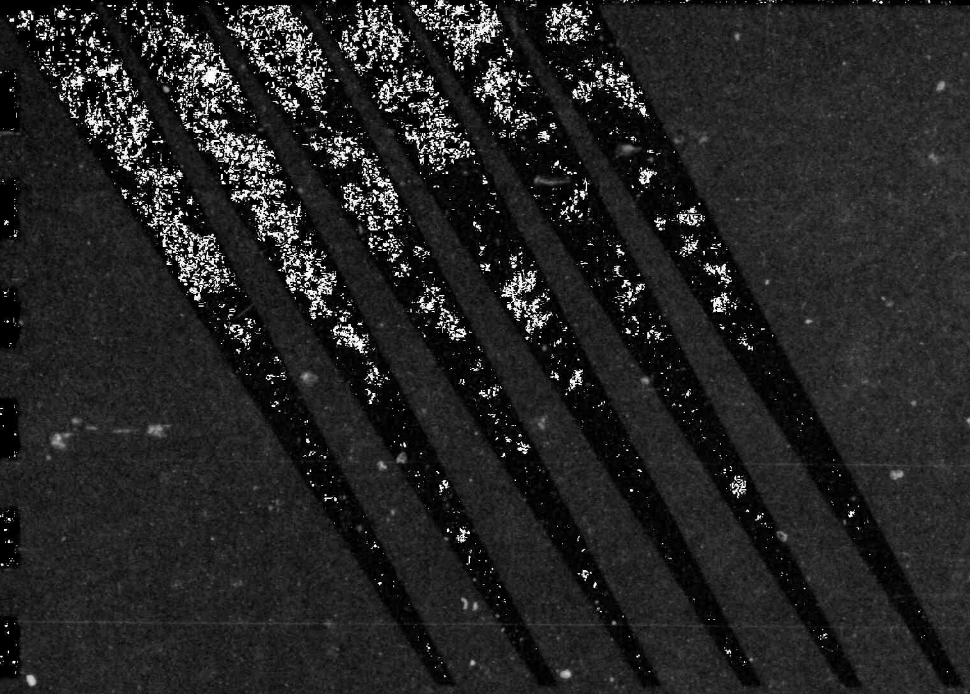

VP-NOS-24

North Anna Unit 2, Cycle 4 Core Performance Report

Nuclear Operations Department

Virginia Electric and Power Company

VP-NOS-24

NORTH ANNA UNIT 2, CYCLE 4
CORE PERFORMANCE REPORT

by

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Section 1

INTRODUCTION AND SUMMARY

On February 20, 1986, North Anna Unit 2 completed Cycle 4. Since the initial criticality of Cycle 4 on November 2, 1984, the reactor core produced approximately 95 x 10^6 MBTU (15,934 Megawatt days per metric ton of contained uranium) which has resulted in the generation of approximately 9.2 x 10^9 KWHr gross (8.7 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 4. The physics tests that were performed during the startup of this cycle were covered in the North Anna Unit 2, Cycle 4 Startup Physics Test Report[1] and, therefore, will not be included here.

North Anna Unit 2 was in coastdown from January 23, 1986, at which time the burnup was approximately 14,938 MWD/MTU. The coastdown, therefore, accounted for an additional core burn of 996 MWD/MTU from the end of full power reactivity.

The fourth cycle core consisted of four batches of fuel. The North Anna 2, Cycle 4 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 North Anna Unit 2 Technical Specifications, and to assess the integrity of the fuel.

Each of the four performance indicators is discussed in detail for the North Anna 2, Cycle 4 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 ±0.29% with the burnup accumulation in each batch deviating from design prediction by less than 1.8%.

2. Reactivity Depletion Follow - The critical boron concentration, used to monitor reactivity depletion, was consistently within ±0.22% ΔK/K of the design prediction which is well within the ±1% ΔK/K margin allowed by Section 4.1.1.1.2 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 4 was approximately 2.0×10^{-2} µCi/gm. This corresponds to 2% 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

NORTH ANNA UNIT 2 - CYCLE 4

CORE LOADING MAP

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
						R32	S15	R52							1
				S26	S27	T22 4P	R09	T34 4P	S32	S18					2
			S33	T36 4P	T59 16P	R05	T61 20P	R33	T07 16P	T60 4P	S19				3
		S12	S07	T54 16P	S54	T46 20P	S21 SS	T51 20P	S46	T33 16P	S48	S47			4
	S55	T19 4P	T32 16P	R37	T20 20P	S31 4P	S53	S24 4P	T25 20P	R28	T30 16P	T05 4P	S17		5
	S20	T44 16P	S04	T04 20P	R47	T16 16P	R19	T53 16P	R10	T21 20P	S10	T56 16P	S05		6
R44	T10 4P	R01	T64 20P	S56 4P	T09 16P	R12	T24 16P	R43	T12 16P	S06 4P	T45 20P	R21	T11 4P	R46	7
S09	R14	T47 20P	S45	S03	R40	T31 16P	P39	T41 16P	R30	S11	S14 SS	T42 20P	R26	S13	8
R38	T03 4P	R15	T14 20P	S34 4P	T29 16P	R17	T02 16P	R50	T13 16P	S36 4P	T27 20P	R24	T17 4P	R11	9
	S43	T58 16P	S49	T35 20P	R13	T39 16P	R36	T50 16P	R08	T38 20P	S52	T55 16P	S08		10
	S23	T52 4P	T48 16P	R25	T43 20P	S02 4P	S38	S41 4P	T63 20P	R20	T26 16P	T08 4P	S16		11
		S42	S44	T28 16P	S37	T18 20P	S40 SS	T40 20P	S35	T49 16P	S01	S29			12
			S39	T37 4P	T62 16P	R29	T01 20P	R16	T23 16P	T06 4P	S50				13
				S30	S28	T57 4P	R07	T15 4P	S51	S25					14
						R03	S22	R02							15

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

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

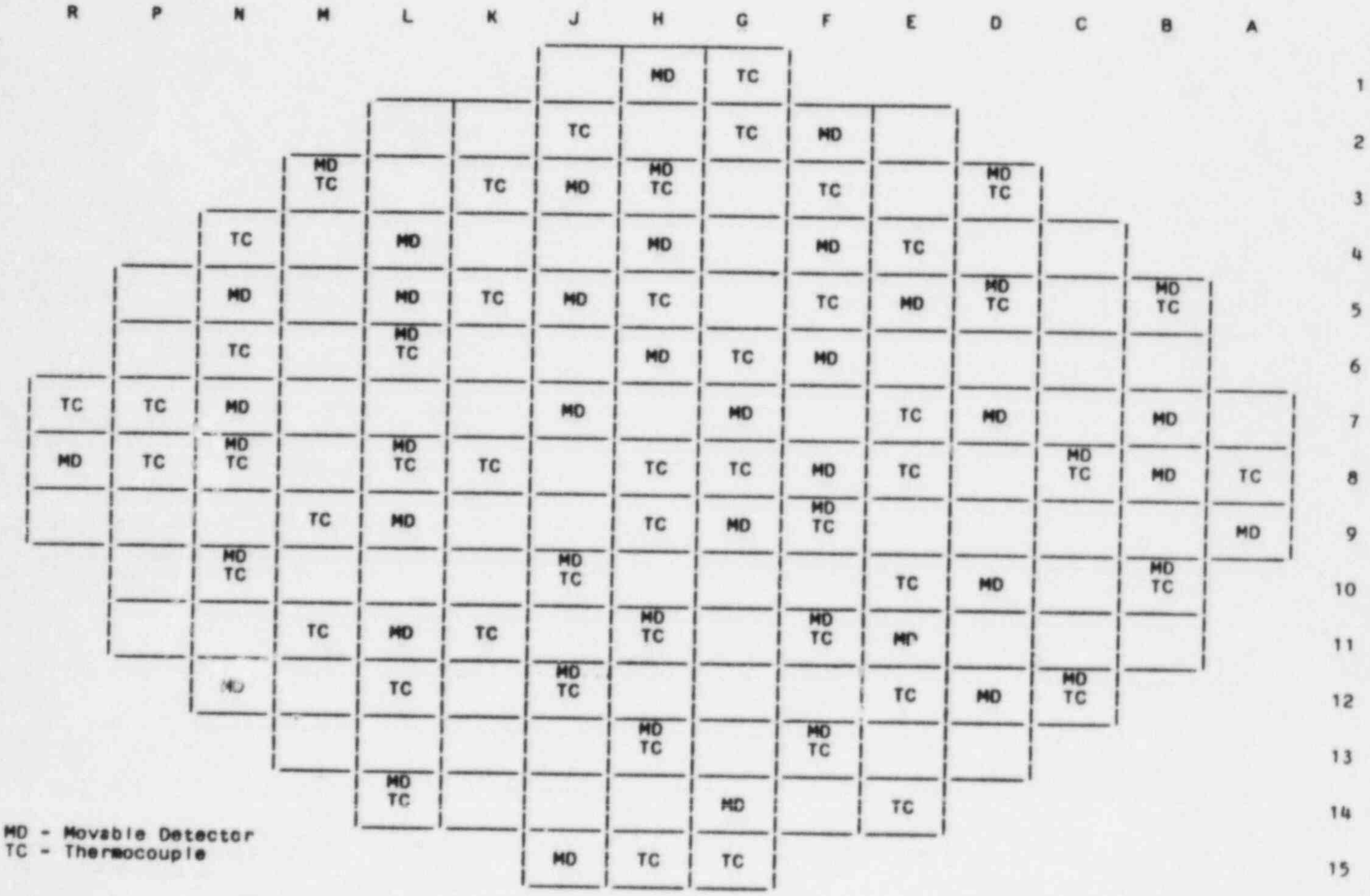
FUEL ASSEMBLY DESIGN PARAMETERS

	SUB-BATCH			
	3A3	4A2	5A	6A
INITIAL ENRICHMENT (W/O U-235)	3.10	3.41	3.59	3.60
ASSEMBLY TYPE	17X17	17X17	17X17	17X17
NUMBER OF ASSEMBLIES	1	36	56	64
FUEL RODS PER ASSEMBLY	264	264	264	264
ASSEMBLY IDENTIFICATION	P39	R01-R03 R05 R07-R17 R19-R21 R24-R26 R28-R30 R32,R33 R36-R38 R40,R43 R44,R46 R47,R50 R52	S01-S56	T01-T64

Figure 1.2

NORTH ANNA UNIT 2 - CYCLE 4

MOVABLE DETECTOR AND THERMOCOUPLE LOCATIONS



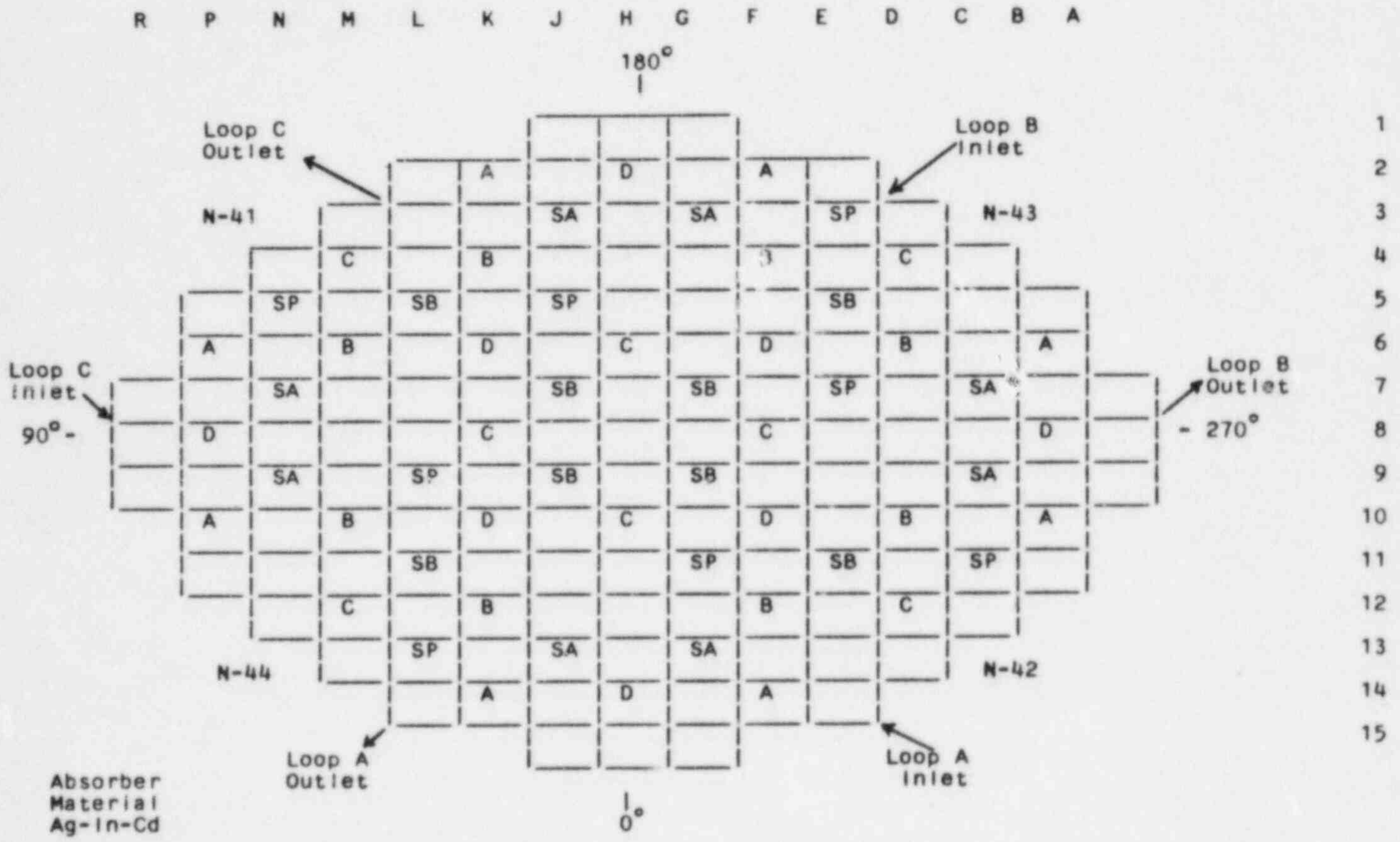
	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1								MD	TC						
2							TC		TC	MD					
3				MD TC		TC	MD	MD TC		TC		MD TC			
4			TC		MD			MD		MD	TC				
5			MD		MD	TC	MD	TC		TC	MD	MD TC		MD TC	
6			TC		MD TC			MD	TC	MD					
7	TC	TC	MD				MD		MD		TC	MD		MD	
8	MD	TC	MD TC		MD TC	TC		TC	TC	MD	TC		MD TC	MD	TC
9				TC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

NORTH ANNA UNIT 2 - CYCLE 4

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 North Anna Unit 2, Cycle 4 core is graphically depicted in Figure 2.1. The North Anna 2, Cycle 4 core achieved a burnup of 15,934 MWD/MTU. As shown in Figure 2.2, the average load factor for Cycle 4 was 87.6% when referenced to rated thermal power (2775 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 4 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 4 operation is also given. As can be seen from this figure, the accumulated assembly burnups were generally within ±4% of the predicted values. In addition, deviation from quadrant symmetry in the core throughout the cycle was no greater than ±0.29%.

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 North Anna Unit 2, Cycle 4 followed design predictions closely with each batch deviating less than 1.8% from design.

Symmetric burnup in conjunction with agreement between actual and predicted assemblywise burnups and batch burnup sharing indicate that the Cycle 4 core did deplete as designed.

Figure 2.1

NORTH ANNA UNIT 2 - CYCLE 4

CORE BURNUP HISTORY

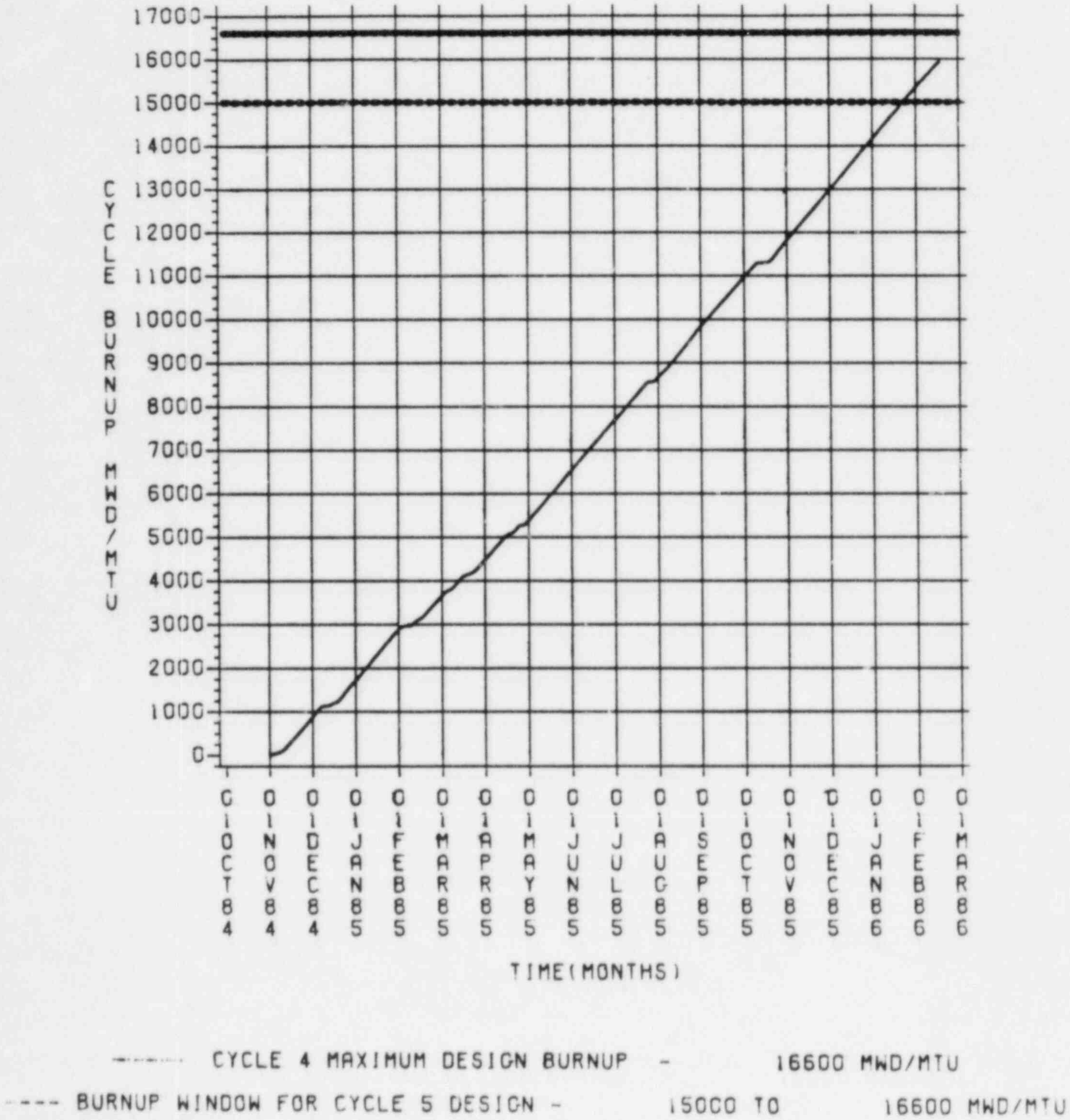
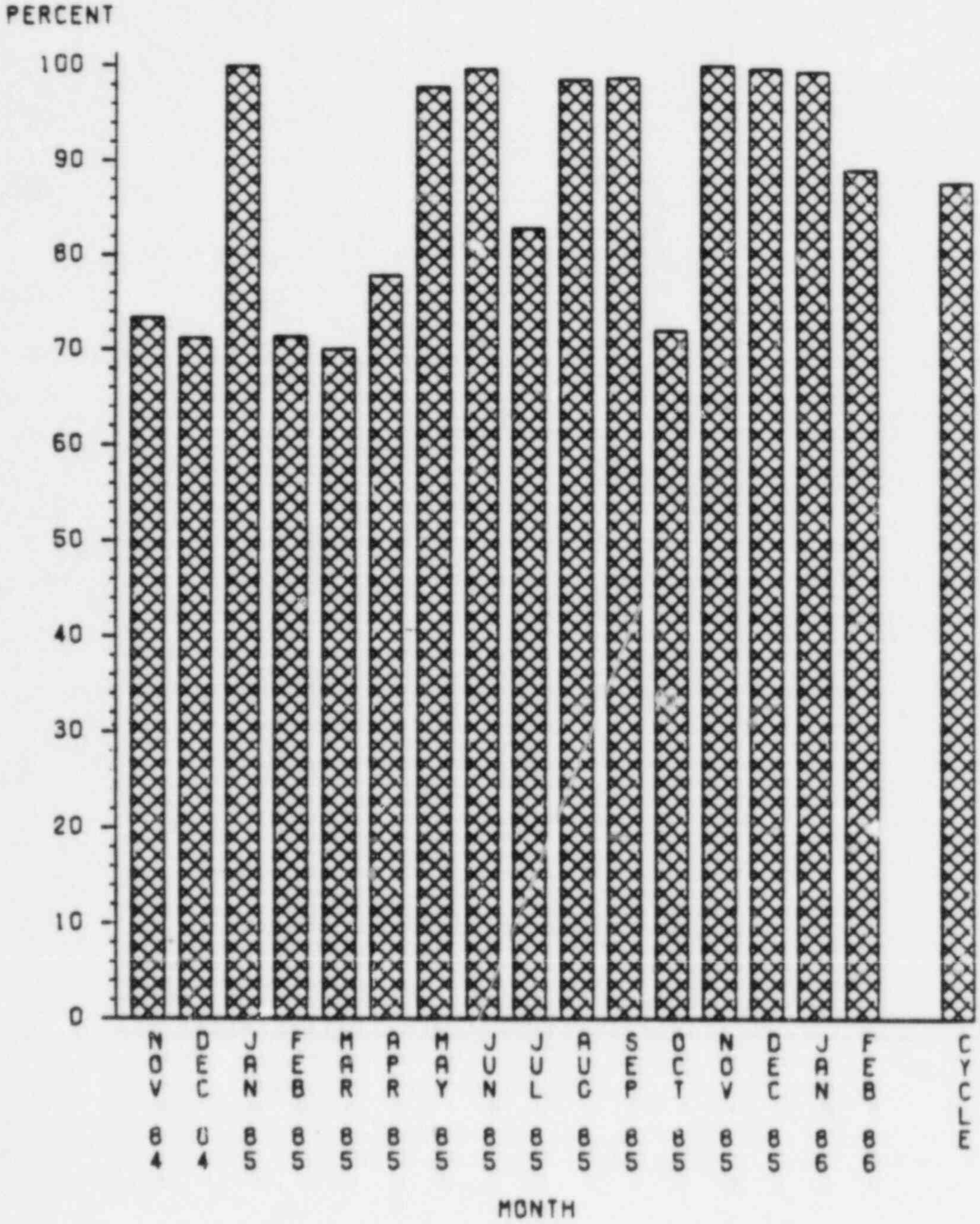


Figure 2.2

NORTH ANNA UNIT 2 - CYCLE 4

MONTHLY AVERAGE LOAD FACTORS



LOAD FACTOR = THERMAL ENERGY GENERATION IN MONTH(MWHT) / AUTHORIZED POWER LEVEL (MWT) X HOURS IN MONTH (EXCLUDES REFUELING OUTAGES)

Figure 2.3

NORTH ANNA UNIT 2 - CYCLE 4

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							24.15 24.26	22.14 21.96	24.97 24.26							1
2					26.39 26.45	29.32 29.58	16.39 16.65	28.86 28.99	16.21 16.65	29.51 29.58	26.16 26.45					2
3				26.97 27.06	16.58 17.20	17.92 18.68	33.13 33.60	18.99 19.69	32.97 33.60	18.39 18.68	16.77 17.20	26.96 27.06				3
4			27.00 26.97	28.08 28.61	19.11 19.55	36.12 36.41	19.83 20.32	37.03 37.14	19.73 20.32	36.30 36.41	19.24 19.55	28.45 28.61	26.59 26.97			4
5		26.25 26.44	17.01 17.11	18.91 19.47	38.64 39.10	19.68 20.22	33.73 33.86	36.54 36.52	33.93 33.86	20.24 20.22	39.16 39.10	19.13 19.47	16.72 17.11	26.75 26.44		5
6		29.36 29.51	18.62 18.66	36.39 36.42	19.87 20.25	40.24 40.55	20.42 20.38	40.69 40.23	20.49 20.38	40.88 40.55	19.99 20.25	36.02 36.42	18.18 18.66	29.30 29.51		6
7	24.32 24.11	16.47 16.65	33.75 33.64	19.97 20.33	33.74 33.82	20.13 20.44	40.66 40.52	20.43 20.22	41.83 40.52	20.70 20.44	33.50 33.82	19.33 20.33	33.08 33.64	16.28 16.65	24.17 24.11	7
8	22.45 22.13	28.95 29.03	19.46 19.69	36.78 37.00	36.64 36.91	40.46 40.23	20.53 20.28	39.88 39.43	20.34 20.28	40.33 40.23	36.80 36.91	36.30 37.00	19.24 19.69	28.92 29.03	22.16 22.13	8
9	24.47 24.11	16.24 16.65	32.63 33.64	19.90 20.33	33.72 33.82	20.10 20.44	39.45 40.52	20.02 20.22	40.25 40.52	20.38 20.44	33.48 33.82	19.72 20.33	33.71 33.64	16.58 16.65	23.96 24.11	9
10		29.42 29.51	17.88 18.66	35.93 36.42	20.41 20.25	40.62 40.55	19.75 20.38	39.77 40.23	20.01 20.38	40.43 40.55	19.97 20.25	36.41 36.42	18.66 18.66	29.89 29.51		10
11		26.45 26.44	16.82 17.11	19.30 19.47	39.23 39.10	19.69 20.22	33.37 33.86	35.86 36.52	33.39 33.86	19.90 20.22	39.09 39.10	19.41 19.47	17.00 17.11	26.56 26.44		11
12			27.32 26.97	28.57 28.61	19.54 19.55	36.10 36.41	19.56 20.32	36.11 37.14	19.54 20.32	35.96 36.41	19.17 19.55	29.18 28.61	27.03 26.97			12
13				27.07 27.06	17.12 17.20	18.21 18.68	32.84 33.60	18.91 19.69	33.24 33.60	18.03 18.68	16.64 17.20	27.09 27.06				13
14					26.80 26.45	29.87 29.58	16.39 16.65	28.63 28.99	16.05 16.65	29.28 29.58	26.15 26.45					14
15							24.32 24.26	22.16 21.96	24.09 24.26							15
	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	

Figure 2.4

NORTH ANNA UNIT 2 - CYCLE 4

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							24.15 -0.45	22.14 0.80	24.97 2.92							1
2					26.39 -0.25	29.32 -0.87	16.39 -1.58	28.86 -0.44	16.21 -2.66	29.51 -0.24	26.16 -1.10					2
3				26.97 -0.31	16.58 -3.58	17.92 -4.09	33.13 -1.38	18.99 -3.54	32.97 -1.88	18.39 -1.54	16.77 -2.48	26.96 -0.34				3
4			27.00 0.09	28.08 -1.86	19.11 -2.23	36.12 -0.80	19.83 -2.40	37.03 -0.29	19.73 -2.89	36.30 -0.31	19.24 -1.58	28.45 -0.58	26.59 -1.44			4
5		26.25 -0.74	17.01 -0.59	18.91 -2.84	38.64 -1.16	19.68 -2.65	33.73 -0.39	36.54 0.06	33.93 0.21	20.24 0.14	39.16 0.15	19.13 -1.75	16.72 -2.30	26.75 1.16		5
6		29.36 -0.50	18.62 -0.20	36.39 -0.10	19.87 -1.87	40.24 -0.78	20.42 0.22	40.69 1.14	20.49 0.57	40.88 0.81	19.99 -1.30	36.02 -1.10	18.18 -2.55	29.30 -0.73		6
7	24.32 0.85	16.47 -1.09	33.75 0.32	19.97 -1.79	33.74 -0.23	20.13 -1.49	40.66 0.33	20.43 1.06	41.83 3.23	20.70 1.27	33.50 -0.95	19.33 -4.93	33.08 -1.69	16.28 -2.21	24.17 0.23	7
8	22.45 1.41	28.95 -0.26	19.46 -1.17	36.78 -0.58	36.64 -0.72	40.46 0.57	20.53 1.24	39.88 1.13	20.34 0.29	40.33 0.25	36.80 -0.30	36.30 -1.89	19.24 -2.28	28.92 -0.35	22.16 0.10	8
9	24.47 1.47	16.24 -2.45	32.63 -3.01	19.90 -2.11	33.72 -0.29	20.10 -1.64	39.45 -2.65	20.02 -0.98	40.25 -0.68	20.38 -0.27	33.48 -1.02	19.72 -3.00	33.71 0.20	16.58 -0.43	23.96 -0.65	9
10		29.42 -0.32	17.88 -4.18	35.93 -1.36	20.41 0.76	40.62 0.18	19.75 -3.10	39.77 -1.14	20.01 -1.82	40.43 -0.29	19.97 -1.42	36.41 -0.03	18.66 0.01	29.89 1.29		10
11		26.45 0.04	16.82 -1.70	19.30 -0.87	39.23 0.34	19.69 -2.62	33.37 -1.45	35.86 -1.81	33.39 -1.40	19.90 -1.55	39.09 -0.02	19.41 -0.29	17.00 -0.68	26.56 0.44		11
12			27.32 1.27	28.57 -0.16	19.54 -0.03	36.10 -0.86	19.56 -3.77	36.11 -2.77	19.54 -3.83	35.96 -1.24	19.17 -1.94	29.18 1.99	27.03 0.20			12
13				27.07 0.06	17.12 -0.46	18.21 -2.52	32.84 -2.26	18.91 -3.94	33.24 -1.07	18.03 -3.50	16.64 -3.27	27.09 0.12				13
14					26.80 1.31	29.87 0.97	16.39 -1.58	28.63 -1.25	16.05 -3.57	29.28 -1.00	26.15 -1.12					14
15							24.32 0.25	22.16 0.90	24.09 -0.69							15
	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	

MEASURED
M/P % DIFF

STANDARD DEV = 1.08

ARITHMETIC AVG PCT DIFF = -0.88

AVG ABS PCT DIFF = 1.29

BURNUP SHARING (MWD/MTU)

BATCH	CYCLE 1	CYCLE 2	CYCLE 3	CYCLE 4	TOTAL
3A3	13997	9255	0	16623	39875
4A2	0	7447	11795	14555	33797
5A	0	0	17121	13538	30659
6A	0	0	0	18784	18784
CORE AVERAGE				15934	

BURNUP TILT

NW = +0.02

NE = +0.22

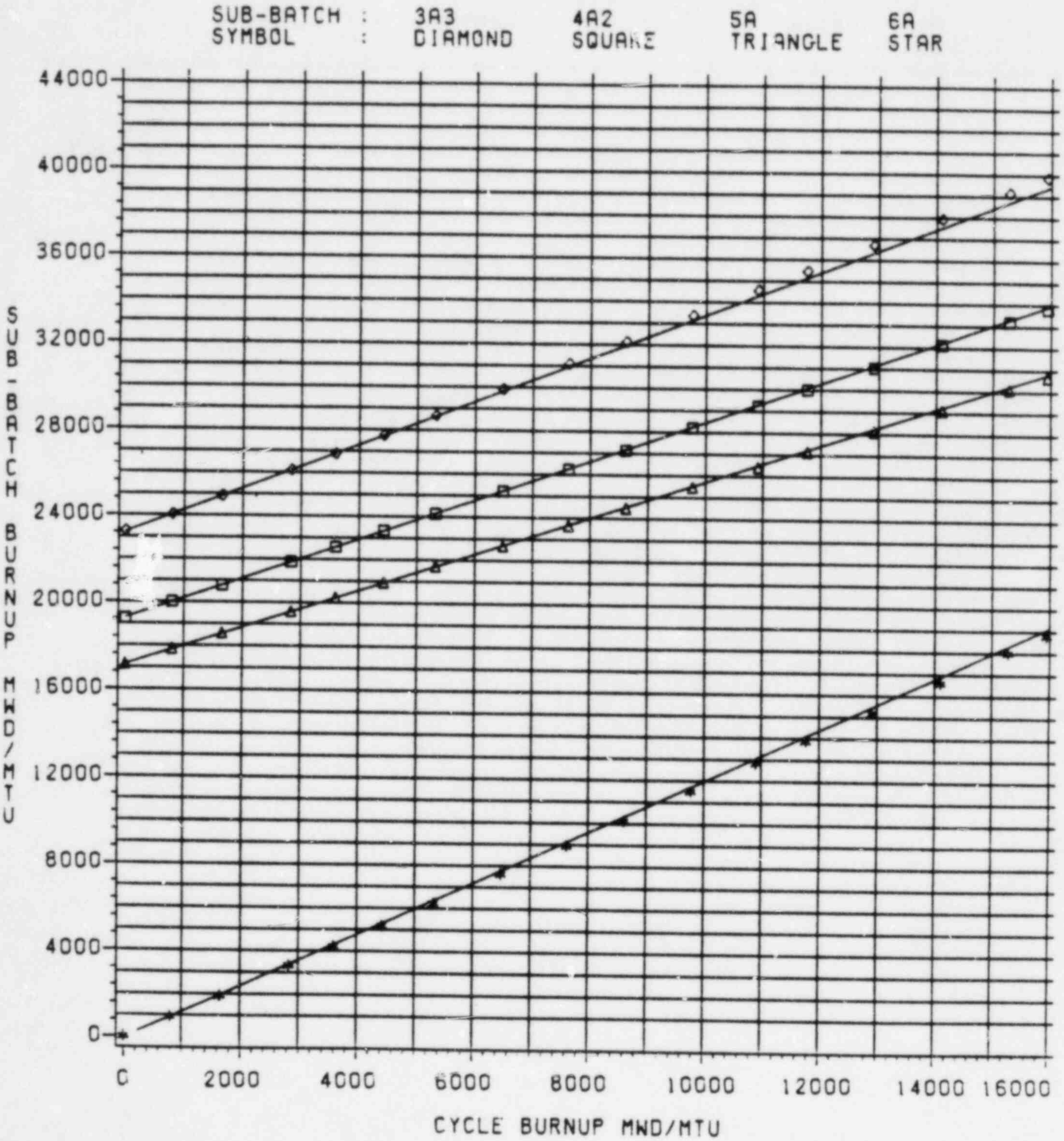
SW = -0.15

SE = -0.09

Figure 2.5

NORTH ANNA UNIT 2 - CYCLE 4

SUB-BATCH BURNUP SHARING



Section 3

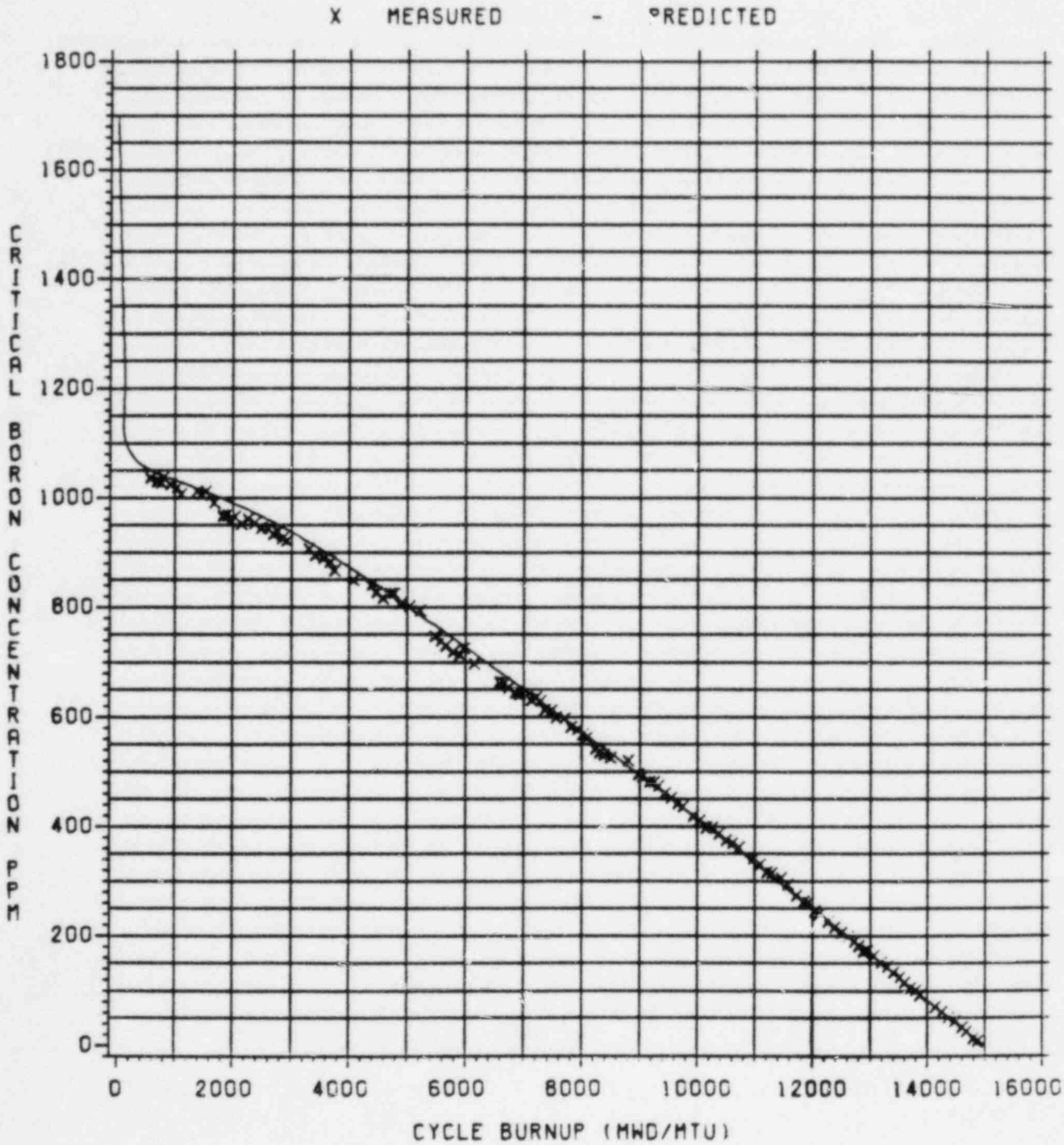
REACTIVITY DEPLETION FOLLOW

The primary coolant critical boron concentration is monitored for the purposes of following core reactivity and to identify any anomalous reactivity behavior. The FOLLOW[*] 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 North Anna 2, Cycle 4 core is shown in Figure 3.1. It can be seen that the measured data typically compare to within 30 ppm of the design prediction. This corresponds to less than ±0.22% ΔK/K which is well within the ±1% ΔK/K criterion for reactivity anomalies set forth in Section 4.1.1.1.2 of the Technical Specifications. In conclusion, the trend indicated by the critical boron concentration verifies that the Cycle 4 core depleted as expected without any reactivity anomalies.

Figure 3.1

NORTH ANNA UNIT 2 - CYCLE 4

CRITICAL BORON CONCENTRATION vs. BURNUP (HFP,ARO)



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 North Anna 2, Cycle 4 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 at the end of Cycle 4 life. The measured relative assembly powers were generally within 4.5% and the average percent difference was equal to 1.9%. 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 Cycle 4 Technical Specifications limit on the axially dependent heat flux hot channel factor, $F_Q(Z)$, was 2.20 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 2.20 $F_Q(Z)$ 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 4, 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 4 is given in Figure 4.8. Figure 4.9 shows the maximum values for the Heat Flux Hot Channel Factor measured during Cycle 4. As can be seen from the figure, there was an 18.6% margin to the limit at the beginning of the cycle, with the margin generally increasing 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. For the majority of Cycle 4, the enthalpy rise hot channel factor limit was 1.55 x (1+0.3(1-P)) x (1-RBP(BU)), where P is the fractional power level and RBP(BU) is the burnup dependent rod bow penalty. On October 24, 1985, the Nuclear Regulatory Commission issued Amendment No. 55 to the Operating License for North Anna Power Station and eliminated the rod bow penalty. Therefore, at the end of Cycle 4, the F-delta-H limit was 1.55 x (1+0.3(1-P)). A summary of the maximum values for the Enthalpy Rise Hot Channel Factor measured during Cycle 4 is given in Figure 4.10. As can be seen from this figure, the smallest margin to the limit was in the middle of the cycle and was equal to approximately 6.6%.

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 -2.5% at the beginning of Cycle 4. After approximately one-third of the cycle, delta flux values had shifted to -4.0% and then moved to -3.5% near the end of Cycle 4. At the very end of Cycle 4, the delta flux values rose dramatically to approximately +2.5% due to the coastdown. This 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 N2-4-07 (Figure 4.12), taken at 230 MWD/MTU, the axial power distribution had a shape peaked slightly toward the bottom of the core with a peaking factor of 1.20. In Map N2-4-23 (Figure 4.13), taken at approximately 7,900 MWD/MTU, the axial power distribution had become more peaked toward the bottom of the core with an axial peaking factor of 1.16. Finally, in Map N2-4-38 (Figure 4.14), taken at approximately 15,250 MWD/MTU, the axial peaking factor was 1.11, with a slightly concave axial power distribution. The history of F-Z during the cycle can be seen more clearly in a plot of F-Z versus burnup given in

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*Delta Flux = $\frac{Pt-Pb}{2775} \times 100$ where Pt = power in top of core (MW(t))
Pb = power in bottom of core (MW(t))

Figure 4.15.

In conclusion, the North Anna 2, Cycle 4 core performed satisfactorily with 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

NORTH ANNA UNIT 2 - CYCLE 4

SUMMARY OF INCORE 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) MAX 3	QPTR 4		AXIAL OFF SET (%)	NO. OF THIMBLES
					ASSY	PIN	AXIAL POINT	F-Q(T)	ASSY	PIN	F-DH(N)	AXIAL POINT	F(Z)		MAX	LOC		
7	11-16-84	230	100	216	P07	OG	37	1.789	P07	OG	1.420	37	1.203	1.493	1.015	NW	-2.47	46
8	12- 7-84	1060	100	228	L13	KO	37	1.723	L13	KO	1.375	38	1.197	1.475	1.010	NW	-2.44	49
9(5)	12- 8-84	1084	100	221	L13	KO	37	1.736	L13	KO	1.374	38	1.210	1.473	1.014	NW	-4.30	50
13(6)	12-19-84	1170	100	206	L13	KO	37	1.740	L13	KO	1.388	38	1.201	1.475	1.009	NW	-3.53	50
16(7)	1- 8-85	1967	100	217	L13	KO	37	1.733	L13	KO	1.386	38	1.201	1.490	1.007	SW	-3.53	48

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

(1). F-Q(T) INCLUDES A TOTAL UNCERTAINTY OF 1.05 X 1.03.

(2). F-DH(N) INCLUDES A MEASUREMENT UNCERTAINTY OF 1.04.

(3). F(XY) INCLUDES A TOTAL UNCERTAINTY OF 1.05 X 1.03.

(4). QPTR - QUADRANT POWER TILT RATIO.

(5). MAPS 10 AND 12 WERE TAKEN FOR INCORE/EXCORE CALIBRATION.

(6). MAP 11 WAS ABORTED DURING AQUISITION AND NOT ANALYZED.

(7). MAPS 14 AND 15 WERE TAKEN FOR INCORE/EXCORE CALIBRATION.

TABLE 4.1 (CONT.)

MAP NO.	DATE	BURN UP MWD/ MTU	PWR (%)	BANK D STEPS	F-Q (T) HOT CHANNEL FACTOR				F-DH(N) HOT CHNL. FACTOR			CORE F(Z) MAX		F(XY) MAX [3]	QPTR [4]		AXIAL OFF SET (%)	NO. OF THIMBLES
					ASSY	PIN	AXIAL POINT	F-Q(T)	ASSY	PIN	F-DH(N)	AXIAL POINT	F(Z)		MAX	LOC		
17	2-19-85	3218	100	220	F07	JI	38	1.710	G06	IP	1.389	38	1.182	1.483	1.008	NW	-3.15	46
18	3-27-85	4257	100	224	F07	JI	38	1.703	F07	JI	1.398	38	1.170	1.497	1.005	NW	-3.02	48
21(8)	5- 3-85	5414	100	221	L10	JI	39	1.711	J08	HI	1.413	46	1.163	1.505	1.007	SW	-3.79	48
22	6- 4-85	6610	100	220	L10	IJ	46	1.698	F07	JI	1.418	46	1.158	1.508	1.004	NE	-3.81	46
23	7- 8-85	7906	100	222	F05	HI	46	1.710	F07	JI	1.422	47	1.158	1.505	1.008	NE	-4.10	47
26(9)	8- 9-85	8714	100	226	G06	IJ	47	1.677	F07	JI	1.430	47	1.139	1.532	1.007	NE	-3.05	39
27	9- 9-85	10083	100	228	F05	HI	47	1.689	F07	LK	1.422	48	1.146	1.506	1.006	NE	-3.66	45
28	10-10-85	11267	100	228	F05	HI	47	1.697	F07	LK	1.428	48	1.142	1.507	1.004	SE	-3.21	49
29	10-24-85	11461	100	227	F11	HI	48	1.747	F11	HI	1.429	48	1.156	1.517	1.004	SE	-4.42	42
32(10)	11-12-85	12204	100	228	D09	HI	52	1.682	F07	LK	1.418	53	1.143	1.509	1.009	NE	-3.45	46
33	12-16-85	13510	100	228	G06	KL	53	1.683	F05	HI	1.407	53	1.150	1.489	1.010	NE	-3.48	43
34	1-14-86	14612	100	228	E10	IJ	53	1.674	F09	MF	1.399	53	1.158	1.487	1.006	NE	-3.55	45
37(11)	1-18-86	14736	100	217	F05	IJ	53	1.761	F05	IJ	1.395	53	1.218	1.470	1.019	NE	-6.94	40
38	1-31-86	15257	95	228	F05	HI	13	1.624	F11	HI	1.403	12	1.106	1.485	1.010	NE	-0.57	39
39	2-10-86	15600	88	228	F11	HI	11	1.699	F11	HI	1.405	12	1.149	1.496	1.009	NE	2.59	39

(8). MAPS 19 AND 20 WERE TAKEN FOR INCORE/EXCORE CALIBRATION.

(9). MAPS 24 AND 25 WERE TAKEN FOR INCORE/EXCORE CALIBRATION.

(10). MAPS 30 AND 31 WERE TAKEN FOR INCORE/EXCORE CALIBRATION.

(11). MAPS 35 AND 36 WERE TAKEN FOR INCORE/EXCORE CALIBRATION.

Figure 4.1

NORTH ANNA UNIT 2 - CYCLE 4
ASSEMBLYWISE POWER DISTRIBUTION N2-4-07

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

 ...............                                .........................                       ................
 .  PREDICTED  .                                .  0.42 .  0.54 .  0.42 .                       .   PREDICTED  .
 .  MEASURED   .                                .  0.45 .  0.57 .  0.44 .                       .   MEASURED   .          1
 .PCT DIFFERENCE.                               .   5.4 .   5.3 .   3.9 .                       .PCT DIFFERENCE.
 ...............                .........................................................       ................
                                .  0.47 .  0.71 .  1.09 .  1.01 .  1.09 .  0.71 .  0.47 .
                                .  0.48 .  0.74 .  1.12 .  1.03 .  1.11 .  0.73 .  0.47 .                                 2
                                .   2.1 .   3.4 .   2.8 .   1.9 .   1.6 .   2.2 .   0.2 .
                        .........................................................................
                        .  0.55 .  1.10 .  1.15 .  1.14 .  1.20 .  1.14 .  1.15 .  1.10 .  0.55 .
                        .  0.55 .  1.10 .  1.16 .  1.15 .  1.20 .  1.14 .  1.16 .  1.10 .  0.54 .                         3
                        .   0.1 .  -0.1 .   0.6 .   0.4 .  -0.0 .  -0.3 .   0.9 .  -0.1 .  -1.9 .
                .........................................................................................
                .  0.54 .  0.93 .  1.19 .  1.21 .  1.21 .  1.22 .  1.21 .  1.21 .  1.19 .  0.93 .  0.54 .
                .  0.55 .  0.94 .  1.20 .  1.23 .  1.21 .  1.23 .  1.19 .  1.22 .  1.18 .  0.92 .  0.53 .                 4
                .   1.6 .   0.9 .   0.7 .   1.1 .   0.4 .   0.3 .  -1.7 .   0.5 .  -0.9 .  -1.2 .  -1.6 .
        .........................................................................................................
        .  0.47 .  1.09 .  1.18 .  1.06 .  1.16 .  1.18 .  1.19 .  1.18 .  1.16 .  1.06 .  1.18 .  1.09 .  0.47 .
        .  0.47 .  1.11 .  1.18 .  1.05 .  1.16 .  1.19 .  1.20 .  1.19 .  1.17 .  1.05 .  1.17 .  1.08 .  0.47 .         5
        .   1.2 .   1.1 .  -0.3 .  -0.7 .  -0.4 .   0.7 .   0.8 .   0.5 .   0.8 .  -0.2 .  -0.9 .  -1.4 .   0.6 .
        .........................................................................................................
        .  0.71 .  1.15 .  1.21 .  1.17 .  1.03 .  1.20 .  1.05 .  1.20 .  1.03 .  1.17 .  1.21 .  1.15 .  0.71 .
        .  0.73 .  1.18 .  1.23 .  1.16 .  1.03 .  1.21 .  1.06 .  1.21 .  1.04 .  1.16 .  1.19 .  1.13 .  0.71 .         6
        .   2.8 .   2.7 .   1.2 .  -0.4 .   0.3 .   0.9 .   0.9 .   0.9 .   1.1 .  -0.9 .  -1.8 .  -1.5 .   0.4 .
.........................................................................................................................
.  0.42 .  1.09 .  1.14 .  1.21 .  1.18 .  1.20 .  1.02 .  1.18 .  1.02 .  1.20 .  1.18 .  1.21 .  1.14 .  1.09 .  0.42 .
.  0.44 .  1.14 .  1.19 .  1.22 .  1.17 .  1.20 .  1.04 .  1.19 .  1.03 .  1.21 .  1.17 .  1.17 .  1.12 .  1.08 .  0.42 . 7
.   4.6 .   4.5 .   4.4 .   0.8 .  -1.1 .  -0.3 .   1.1 .   1.0 .   0.7 .   0.6 .  -0.9 .  -3.6 .  -2.3 .  -1.4 .   0.4 .
.........................................................................................................................
.  0.54 .  1.01 .  1.20 .  1.22 .  1.19 .  1.06 .  1.18 .  0.97 .  1.18 .  1.06 .  1.19 .  1.22 .  1.20 .  1.01 .  0.54 .
.  0.56 .  1.06 .  1.25 .  1.25 .  1.21 .  1.07 .  1.20 .  0.98 .  1.17 .  1.05 .  1.16 .  1.18 .  1.17 .  1.02 .  0.56 . 8
.   4.5 .   4.6 .   4.6 .   2.5 .   1.5 .   1.6 .   1.2 .   0.7 .  -0.9 .  -1.0 .  -2.8 .  -3.6 .  -2.4 .   0.7 .   3.8 .
.........................................................................................................................
.  0.42 .  1.09 .  1.14 .  1.21 .  1.18 .  1.20 .  1.02 .  1.18 .  1.02 .  1.20 .  1.18 .  1.21 .  1.14 .  1.09 .  0.42 .
.  0.44 .  1.11 .  1.12 .  1.22 .  1.20 .  1.20 .  0.99 .  1.16 .  1.01 .  1.18 .  1.16 .  1.19 .  1.13 .  1.11 .  0.44 . 9
.   4.6 .   1.4 .  -1.8 .   0.5 .   1.6 .  -0.1 .  -3.5 .  -1.6 .  -1.5 .  -1.7 .  -1.7 .  -1.8 .  -0.9 .   1.2 .   3.6 .
.........................................................................................................................
        .  0.71 .  1.15 .  1.21 .  1.17 .  1.03 .  1.20 .  1.05 .  1.20 .  1.03 .  1.17 .  1.21 .  1.15 .  0.71 .
        .  0.70 .  1.13 .  1.22 .  1.19 .  1.03 .  1.17 .  1.04 .  1.17 .  1.01 .  1.15 .  1.22 .  1.15 .  0.73 .         10
        .  -1.0 .  -1.8 .   0.7 .   2.1 .   0.1 .  -2.2 .  -1.3 .  -2.2 .  -1.7 .  -1.6 .   0.9 .   0.5 .   3.2 .
        .........................................................................................................
        .  0.47 .  1.09 .  1.18 .  1.06 .  1.16 .  1.18 .  1.19 .  1.18 .  1.16 .  1.06 .  1.18 .  1.09 .  0.47 .
        .  0.47 .  1.10 .  1.20 .  1.08 .  1.15 .  1.15 .  1.16 .  1.15 .  1.15 .  1.05 .  1.19 .  1.10 .  0.47 .         11
        .   0.9 .   0.9 .   1.3 .   2.1 .  -1.5 .  -2.5 .  -2.3 .  -2.2 .  -1.0 .  -0.3 .   0.6 .   0.3 .   0.7 .
        .........................................................................................................
                .  0.54 .  0.93 .  1.19 .  1.21 .  1.21 .  1.22 .  1.21 .  1.21 .  1.19 .  0.93 .  0.54 .
                .  0.56 .  0.96 .  1.21 .  1.20 .  1.18 .  1.19 .  1.17 .  1.19 .  1.17 .  0.94 .  0.54 .                 12
                .   3.6 .   2.9 .   2.1 .  -0.8 .  -2.7 .  -2.6 .  -2.8 .  -1.6 .  -1.1 .   0.7 .   0.1 .
                .........................................................................................
                        .  0.55 .  1.10 .  1.15 .  1.14 .  1.20 .  1.14 .  1.15 .  1.10 .  0.55 .
                        .  0.56 .  1.11 .  1.13 .  1.10 .  1.16 .  1.10 .  1.12 .  1.08 .  0.55 .                         13
                        .   2.0 .   0.3 .  -1.6 .  -3.7 .  -3.7 .  -3.5 .  -3.1 .  -1.6 .   0.1 .
                        .........................................................................
                                .  0.47 .  0.71 .  1.09 .  1.01 .  1.09 .  0.71 .  0.47 .
                                .  0.47 .  0.73 .  1.11 .  1.02 .  1.06 .  0.69 .  0.45 .                                 14
                                .   0.3 .   3.0 .   1.8 .   0.7 .  -3.5 .  -3.0 .  -3.1 .
 ...............                .........................................................       ................
 .  STANDARD   .                                .  0.42 .  0.54 .  0.42 .                       .    AVERAGE   .
 .  DEVIATION  .                                .  0.45 .  0.57 .  0.45 .                       .PCT DIFFERENCE.          15
 .   =1.351    .                                .   5.7 .   5.6 .   5.7 .                       .    = 1.7     .
 ...............                                .........................                       ................
```

SUMMARY

```
MAP NO: N2-4-07              DATE: 11/16/84              POWER:  100%

CONTROL ROD POSITIONS:       F-Q(T)  = 1.789             QPTR:

D BANK AT 216 STEPS          F-DH(N) = 1.420             NW   1.015 | NE  0.996
                                                         -----------|----------
                             F(Z)    = 1.203             SW   1.001 | SE  0.988

                             F(XY)   = 1.493

                             BURNUP  =   230 MWD/MTU    A.O =  -2.47(%)
```

Figure 4.2

NORTH ANNA UNIT 2 - CYCLE 4
ASSEMBLYWISE POWER DISTRIBUTION N2-4-23

PREDICTED
MEASURED
PCT DIFFERENCE

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
						0.41 0.42 1.8	0.52 0.53 1.8	0.41 0.42 1.6							1
				0.47 0.47 0.5	0.68 0.66 -3.9	1.01 1.00 -1.0	0.93 0.92 -1.1	1.01 1.01 -0.2	0.68 0.69 1.3	0.47 0.47 0.1					2
			0.54 0.54 -1.5	1.06 1.04 -1.8	1.16 1.11 -4.6	1.08 1.03 -4.8	1.22 1.17 -4.0	1.08 1.07 -0.8	1.16 1.17 0.9	1.06 1.06 0.2	0.54 0.54 -1.1				3
		0.54 0.54 0.5	0.91 0.91 -0.4	1.22 1.21 -0.5	1.17 1.17 -0.2	1.27 1.26 -1.4	1.16 1.14 -1.6	1.27 1.25 -1.7	1.17 1.19 1.7	1.22 1.22 0.1	0.91 0.91 -0.1	0.54 0.53 -0.9			4
	0.47 0.48 2.3	1.05 1.08 2.6	1.21 1.19 -1.6	1.07 1.05 -1.4	1.28 1.26 -0.9	1.18 1.19 1.5	1.14 1.15 1.6	1.18 1.20 2.0	1.28 1.31 2.4	1.07 1.08 1.3	1.21 1.22 0.3	1.05 1.04 -0.8	0.47 0.47 0.7		5
	0.68 0.70 2.3	1.16 1.18 2.3	1.17 1.18 0.3	1.28 1.27 -0.8	1.07 1.07 0.6	1.28 1.31 1.9	1.05 1.08 2.3	1.28 1.32 3.0	1.07 1.10 3.3	1.28 1.28 0.3	1.17 1.16 -1.0	1.16 1.14 -1.4	0.68 0.69 0.2		6
0.41 0.41 1.2	1.01 1.01 0.2	1.08 1.07 -0.3	1.27 1.25 -1.1	1.18 1.16 -1.9	1.28 1.28 -0.3	1.06 1.08 2.5	1.27 1.31 2.7	1.06 1.09 2.9	1.28 1.32 3.1	1.18 1.19 0.7	1.27 1.23 -3.7	1.08 1.06 -1.8	1.01 1.01 -0.2	0.41 0.41 1.4	7
0.52 0.53 1.2	0.93 0.93 0.1	1.22 1.21 -0.7	1.16 1.16 0.2	1.14 1.15 0.9	1.06 1.07 1.5	1.28 1.31 2.7	1.02 1.05 3.0	1.28 1.30 1.6	1.06 1.07 1.5	1.14 1.12 -1.2	1.16 1.12 -3.7	1.22 1.21 -1.2	0.93 0.93 0.7	0.52 0.53 2.1	8
0.41 0.41 1.2	1.01 0.99 -1.7	1.08 1.04 -3.3	1.27 1.26 -1.1	1.18 1.19 1.0	1.28 1.28 -0.1	1.06 1.03 -2.3	1.27 1.28 0.5	1.06 1.07 1.1	1.28 1.29 0.8	1.18 1.18 0.1	1.27 1.26 -1.3	1.08 1.06 0.5	1.01 1.02 1.3	0.41 0.42 2.0	9
	0.68 0.66 -3.3	1.16 1.12 -3.3	1.17 1.17 0.2	1.28 1.31 2.1	1.07 1.07 0.5	1.28 1.26 -1.3	1.05 1.06 0.3	1.28 1.27 -0.6	1.07 1.07 0.1	1.28 1.27 -0.3	1.17 1.19 2.0	1.16 1.17 1.3	0.68 0.70 2.5		10
	0.47 0.46 -0.3	1.05 1.05 -0.3	1.21 1.22 0.6	1.07 1.09 2.3	1.28 1.27 -0.8	1.18 1.16 -1.6	1.14 1.12 -1.5	1.18 1.16 -1.4	1.28 1.28 -0.0	1.07 1.07 0.5	1.21 1.23 1.3	1.05 1.06 0.9	0.47 0.47 1.3		11
		0.54 0.55 2.7	0.91 0.93 2.5	1.22 1.25 2.3	1.17 1.17 -0.3	1.27 1.24 -2.3	1.16 1.14 -2.2	1.27 1.24 -2.5	1.17 1.16 -1.0	1.22 1.21 -0.5	0.91 0.92 1.4	0.54 0.54 0.6			12
			0.54 0.55 1.7	1.06 1.06 0.0	1.16 1.15 -0.9	1.08 1.04 -3.4	1.22 1.19 -2.5	1.08 1.05 -2.6	1.16 1.14 -2.0	1.06 1.04 -1.5	0.54 0.55 0.5				13
				0.47 0.47 0.0	0.68 0.70 2.2	1.01 1.01 -0.1	0.93 0.92 -0.4	1.01 0.99 -2.4	0.68 0.67 -1.0	0.47 0.45 -3.2					14
						0.41 0.42 3.7	0.52 0.53 1.7	0.41 0.41 -0.5							15

STANDARD
DEVIATION
=1.023

AVERAGE
PCT DIFFERENCE
= 1.4

SUMMARY

MAP NO: N2-4-23

CONTROL ROD POSITIONS:

D BANK AT 222 STEPS

DATE: 7/ 8/85

F-Q(T) = 1.710

F-DH(N) = 1.422

F(Z) = 1.158

F(XY) = 1.505

BURNUP = 7906 MWD/MTU

A.O = -4.10(%)

POWER: 100%

QPTR:

NW 0.995	NE 1.008
SW 0.998	SE 0.999

Figure 4.3

NORTH ANNA UNIT 2 - CYCLE 4

ASSEMBLYWISE POWER DISTRIBUTION N2-4-38

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
		PREDICTED MEASURED PCT DIFFERENCE				0.45 0.46 1.1	0.57 0.58 1.1	0.46 0.46 0.7				PREDICTED MEASURED PCT DIFFERENCE			1
				0.50 0.50 0.8	0.71 0.74 3.4	1.02 1.03 0.5	0.96 0.96 0.4	1.02 1.02 -0.6	0.71 0.71 0.2	0.50 0.50 0.2					2
			0.57 0.56 -0.7	1.05 1.04 -0.8	1.16 1.17 0.6	1.06 1.07 0.2	1.23 1.23 -0.1	1.06 1.05 -1.1	1.16 1.17 0.2	1.05 1.05 0.2	0.57 0.56 -2.6				3
		0.56 0.56 -0.1	0.92 0.92 -0.1	1.21 1.21 0.1	1.14 1.15 1.2	1.27 1.27 0.5	1.13 1.13 0.4	1.27 1.25 -1.6	1.14 1.17 2.8	1.21 1.22 0.2	0.92 0.92 0.0	0.56 0.56 -1.0			4
	0.50 0.49 -1.0	1.05 1.04 -1.0	1.21 1.20 -0.8	1.06 1.05 -0.7	1.28 1.27 -0.2	1.15 1.16 1.2	1.10 1.11 1.1	1.15 1.17 1.7	1.28 1.31 3.0	1.06 1.07 1.2	1.21 1.21 -0.1	1.05 1.04 -1.0	0.50 0.50 0.6		5
	0.71 0.72 0.6	1.16 1.17 0.6	1.14 1.14 0.3	1.28 1.27 -0.2	1.06 1.07 1.0	1.26 1.29 2.1	1.03 1.06 2.2	1.26 1.30 2.8	1.06 1.09 2.9	1.28 1.29 1.2	1.14 1.14 0.0	1.16 1.15 -1.1	0.71 0.71 -0.5		6
0.45 0.46 2.2	1.02 1.02 -0.2	1.06 1.06 -0.1	1.27 1.26 -0.8	1.15 1.13 -1.5	1.26 1.27 0.8	1.04 1.07 2.4	1.26 1.29 2.5	1.04 1.07 2.5	1.26 1.30 2.7	1.15 1.18 2.8	1.27 1.24 -2.1	1.06 1.06 -0.3	1.02 1.02 -0.3	0.46 0.46 0.6	7
0.57 0.55 -2.8	0.96 0.96 -0.3	1.23 1.22 -0.5	1.13 1.13 -0.0	1.10 1.10 0.2	1.04 1.05 1.1	1.26 1.30 2.9	1.01 1.04 3.1	1.26 1.28 1.8	1.04 1.06 1.7	1.10 1.10 0.3	1.13 1.10 -2.1	1.23 1.23 -0.4	0.96 0.96 -0.2	0.57 0.57 0.7	8
0.46 0.44 -2.6	1.02 0.99 -2.7	1.06 1.04 -2.7	1.27 1.25 -1.2	1.15 1.15 0.3	1.26 1.25 -0.9	1.04 1.00 -3.4	1.26 1.26 0.4	1.04 1.06 1.6	1.26 1.28 1.3	1.15 1.15 0.7	1.27 1.27 -0.1	1.06 1.07 0.6	1.02 1.02 0.2	0.45 0.46 2.4	9
	0.71 0.69 -2.6	1.16 1.14 -2.6	1.14 1.13 -0.9	1.28 1.29 1.0	1.06 1.04 -1.3	1.26 1.22 -3.4	1.03 1.04 0.2	1.26 1.28 1.1	1.06 1.07 1.7	1.28 1.29 1.1	1.14 1.17 2.4	1.16 1.18 1.7	0.71 0.72 1.7		10
	0.50 0.49 -0.2	1.05 1.04 [illegible]	1.21 1.21 -0.2	1.06 1.07 1.0	1.28 1.23 -3.6	1.15 1.11 -3.3	1.10 1.06 -3.8	1.15 1.18 3.3	1.28 1.32 [illegible]	1.06 1.08 2.0	1.21 1.23 1.6	1.05 1.06 1.1	0.50 0.50 0.8		11
		0.56 0.58 2.2	0.92 0.94 2.2	1.21 1.20 -0.8	1.14 1.10 -3.5	1.27 1.22 -3.8	1.13 1.09 -3.5	1.27 1.24 -2.1	1.14 1.15 0.8	1.21 1.22 0.7	0.92 0.93 1.5	0.56 0.57 0.7			12
			0.57 0.57 0.7	1.05 1.04 -0.8	1.16 1.14 -2.2	1.06 1.03 -3.5	1.23 1.20 -2.5	1.06 1.05 -1.0	1.16 1.14 -1.8	1.05 1.04 -0.8	0.57 0.57 0.7				13
				0.50 0.49 -0.8	0.71 0.71 -0.8	1.02 1.01 -0.8	0.96 0.95 -1.6	1.02 1.00 -1.8	0.71 0.70 -1.8	0.50 0.49 -2.1					14
		STANDARD DEVIATION =1.031				0.46 0.45 -0.8	0.57 0.56 -1.6	0.46 0.44 -1.6				AVERAGE PCT DIFFERENCE = 1.3			15

SUMMARY

MAP NO: N2-4-38

CONTROL ROD POSITIONS:

D BANK AT 228 STEPS

DATE: 1/31/86

F-Q(T) = 1.624

F-DH(N) = 1.403

F(Z) = 1.106

F(XY) = 1.485

BURNUP = 15257 MWD/MTU

A.O = -0.57(%)

POWER: 95%

QPTR:

NW	0.999	NE	1.010
SW	0.988	SE	1.003

Figure 4.4

HOT CHANNEL FACTOR NORMALIZED
OPERATING ENVELOPE

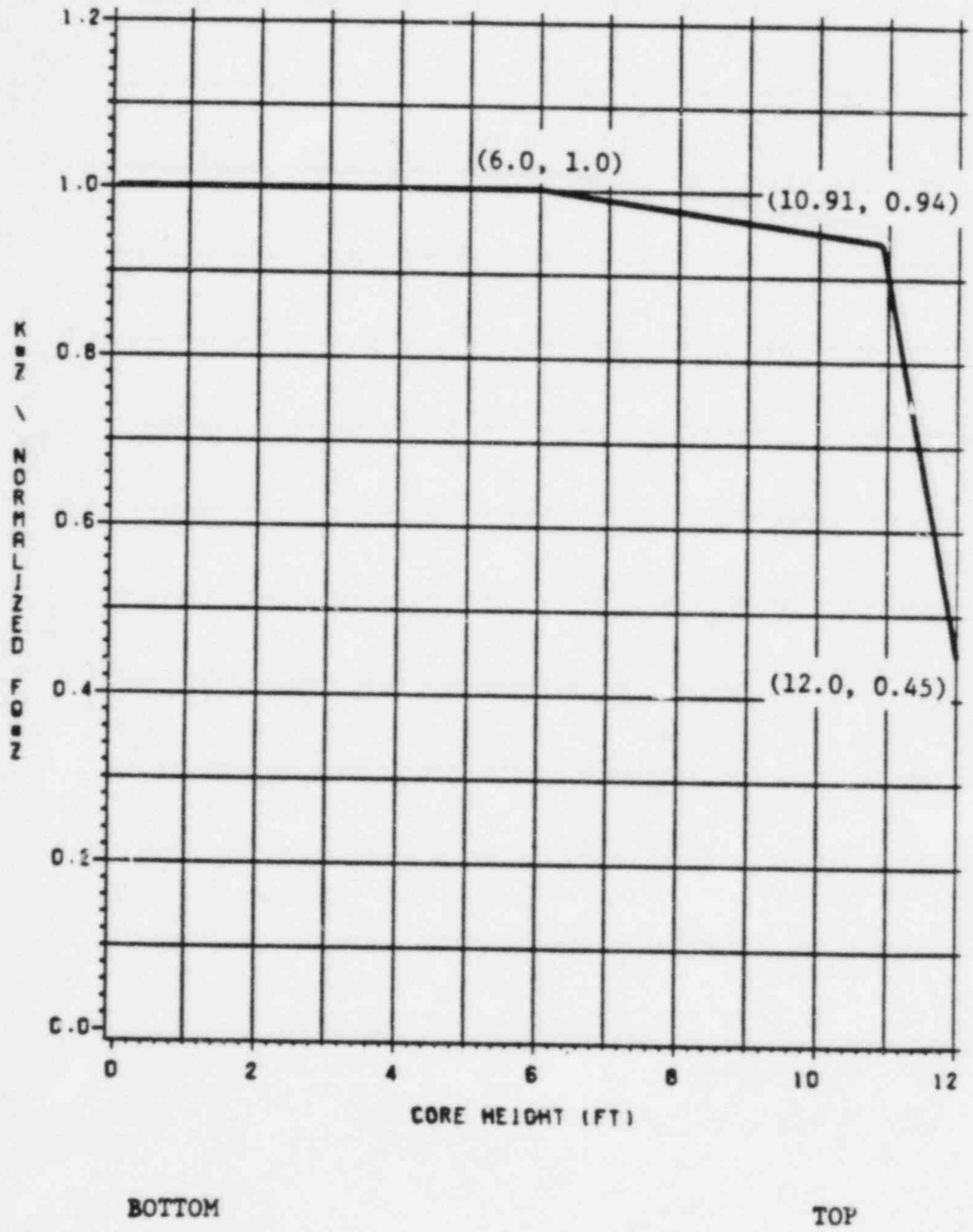


Figure 4.5

NORTH ANNA UNIT 2 - CYCLE 4

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

N2-4-07

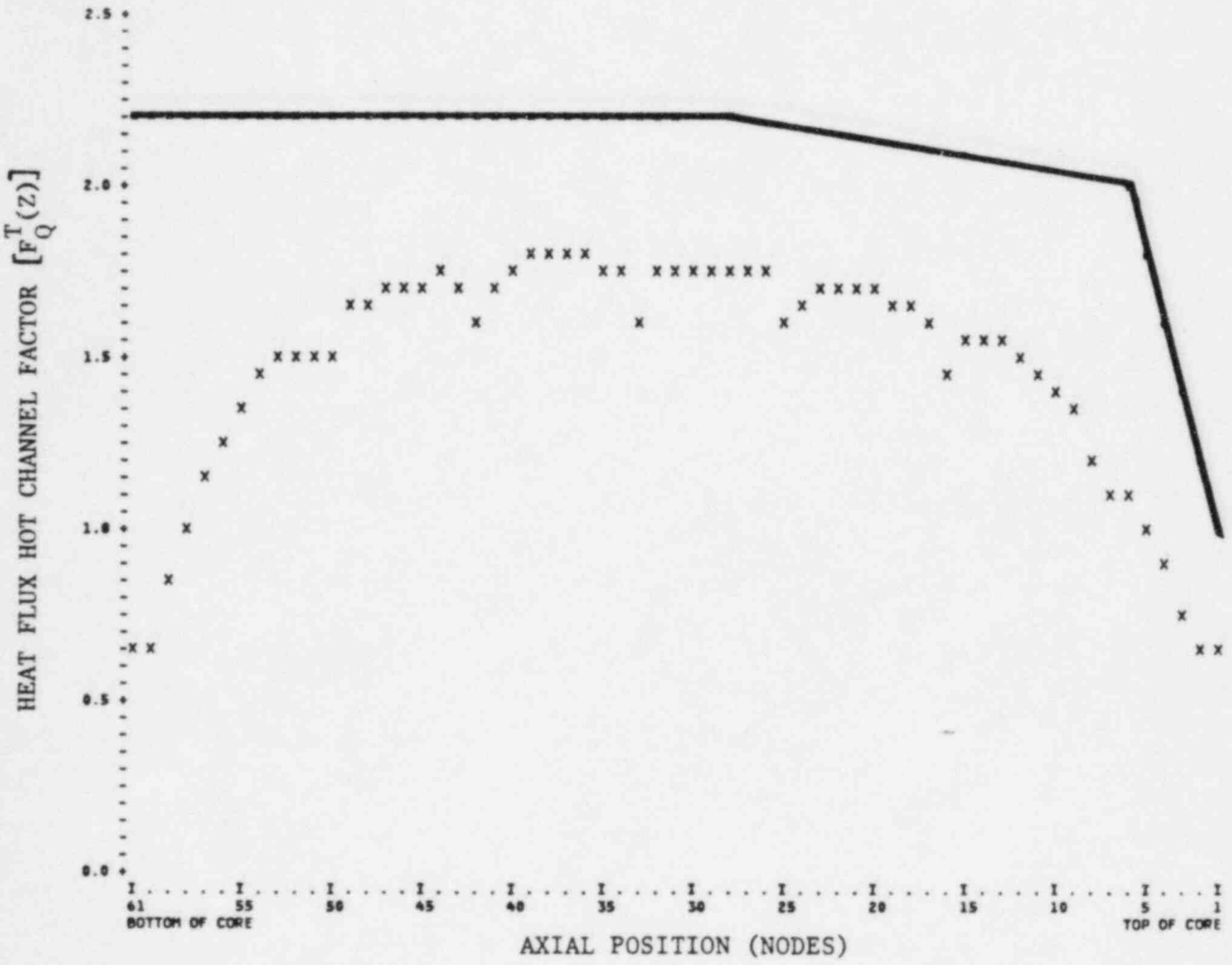


Figure 4.6

NORTH ANNA UNIT 2 - CYCLE 4
HEAT FLUX HOT CHANNEL FACTOR, $F_Q^T(Z)$
N2-4-23

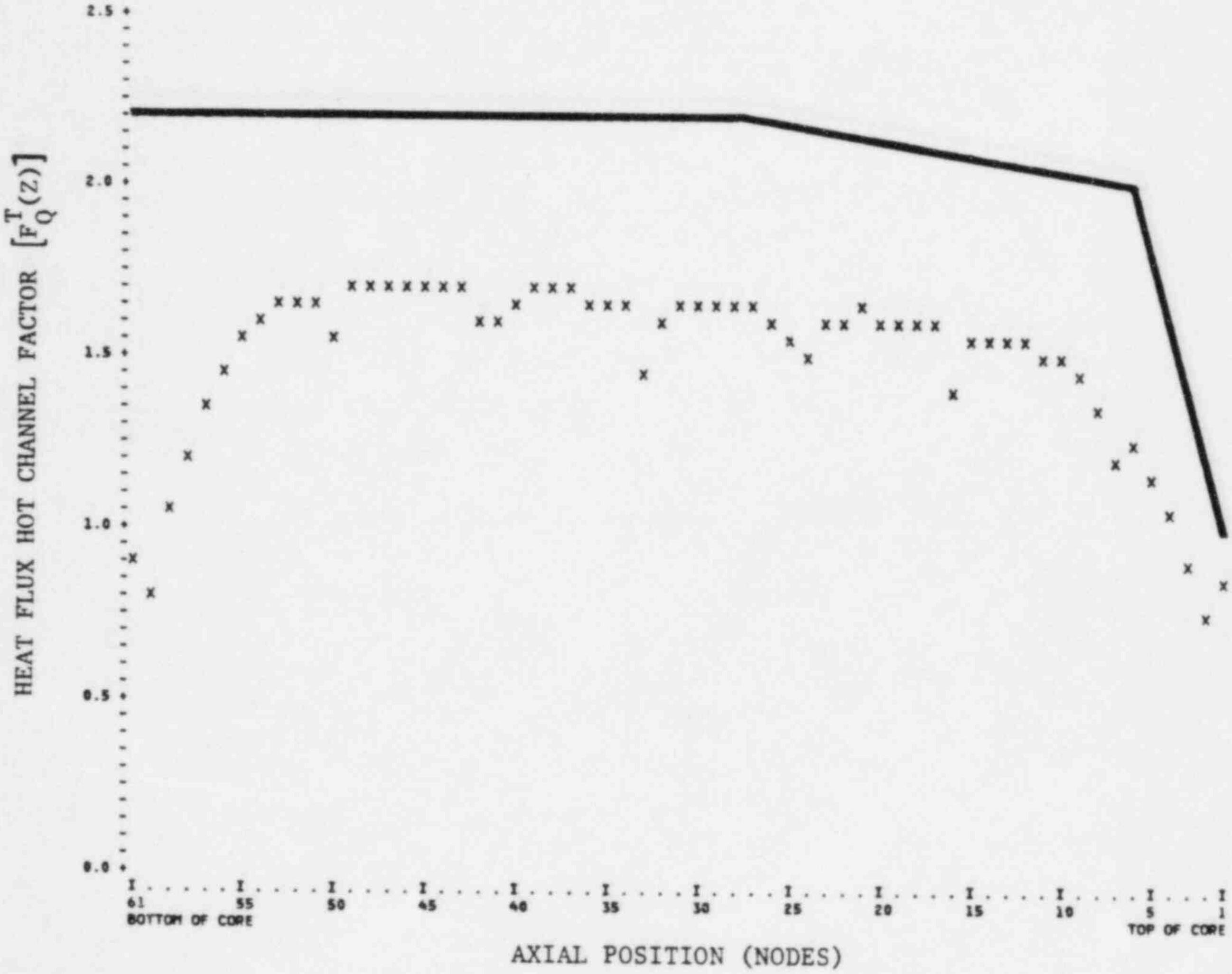


Figure 4.7

NORTH ANNA UNIT 2 - CYCLE 4
HEAT FLUX HOT CHANNEL FACTOR, $F_Q^T(Z)$
N2-4-38

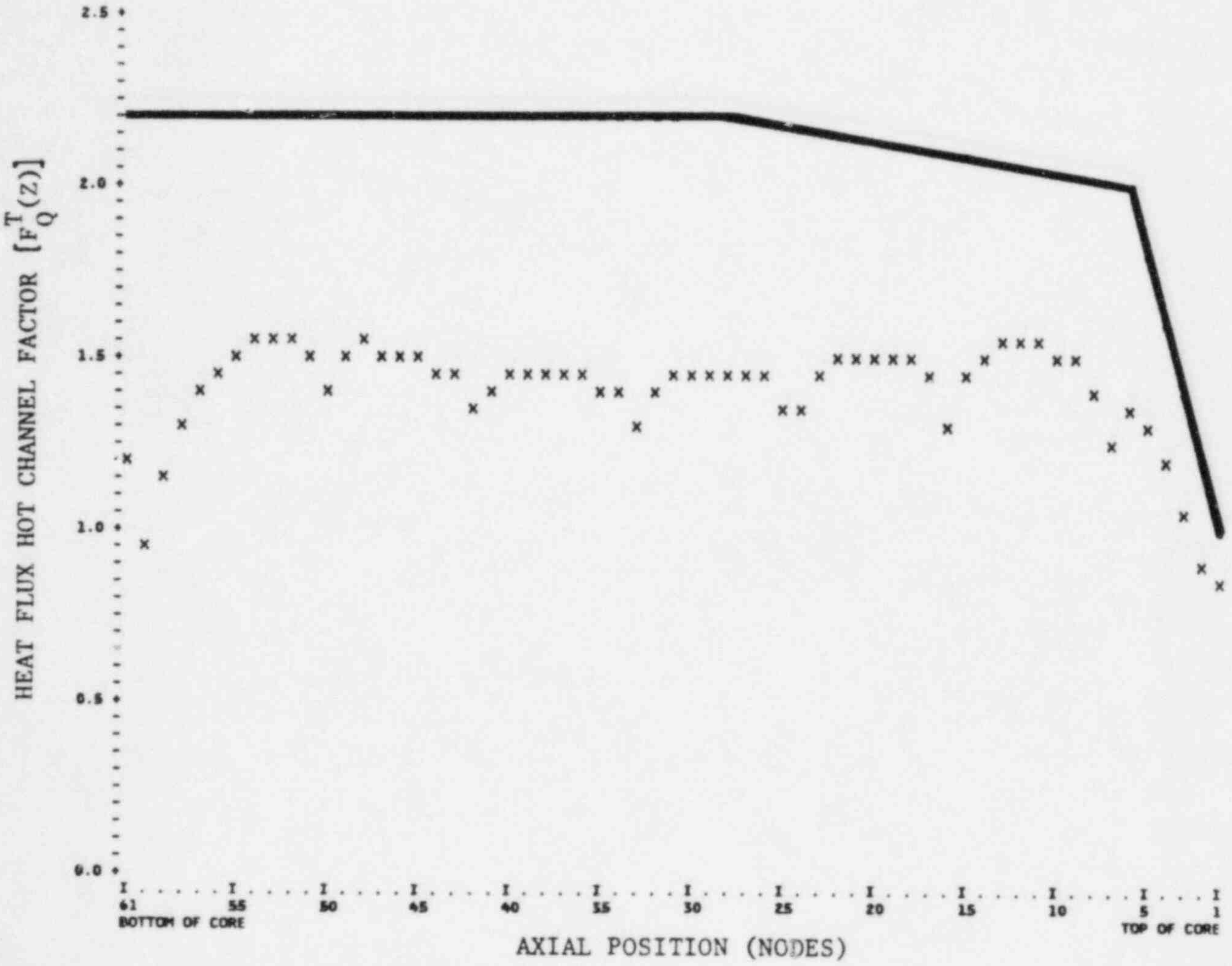


Figure 4.8

NORTH ANNA UNIT 2 - CYCLE 4

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

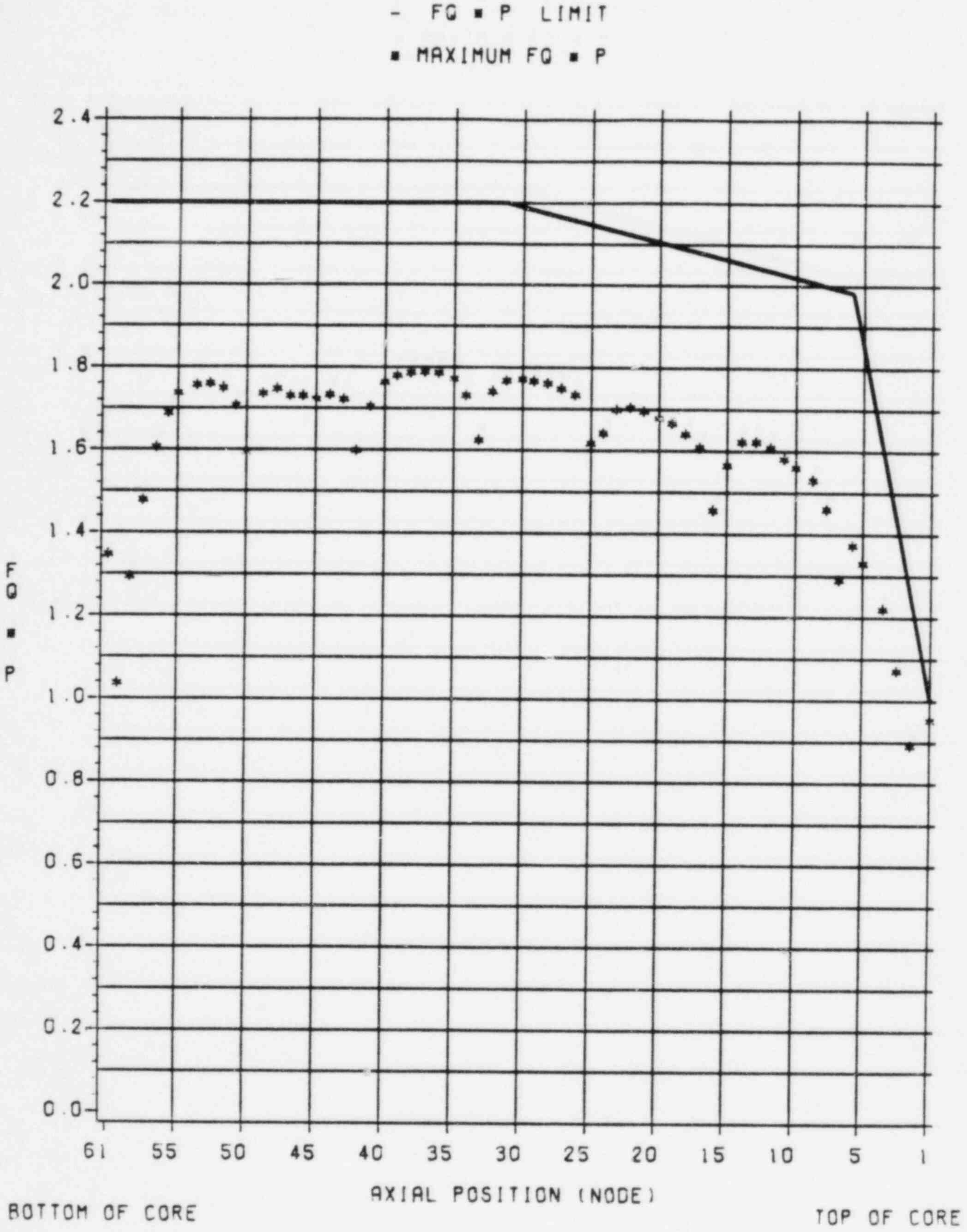


Figure 4.9

NORTH ANNA UNIT 2 - CYCLE 4

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

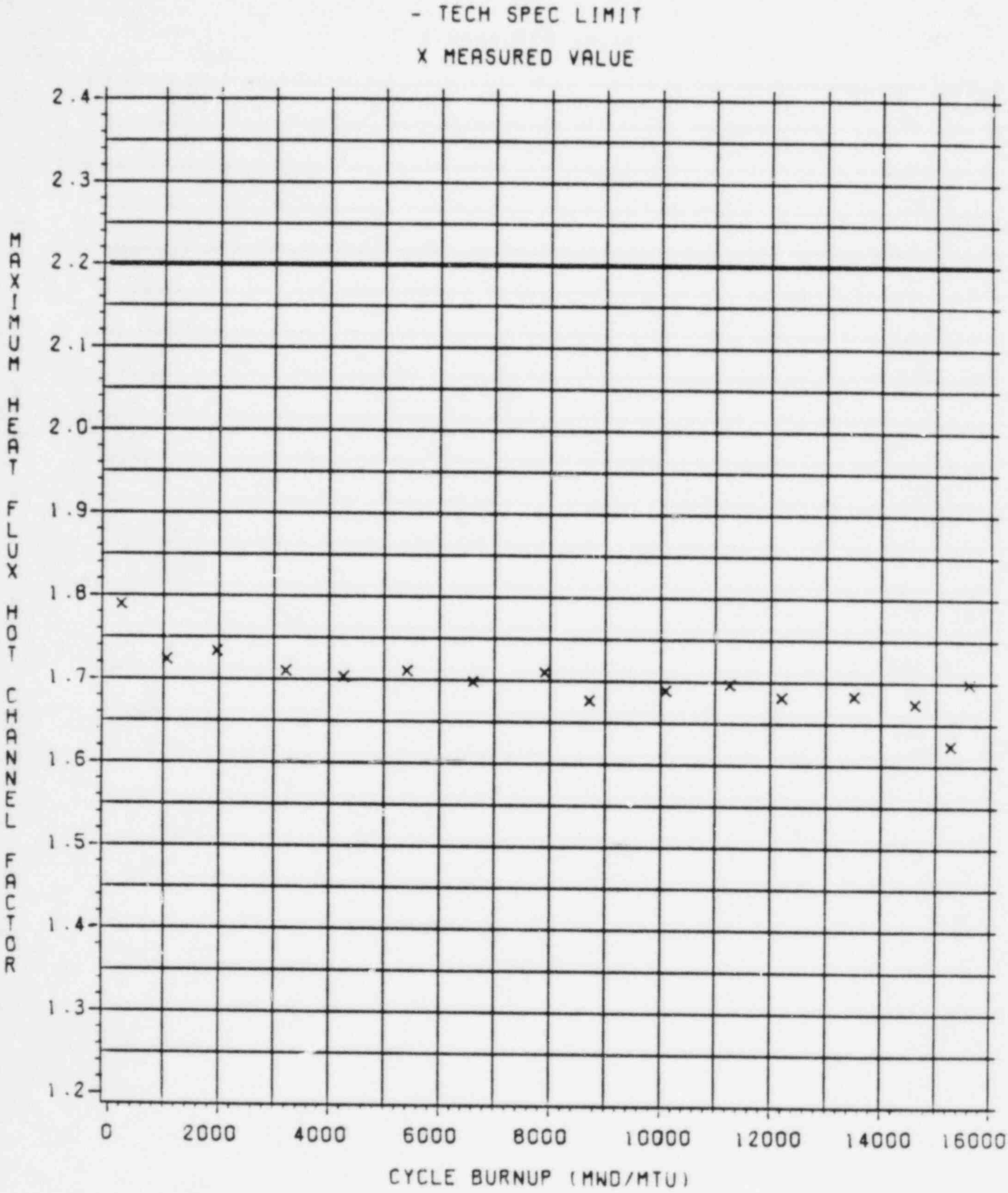


Figure 4.10

NORTH ANNA UNIT 2 - CYCLE 4

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

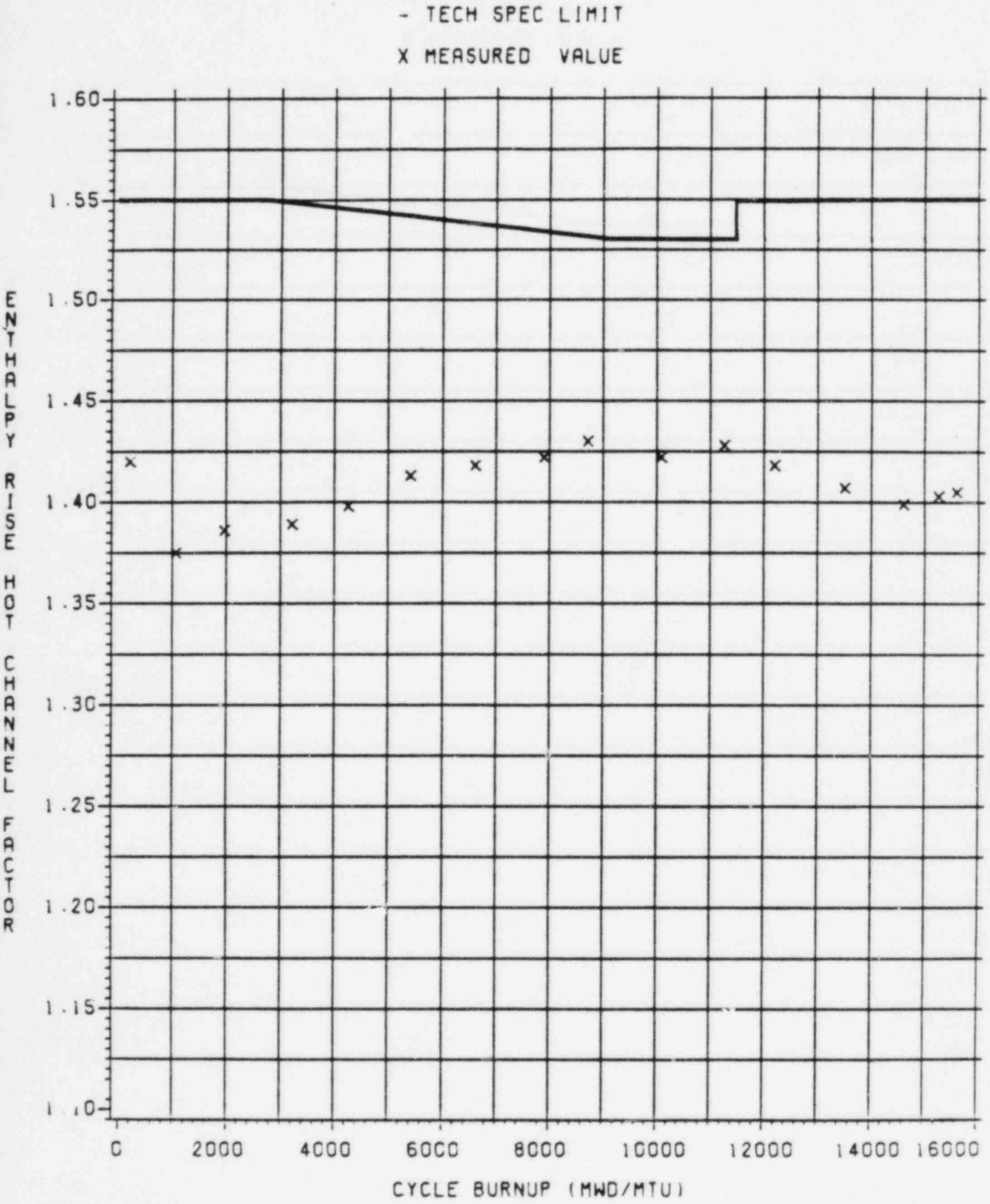


Figure 4.11

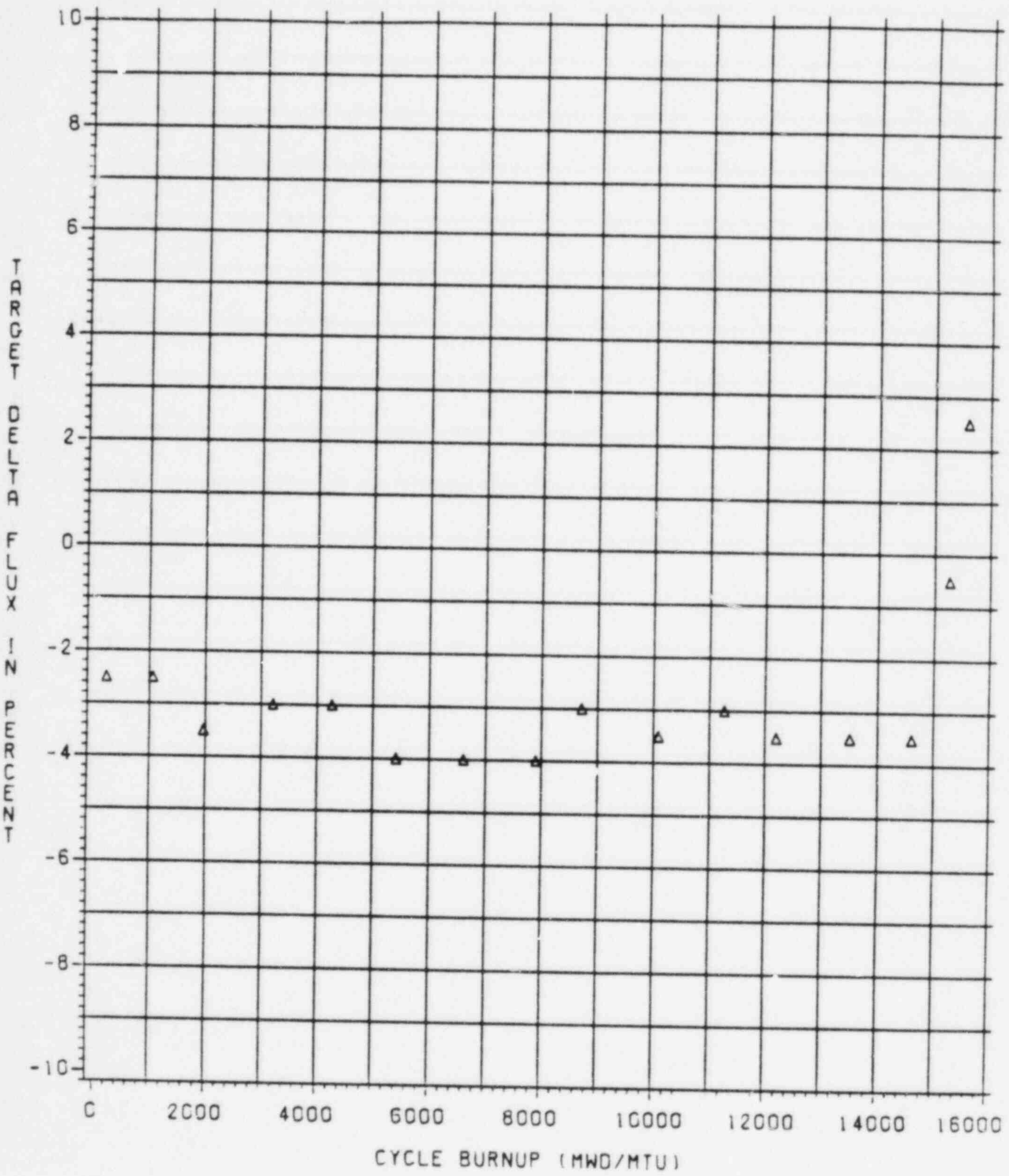

NORTH ANNA UNIT 2 - CYCLE 4
TARGET DELTA FLUX VS. BURNUP
TARGET DELTA FLUX IN PERCENT
10
8
6
4
2
0
-2
-4
-6
-8
-10
C
2000
4000
6000
8000
10000
12000
14000
16000
CYCLE BURNUP (MWD/MTU)

Figure 4.12

NORTH ANNA UNIT 2 - CYCLE 4

CORE AVERAGE AXIAL POWER DISTRIBUTION

N2-4-07

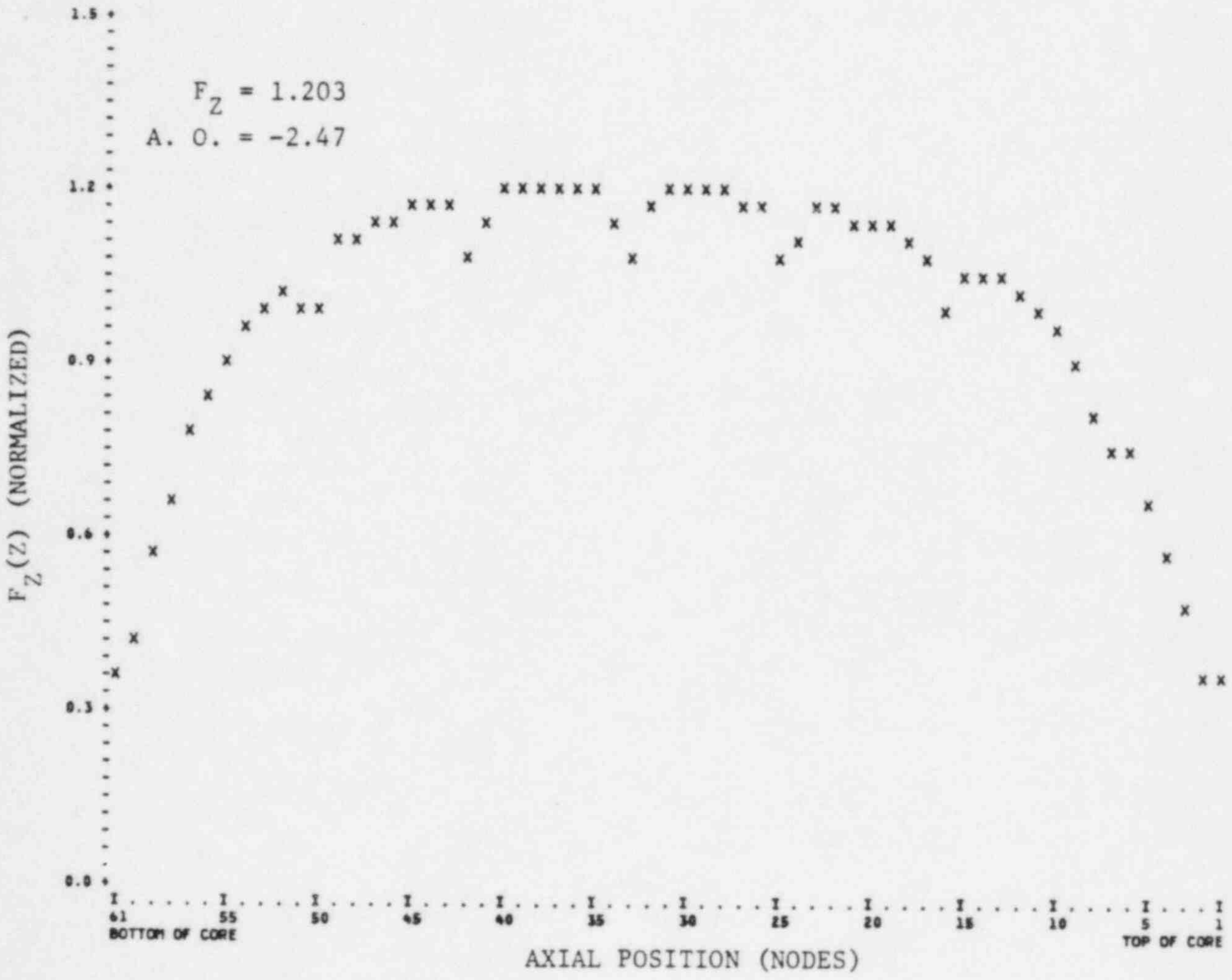


Figure 4.13

NORTH ANNA UNIT 2 - CYCLE 4

CORE AVERAGE AXIAL POWER DISTRIBUTION

N2-4-23

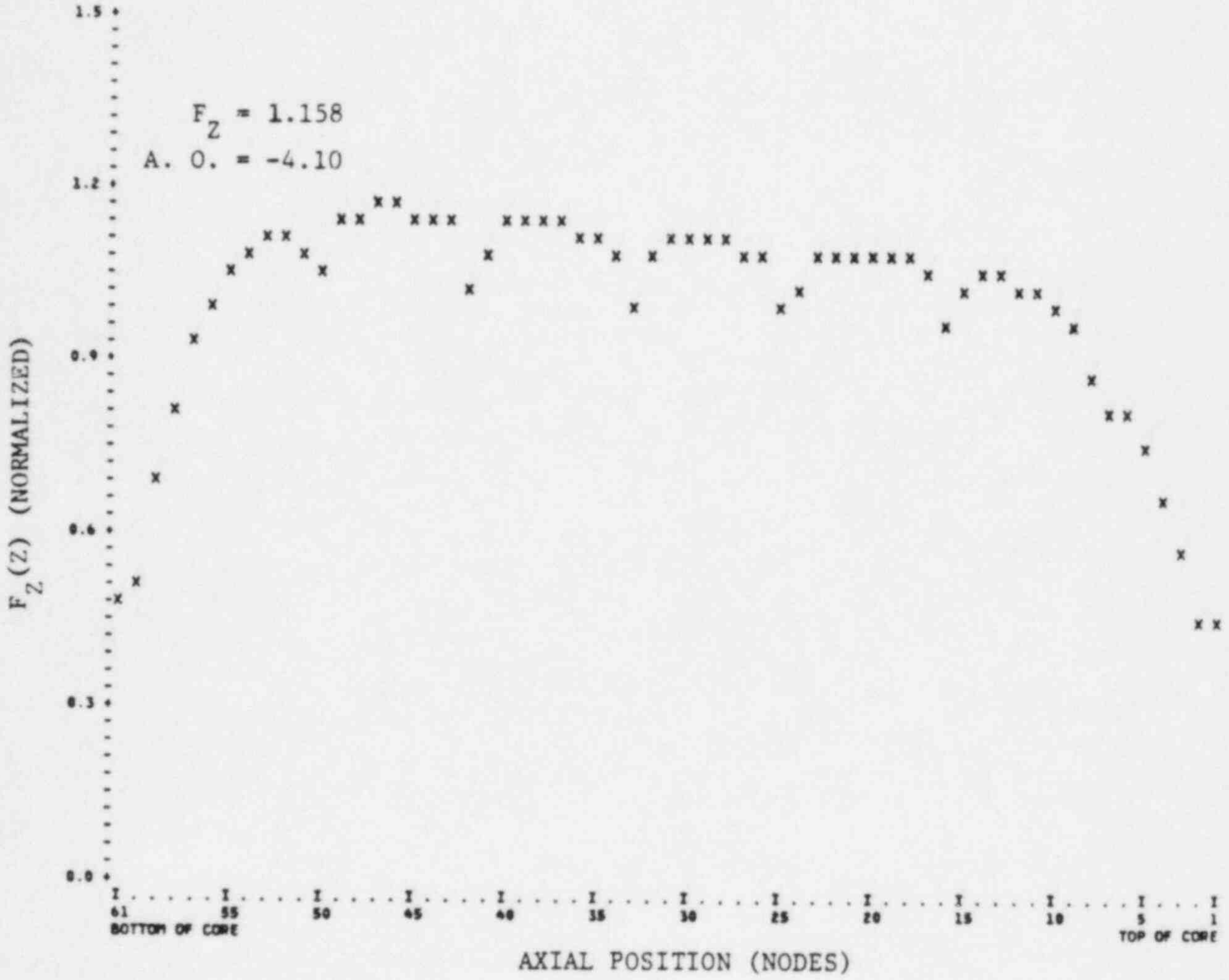


Figure 4.14

NORTH ANNA UNIT 2 - CYCLE 4
CORE AVERAGE AXIAL POWER DISTRIBUTION
N2-4-38

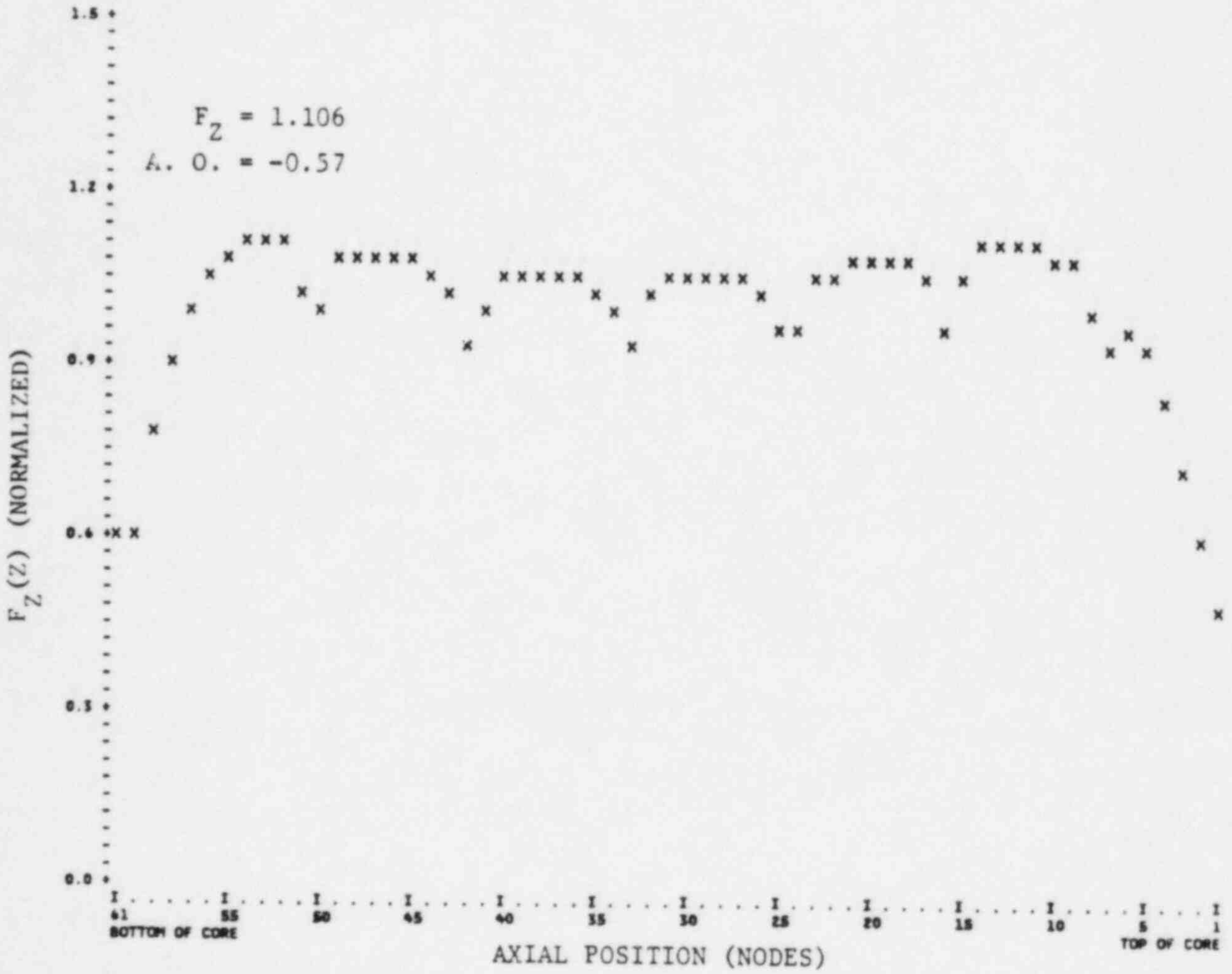
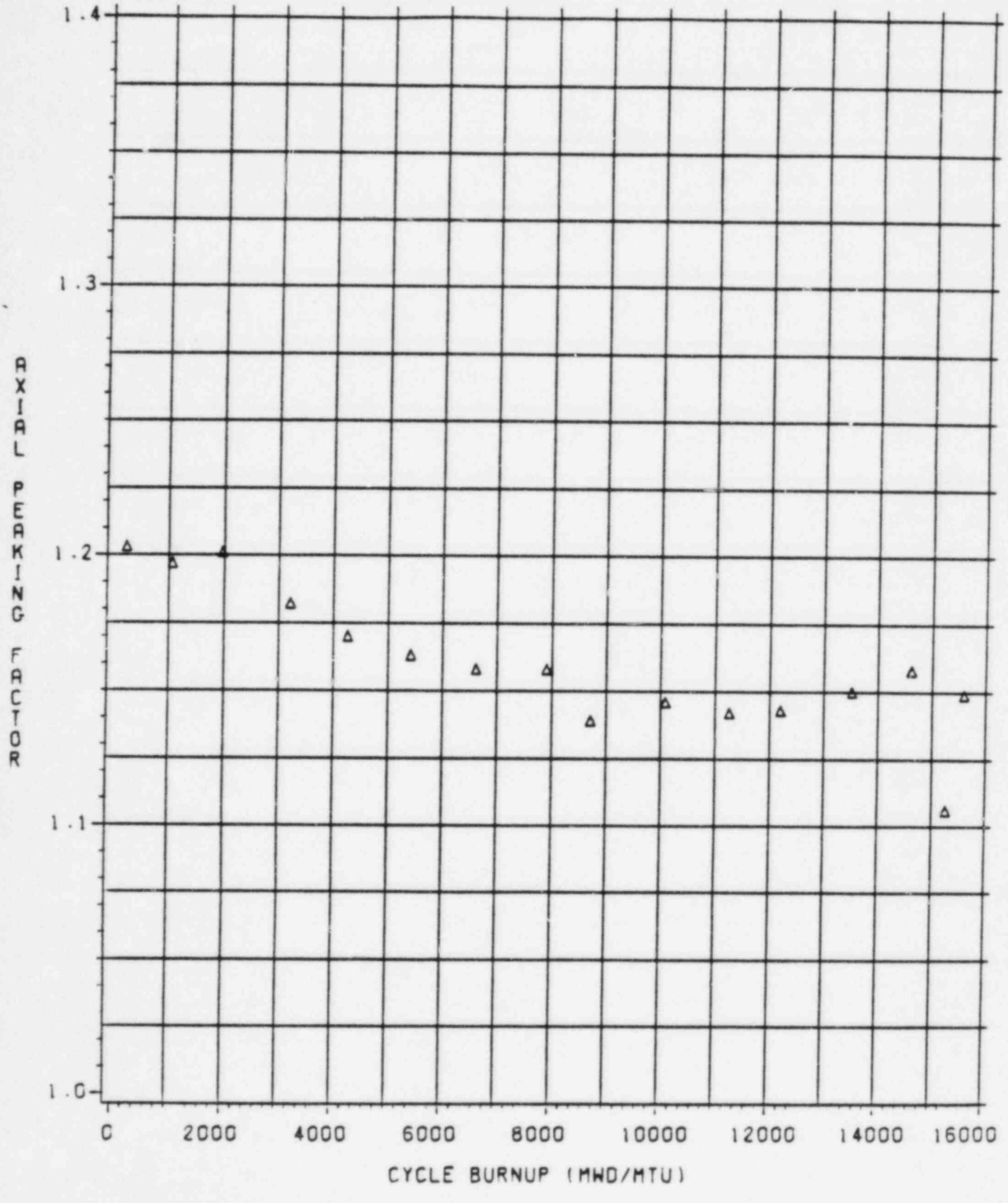


Figure 4.15

NORTH ANNA UNIT 2 - CYCLE 4

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 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 North Anna 2 Technical Specifications, the dose equivalent I-131 concentration in the primary coolant was 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 North Anna 2, Cycle 4 core. The demineralizer flow rate averaged 75.7 gpm during power operation. The data shows that during Cycle 4, the core operated substantially below the 1.0 µCi/gm limit during steady state operation. Specifically, the average dose equivalent I-131 concentration of 2.0×10^{-2} µCi/gm is equal to 2% of the Technical Specifications limit.

The step increase in coolant activity in July, 1985, was due to the recalibration of the germanium-lithium detector that is used to count the coolant samples. The change in the coolant activity measurements was not caused by fuel cladding defect formation.

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 leaving the I-131 dominant in activity, thereby causing the ratio to be 0.5 or more. In the case of large leaks and "tramp"* material, 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 North Anna 2, Cycle 4 core at a general average value of 0.09. These data indicate that there were probably no defects in the fuel used during Cycle 4, but tramp material remained from the previous cycle during which fuel defects were present.

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*"Tramp" consists of fissionable material which adheres to the outside of the fuel.

Figure 5.1

NORTH ANNA UNIT 2 - CYCLE 4

DOSE EQUIVALENT I-131 vs. TIME

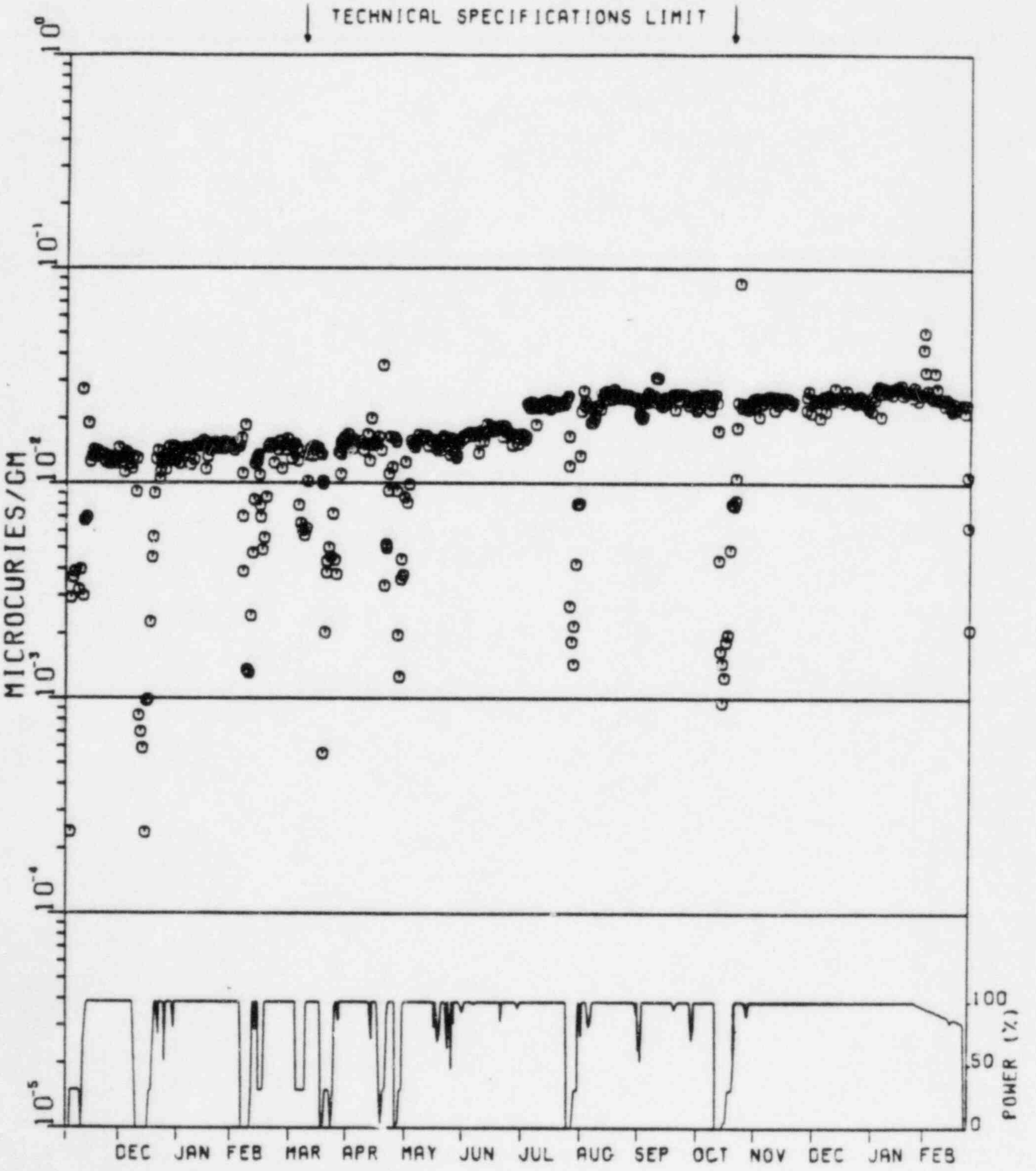
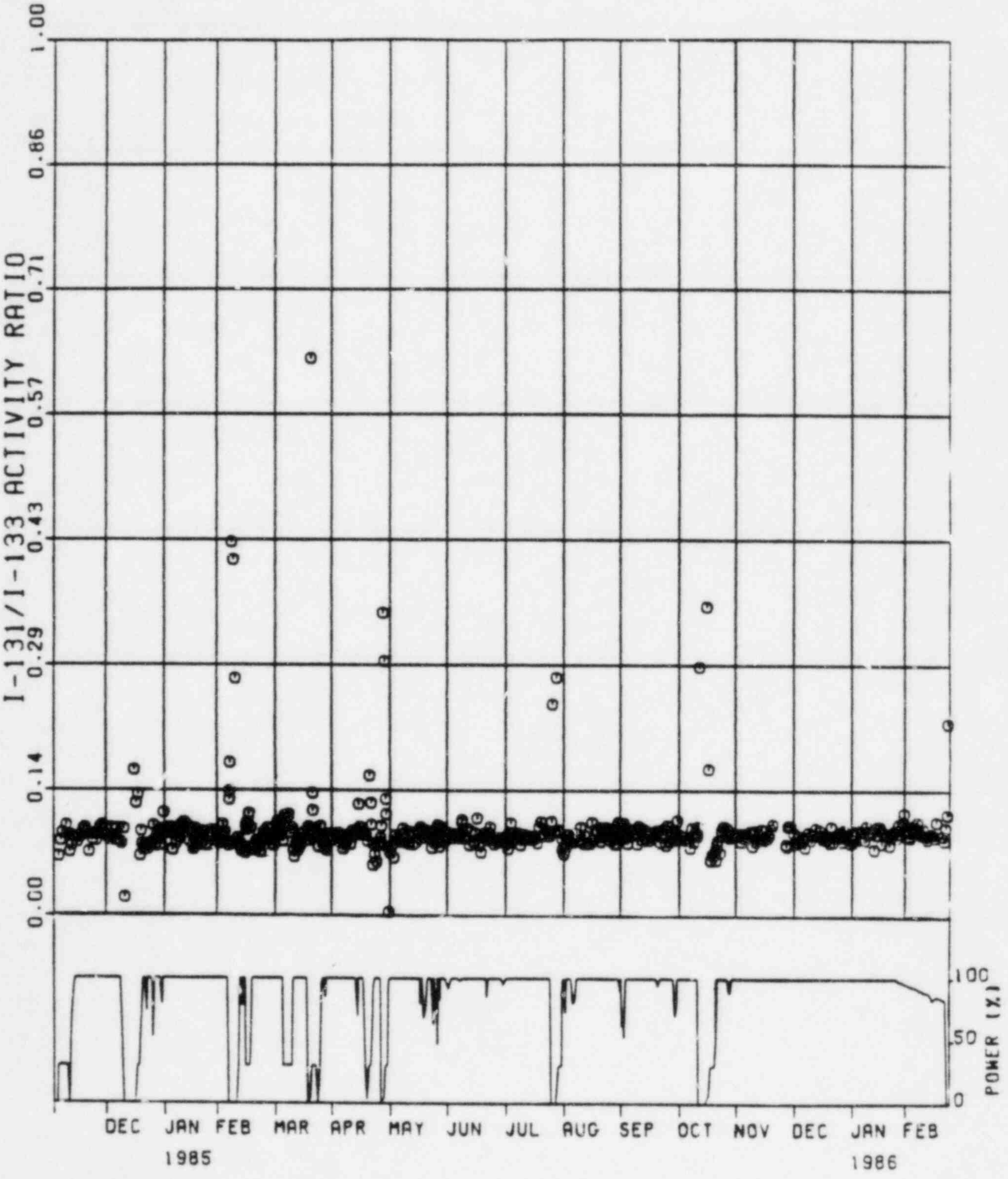


Figure 5.2

NORTH ANNA UNIT 2 - CYCLE 4

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



CONCLUSIONS

The North Anna 2, Cycle 4 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 mechanical integrity of the fuel has not changed significantly throughout Cycle 4 as indicated by the radioiodine analysis.

Section 7

REFERENCES

1) B. D. Mann, "North Anna Unit 2, Cycle 4 Startup Physics Test Report," VEP-NOS-14, November, 1984.

2) North Anna Power Station Unit 2 Technical Specifications, Sections 3/4.1 and 3/4.2.

3) T. K. Ross, "NEWTOTE Code", VEPCO NFO-CCR-6 , Rev. 8, April, 1981.

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.