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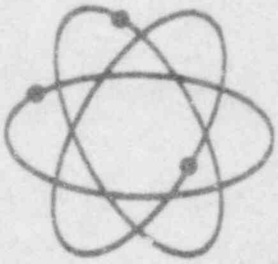
NORTH ANNA UNIT 1, CYCLE 3 CORE PERFORMANCE REPORT



FUEL RESOURCES DEPARTMENT
VIRGINIA ELECTRIC AND POWER COMPANY

VEP-FRD-50

NORTH ANNA UNIT 1, CYCLE 3

CORE PERFORMANCE REPORT

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July, 1982

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ACKNOWLEDGEMENTS

The authors would like to acknowledge the cooperation of the North Anna Power Station personnel in supplying the basic data for this report. Special thanks are due Messrs. R. S. Thomas and J. P. Smith. Also, the authors would like to express their gratitude to Dr. E. J. Lozito and Mr. C. T. Snow for their aid and guidance in preparing this report.

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INTRODUCTION AND SUMMARY

On May 17, 1982, North Anna Unit 1 completed Cycle 3. Since the initial criticality of Cycle 3 on April 6, 1981, the reactor core produced approximately 79 x 10^6 MBTU (13,335 Megawatt days per metric ton of contained uranium) which has resulted in the generation of approximately 7.4 x 10^9 KWHr gross (7.0 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 3. The physics tests that were performed during the startup of this cycle were covered in the North Anna Unit 1, Cycle 3 Startup Physics Test Report[1] and, therefore, will not be included here.

The third cycle core consisted of four batches of fuel. Two once burned batches and one twice burned batch were brought from Cycles 1 and 2 (Batches 1A3, 3A2, and 4). One fresh batch of fuel was added to the Cycle 3 core. The North Anna 1, Cycle 3 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 1 Technical Specifications[2], and to assess the integrity of the fuel.

Each of the four performance indicators is discussed in detail for the North Anna 1, Cycle 3 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 ±0.5% with the burnup accumulation in each batch deviating from design prediction by less than 0.9%.

2. Reactivity Depletion Follow - The critical boron concentration, used to monitor reactivity depletion, was consistently within ±0.6% delta K/K of the design prediction which is well within the ±1% delta K/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 3%. 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 3 was approximately 8.2 $\times 10^{-2}$ micro-Ci/gm. This corresponds to less than 9% 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 1 - CYCLE 3

CORE LOADING MAP

R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
						C33	E59	C46							1
				C11	E53	E21 8P	D51	E41 8P	E51	C29					2
			C17	E64 4P	E18 20P	D32	C05 SS	D08	E06 20P	E56 4P	C45				3
		C08	D44	E04 20P	D06	E29 20P	D18 8P	E61 20P	D30	E14 20P	D35	C19			4
	C24	E40 4P	E13 20P	D05	E19 20P	C13	D34 12P	C48	E50 20P	D47	E02 20P	E60 4P	C37		5
	E08	E24 20P	D17	E30 20P	C32	D45 12P	D03	D14 12P	C28	E47 20P	D02	E16 20P	E57		6
C50	E01 8P	D39	E54 20P	C27	D22 12P	D07	E45 20P	D37	D20 12P	C51	E39 20P	D40	E07 8P	C26	7
E33	D41	C43	D23 8P	D09 12P	D31	E15 20P	A11	E35 20P	D27	D15 12P	D49 8P	C49 SS	D42	E20	8
C06	E44 8P	D50	E17 20P	C42	D10 12P	D29	E10 20P	D21	D48 12P	C12	E52 20P	D46	E27 8P	C04	9
	E09	E63 20P	D13	E46 20P	C14	D26 12P	D04	D25 12P	C25	E22 20P	D19	E31 20P	E38		10
	C38	E32 4P	E23 20P	D11	E26 20P	C44	D28 12P	C10	E49 20P	D33	E58 20P	E36 4P	C20		11
		C36	D16	E55 20P	D12	E42 20P	D38 8P	E25 20P	D43	E11 20P	D52	C07			12
			C03	E12 4P	E03 20P	D01	C02 SS	D24	E37 20P	E05 4P	C21				13
				C23	E34	E62 8P	D36	E28 8P	E48	C30					14
						C39	E43	C40							15

--> ASSEMBLY ID
--> ONE OF THE
FOLLOWING:
A. SS - SECONDARY SOURCE
B. XXP - BURNABLE POISON ASSEMBLY
(XX-NUMBER OF RODS)

FUEL ASSEMBLY DESIGN PARAMETER

	BATCH			
	1A3	3A2	4	5
INITIAL ENRICHMENT (W/O U235)	2.11	3.10	3.21	3.41
ASSEMBLY TYPE	17 X 17	17 X 17	17 X 17	17 X 17
NUMBER OF ASSEMBLIES	1	40	52	64
FUEL RODS PER ASSEMBLY	264	264	264	264
ASSEMBLY IDENTIFICATION	A11	C02-C08 C10-C14 C17 C19-C21 C23-C30 C32,C33 C36-C40 C42-C46 C48-C51	D01-D52	E01-E64

Figure 1.2

NORTH ANNA UNIT 1 - CYCLE 3

MOVABLE DETECTOR AND
THERMOCOUPLE LOCATIONS

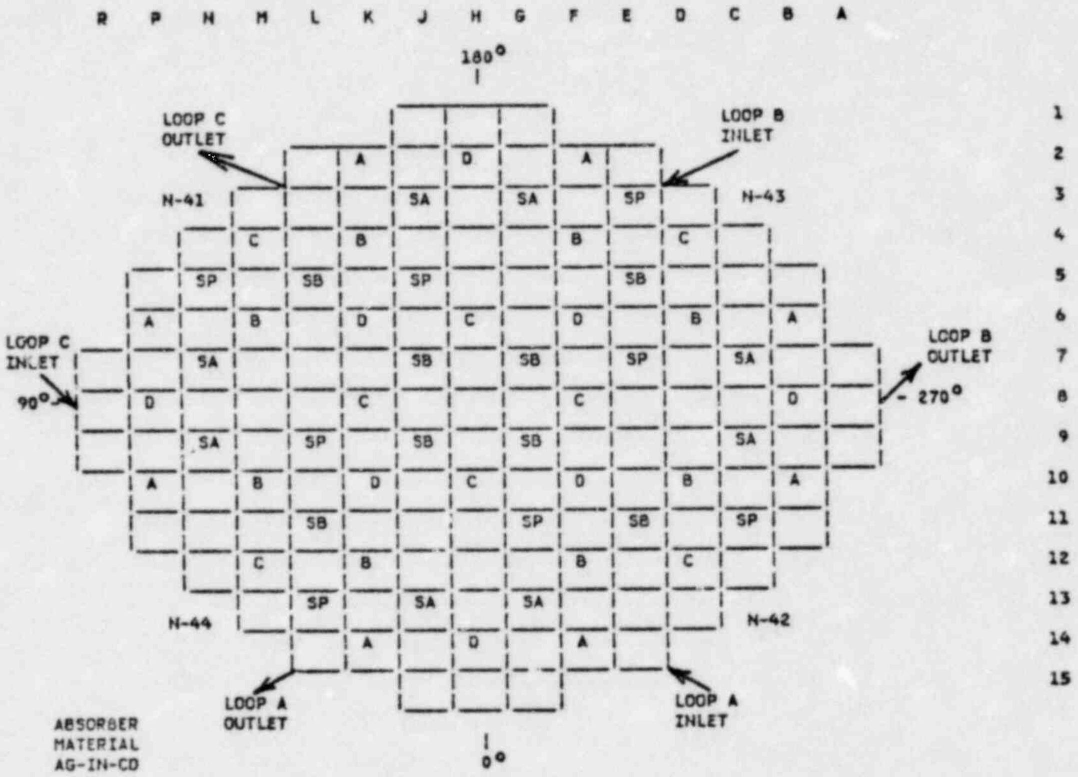
R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
							MD	TC							1
						TC		TC	MD						2
			MD TC		TC	MD	MD TC		TC		MD TC				3
		TC		MD			MD		MD	TC					4
		MD		MD	TC	MD	TC		TC	MD	MD TC		MD TC		5
		TC		MD TC			MD	TC	MD						6
TC	TC	MD				MD		MD		TC	MD		MD		7
MD	TC	MD TC		MD TC	TC		TC	TC	MD	TC		MD TC	MD	TC	8
			TC	MD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

MD - MOVABLE DETECTOR
TC - THERMOCOUPLE

Figure 1.3

NORTH ANNA UNIT 1 - CYCLE 3

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 1, Cycle 3 core is graphically depicted in Figure 2.1. The North Anna 1, Cycle 3 core achieved a burnup of 13,335 MWD/MTU. As shown in Figure 2.2, the average load factor for Cycle 3 was 79.5% 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 3 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 3 operation is also given. As can be seen from this figure, the accumulated assembly burnups were generally within ±3% of the predicted values. In addition, deviation from quadrant symmetry in the core, as indicated by the burnup tilt factors, was less than ±0.5%.

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 1, Cycle 3 followed design predictions very closely with each batch deviating less than 0.9% from design; this is considered excellent agreement. Therefore, symmetric burnup in conjunction with good agreement between actual and predicted assemblywise burnups and batch burnup sharing indicate that the Cycle 3 core did deplete as designed.

FIGURE 2.1

NORTH ANNA UNIT 1 - CYCLE 3

CORE BURNUP HISTORY

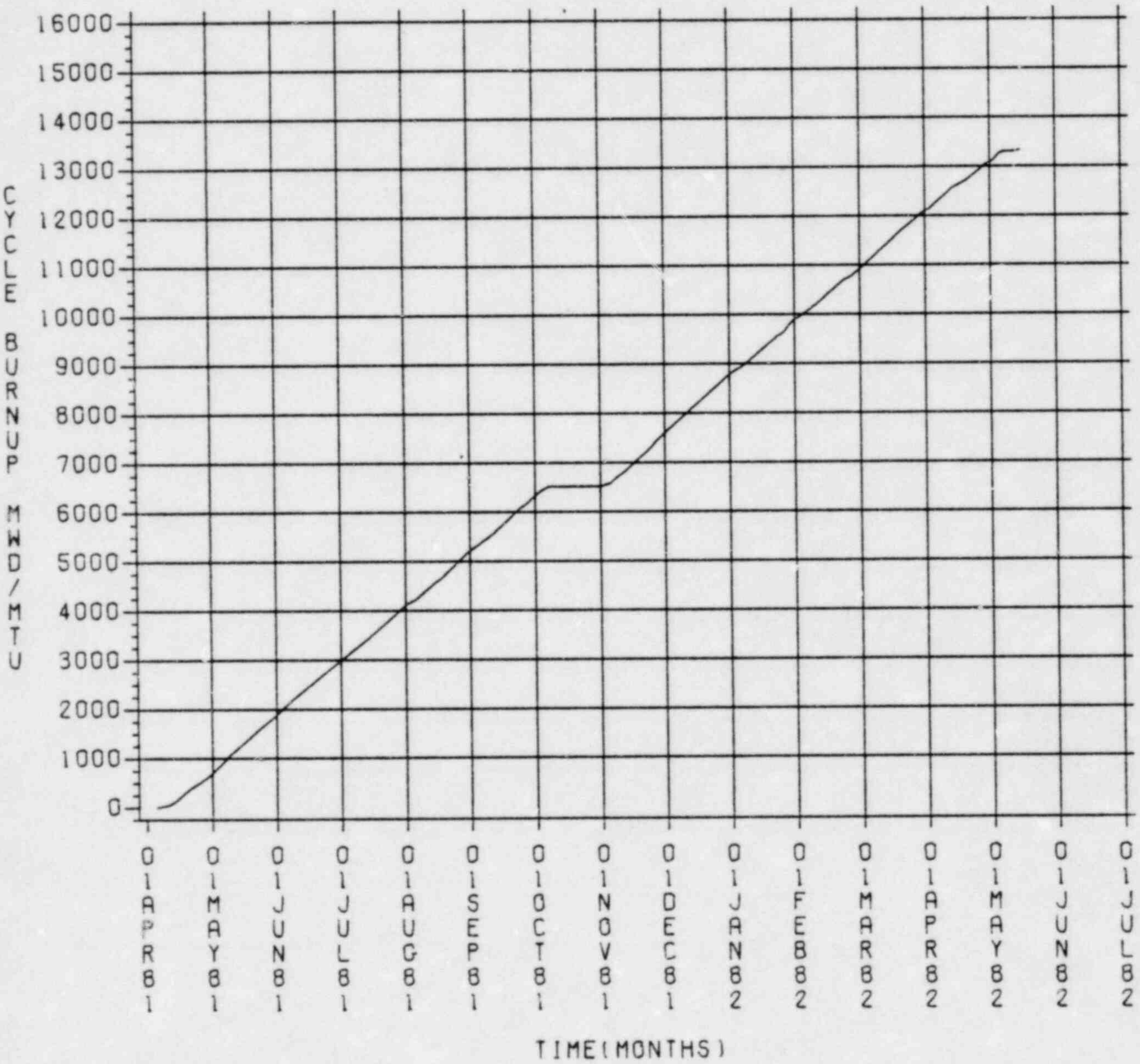
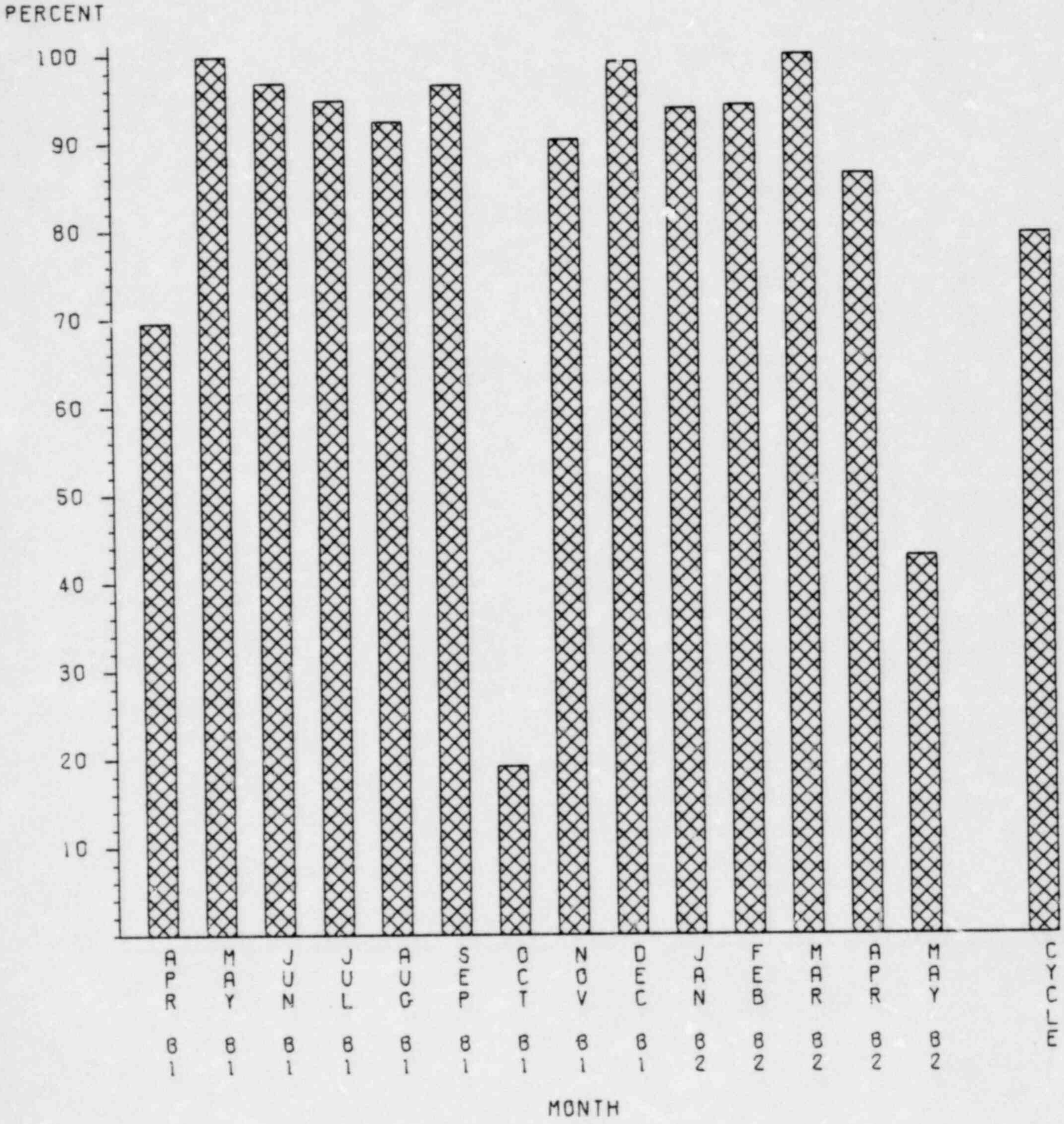


FIGURE 2.2

NORTH ANNA 1 - CYCLE 3
MONTHLY AVERAGE LOAD FACTORS



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

Figure 2.3

NORTH ANNA UNIT 1 - CYCLE 3

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							31.06 31.33	8.92 8.85	31.34 31.33							1
2					28.32 27.93	11.74 11.86	13.84 13.98	21.44 21.56	13.96 13.98	12.03 11.86	28.11 27.93					2
3				30.55 30.27	14.29 13.99	15.63 15.70	27.16 27.56	33.65 34.03	27.43 27.56	15.92 15.70	14.42 13.99	30.68 30.27				3
4			30.46 30.27	20.47 20.48	16.36 16.13	28.27 28.59	16.44 16.65	23.56 23.62	16.49 16.65	28.65 28.59	16.50 16.13	20.71 20.48	30.37 30.27			4
5		28.04 27.93	13.96 13.99	16.01 16.13	27.40 27.54	16.78 16.98	35.12 35.47	22.84 23.17	35.30 35.47	17.08 16.98	27.63 27.54	16.23 16.13	14.56 13.99	28.51 27.93		5
6		11.86 11.86	15.81 15.70	28.43 28.59	16.70 16.98	34.94 35.05	22.77 23.10	25.39 25.77	22.87 23.10	34.86 35.05	16.95 16.98	28.28 28.59	15.96 15.70	12.28 11.86		6
7	31.64 31.33	14.00 13.98	27.29 27.56	16.43 16.65	34.70 35.47	22.56 23.10	26.31 27.10	16.72 17.24	26.83 27.10	22.64 23.10	35.50 35.47	16.48 16.65	27.53 27.56	13.78 13.98	31.24 31.33	7
8	8.86 8.85	21.19 21.56	34.28 34.03	23.29 23.62	22.91 23.17	24.98 25.77	16.84 17.24	27.19 27.38	16.80 17.24	25.42 25.77	22.68 23.17	23.49 23.62	33.81 34.03	21.61 21.56	9.07 8.85	8
9	31.25 31.33	13.95 13.98	27.60 27.56	16.50 16.65	35.26 35.47	22.67 23.10	26.57 27.10	16.87 17.24	26.42 27.10	22.83 23.10	35.03 35.47	16.64 16.65	27.49 27.56	14.26 13.98	31.40 31.33	9
10		11.87 11.86	15.81 15.70	28.47 28.59	16.92 16.98	34.69 35.05	22.76 23.10	25.27 25.77	22.42 23.10	34.52 35.05	16.76 16.98	28.64 28.59	15.87 15.70	12.44 11.86		10
11		28.13 27.93	14.37 13.99	16.45 16.13	27.43 27.54	16.74 16.98	35.10 35.47	22.74 23.17	34.97 35.47	16.86 16.98	27.11 27.54	16.51 16.13	14.38 13.99	27.98 27.93		11
12			30.74 30.27	21.07 20.48	16.17 16.13	28.71 28.59	16.49 16.65	23.36 23.62	16.53 16.65	28.54 28.59	16.15 16.13	20.93 20.48	30.60 30.27			12
13				30.63 30.27	14.95 13.99	16.19 15.70	27.55 27.56	33.81 34.03	27.51 27.56	15.85 15.70	14.13 13.99	30.57 30.27				13
14					28.40 27.93	12.75 11.86	14.46 13.98	21.73 21.56	13.92 13.98	11.90 11.86	27.95 27.93					14
15							31.92 31.33	9.16 8.85	31.55 31.33							15
	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	

Figure 2.4

NORTH ANNA UNIT 1 - CYCLE 3

ASSEMBLYWISE ACCUMULATED BURNUP
COMPARISON OF MEASURED WITH PREDICTED
(1000 MWD/MTU)

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
1							31.06 -0.88	8.92 0.79	31.34 0.02							1
2					28.32 1.42	11.74 -1.04	13.84 -1.03	21.44 -0.56	13.96 -0.17	12.03 1.46	28.11 0.66					2
3				30.55 0.92	14.29 2.20	15.63 -0.45	27.16 -1.43	33.65 -1.12	27.43 -0.45	15.92 1.41	14.42 3.13	30.68 1.37				3
4			30.46 0.63	20.47 -0.04	16.36 1.45	28.27 -1.12	16.44 -1.26	23.56 -0.27	16.49 -0.95	28.65 0.20	16.50 2.30	20.71 1.10	30.37 0.33			4
5		28.06 0.40	13.96 -0.17	16.01 -0.72	27.40 -0.51	16.78 -1.17	35.12 -0.98	22.84 -1.45	35.30 -0.49	17.08 0.59	27.63 0.32	16.23 0.64	14.56 4.09	28.51 2.10		5
6		11.86 0.04	15.81 0.67	28.43 -0.55	16.70 -1.66	34.94 -0.31	22.77 -1.43	25.39 -1.46	22.87 -1.02	34.86 -0.52	16.95 -0.16	28.28 -1.10	15.96 1.64	12.28 3.52		6
7	31.64 0.99	14.00 0.14	27.29 -0.98	16.43 -1.36	34.70 -2.18	22.56 -2.36	26.31 -2.91	16.72 -3.00	26.83 -0.99	22.64 -2.00	35.50 0.09	16.48 -1.06	27.53 -0.10	13.78 -1.45	31.24 -0.28	7
8	8.86 0.17	21.19 -1.71	34.28 0.73	23.29 -1.38	22.91 -1.11	24.98 -3.07	16.84 -2.34	27.19 -0.70	16.80 -2.58	25.42 -1.33	22.68 -2.11	23.49 -0.55	33.81 -0.65	21.61 0.24	9.07 2.48	8
9	31.25 -0.27	13.95 -0.25	27.60 0.16	15.50 -0.93	35.26 -0.59	22.67 -1.88	26.57 -1.93	16.87 -2.14	26.42 -2.51	22.83 -1.19	35.03 -1.24	16.64 -0.11	27.49 -0.24	14.26 1.96	31.40 0.22	9
10		11.87 0.04	15.81 0.67	28.47 -0.44	16.92 -0.35	34.69 -1.01	22.76 -1.47	25.27 -1.92	22.42 -2.96	34.52 -1.51	16.76 -1.29	28.64 0.16	15.87 1.05	12.44 4.86		10
11		28.13 0.72	14.37 2.74	16.45 2.01	27.43 -0.42	16.74 -1.41	35.10 -1.05	22.74 -1.89	34.97 -1.41	16.86 -0.74	27.11 -1.56	16.51 2.35	14.38 2.81	27.98 0.19		11
12			30.74 1.56	21.07 2.85	16.17 0.26	28.71 0.42	16.49 -1.01	23.36 -1.09	16.53 -0.72	28.54 -0.19	16.15 0.13	20.93 2.20	30.60 1.10			12
13				30.83 1.85	14.95 6.91	16.19 3.11	27.55 -0.02	33.81 -0.65	27.51 -0.19	15.85 0.96	14.13 1.01	30.57 1.01				13
14					28.40 1.72	12.75 7.54	14.46 3.44	21.73 0.80	13.92 -0.42	11.90 0.34	27.95 0.07					14
15							31.92 1.89	9.16 3.56	31.55 0.71							15
	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	

MEASURED
M/P % DIFF

ARITHMETIC AVG
PCT DIFF = 0.03

AVG ABS PCT
DIFF = 1.27

STANDARD DEV
= 1.16

Burnup Sharing
(10^3 MWD/MTU)

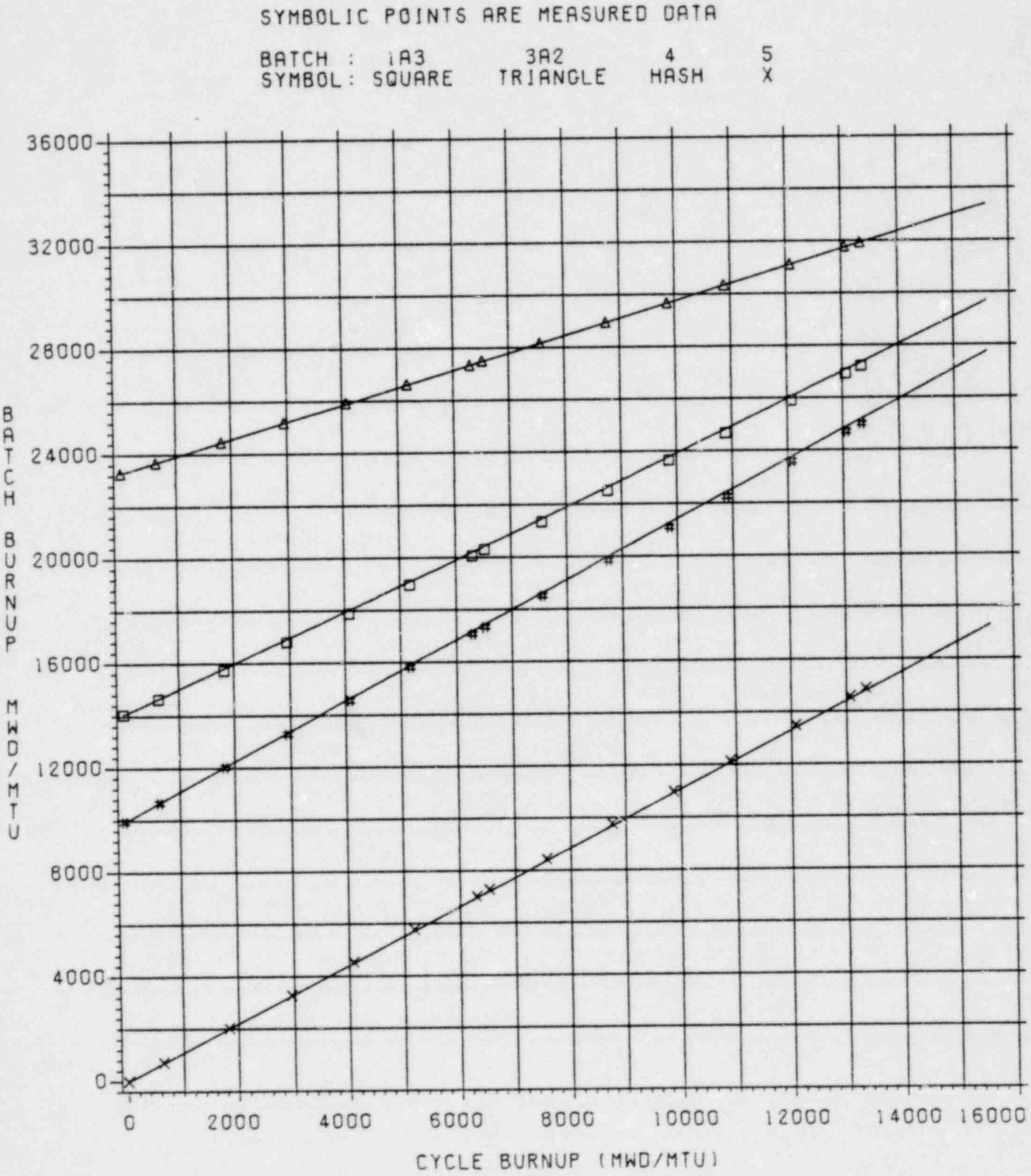
Batch	Cycle 1	2	3	Total
1A3	14.05	-	13.14	27.19
3A2	11.57	11.70	8.66	31.93
4	-	9.94	15.06	25.00
5	-	-	14.87	14.87
Core Average			13.34	

Burnup Tilt

NW - 0.9951
NE - 1.0019
SW - 1.0037
SE - 0.9993

FIGURE 2.5

NORTH ANNA 1 - CYCLE 3
BATCH BURNUP SHARING

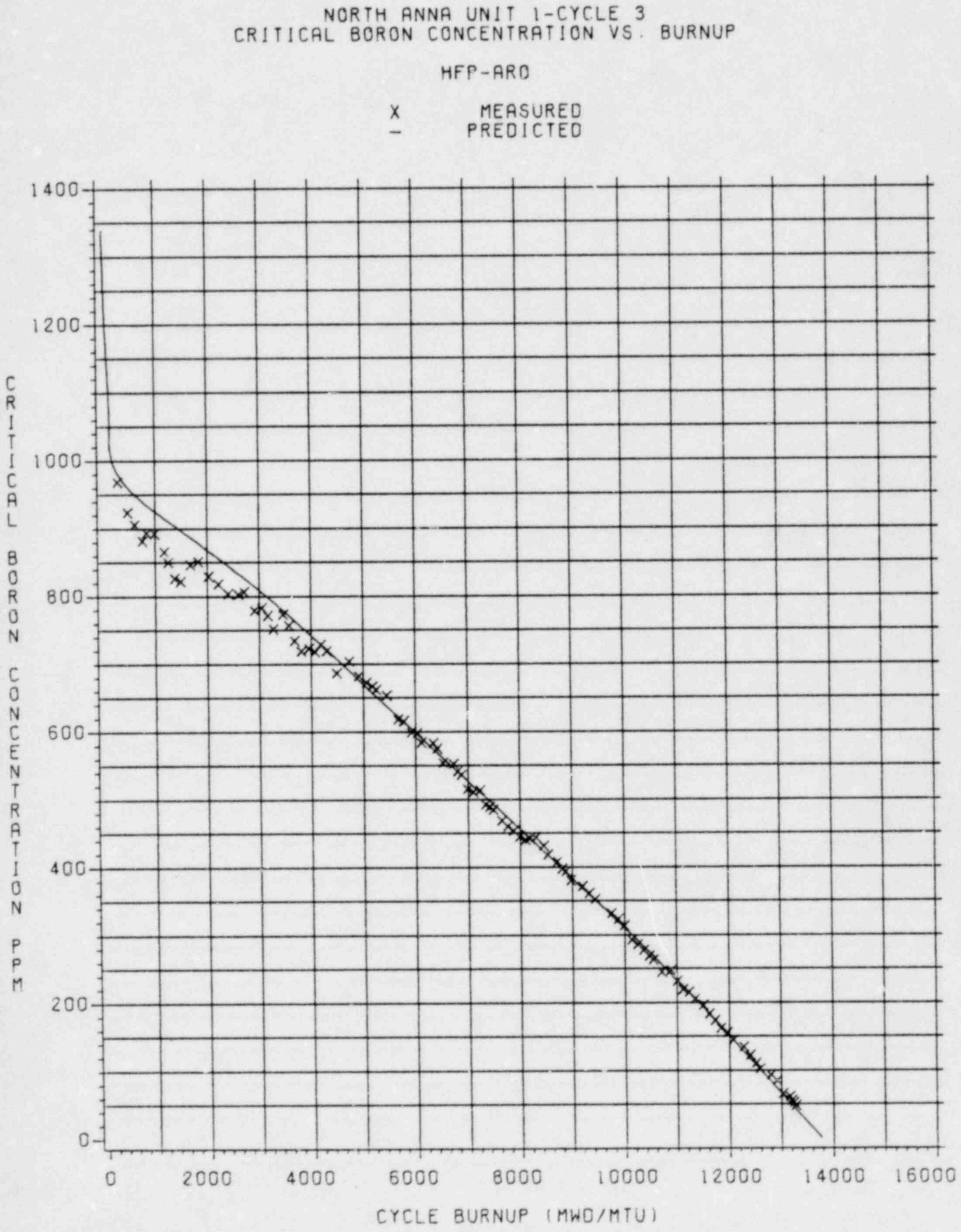


Section 3

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[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 North Anna 1, Cycle 3 core is shown in Figure 3.1. It can be seen that the measured data typically compare to within 75 ppm of the design prediction. This corresponds to less than ±0.6% delta K/K which is well within the ±1% delta K/K criteria 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 3 core depleted as expected without any reactivity anomalies.

FIGURE 3.1


NORTH ANNA UNIT 1-CYCLE 3
CRITICAL BORON CONCENTRATION VS. BURNUP
HFP-ARO
X MEASURED
— PREDICTED
CRITICAL BORON CONCENTRATION PPM
0
200
400
600
800
1000
1200
1400
CYCLE BURNUP (MWD/MTU)
0
2000
4000
6000
8000
10000
12000
14000
16000

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 North Anna 1, Cycle 3 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 3 life. Most of 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 5% of the predicted values with an average percent difference of approximately 2.2%.

The North Anna Unit 1 quadrant power tilt anomaly was described in the Cycle 2 Core Performance Report[6] and in the Cycle 3 Startup Physics

Test Report[1]. Further evaluations of the power tilt behavior during Cycle 3 indicated that the measured quadrant tilt did not exceed 1.2% at beginning-of-life, full-power, equilibrium conditions, and had decreased to less than 0.5% by the end of cycle operation.

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. During most of Cycle 3 the Technical Specifications limit on the axially dependent heat flux hot channel factor, F-Q(Z), was 2.10 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 2.10 F-Q(Z) limit. On April 13, 1982, the Nuclear Regulatory Commission issued Amendment No. 39 to the Operating License for North Anna Power Station[7], which revised the Technical Specifications limit on F-Q(Z) to be 2.14 x K(Z). All of the full core flux maps were performed prior to this license amendment. Therefore the results of those maps were compared to the original limit value. 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 1, the measured values of F-Q(Z) were within the Technical Specifications limit. The maximum values for the Heat Flux Hot Channel Factor measured during Cycle 3 are given in Figure 4.8. As can be seen from the figure, there was a 7% 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. The Cycle 3 limit on the enthalpy rise hot channel factor was set at 1.55 x (1+0.2(1-P)) x (1-RBP(BU)) , where P is the fractional power level, and RBP(BU) is the rod bow penalty. At end-of-life, the rod bow penalty reduced the F-delta H limit by approximately 1%. A summary of the maximum values for the Enthalpy Rise Hot Channel Factor measured during Cycle 3 is given in Figure 4.9. As can be seen from this figure, there was a 4% margin to the limit at the beginning of the cycle, with the margin generally increasing throughout cycle operation.

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

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

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 4.10, shows the value of this parameter to have been approximately -8% at the beginning of Cycle 3. By the middle of the cycle, the value of delta flux had shifted to -5% and then moved to -4% by the end of Cycle 3. This power shift can also be observed in the corresponding core average axial power distribution for a representative series of maps given in Figures 4.11 through 4.13. In Map N1-3-14 (Figure 4.11), taken at approximately 500 MWD/MTU, the axial power distribution had a cosine shape with a peaking factor of 1.26. In Map N1-3-33 (Figure 4.12), taken at approximately 6,900 MWD/MTU, the axial power distribution had flattened somewhat with an axial peaking factor of 1.18. Finally, in Map N1-3-87 (Figure 4.13), taken at approximately 12,400 MWD/MTU, the axial power distribution was slightly concave with an axial peaking factor of 1.16. The history of F-Z during the cycle can be seen more clearly in a plot of F-Z versus burnup given in Figure 4.14.

In conclusion, the North Anna 1, Cycle 3 core performed very satisfactorily with power distribution analyses verifying that design predictions were accurate and that the values of the hot channel factors were within the limits of the Technical Specifications.

TABLE 4.1

NORTH ANNA UNIT 1 - CYCLE 3

SUMMARY OF INCORE FLUX MAPS FOR ROUTINE OPERATION

MAP NO.	DATE	BURN UP MWD/MTU	PWR (%)	BANK D STEPS	F-Q(T) HOT CHANNEL FACTOR 1				F-DH(N) HOT CHNL.FACTOR 2			CORE F(Z) MAX		F(XY) 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		
14	4-27-81	486	100	224	K14	MN	37	1.953	K14	MN	1.474	38	1.264	1.553	1.013	SW	-7.88	42
15	5-13-81	1120	100	218	K14	MN	37	1.912	K14	MN	1.452	38	1.261	1.523	1.009	SW	-6.88	46
16	5-18-81	1332	100	218	L13	OK	37	1.910	K14	MN	1.447	38	1.256	1.524	1.009	SW	-6.59	46
17	5-18-81	1333	98	207	L13	OK	37	1.953	K14	MN	1.451	38	1.289	1.522	1.011	SW	-10.33	45
20(5)	5-19-81	1351	100	218	L13	OK	35	1.887	K14	MN	1.450	37	1.239	1.534	1.012	SW	-3.66	46
21	5-20-81	1389	100	221	L13	OK	36	1.890	K14	MN	1.447	37	1.249	1.522	1.011	SW	-5.22	46
23(6)	6-11-81	2232	100	221	L13	OK	36	1.864	L13	OK	1.438	38	1.237	1.517	1.011	SW	-5.42	46
24	7-15-81	3440	100	216	L13	OK	46	1.824	L13	OK	1.414	38	1.231	1.487	1.009	SW	-7.39	46
25	8-10-81	4415	100	211	F05	QQ	39	1.781	L13	OK	1.403	38	1.214	1.469	1.006	SW	-6.39	46
27(7)	8-12-81	4475	100	205	L13	OK	46	1.849	L13	OK	1.412	45	1.243	1.479	1.007	SW	-9.80	46

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 18 AND 19 WERE QUARTER CORE MAPS TAKEN FOR INCORE/EXCORE CALIBRATION.

6. MAP 22 WAS ABORTED DUE TO AN INSUFFICIENT NUMBER OF THIMBLES.

7. MAP 26 WAS NOT USABLE FOR INCORE/EXCORE CALIBRATION DUE TO ITS AXIAL FLUX DIFFERENCE SIMILARITY TO MAP 25. THEREFORE, MAP 26 WAS NOT ANALYZED.

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	QPTR		AXIAL OFF SET (%)	NO. OF THIMBLES
					ASSY	PIN	AXIAL POINT	F-Q(T)	ASSY	PIN	F-DH(N)	AXIAL POINT	F(Z)		MAX	LOC		
28	8-13-81	4512	100	217	L13	OK	29	1.729	L13	OK	1.406	29	1.179	1.476	1.006	SW	-1.61	46
29	8-24-81	4938	100	219	F11	QA	37	1.726	L13	OK	1.401	29	1.174	1.472	1.007	SW	-1.50	44
30	9- 9-81	5497	75	143	F05	LK	29	1.804	F05	QQ	1.411	29	1.227	1.482	1.007	SE	-4.21	47
31	9-15-81	5720	100	215	F05	LK	38	1.751	F05	LK	1.405	38	1.186	1.484	1.005	SW	-5.23	44
32	9-17-81	5794	100	195	F05	LK	38	1.817	F05	LK	1.407	38	1.226	1.485	1.005	SW	-8.67	46
33	11-13-81	6883	100	213	F11	LG	47	1.743	F05	LK	1.417	46	1.176	1.494	1.006	SW	-5.10	48
36(8)	12-10-81	7926	99	217	F05	LK	46	1.717	F05	LK	1.546	46	1.156	1.504	1.005	SW	-3.62	48
39(9)	1- 4-82	8899	98	219	L13	GF	47	1.733	F05	LK	1.433	47	1.150	1.512	1.007	NE	-3.23	46
79(10)	1-18-82	9413	99	219	F05	LK	47	1.709	F05	LK	1.437	47	1.142	1.510	1.009	NE	-3.19	47
83(11)	2-10-82	10218	100	218	F05	LK	48	1.736	F05	LK	1.435	47	1.161	1.509	1.007	NE	-5.04	47
84	3-15-82	11434	100	216	F05	ML	53	1.717	F05	ML	1.427	53	1.146	1.503	1.006	NE	-3.92	48
87(12)	4-12-82	12433	99	214	F05	ML	53	1.738	F05	ML	1.427	53	1.155	1.503	1.005	NE	-3.90	48

8. MAPS 34 AND 35 WERE QUARTER CORE MAPS TAKEN FOR INCORE/EXCORE CALIBRATION.

9. MAPS 37 AND 38 WERE 8 SYMMETRIC THIMBLE MAPS TAKEN FOR QUADRANT POWER TILT RATIO VERIFICATION.

10. MAPS 40 AND 42 WERE QUARTER CORE MAPS TAKEN FOR INCORE/EXCORE CALIBRATION. MAPS 41, 43, 44, AND 46 THROUGH 78 WERE SYMMETRIC THIMBLE MAPS TAKEN FOR QUADRANT POWER TILT RATIO VERIFICATION. MAP 45 WAS NOT ANALYZED DUE TO EXCESSIVE POWER CHANGES DURING THE MAPPING.

11. MAPS 80, 81, AND 82 WERE 8 SYMMETRIC THIMBLE MAPS TAKEN FOR QUADRANT POWER RATIO VERIFICATION.

12. MAPS 85 AND 86 WERE QUARTER CORE MAPS TAKEN FOR INCORE/EXCORE CALIBRATION.

Figure 4.1

NORTH ANNA UNIT 1-CYCLE 3

ASSEMBLYWISE POWER DISTRIBUTION

N1-3-14

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

       ................                   ......................                    ................
       .   MEASURED   .                   . 0.40 . 0.75 . 0.39 .                    .   MEASURED   .         1
       .PCT DIFFERENCE.                   .  3.5 .  3.5 .  2.9 .                    .PCT DIFFERENCE.
       ................     ..................................................      ................
                            . 0.41 . 0.93 . 1.13 . 1.14 . 1.14 . 0.96 . 0.43 .                               2
                            . -1.0 . -0.5 .  0.7 .  0.7 .  1.6 .  2.2 .  4.3 .
                     ................................................................
                     . 0.40 . 1.04 . 1.15 . 1.17 . 1.02 . 1.18 . 1.16 . 1.08 . 0.43 .                        3
                     . -1.0 . -1.0 . -0.8 . -1.9 . -2.0 . -1.1 .  0.5 .  2.6 .  6.6 .
              ..............................................................................
              . 0.41 . 0.93 . 1.14 . 1.19 . 1.17 . 1.11 . 1.17 . 1.20 . 1.17 . 0.95 . 0.42 .                 4
              .  1.5 . -0.6 . -1.6 . -1.8 . -2.4 . -2.5 . -2.3 . -1.1 .  1.1 .  2.1 .  3.6 .
       ............................................................................................
       . 0.42 . 1.07 . 1.14 . 1.22 . 1.17 . 0.95 . 1.03 . 0.97 . 1.18 . 1.23 . 1.15 . 1.06 . 0.41 .          5
       .  1.5 .  1.5 . -1.1 . -2.0 . -2.3 . -4.9 . -5.0 . -3.7 . -1.4 . -0.9 . -0.2 .  0.6 .  1.2 .
       ............................................................................................
       . 0.96 . 1.18 . 1.21 . 1.17 . 0.98 . 1.05 . 1.17 . 1.05 . 0.99 . 1.18 . 1.20 . 1.16 . 0.95 .          6
       .  2.0 .  2.0 . -0.2 . -2.4 . -3.1 . -4.8 . -5.0 . -4.5 . -1.6 . -1.1 . -0.8 . -0.0 .  1.2 .
..........................................................................................................
. 0.39 . 1.15 . 1.22 . 1.17 . 0.96 . 1.06 . 1.15 . 1.15 . 1.16 . 1.06 . 0.97 . 1.18 . 1.19 . 1.13 . 0.39 .   7
.  2.6 .  2.6 .  2.6 . -1.8 . -4.2 . -4.1 . -5.3 . -5.5 . -4.7 . -3.5 . -3.0 . -1.3 . -0.4 .  0.5 .  1.2 .
..........................................................................................................
. 0.74 . 1.16 . 1.07 . 1.13 . 1.04 . 1.19 . 1.17 . 0.92 . 1.17 . 1.18 . 1.04 . 1.13 . 1.04 . 1.18 . 0.77 .   8
.  2.6 .  2.6 .  2.6 . -1.4 . -3.5 . -3.6 . -4.0 . -3.1 . -4.2 . -4.3 . -4.1 . -1.2 . -0.4 .  3.9 .  6.4 .
..........................................................................................................
. 0.39 . 1.14 . 1.21 . 1.17 . 0.97 . 1.07 . 1.17 . 1.18 . 1.17 . 1.06 . 0.96 . 1.18 . 1.18 . 1.19 . 0.43 .   9
.  1.3 .  1.3 .  1.3 . -1.8 . -3.1 . -3.5 . -3.9 . -3.0 . -4.1 . -4.3 . -4.2 . -1.3 . -1.3 .  5.6 . 11.3 .
..........................................................................................................
       . 0.95 . 1.17 . 1.20 . 1.18 . 0.98 . 1.06 . 1.19 . 1.07 . 0.98 . 1.17 . 1.19 . 1.13 . 1.04 .         10
       .  1.3 .  1.3 . -0.5 . -1.4 . -2.3 . -3.8 . -3.3 . -3.1 . -2.3 . -2.2 . -1.4 . -2.1 . 11.3 .
       ............................................................................................
       . 0.43 . 1.09 . 1.18 . 1.22 . 1.18 . 0.98 . 1.06 . 0.98 . 1.19 . 1.23 . 1.17 . 1.08 . 0.44 .         11
       .  3.9 .  3.9 .  1.9 . -1.9 . -1.7 . -2.3 . -2.4 . -2.4 . -0.8 . -1.2 .  1.2 .  2.3 .  6.5 .
       ............................................................................................
              . 0.43 . 0.95 . 1.13 . 1.20 . 1.20 . 1.14 . 1.20 . 1.21 . 1.16 . 0.96 . 0.43 .                12
              .  6.5 .  2.4 . -1.9 . -0.5 .  0.2 .  0.1 .  0.3 .  0.4 .  0.4 .  3.1 .  6.5 .
              ..............................................................................
                     . 0.44 . 1.16 . 1.22 . 1.22 . 1.07 . 1.23 . 1.20 . 1.08 . 0.43 .                       13
                     .  8.1 .  9.8 .  5.3 .  2.0 .  3.0 .  3.6 .  3.6 .  2.7 .  6.5 .
                     ................................................................
                            . 0.45 . 1.04 . 1.21 . 1.21 . 1.16 . 0.97 . 0.42 .                              14
                            .  9.8 . 10.8 .  7.7 .  6.5 .  3.7 .  3.7 .  2.7 .
                            ..................................................
                                          . 0.43 . 0.78 . 0.40 .                                            15
                                          . 11.9 .  8.5 .  4.8 .
                                          ......................

STANDARD DEVIATION = 2.363                                                      AVERAGE PCT. DIFFERENCE =   2.9
```

```
                              SUMMARY
                              -------

MAP NO: N1-3-14             DATE:  4/27/81            POWER:  100%

CONTROL ROD POSITIONS:      F-Q(T)  = 1.953           QPTR:

D BANK AT 224 STEPS         F-DH(N) = 1.474           NW  0.987 | NE  0.993
                                                      ----------|----------
                            F(Z)    = 1.264           SW  1.013 | SE  1.007

                            F(XY)   = 1.553

                            BURNUP  =   486 MWD/MTU   A.O =  -7.88(%)
```

Figure 4.2

NORTH ANNA UNIT 1-CYCLE 3

ASSEMBLYWISE POWER DISTRIBUTION

N1-3-33

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

       ................                   ......................                    ................
       .   MEASURED   .                   . 0.36 . 0.64 . 0.36 .                    .   MEASURED   .          1
       .PCT DIFFERENCE.                   .  1.0 .  0.9 .  1.4 .                    .PCT DIFFERENCE.
       ................     ..................................................      ................
                            . 0.43 . 0.87 . 1.01 . 0.97 . 1.02 . 0.89 . 0.43 .                                2
                            .  5.7 . -0.4 . -0.2 . -0.4 .  0.5 .  1.7 .  3.8 .
                     ................................................................
                     . 0.44 . 1.07 . 1.18 . 1.09 . 0.96 . 1.11 . 1.20 . 1.08 . 0.45 .                         3
                     .  3.0 .  2.7 . -0.4 . -1.4 . -1.5 . -0.3 .  1.3 .  2.9 .  6.0 .
              ..............................................................................
              . 0.43 . 0.95 . 1.24 . 1.19 . 1.25 . 1.15 . 1.25 . 1.21 . 1.25 . 0.96 . 0.44 .                  4
              .  2.5 .  1.2 .  1.5 . -0.4 . -1.2 . -1.3 . -1.0 .  0.9 .  2.0 .  2.4 .  4.6 .
       ............................................................................................
       . 0.41 . 1.04 . 1.21 . 1.23 . 1.28 . 1.01 . 1.11 . 1.02 . 1.30 . 1.25 . 1.23 . 1.09 . 0.44 .           5
       . -0.5 . -0.5 . -0.8 . -0.9 . -0.8 . -2.4 . -2.5 . -1.5 .  0.8 .  0.6 .  6.5 .  4.0 .  7.8 .
       ............................................................................................
       . 0.88 . 1.18 . 1.19 . 1.27 . 1.02 . 1.13 . 1.19 . 1.13 . 1.03 . 1.29 . 1.20 . 1.20 . 0.90 .           6
       .  0.4 .  0.4 . -0.5 . -1.3 . -1.3 . -2.4 . -2.4 . -2.0 . -0.1 .  0.3 .  0.2 .  1.7 .  3.5 .
..........................................................................................................
. 0.36 . 1.03 . 1.12 . 1.25 . 1.00 . 1.12 . 1.18 . 1.28 . 1.19 . 1.14 . 1.02 . 1.25 . 1.10 . 1.01 . 0.35 .    7
.  1.2 .  1.1 .  1.1 . -1.0 . -3.1 . -2.8 . -3.3 . -2.9 . -2.2 . -1.5 . -1.0 . -0.5 . -0.8 . -1.0 . -1.2 .
..........................................................................................................
. 0.64 . 0.98 . 0.98 . 1.16 . 1.11 . 1.19 . 1.28 . 1.00 . 1.28 . 1.19 . 1.11 . 1.16 . 0.96 . 0.98 . 0.65 .    8
.  0.9 .  1.0 .  1.1 . -0.5 . -2.2 . -2.2 . -2.3 . -1.7 . -2.4 . -2.5 . -2.4 . -0.5 . -0.8 .  0.9 .  2.0 .
..........................................................................................................
. 0.36 . 1.02 . 1.12 . 1.25 . 1.01 . 1.13 . 1.18 . 1.29 . 1.19 . 1.12 . 1.01 . 1.26 . 1.11 . 1.04 . 0.37 .    9
.  0.4 .  0.7 .  0.7 . -0.7 . -2.0 . -2.4 . -3.2 . -2.1 . -2.5 . -2.7 . -2.2 . -0.1 . -0.1 .  1.9 .  3.2 .
..........................................................................................................
       . 0.88 . 1.18 . 1.20 . 1.29 . 1.02 . 1.12 . 1.19 . 1.13 . 1.02 . 1.28 . 1.20 . 1.19 . 0.91 .           10
       .  0.4 .  0.4 .  0.1 .  0.0 . -1.1 . -3.2 . -2.5 . -2.4 . -1.6 . -1.2 .  0.3 .  0.8 .  4.5 .
       ............................................................................................
       . 0.42 . 1.07 . 1.24 . 1.24 . 1.27 . 1.01 . 1.11 . 1.01 . 1.28 . 1.23 . 1.25 . 1.07 . 0.42 .           11
       .  2.4 .  2.4 .  1.6 .  0.2 . -1.4 . -2.6 . -2.6 . -2.5 . -0.9 . -0.4 .  1.9 .  2.4 .  3.3 .
       ............................................................................................
              . 0.44 . 0.96 . 1.23 . 1.19 . 1.24 . 1.14 . 1.25 . 1.19 . 1.22 . 0.97 . 0.45 .                  12
              .  4.4 .  2.4 .  0.2 . -0.6 . -1.5 . -1.5 . -1.0 . -0.2 . -0.2 .  2.9 .  5.4 .
              ..............................................................................
                     . 0.45 . 1.11 . 1.21 . 1.10 . 0.97 . 1.11 . 1.19 . 1.06 . 0.45 .                         13
                     .  5.5 .  6.6 .  2.6 . -0.6 . -0.5 .  0.3 .  0.5 .  1.0 .  5.4 .
                     ................................................................
                            . 0.44 . 0.93 . 1.05 . 0.99 . 1.02 . 0.88 . 0.42 .                                14
                            .  6.6 .  6.8 .  3.5 .  2.0 .  0.2 .  0.4 .  1.0 .
                            ..................................................
                                          . 0.38 . 0.66 . 0.35 .                                              15
                                          .  6.8 .  3.3 . -0.2 .
                                          ......................

STANDARD DEVIATION = 1.574                                                AVERAGE PCT. DIFFERENCE =   1.8
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```
                              SUMMARY
                              -------

MAP NO: N1-3-33              DATE: 11/13/81              POWER:  100%

CONTROL ROD POSITIONS:       F-Q(T)  = 1.743             QPTR:

D BANK AT 213 STEPS          F-DH(N) = 1.417             NW  0.992 | NE  1.006
                                                         ----------|----------
                             F(Z)    = 1.176             SW  1.006 | SE  0.996

                             F(XY)   = 1.494

                             BURNUP  =   6883 MWD/MTU    A.O =  -5.10(%)
```

Figure 4.3

NORTH ANNA UNIT 1-CYCLE 3

ASSEMBLYWISE POWER DISTRIBUTION

N1-3-87

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

       ................                   ......................               ................
       .   MEASURED   .                   . 0.37 . 0.65 . 0.37 .               .   MEASURED   .             1
       .PCT DIFFERENCE.                   .  2.0 .  1.9 .  2.0 .               .PCT DIFFERENCE.
       ................     ..................................................  ................
                            . 0.45 . 0.86 . 1.00 . 0.95 . 1.00 . 0.87 . 0.44 .                              2
                            .  6.4 .  0.7 .  0.7 .  0.6 .  1.2 .  1.9 .  4.0 .
                     ................................................................
                     . 0.45 . 1.06 . 1.19 . 1.08 . 0.95 . 1.08 . 1.21 . 1.07 . 0.47 .                       3
                     .  2.8 .  2.4 . -0.5 . -0.6 . -0.7 .  0.1 .  1.5 .  3.2 .  6.2 .
              ..............................................................................
              . 0.45 . 0.95 . 1.26 . 1.18 . 1.28 . 1.16 . 1.28 . 1.19 . 1.26 . 0.96 . 0.46 .                4
              .  2.5 .  0.9 .  1.3 . -0.3 . -0.5 . -0.6 . -0.5 .  0.9 .  1.6 .  1.8 .  4.3 .
       ............................................................................................
       . 0.42 . 1.03 . 1.22 . 1.19 . 1.29 . 1.03 . 1.14 . 1.04 . 1.32 . 1.22 . 1.24 . 1.07 . 0.46 .         5
       . -1.1 . -1.1 . -1.6 . -1.7 . -1.3 . -1.5   -1.6 . -0.7 .  0.9 .  0.3 . -0.5 .  3.4 .  8.1 .
       ............................................................................................
       . 0.85 . 1.19 . 1.17 . 1.28 . 1.02 . 1.15 . 1.18 . 1.16 . 1.04 . 1.30 . 1.16 . 1.28 . 0.89 .         6
       . -0.1 . -0.1 . -1.0 . -2.0 . -1.2 . -1.3 . -1.1 . -0.7 .  0.5 . -0.7 . -1.4 .  0.9 .  4.0 .
..........................................................................................................
. 0.37 . 1.00 . 1.09 . 1.27 . 1.01 . 1.14 . 1.17 . 1.31 . 1.18 . 1.16 . 1.03 . 1.26 . 1.07 . 0.99 . 0.36 .  7
.  0.9 .  1.0 .  1.0 . -1.2 . -3.6 . -2.7 . -1.8 . -1.3 . -1.0 . -0.5 . -1.5 . -1.9 . -1.1 . -0.4 . -0.5 .
..........................................................................................................
. 0.64 . 0.95 . 0.97 . 1.17 . 1.14 . 1.17 . 1.31 . 1.02 . 1.31 . 1.18 . 1.13 . 1.15 . 0.95 . 0.95 . 0.65 .  8
.  1.0 .  0.9 .  1.0 . -0.3 . -1.8 . -1.5 . -1.0 . -0.5 . -1.3 . -1.4 . -2.6 . -1.7 . -1.1 .  1.4 .  2.5 .
..........................................................................................................
. 0.36 . 0.99 . 1.08 . 1.27 . 1.03 . 1.14 . 1.16 . 1.30 . 1.17 . 1.15 . 1.03 . 1.28 . 1.09 . 1.02 . 0.38 .  9
. -0.7 .  0.2 .  0.2 . -0.7 . -1.6 . -2.0 . -2.9 . -1.6 . -1.7 . -1.8 . -1.5 .  0.1 .  0.4 .  2.4 .  3.7 .
..........................................................................................................
       . 0.85 . 1.18 . 1.17 . 1.31 . 1.03 . 1.13 . 1.16 . 1.14 . 1.02 . 1.29 . 1.18 . 1.20 . 0.90 .         10
       . -0.8 . -0.8 . -0.4 . -0.1 . -1.0 . -3.2 . -2.3 . -2.4 . -1.5 . -1.2 .  0.2 .  1.2 .  5.0 .
       ............................................................................................
       . 0.43 . 1.06 . 1.25 . 1.21 . 1.28 . 1.01 . 1.13 . 1.01 . 1.29 . 1.20 . 1.27 . 1.07 . 0.44 .         11
       .  1.9 .  1.9 .  1.1 . -0.5 . -1.9 . -3.0 . -3.1 . -3.3 . -1.6 . -0.8 .  2.0 .  2.8 .  3.8 .
       ............................................................................................
              . 0.46 . 0.96 . 1.24 . 1.16 . 1.25 . 1.14 . 1.26 . 1.16 . 1.23 . 0.97 . 0.47 .                12
              .  4.7 .  2.2 . -0.5 . -1.6 . -2.2 . -2.2 . -1.9 . -1.2 . -1.2 .  3.0 .  5.8 .
              ..............................................................................
                     . 0.47 . 1.11 . 1.22 . 1.07 . 0.95 . 1.08 . 1.18 . 1.03 . 0.47 .                       13
                     .  5.9 .  7.1 .  2.3 . -1.5 . -1.2 . -0.5 . -0.6 . -0.6 .  5.8 .
                     ................................................................
                            . 0.45 . 0.92 . 1.03 . 0.96 . 0.99 . 0.85 . 0.42 .                              14
                            .  7.1 .  7.3 .  3.6 .  1.7 . -0.6 . -0.6 . -0.6 .
                            ..................................................
                                          . 0.39 . 0.66 . 0.36 .                                            15
                                          .  7.3 .  3.3 . -0.7 .
                                          ......................

STANDARD DEVIATION = 1.633                                                  AVERAGE PCT. DIFFERENCE =   1.8
```

```
                               SUMMARY
                               -------

MAP NO: NI-3-87          DATE:  4/12/82          POWER:   99%

CONTROL ROD POSITIONS:   F-Q(T)  = 1.738         QPTR:

D BANK AT 214 STEPS      F-DH(N) = 1.427         NW  0.996  | NE  1.005
                                                 -----------|----------
                         F(Z)    = 1.155         SW  1.001  | SE  0.998

                         F(XY)   = 1.503

                         BURNUP  = 12433 MWD/MTU    A.O =  -3.90(%)
```

Figure 4.4

HOT CHANNEL FACTOR NORMALIZED

OPERATING ENVELOPE

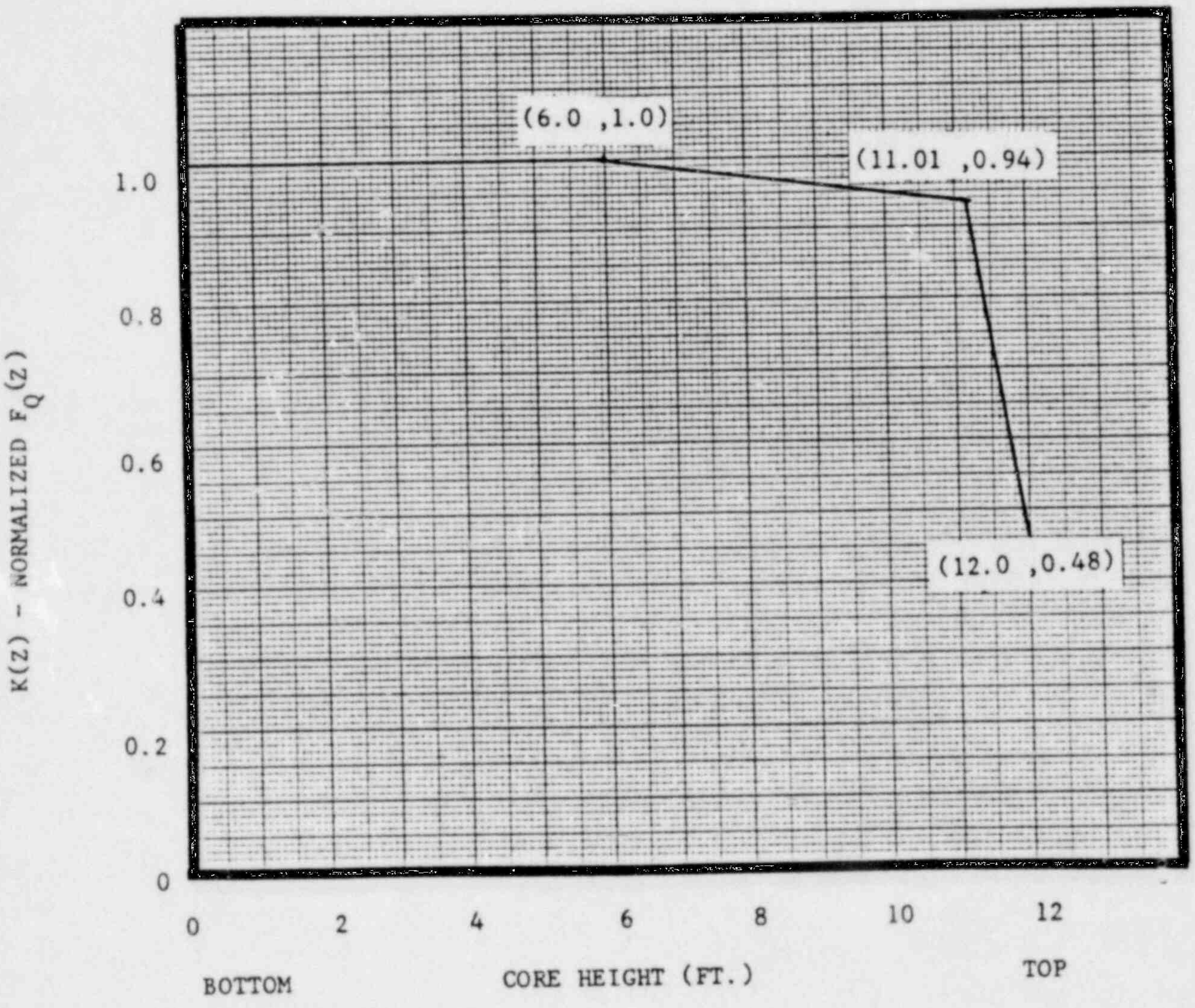


Figure 4.5

NORTH ANNA UNIT 1-CYCLE 3

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

N1-3-14

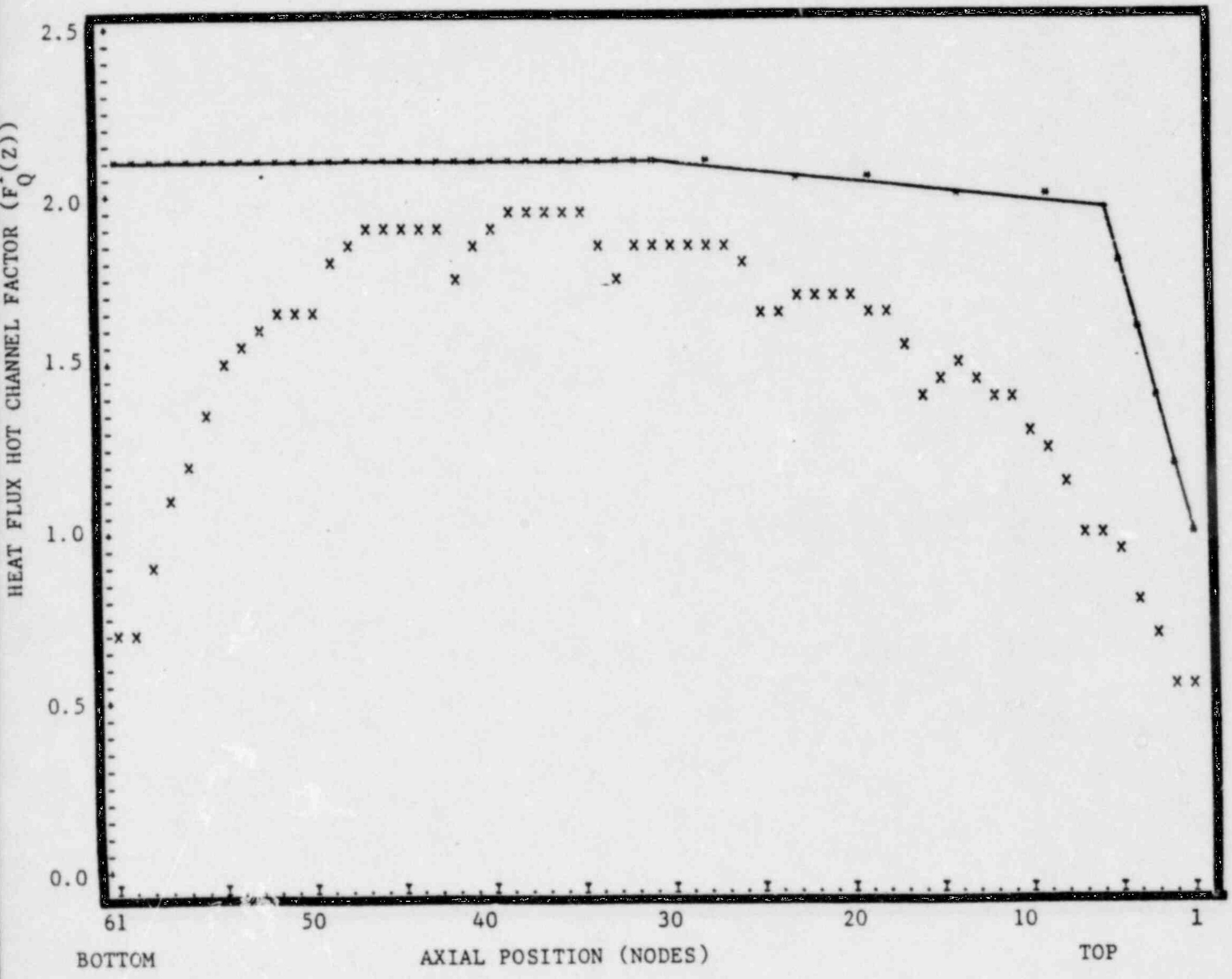


Figure 4.6

NORTH ANNA UNIT 1-CYCLE 3

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

N1-3-33

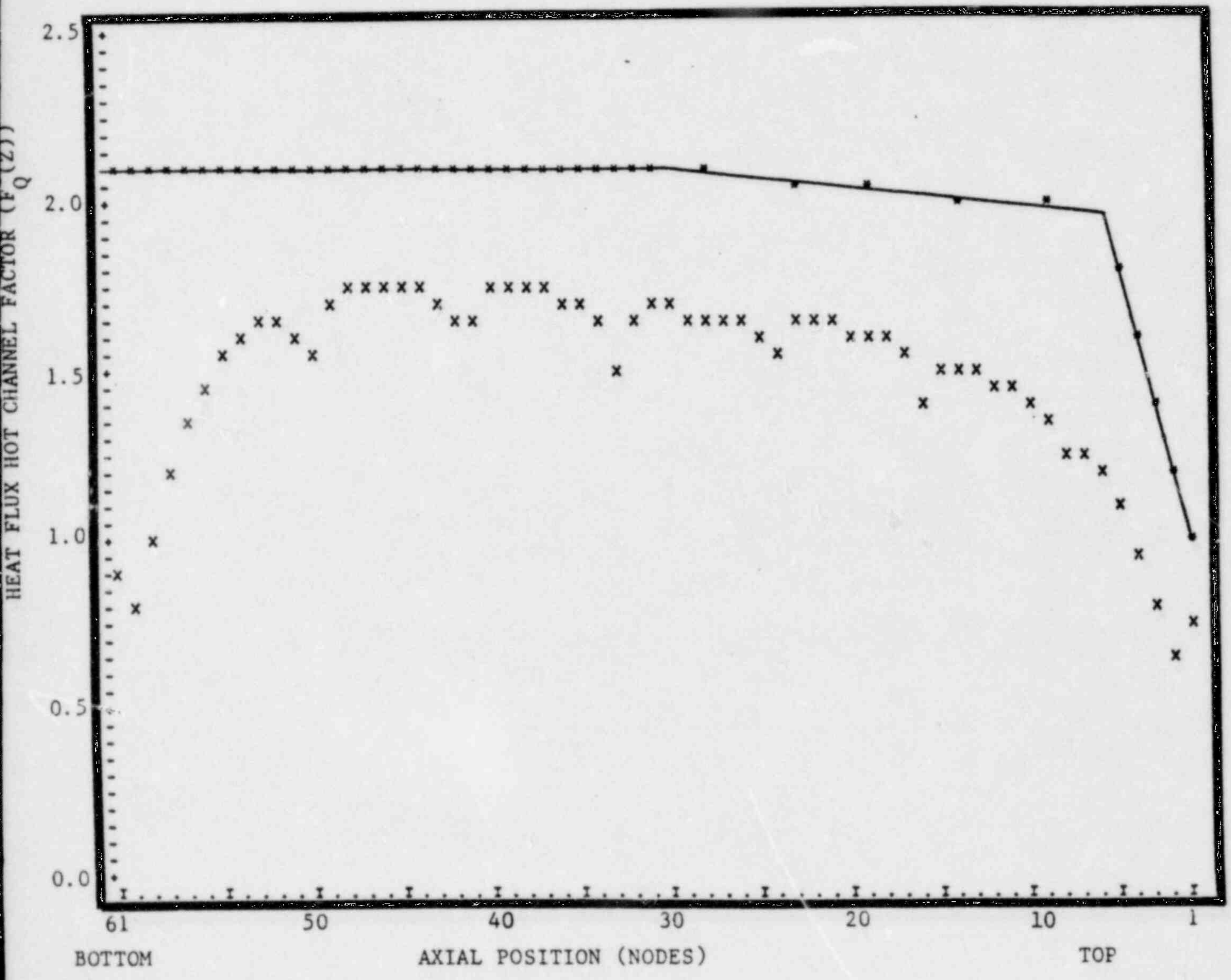


Figure 4.7

NORTH ANNA UNIT 1-CYCLE 3

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

N1-3-87

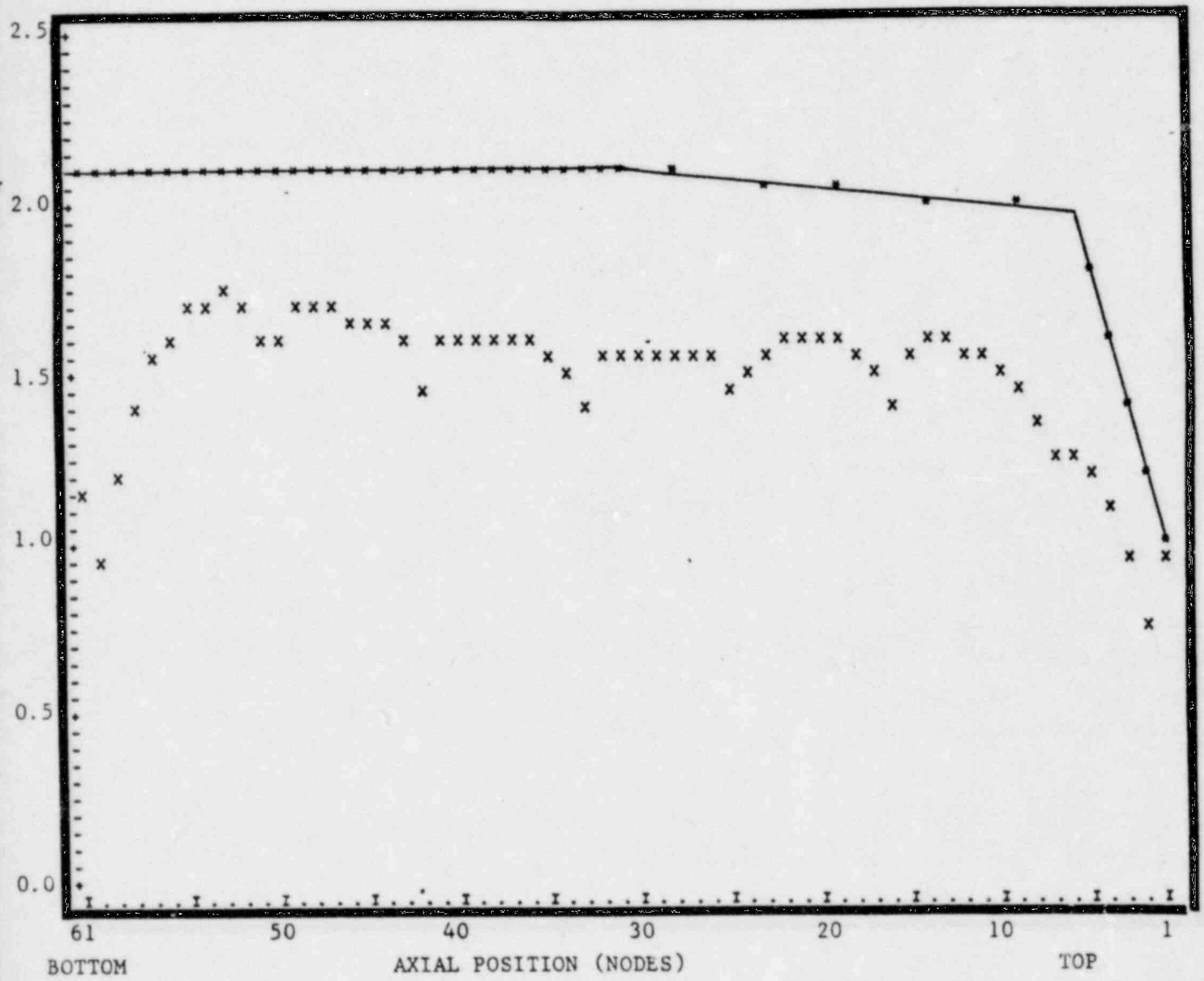


FIGURE 4.8

NORTH ANNA UNIT 1 - CYCLE 3
MAXIMUM HEAT FLUX HOT CHANNEL FACTOR, F-Q VS. BURNUP

- TECH SPEC LIMIT
X MEASURED VALUE

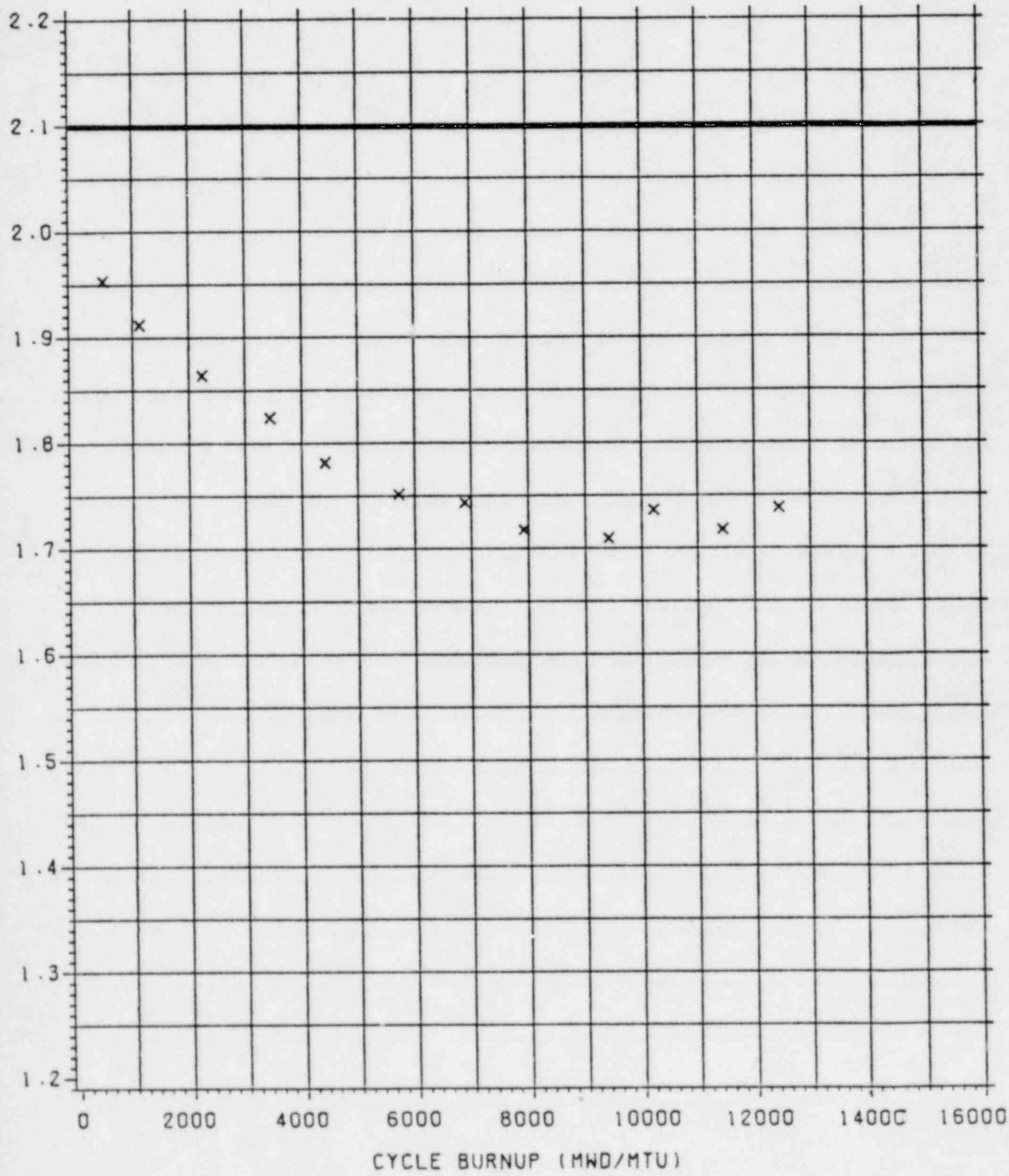


FIGURE 4.9

NORTH ANNA UNIT 1 - CYCLE 3
ENTHALPY RISE HOT CHANNEL FACTOR, F-DH(N) VS. BURNUP

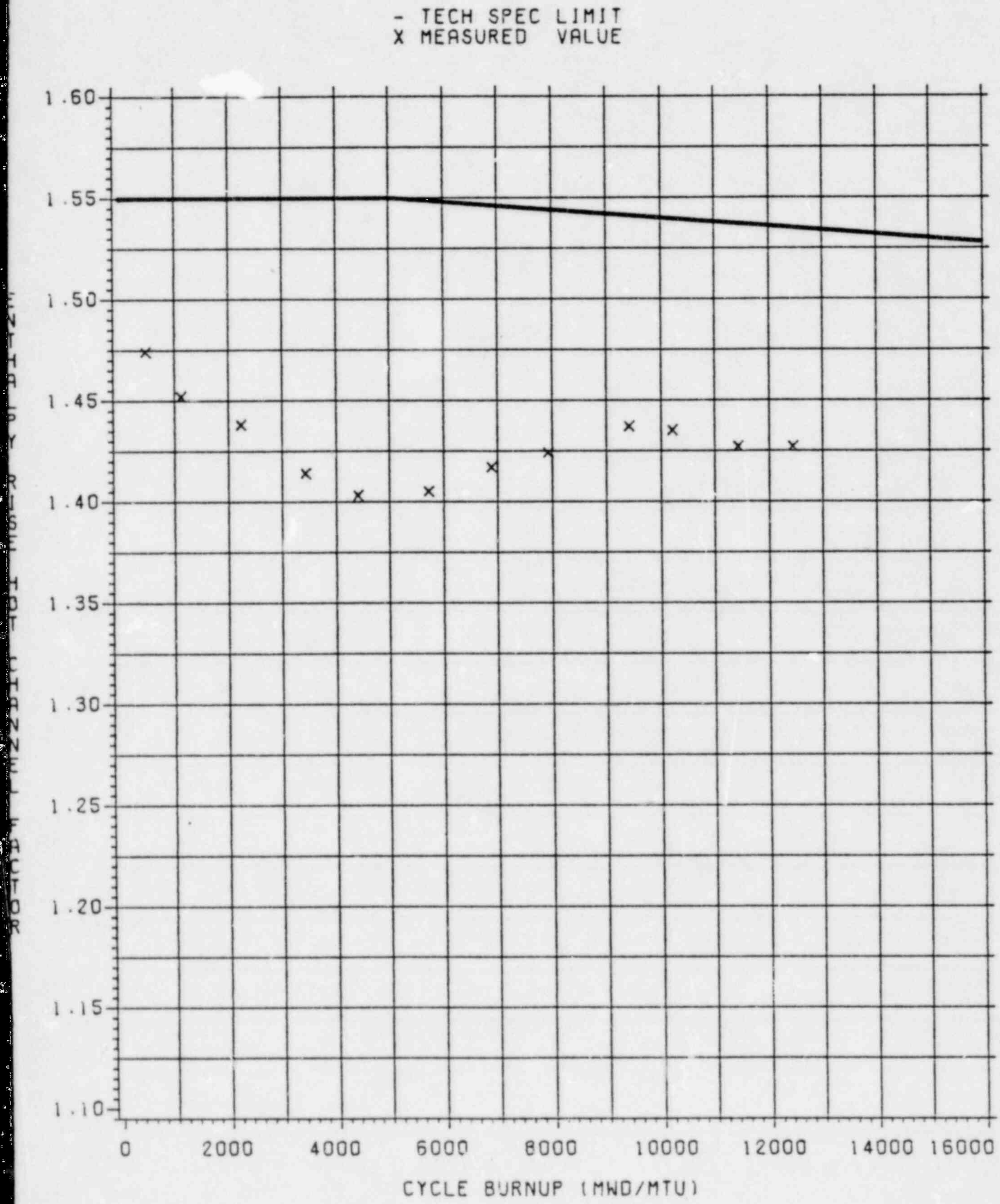
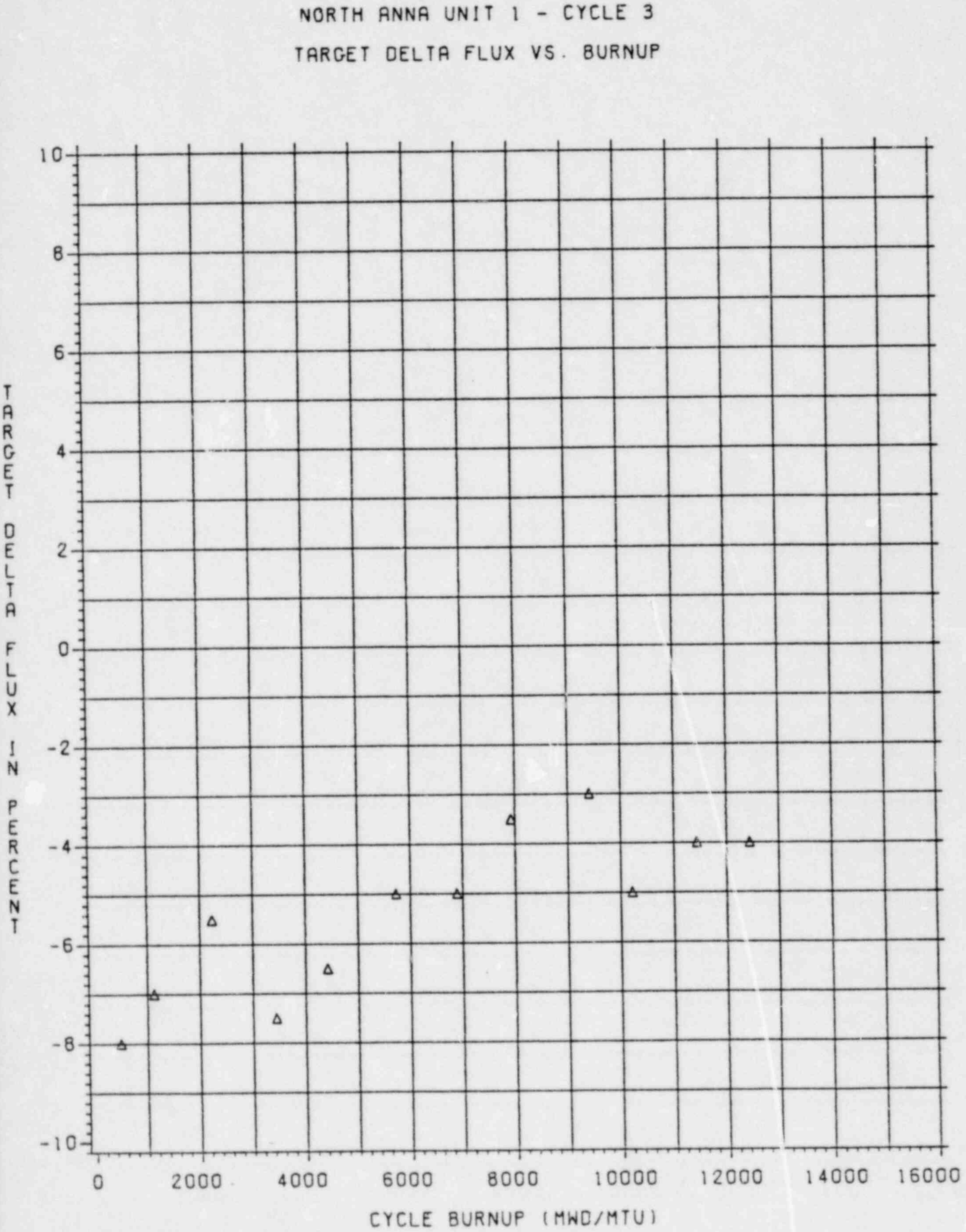


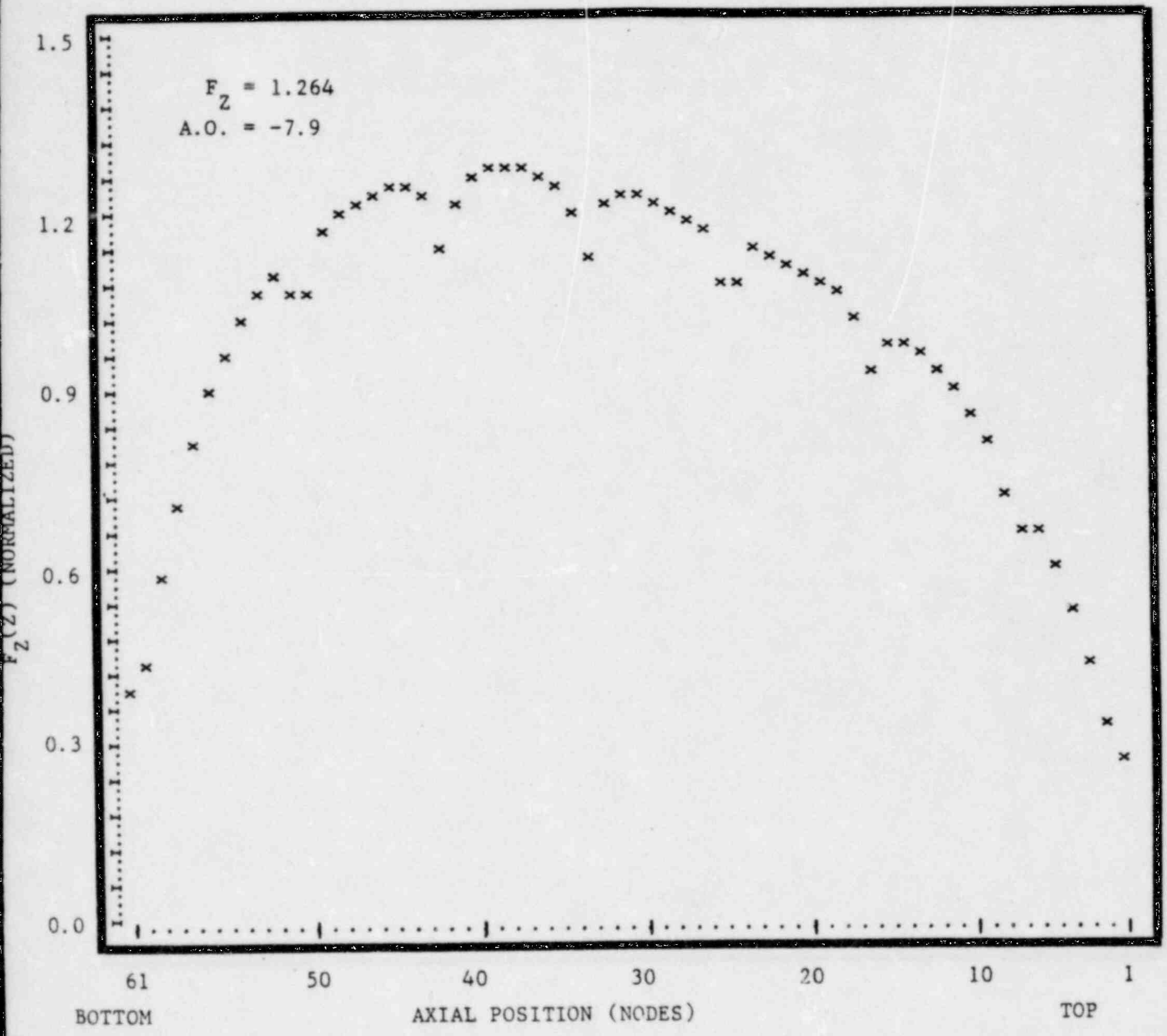
FIGURE 4.10.


NORTH ANNA UNIT 1 - CYCLE 3
TARGET DELTA FLUX VS. BURNUP
10
8
6
4
2
0
-2
-4
-6
-8
-10
TARGET DELTA FLUX IN PERCENT
0
2000
4000
6000
8000
10000
12000
14000
16000
CYCLE BURNUP (MWD/MTU)

NORTH ANNA UNIT 1-CYCLE 3

CORE AVERAGE AXIAL POWER DISTRIBUTION

N1-3-14



NORTH ANNA UNIT 1-CYCLE 3

CORE AVERAGE AXIAL POWER DISTRIBUTION

N1-3-33

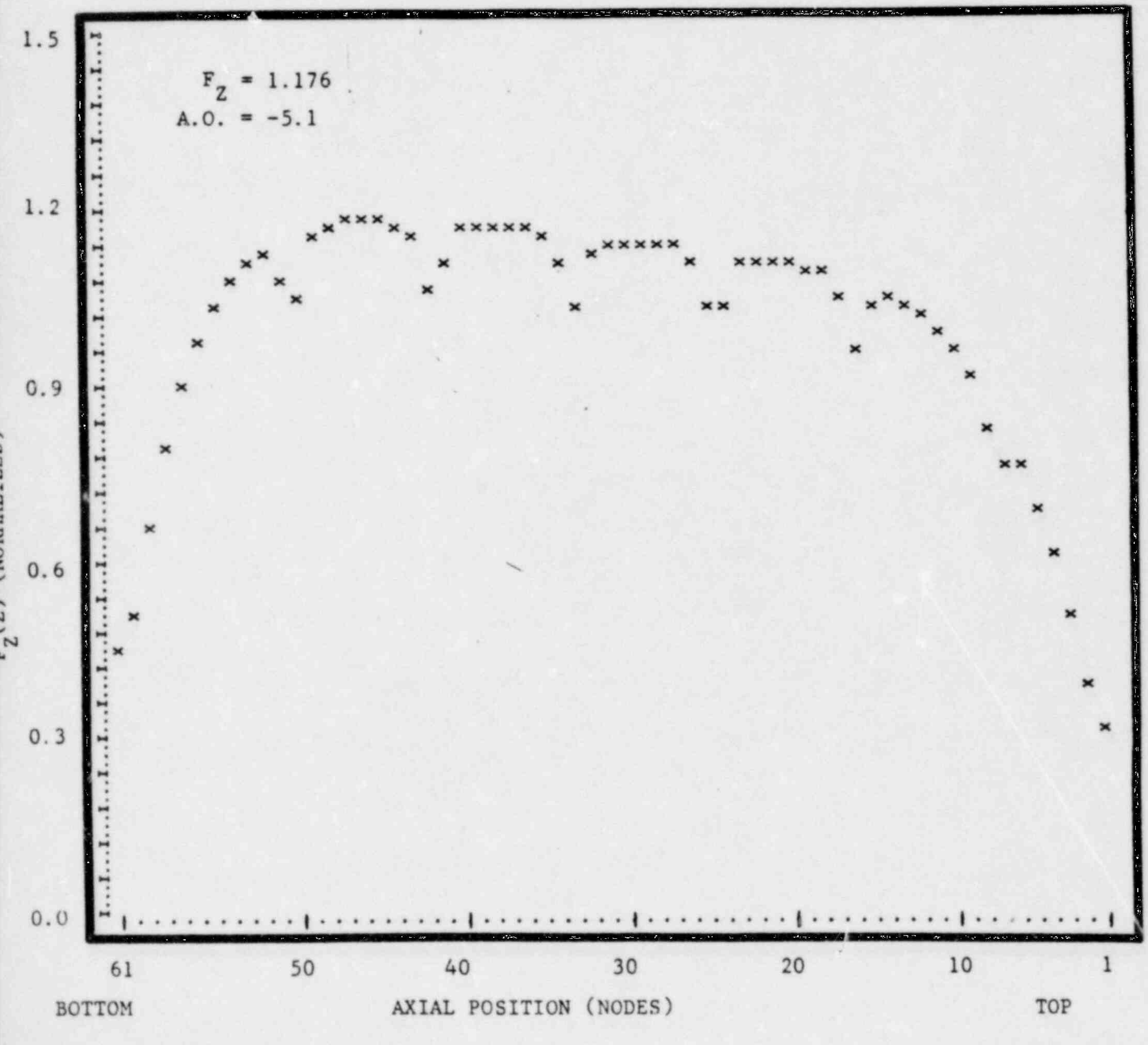


Figure 4.13

NORTH ANNA UNIT 1-CYCLE 3

CORE AVERAGE AXIAL POWER DISTRIBUTION

N1-3-87

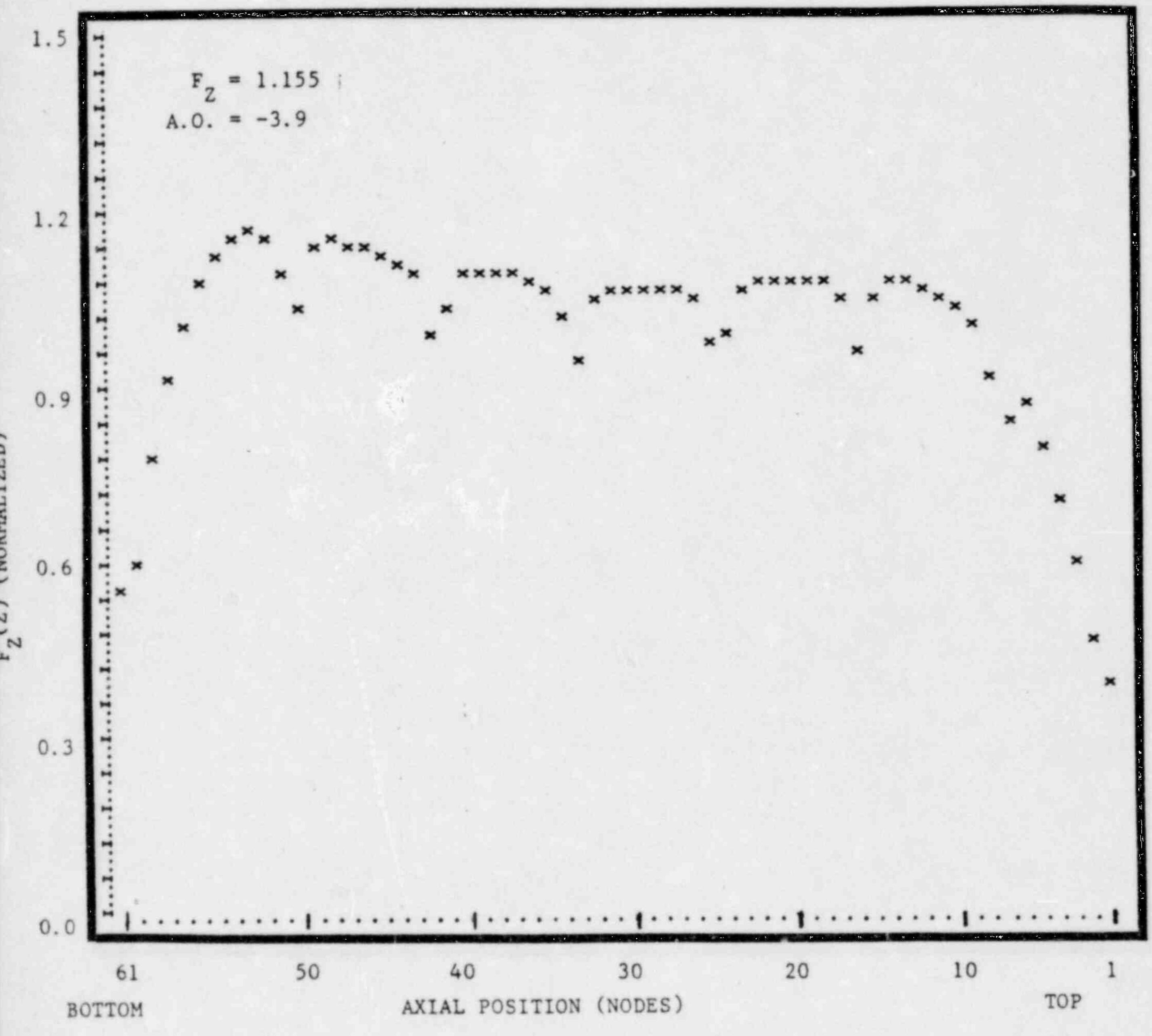
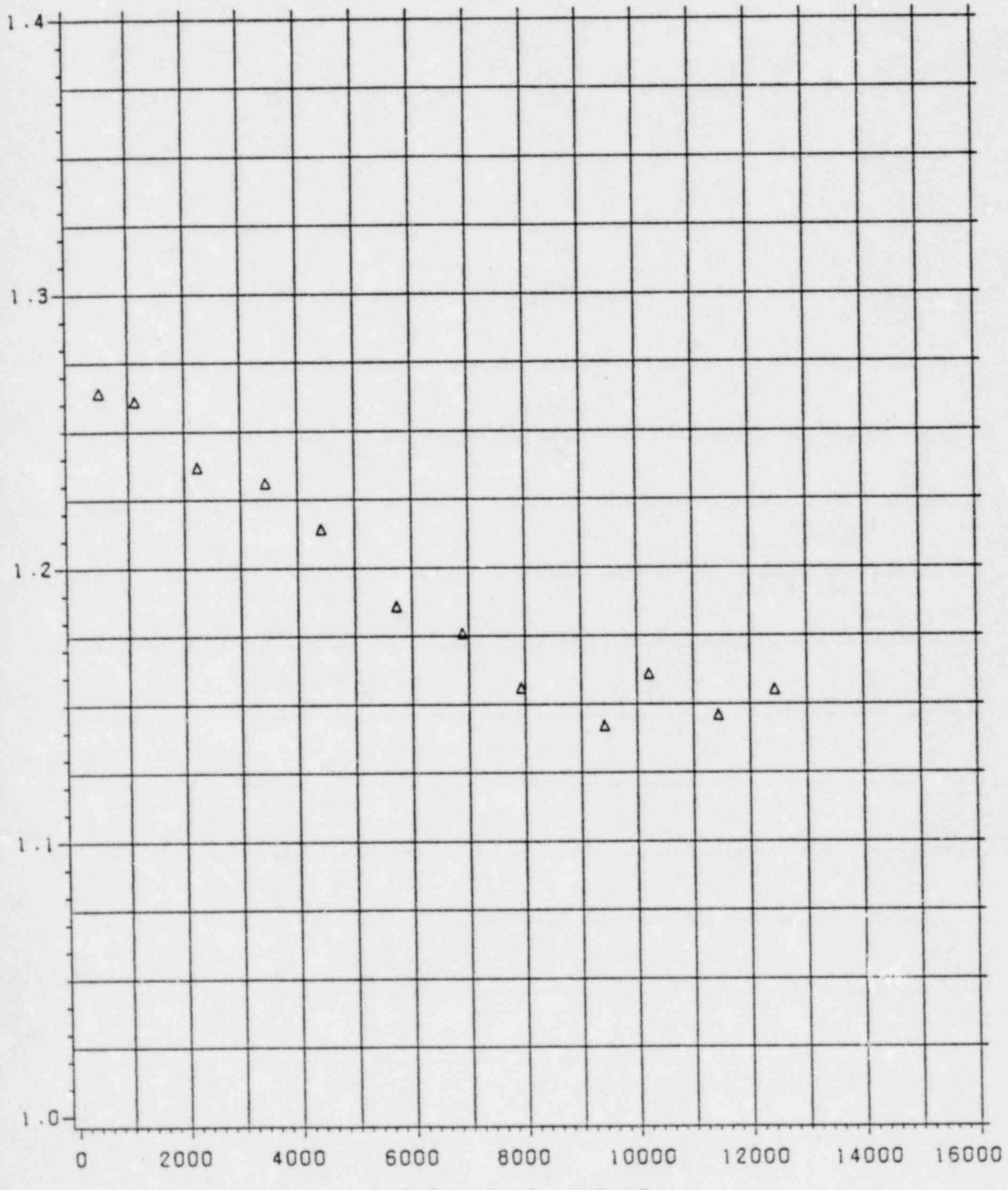


FIGURE 4.14

NORTH ANNA UNIT 1 - CYCLE 3

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 through a breach in the cladding. As indicated in the North Anna 1 Technical Specifications, the dose equivalent I-131 concentration in the primary coolant was limited to 1.0 micro-Ci/gm for normal steady state operation. Figure 5.1 shows the dose equivalent I-131 activity level history for the North Anna 1, Cycle 3 core (the demineralizer flow rate averaged 87 gpm during power operation). The data demonstrate considerable scatter due to the erratic power history but the trend shows a decreasing equilibrium coolant activity level during Cycle 3. The large increase in the coolant activity level that occured early in Cycle 3 indicates a possible defect formation event during the first weeks of Cycle 3 operation. After that time, the equilibrium coolant activity level shows that no further cladding degradation occured during the remainder of the cycle.

Despite the increased coolant activity level, Figure 5.1 shows that the core operated substantially below the 1.0 micro-Ci/gm limit during steady-state operation (the spike data are associated with power transients and unit shutdown). Specifically, the average dose equivalent I-131 concentration of 8.2×10^{-2} micro-Ci/gm is less than 9% of the Technical Specification 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/or "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 North Anna 1, Cycle 3 core. These data generally indicate there were probably pinhole defects in the fuel used during Cycle 3.

The core off-load fuel inspection following Cycle 3 operation revealed no fuel assembly damage which would adversely affect the performance of the fuel to be used in subsequent cycles. The absence of any significant fuel integrity anomalies during the core off-load indicates that satisfactory fuel operability can be expected during Cycle 4.

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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

NORTH ANNA UNIT 1 - CYCLE 3
DOSE EQUIVALENT I-131 vs. TIME

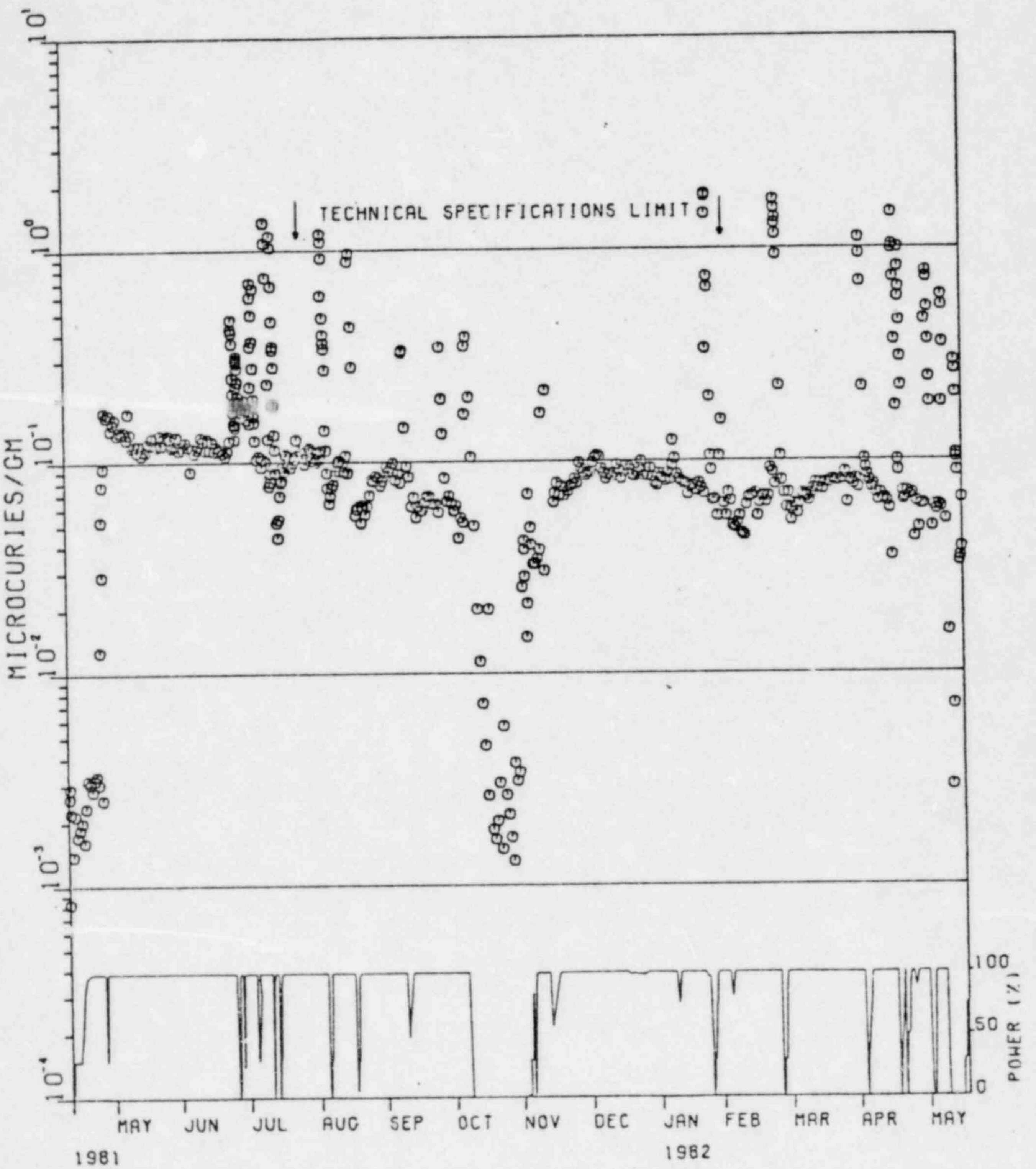
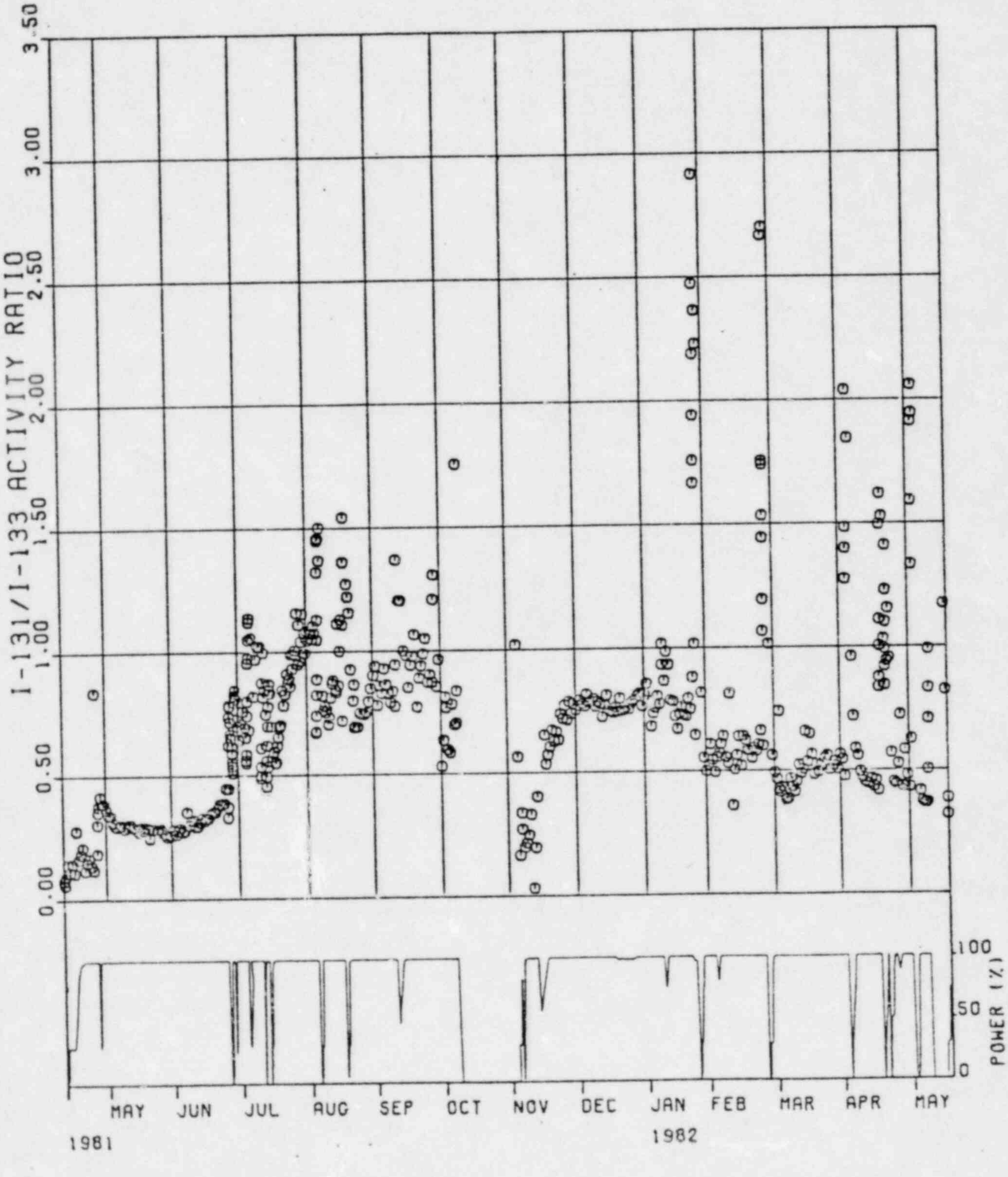


FIGURE 5.2

NORTH ANNA UNIT 1 - CYCLE 3

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



Section 6

CONCLUSIONS

The North Anna 1 core has completed Cycle 3 operation. Throughout this cycle, all core performance indicators compared favorably with the design predictions and all core related Technical Specifications limits were met with significant margin. No abnormalities in reactivity or burnup accumulation were detected. In addition, the mechanical integrity of the fuel has not changed significantly throughout Cycle 3 as indicated by the radioiodine analysis.

Section 7

REFERENCES

1) T. S. Rotella and D. M. Kapuschinsky, "North Anna Unit 1, Cycle 3 Startup Physics Test Report," VEP-FRD-43, May, 1981.

2) North Anna Power Station Unit 1 Technical Specifications, Sections 3/4.1, 3/4.2, and 3/4.4.

3) T. K. Ross, "NEWTOTE Code",Vepco NFO-CCR-6, Revision 3, February, 1982.

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.

6) J. R. Ju and T. S. Rotella, "North Anna Unit 1, Cycle 2 Core Performance Report," VEP-FRD-40, March, 1981.

7) Letter from L. B. Engle (NRC) to R. H. Leasburg (Vepco), dated April 13, 1982 (Docket Nos. 50-338 and 50-339).