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H. B. ROBINSON UNIT 2, CYCLE 11

STARTUP TEST REPORT

BY

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1.0 Introduction and Cycle Description

This report documents the startup test results for Cycle 11 at H. B. Robinson Unit 2. The startup tests are a technical specification requirement performed to verify proper core loading, along with various calculated parameters related to reactor safety and performance. The report is not intended to discuss the detailed startup procedures (refer to Startup Procedure EST-50) or to present the detailed data which are on file at the H. B. Robinson Plant.

Items to be specifically addressed include core design parameters, fuel specifications, startup test results, including boron worth and end points, control rod worth and drop times, moderator temperature coefficients, and power distribution. The report presents a comparison of Exxon Nuclear Company's design predictions to startup measurements.

H. B. Robinson Unit 2 is a three-loop Westinghouse PWR currently in its eleventh cycle of operation at a rated power level of 2,300 MWt. The core consists of 157 (15x15) Exxon fuel assemblies having an initial U-235 enrichment of 3.48 w/o for Region 14, 3.08 w/o for Region 13A, 1.24 w/o for Region 13, 2.85 w/o for Region 12 fuel, and 2.90 w/o for the remainder of the fuel. A total of 40 out of the 48 fresh assemblies inserted at the start of Cycle 11 contain a total of 288 gadolinia pins of 4.00 w/o gadolinia and 96 gadolinia pins of 6.00 w/o gadolinia.

Tables 1.1 and 1.2 contain appropriate core design parameters and fuel specifications, respectively. The Cycle 11 loading pattern is depicted in Figure 1.1 showing assembly identification, exposure, and region number. Each assembly consists of 204 fuel rods, 20 RCC guide tubes, and 1 instrumentation tube. The core contains 45 full-length control rods grouped into 6 banks and are located as depicted in Figure 1.2. Also included in Figure 1.2 are the thimble locations for the movable incore fission detectors.

The Cycle 11 initial criticality was achieved on March 22, 1986. After achieving criticality, period measurements were performed and compared to the indicated startup rates from the reactivity computer (reactimeter), which used the N-44 power range detector for the source signal. Exxon Nuclear Company's six-group delayed neutron fractions and decay constants, which were used by the reactimeter, are depicted in Table 1.3. Period measurements for both positive and negative insertions of reactivity were checked and found to be satisfactory. Following reactimeter checkout, HZP physics tests were commenced in accordance with established startup procedures as outlined in Table 1.4. The results and pertinent acceptance criteria are summarized in Tables 1.5 and 1.6, respectively.

2.0 Control Rod Bank Worth Measurements

Differential and integral control rod bank worths were obtained using the reactimeter in accordance with Startup Procedure EST-50, Appendix D, with the reactor at zero power. With the reactor just critical near the ARO state, the controlling bank was diluted into the core at a fairly constant boron dilution rate. The reactimeter continuously recorded the reactivity change associated with the bank movement and the accompanying boron compensation. The reactimeter trace was used to determine the differential rod worth, defined as the ratio of the change in reactivity to the associated change in bank position. The integral rod worth is simply the cumulative sum of the differential rod worths between selected rod positions. Startup Procedure EST-50 required that the individual worths of Banks D and C be measured in the insertion sequence (not in overlap). The acceptance criteria required that the integral worth of each be within ±15 percent of predicted and that the total integral worth be within ±10 percent. If the above criteria were not met, the worth of the next two banks, B and A, were to be determined. If the total integral worth of D + C + B + A was not within ±10 percent of predicted or the individual integral worths of Control Banks B and A were not within ±15 percent, Shutdown Bank B was to be evaluated. If the corresponding criteria were not met, the worth of Shutdown Bank A and the N-1 worth were to be determined. The N-1 worth must be greater than 95 percent of predicted or PNSC approval is required before power escalation.

Table 1.5 presents a summary of the predicted control rod bank worths and the corresponding worths measured during the startup program. The acceptance criteria were met by Exxon Nuclear Company for D and C measurements; consequently, no other rod banks were measured. Figures 2.1 through 2.4 illustrate the predicted differential and integral rod worth curves together with the measured data points.

3.0 Isothermal Temperature Coefficient Measurements

The isothermal temperature coefficient was measured during zero power physics tests to ensure that the moderator temperature coefficient was less than +5.00 pcm/°F as required by technical specifications. The coefficient was obtained by slow uniform heat-up/cool-down of the primary system and recording the resultant reactivity change (as obtained from the reactimeter) versus temperature (as obtained from the auctioneered T_{avg}) on an X-Y plotter. All measurements were performed below the nuclear heating range to ensure maintaining the moderator and fuel at approximately the same temperature to preclude Doppler feedback. Over the temperature range of interest (530°F to 540°F), the relationship between reactivity and temperature was approximately linear, such that the temperature coefficient could be determined by the ratio of the change in reactivity to the change in temperature ($\Delta\rho/\Delta T$). The average of the heat-up/cool-down coefficients was used to negate the effects of any inadvertent reactivity additions through boron concentration mismatches between the reactor coolant system and pressurizer.

The isothermal temperature coefficent was measured with Control Bank D nearly withdrawn and fully inserted. Table 3.1 gives the predicted and measured isothermal temperature coefficents, while Table 1.5 presents the measured moderator temperature coefficent assuming a Doppler coefficient of -1.66 pcm/°F. Figures 3.1 through 3.4 depict the X-Y recorder traces for the respective measurements.

The technical specification limit on the moderator temperature coefficients being less than +5.00 pcm/°F during power escalation to 50 percent and less than 0.00 pcm/°F at 100 percent power was met by the moderator temperature coefficients being already less than +5.00 pcm/°F negative at the HZP, ARO state; consequently, there was no control rod withdrawal limitations during power escalation. (Power defect and xenon buildup together force the moderator temperature coefficient to be quite negative even before the 30 percent power flux map is taken).

The Cycle 11 moderator temperature coefficient is placed in perspective with previous cycles in Table 3.2. The addition of the burnable poison rods in Cycle 11 once again caused the moderator temperature coefficient to be less than zero at the HZP, ARO state.

4.0 Boron Worth and Endpoint Measurements

Commensurate with dilution and boration of the reactor coolant system, boron samples were acquired approximately every 15 minutes to determine boron reactivity and concentration endpoints at various control bank configurations. For the endpoint measurements, three successive samples were acquired to provide adequate statistics, the average being used for the endpoint concentration. Figure 4.1 depicts the predicted and measured boron endpoints. The 50 ppm acceptance criteria on the ARO endpoint was satisfied by Exxon Nuclear Company. Figure 4.2 is a representation of the boron endpoints showing the measured integrated reactivity versus boron concentration. The slope of the curve is the differential boron worth at HZP.

5.0 Power Distribution

The core power distribution is verified to ensure proper core loading in compliance with technical specification limits relating to hot channel factors, thermal-hydraulic constraints, and power density. The necessary data for this verification is obtained from the INCORE code, which processes the movable in-core detector data. Table 5.1 summarizes the pertinent startup test flux maps - 32.52 percent, 72.38 percent, 89.37 percent, and 94.80 percent power maps being denoted by Map Numbers 498, 499, 505, and 506, respectively. Table 5.2 presents statistics for evaluating the flux map quality. The percent difference between the measured reaction rate and that predicted by Exxon Nuclear Company is less than 5 percent. The HZP map was excluded from the startup procedures for Cycle 11 because of the instabilities noted in the HZP map due to the inadequate signal-to-noise ratio response of in-core detectors. The HZP acceptance criteria applied to previous cycles was met by the 32.52 percent map.

Figures 5.1 through 5.4 depict quarter-core averaged power distributions for the flux maps listed in Table 5.1 The corresponding full-core distributions are included in Appendix A, Figures A-1 through A-4. The agreement between predicted and measured power distributions is good, with a standard deviation of less than 3 percent. Figures 5.5

through 5.10 indicate F_Q^T versus height for the startup test maps; and Figures 5.11 through 5.17, respectively, show maximum F_Q^T, limiting F_Q^T, $F\Delta_H^N$, peak kilowatts/foot, F_{xy}, peak and average F_z, and assembly radial peaking factors. Acceptance criteria were met by all maps.

6.0 Control Rod Drop Times

The control rod drop test (refer to Startup Procedure EST-48) was performed to determine the drop time of each full-length control rod in the cold and hot full-flow conditions. Beginning with all rods in the core, a control bank was selected and pulled to the fully withdrawn position. Each rod of the bank was then dropped individually by physically removing the fuse in the stationary gripper coil current. A trace of the falling rod was obtained on a visicorder from the Linear Voltage Displacement Transmitter output. Using an accompanying AC timing trace, the drop times were determined. Technical specifications require that the rod drop time of each full-length control rod be less than 1.8 seconds at full flow and operating temperature from the beginning of rod motion to dash pot entry. Tables 6.1 and 6.2 summarize the rod drop time results for each control rod in the cold and hot condition, respectively.

7.0 Conclusions

The data obtained during the startup physics test for Cycle 11 indicate good agreement between measured and predicted parameters. The results of the startup tests yield good confidence in Exxon Nuclear Company's design model and our ability to predict Cycle 11 core responses.

REFERENCES

1. "H. B. Robinson Unit 2, Cycle 11 Startup and Operations Report": XN-NF-86-19(P); February 1986; Exxon Nuclear Company, Inc.; Richland, Washington.

TABLE 1.1

H. B. ROBINSON UNIT 2
CORE DESIGN PARAMETERS

	Cycle 10	Cycle 11
Power Rating (MWt)	2,300	2,300
As-Built Zero Burnup Loading (MTU)		
Region 11**	20.70	1.73
Region 12	18.97	17.24
Region 12A	.43	.43
Region 12B	3.46	3.46
Region 13*	3.66	3.66
Region 13A	18.89	18.89
Region 14		20.81
Total	66.11	66.22
System Pressure (psia)	2,250	2,250
Core Average Moderator Temperature at HZP (°F)	547	547
Core Average Moderator Temperature at HZP (°F)	575	575
Core Size		
Equivalent Diameter (Inches)	119.7	119.7
Fuel Pellet Stack Height Cold (Inches)	144.0	144.0
Average Thermal Output (Kilowatts/Foot)	5.98	5.98
Maximum Thermal Output for Normal Operation Based on ECCS Limitation (Kilowatts/Foot)	13.52	13.52
Core Power Density (Kilowatts/Liter)	86.35	86.35
Number of Burnable Poison Rods	348	384

*PLSA lower 36 inches of central 132 inches contains 304 stainless steel.
**Four of the prematurely discharged Region 11 assemblies in Cycle 9 are reinserted.

TABLE 1.2

H. B. ROBINSON UNIT 2, CYCLE 11
FUEL SPECIFICATIONS

Region	Nominal Design	As Loaded	Percent Theoretical Density	Weight Percent U-235 in $UO_2Gd_2O_3$	Pellet O.D. (Inches)	Gas Fill
11	2.90	2.903	94.0	-	0.3565	He
12	2.85	2.850	94.0	-	0.3565	He
12*	2.85	2.850	94.0	2.20	0.3565	He
12**	2.85	2.850	94.0	2.20	0.3565	He
12A***	2.85	2.850	94.0	2.20	0.3565	He
12B	2.85	2.850	94.0	-	0.3565	He
13+	1.24	1.240	94.0	-	0.3565	He
13A	3.12	3.120	94.0	-	0.3565	He
13A**	3.09	3.090	94.0	2.37	0.3565	He
13A***	3.02	3.020	94.0	2.37	0.3565	He
14	3.48	3.480	94.0	-	0.3565	He
14*	3.48	3.480	94.0	2.60	0.3565	He
14**	3.43	3.430	94.0	2.60	0.3565	He
14***	3.41	3.410	94.0	2.60	0.3565	He
14****	3.41	3.410	94.0	2.60	0.3565	He

Fuel Rod Specifications

Fuel Rod O.D. - 0.424
Clad Material - Zircaloy-4
Clad Thickness - 0.0290 Inches

*Fuel with 4 pins of 4.00 w/o gadolinia per assembly.
**Fuel with 8 pins of 4.00 w/o gadolinia per assembly.
***Fuel with 12 pins of 4.00 w/o gadolinia per assembly.
****Fuel with 12 pins of 6.00 w/o gadolinia per assembly.
+PLSA lower 36 inches of central 132 inches contains 304 stainless steel.

TABLE 1.3

H. B. ROBINSON UNIT 2, CYCLE 11
INPUT PARAMETERS TO REACTIVITY COMPUTER†

Prompt Neutron Lifetime, ℓ* = 23.8 μSeconds

Delayed Neutron Importance, I = 0.965

All-Rod-Out - Use for Unrodded Measurements

Precursor Data	I*βi†† Decimal	I*βi†† Octal	λi Decimal	λi Octal
Group 1	0.000198	0.000063717000	0.012542	0.006327636500
Group 2	0.001250	0.000507534100	0.030775	0.017603366400
Group 3	0.001129	0.000447753600	0.117827	0.074247510100
Group 4	0.002418	0.001171672300	0.315995	0.241624143000
Group 5	0.000892	0.000351652100	1.261426	1.205663204000
Group 6	0.000218	0.000071113300	3.460418	3.353567642000
	0.006104			

$\overline{\beta}/\overline{\lambda}$ = 0.077062

Bank D In - Use for Bank D Measurements

Precursor Data	I*βi†† Decimal	I*βi†† Octal	λi Decimal	λi Octal
Group 1	0.000200	0.000064333400	0.012539	0.006327014000
Group 2	0.001256	0.000511201300	0.030776	0.017603574600
Group 3	0.001136	0.000451627200	0.117684	0.074202117000
Group 4	0.002435	0.001176244100	0.315669	0.241476570000
Group 5	0.000896	0.000352703000	1.259497	1.204671452000
Group 6	0.000218	0.000071113360	3.457489	3.352167776000
	0.006141			

$\overline{\beta}/\overline{\lambda}$ = 0.077606

†R. J. Tuttle; "Delayed Neutron Data for Reactor - Physics Analysis: Nuclear Science and Engineering; 1975; Page 56 and Pages 37-71.

††The delayed neutron fractions have been multiplied by the importance factor, I.

TABLE 1.3
(CONTINUED)

Bank (D + C) In - Use for Bank C Measurements

Precursor Data	I*βi†† Decimal	I*βi†† Octal	λi Decimal	λi Octal
Group 1	0.000201	0.000064541600	0.012537	0.006326377500
Group 2	0.001260	0.000512232200	0.030774	0.017603160200
Group 3	0.001139	0.000452452000	0.117592	0.074152023000
Group 4	0.002442	0.001200117500	0.315484	0.241416171600
Group 5	0.000896	0.000352703000	1.258506	1.204265630000
Group 6	0.000218	0.000071113300	3.454382	3.350511410000
	0.006157			

$\overline{\beta/\lambda}$ = 0.077868

Bank (D + C + B) In - Use for Bank B Measurements

Precursor Data	I*βi†† Decimal	I*βi†† Octal	λi Decimal	λi Octal
Group 1	0.000195	0.000063074300	0.012544	0.006330253100
Group 2	0.001239	0.000504627600	0.030767	0.017601304600
Group 3	0.001118	0.000445047300	0.117933	0.074303333200
Group 4	0.002391	0.001162622400	0.316246	0.241725773500
Group 5	0.000883	0.000347362200	1.262442	1.206275461000
Group 6	0.000216	0.000070477000	3.457889	3.352340665000
	0.006042			

$\overline{\beta/\lambda}$ = 0.076288

Bank (D + C + B + A) In - Use for Bank A Measurements

Precursor Data	I*βi†† Decimal	I*βi†† Octal	λi Decimal	λi Octal
Group 1	0.000199	0.000064125200	0.012538	0.006326605600
Group 2	0.001256	0.000511201300	0.030770	0.017602127300
Group 3	0.001134	0.000451212700	0.117627	0.074163154500
Group 4	0.002429	0.001174576600	0.315558	0.241441505600
Group 5	0.000892	0.000351652100	1.258691	1.204346226000
Group 6	0.000217	0.000070705200	3.452700	3.347620455000
	0.006126			

$\overline{\beta/\lambda}$ = 0.077500

††The delayed neutron fractions have been multiplied by the importance factor, I.

TABLE 1.3
(CONTINUED)

Bank (D + C + B + A + SB) In - Use for Bank SB Measurements

Precursor Data	I*βi†† Decimal	I*βi†† Octal	λi Decimal	λi Octal
Group 1	0.000203	0.000065156100	0.012534	0.006325555000
Group 2	0.001267	0.000514105600	0.030775	0.017603366400
Group 3	0.001146	0.000454325400	0.117434	0.074100474500
Group 4	0.002457	0.001204054700	0.315109	0.241253736000
Group 5	0.000898	0.000353317400	1.256165	1.203120074000
Group 6	0.000218	0.000071113300	3.450495	3.346516437000
	0.006413			

$\overline{\beta}/\overline{\lambda}$ = 0.078376

Bank (N-1) In - Use for Bank N-1 Measurements

Precursor Data	I*βi†† Decimal	I*βi†† Octal	λi Decimal	λi Octal
Group 1	0.000203	0.000065156100	0.012533	0.006325346600
Group 2	0.001268	0.000514314000	0.030773	0.017602752100
Group 3	0.001146	0.000454325400	0.117400	0.074067551200
Group 4	0.002460	0.001204677400	0.315042	0.241232275400
Group 5	0.000899	0.000353525500	1.255756	1.202744715000
Group 6	0.000218	0.000071113300	3.449021	3.345714122000
	0.006192			

$\overline{\beta}/\overline{\lambda}$ = 0.078461

††The delayed neutron fractions have been multiplied by the importance factor, I.

Table 1.4

H. B. Robinson Unit 2 - Cycle 11
Startup Physics Test Procedures

Procedure	Number	Revision
Startup Procedure	EST-050	7
Initial Criticality	EST-050, Appendix A	7
Boron Endpoint Measurement	EST-050, Appendix B	7
Moderator Temperature Coefficient	EST-050, Appendix C	7
Control Rod Reactivity Worth Measurement	EST-050, Appendix D	7
Connection of Reactimeter for Startup Physics Test	EST-050, Appendix E	7
Control Rod Drop Test	EST-048	4
Power Distribution Maps	EST-02	5

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TABLE 1.5

H. B. ROBINSON UNIT 2, CYCLE 11
STARTUP TEST SUMMARY

Boron Endpoint (ppm)

Configuration	Measured	Predicted	Difference
ARO	1,249	1,269	-20
D In	1,193	1,193	0
D + C	1,006	1,000	+6

Control Rod Worths (pcm)

Bank	Measured	ENC Predicted	Percent Difference
D	645	665	-3.0
C	1,801 (D Inserted)	1,702	+5.8
C + D	2,446 (In Overlap)	2,367	+3.3

Moderator Temperature Coefficient (pcm/°F)

Configuration	Measured	Predicted	Difference
D at 195	-0.01	+0.7	-0.71
D at 0	-2.63	-1.4	-1.23

Differential Boron Worth (pcm/ppm)

Measured	ENC Predicted	Percent Difference
-11.52	-8.75	-31.7

Power Distribution at HFP

	Measured*	ENC Predicted***	Percent Difference
F_Q^T**	2.08	2.09	-0.48
$F\Delta_H^N$	1.57	1.54	+1.95

*Values at 100 MWD/MT and 89.4 percent power.
**Include V(z) for ±3 percent bands.
***Values at 100 MWD/MT and 100 percent power.

TABLE 1.6

H. B. ROBINSON UNIT 2, CYCLE 11
STARTUP PHYSICS TEST PROCEDURES
ACCEPTANCE CRITERIA

Test	Criteria
Boron Endpoint	ARO boron centration is within ±50 ppm of predicted.
Moderator Temperature Coefficient	a. The HZP temperature coefficient with D-bank inserted is less than +2.0 pcm/°F. (If not, PNSC approval is required.)
	b. The moderator temperature coefficient during power escalation is less than +5.0 pcm/°F from 0 to 50 percent power and decreasing linearly to less than 0.0 pcm/°F at 100 percent power.
Control Rod Worth	a. D and C each are within ±15 percent of the predicted worth.
	b. D + C are within ±10 percent of the predicted total.
	c. If not a and b, include B and A; if still not, include SB.
	d. If not a, b, or c, determine SA and N-1 worth. N-1 worth predicted 95* percent or PNSC approval is required.
Power Distribution Maps*	Power Maps
	a. $F_Q(Z)$ minimum (4.62, 2.32/P) x K(Z), where P = a fraction of 2,300 MWt.
	b. $F\Delta^N_H = 1.65 * \underline{1 + 0.2 (1 - P)}$
	c. Quadrant Tilts = 1.02
Control Rod Drop	The drop time to dashpot under hot conditions = 1.8 seconds.

*The HZP flux map was removed from the startup procedures for Cycle 11.

TABLE 3.1

H. B. ROBINSON UNIT 2, CYCLE 11
ISOTHERMAL TEMPERATURE COEFFICIENT SUMMARY

Configuration		Isothermal Temperature Coefficient (pcm/°F)				
		Measured				
D-Steps	C-Steps	Heat-Up	Cool-Down	Average	ENC Predicted*	Difference From Measured
195	228	-2.34	-1.00	-1.64	-1.0	-0.64
0	217	-5.34	-3.23	-4.29	-3.1	-1.19

TABLE 3.2

H. B. ROBINSON UNIT 2
MEASURED TEMPERATURE COEFFICIENTS

Cycle	All Rods Out Boron (ppm)	All Rods Out Moderator (pcm/°F)	D-Bank In Boron (ppm)	D-Bank In Moderator (pcm/°F)
3	1,297	-0.34	1,220	-1.98
4	1,267	+0.66	1,200	-1.62
5	1,320	+2.79	1,250	+0.66
6	1,278	+3.33	1,194	+0.84
7	1,215	+2.82	1,165	+0.26
8	1,269	+2.38	1,193	+0.27
9	1,094	+1.66	1,032	-1.34
10	1,115	-0.19	1,047	-2.78
11	1,249	-0.01	1,193	-2.63

*-1.66 pcm/°F assumed for the Doppler coefficient.

TABLE 5.1

H. B. ROBINSON UNIT 2, CYCLE 11
FLUX MAP SUMMARY

Map Number	MWD/ MT	Date	PWR %	D-Bank	Core Average AO	Core Average FZ	FΔH	Location FΔH	Kilowatt/ Foot	Limiting FQ	FQ	Location FQ	FR	APL 3% Band	APL 5% Band	FZ	Location FZ
498	10	03/26/86	33	151	-3.39	1.245	1.605	D12	4.11	2.100	2.105	B7	1.378	102.29	99.52	1.693	R9
499	52	03/28/86	72	181	-5.07	1.208	1.568	D12	8.73	1.977	2.009	B7	1.393	108.65	105.71	1.705	G1
505	100	03/31/86	89	211	-1.13	1.156	1.568	E11	10.20	1.922	1.902	L9	1.408	111.77	108.75	1.650	G1
506	190	04/02/86	95	219	-1.64	1.161	1.564	D10	10.92	1.917	1.919	L9	1.407	112.09	109.06	1.638	G15

FQ includes a 1.03 engineering factor and a 1.05 measurement uncertainty.
FΔH includes a 1.04 measurement uncertainty.
Kilowatt/Foot includes a 1.03 engineering factor and a 1.05 measurement uncertainty.
* indicates that the map was analyzed with quarter-core symmetry.

Map Number	Quadrant Tilt NW	NE	SW	SE	Power Fraction 14	13A	12A	12B	13	12	Standard Deviation 14	13A	12A	12B	13	12
498	1.005	0.999	1.002	0.995	1.069	1.231	0.817	1.260	0.219	0.863	3.224	2.440	5.316	1.918	3.381	2.692
499	1.002	0.999	1.003	0.997	1.052	1.237	0.926	1.230	0.212	0.880	2.230	1.572	1.636	2.150	2.316	1.757
505	0.997	0.999	0.998	1.005	1.035	1.241	1.057	1.216	0.212	0.895	2.772	1.576	2.105	1.597	2.558	2.467
506	1.000	1.003	0.997	1.001	1.034	1.241	1.059	1.213	0.212	0.896	2.557	1.441	2.306	1.358	2.275	2.151

TABLE 5.2

H. B. ROBINSON UNIT 2, CYCLE 11
FLUX MAP THIMBLE STATISTICS

Map Number	Number of Good Thimbles	Number of Bad/Missing Thimbles	Reaction Rate Percent Difference*
498	40	2/8	4.89
499	40	2/0	4.58
505	45	0/2	3.36
506	44	0/3	3.69

*Only includes the high enriched region.

TABLE 6.1

H. B. ROBINSON UNIT 2, CYCLE 11
COLD CONTROL ROD DROP TIMES

RCCA Band Number	RCCA Grid Location	Drop Time to Dash Pot (t_1) (Seconds)	Dash Pot to Rod Bottom Time (t_2) (Seconds)	Total Drop Time ($t_1 + t_2$) (Seconds)	RCS Tavg (°F)	RCS Flow (Percent)	RCS Pressure (psig)
SDA	G-3	1.34	.58	1.92	136	120% B&C	350
	C-9	1.37	.63	2.00	136	120% B&C	350
	J-13	1.35	.63	1.98	136	120% B&C	350
	N-7	1.32	.63	1.95	136	120% B&C	350
	J-3	1.40	.63	2.03	136	120% B&C	350
	C-7	1.34	.63	1.97	136	120% B&C	350
	G-13	1.29	.61	1.90	136	120% B&C	350
	N-9	1.39	.61	2.00	136	120% B&C	350
SDB	E-5	1.40	.66	2.06	136	120% B&C	350
	E-11	1.38	.61	1.99	136	120% B&C	350
	L-11	1.30	.62	1.92	136	120% B&C	350
	L-5	1.40	.66	2.06	136	120% B&C	350
	H-6	1.29	.61	1.90	136	120% B&C	350
	F-8	1.35	.63	1.98	136	120% B&C	350
	H-10	1.34	.62	1.96	136	120% B&C	350
	K-8	1.37	.64	2.01	136	120% B&C	350
CA	G-5	1.33	.61	1.94	136	120% B&C	350
	E-9	1.31	.60	1.91	136	120% B&C	350
	J-11	1.38	.62	2.00	136	120% B&C	350
	L-7	1.33	.59	1.92	136	120% B&C	350
	J-5	1.38	.60	1.98	136	120% B&C	350
	E-7	1.28	.62	1.90	136	120% B&C	350
	G-11	1.33	.59	1.92	136	120% B&C	350
	L-9	1.27	.63	1.90	136	120% B&C	350
CB	F-2	1.34	.63	1.97	136	120% B&C	350
	B-10	1.37	.62	1.99	136	120% B&C	350
	K-14	1.48	.72	2.20	136	120% B&C	350
	P-6	1.23	.64	1.87	136	120% B&C	350
	K-2	1.35	.68	2.03	136	120% B&C	350
	B-6	1.33	.59	1.92	136	120% B&C	350
	F-14	1.28	.63	1.91	136	120% B&C	350
	P-10	1.34	.63	1.97	136	120% B&C	350

TABLE 6.1
(CONTINUED)

RCCA Band Number	RCCA Grid Location	Drop Time to Dash Pot (t_1) (Seconds)	Dash Pot to Rod Bottom Time (t_2) (Seconds)	Total Drop Time ($t_1 + t_2$) (Seconds)	RCS Tavg (°F)	RCS Flow (Percent)	RCS Pressure (psig)
CC	F-4	1.29	.61	1.90	136	120% B&C	350
	D-10	1.38	.66	2.04	136	120% B&C	350
	K-12	1.28	.62	1.90	136	120% B&C	350
	M-6	1.33	.61	1.94	136	120% B&C	350
	K-4	1.24	.58	1.82	136	120% B&C	350
	D-6	1.26	.66	1.92	136	120% B&C	350
	F-12	1.31	.60	1.91	136	120% B&C	350
	M-10	1.30	.61	1.91	136	120% B&C	350
CD	D-8	1.29	.61	1.90	136	120% B&C	350
	M-8	1.40	.70	2.10	136	120% B&C	350
	H-4	1.28	.65	1.93	136	120% B&C	350
	H-12	1.32	.61	1.93	136	120% B&C	350
	H-8	1.37	.59	1.96	136	120% B&C	350

TABLE 6.2

H. B. ROBINSON UNIT 2, CYCLE 11
HOT CONTROL ROD DROP TIMES

RCCA Band Number	RCCA Grid Location	Drop Time to Dash Pot (t_1) (Seconds)	Dash Pot to Rod Bottom Time (t_2) (Seconds)	Total Drop Time ($t_1 + t_2$) (Seconds)	RCS Tavg (°F)	RCS Flow (Percent)	RCS Pressure (psig)
SDA	G-3	1.27	.53	1.80	543	100	2,235
	C-9	1.35	.55	1.90	543	100	2,235
	J-13	1.25	.56	1.81	543	100	2,235
	N-7	1.25	.57	1.82	543	100	2,235
	J-3	1.35	.55	1.90	543	100	2,235
	C-7	1.26	.58	1.84	543	100	2,235
	G-13	1.27	.52	1.79	543	100	2,235
	N-9	1.28	.56	1.84	540	100	2,235
SDB	E-5	1.37	.56	1.93	540	100	2,235
	E-11	1.38	.53	1.91	540	100	2,235
	L-11	1.77	.55	1.82	540	100	2,235
	L-5	1.39	.60	1.99	540	100	2,235
	H-6	1.30	.53	1.83	541	100	2,235
	F-8	1.39	.53	1.92	541	100	2,235
	H-10	1.37	.55	1.92	541	100	2,235
	K-8	1.38	.59	1.97	541	100	2,235
CA	G-5	1.29	.51	1.80	540	100	2,235
	E-9	1.34	.51	1.85	540	100	2,235
	J-11	1.39	.52	1.91	540	100	2,235
	L-7	1.28	.54	1.82	540	100	2,235
	J-5	1.44	.51	1.95	540	100	2,235
	E-7	1.30	.55	1.85	540	100	2,235
	G-11	1.38	.51	1.89	540	100	2,235
	L-9	1.32	.59	1.91	540	100	2,235
CB	F-2	1.32	.51	1.83	543	100	2,235
	B-10	1.40	.54	1.94	543	100	2,235
	K-14	1.46	.57	2.03	543	100	2,235
	P-6	1.30	.53	1.83	543	100	2,235
	K-2	1.38	.62	2.00	543	100	2,235
	B-6	1.34	.57	1.91	543	100	2,235
	F-14	1.33	.54	1.87	542	100	2,235
	P-10	1.32	.52	1.84	542	100	2,235

TABLE 6.2
(CONTINUED)

RCCA Band Number	RCCA Grid Location	Drop Time to Dash Pot (t_1) (Seconds)	Dash Pot to Rod Bottom Time (t_2) (Seconds)	Total Drop Time ($t_1 + t_2$) (Seconds)	RCS Tavg (°F)	RCS Flow (Percent)	RCS Pressure (psig)
CC	F-4	1.30	.51	1.81	545	100	2,235
	D-10	1.41	.55	1.96	545	100	2,235
	K-12	1.28	.53	1.81	545	100	2,235
	M-6	1.39	.53	1.92	545	100	2,235
	K-4	1.28	.51	1.79	545	100	2,235
	D-6	1.27	.59	1.86	545	100	2,235
	F-12	1.37	.51	1.88	541	100	2,235
	M-10	1.28	.54	1.82	542	100	2,235
CD	D-8	1.34	.51	1.85	540	100	2,235
	M-8	1.41	.72	2.13	540	100	2,235
	H-4	1.32	.56	1.88	540	100	2,235
	H-12	1.32	.52	1.84	540	100	2,235
	H-8	1.42	.50	1.92	540	100	2,235

Figure 1.1

H. B. ROBINSON UNIT 2 CYCLE 11

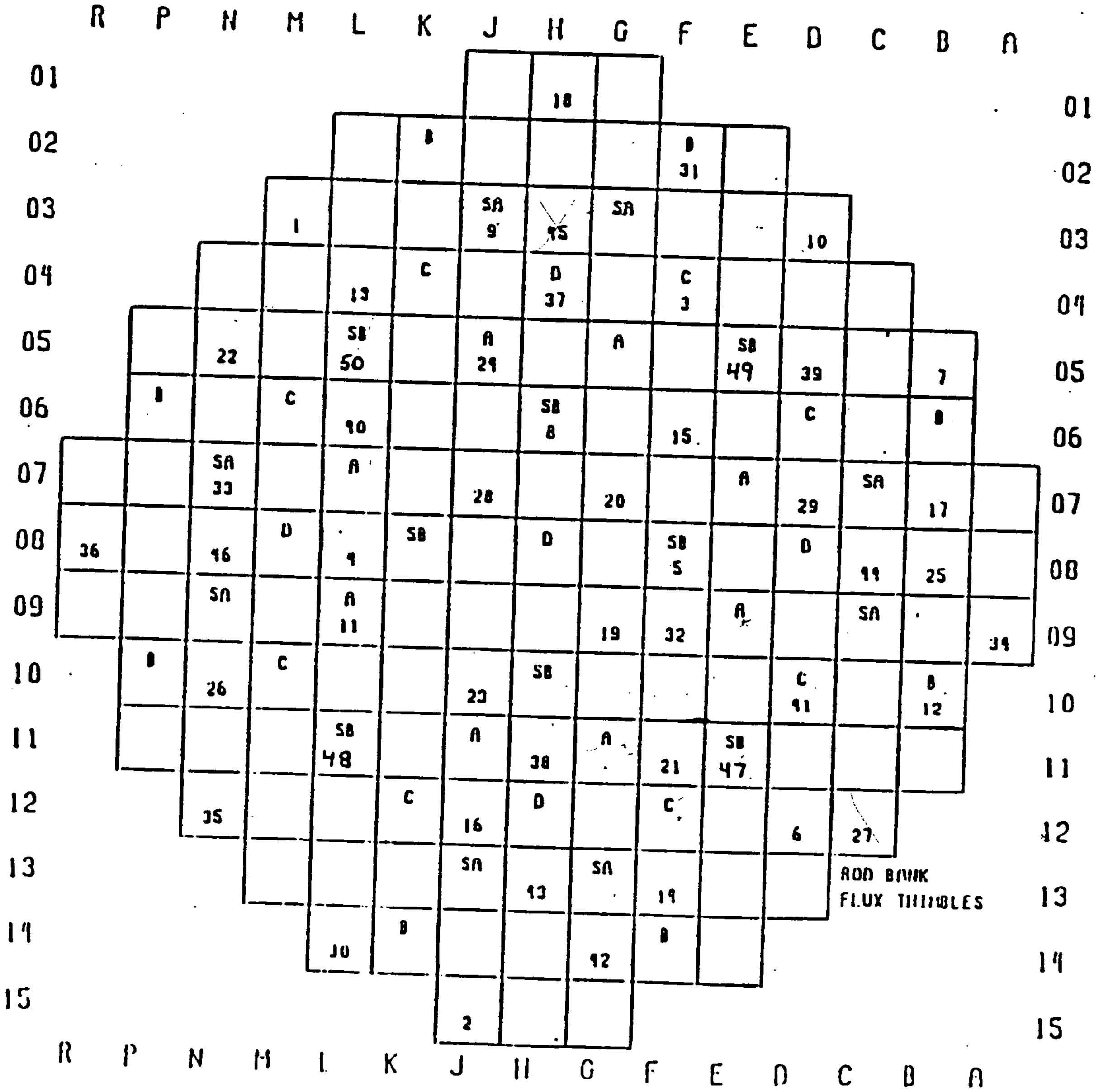
LOADING PATTERN

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
01							N47 3877 5.00	N51 4816 5.00	N55 3861 5.00							01
02					P01 0 1.00	F33 0 1.00	P41 0 1.00	N19 13800 2.00	P42 0 1.00	P34 0 1.00	P02 0 1.00					02
03				M48 24067 6.00	P20 0 1.00	N09 14342 2.00	M01 20826 6.00	P30 0 1.00	M02 20915 6.00	N10 14702 2.00	P21 0 1.00	M17 25667 6.00				03
04			M26 25036 6.00	P14 0 1.00	M20 10153 4.00	N43 12482 2.00	N23 12079 2.00	M35 23520 6.00	N31 12351 2.00	N44 12051 2.00	M21 9890 4.00	P15 0 1.00	M49 24371 6.00			04
05		F05 0 1.00	P10 0 1.00	M24 10155 4.00	N37 12654 2.00	L36 23658 7.00	N03 7947 2.00	M34 23099 6.00	N04 7583 2.00	L35 23648 7.00	N38 12905 2.00	M25 10606 4.00	P11 0 1.00	P06 0 1.00		05
06		P37 0 1.00	N13 13836 2.00	N36 12689 2.00	M11 21446 6.00	P26 0 1.00	M43 22558 6.00	P17 0 1.00	M44 22510 6.00	P25 0 1.00	M12 21754 6.00	N36 12980 2.00	N14 14608 2.00	P38 0 1.00		06
07	N54 3955 5.00	P45 0 1.00	M13 20759 6.00	N30 12174 2.00	N07 7954 2.00	M52 22944 6.00	M32 24496 6.00	N27 12706 2.00	M31 24684 6.00	M45 22852 6.00	N08 8190 2.00	N24 12656 2.00	M14 20341 6.00	P46 0 1.00	N48 4161 5.00	07
08	N50 4805 5.00	N18 14366 2.00	P28 0 1.00	M39 22724 6.00	M38 23350 6.00	P16 0 1.00	N26 12495 2.00	M53 14093 3.00	N28 12965 2.00	P18 0 1.00	M40 22597 6.00	M37 23268 6.00	P29 0 1.00	N20 13783 2.00	N52 5042 5.00	08
09	N46 3870 5.00	P48 0 1.00	M16 21024 6.00	N22 11942 2.00	N06 7647 2.00	M51 22488 6.00	M30 24698 6.00	N25 13183 2.00	M29 24401 6.00	M46 22712 6.00	N05 7750 2.00	N32 12382 2.00	M15 20699 6.00	P47 0 1.00	N56 4006 5.00	09
10		P40 0 1.00	N16 14585 2.00	N34 12321 2.00	M10 21571 6.00	P31 0 1.00	M42 22858 6.00	P19 0 1.00	M41 23165 6.00	P27 0 1.00	M09 21015 6.00	N33 12314 2.00	N15 14315 2.00	P39 0 1.00		10
11		F08 0 1.00	P09 0 1.00	M23 9856 4.00	N40 12924 2.00	L12 23561 7.00	N02 8035 2.00	M36 23217 6.00	N01 8272 2.00	L42 23678 7.00	N39 12346 2.00	M22 10109 4.00	P24 0 1.00	P07 0 1.00		11
12			M47 24217 6.00	P13 0 1.00	M19 10316 4.00	N42 12860 2.00	N29 12559 2.00	M33 22739 6.00	N21 12579 2.00	N41 12715 2.00	M18 10362 4.00	P12 0 1.00	M27 25496 6.00			12
13				M28 25212 6.00	P23 0 1.00	N12 14348 2.00	M04 20513 6.00	P32 0 1.00	M03 20740 6.00	N11 13745 2.00	P22 0 1.00	M50 21514 6.00	ASSEMBLY ID BOC EXPOSURE REGION NUMBER			13
14					F04 0 1.00	P36 0 1.00	P44 0 1.00	N17 14492 2.00	P43 0 1.00	P35 0 1.00	P03 0 1.00					14
15							N53 4057 5.00	N49 5093 5.00	N45 4061 5.00							15
	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	

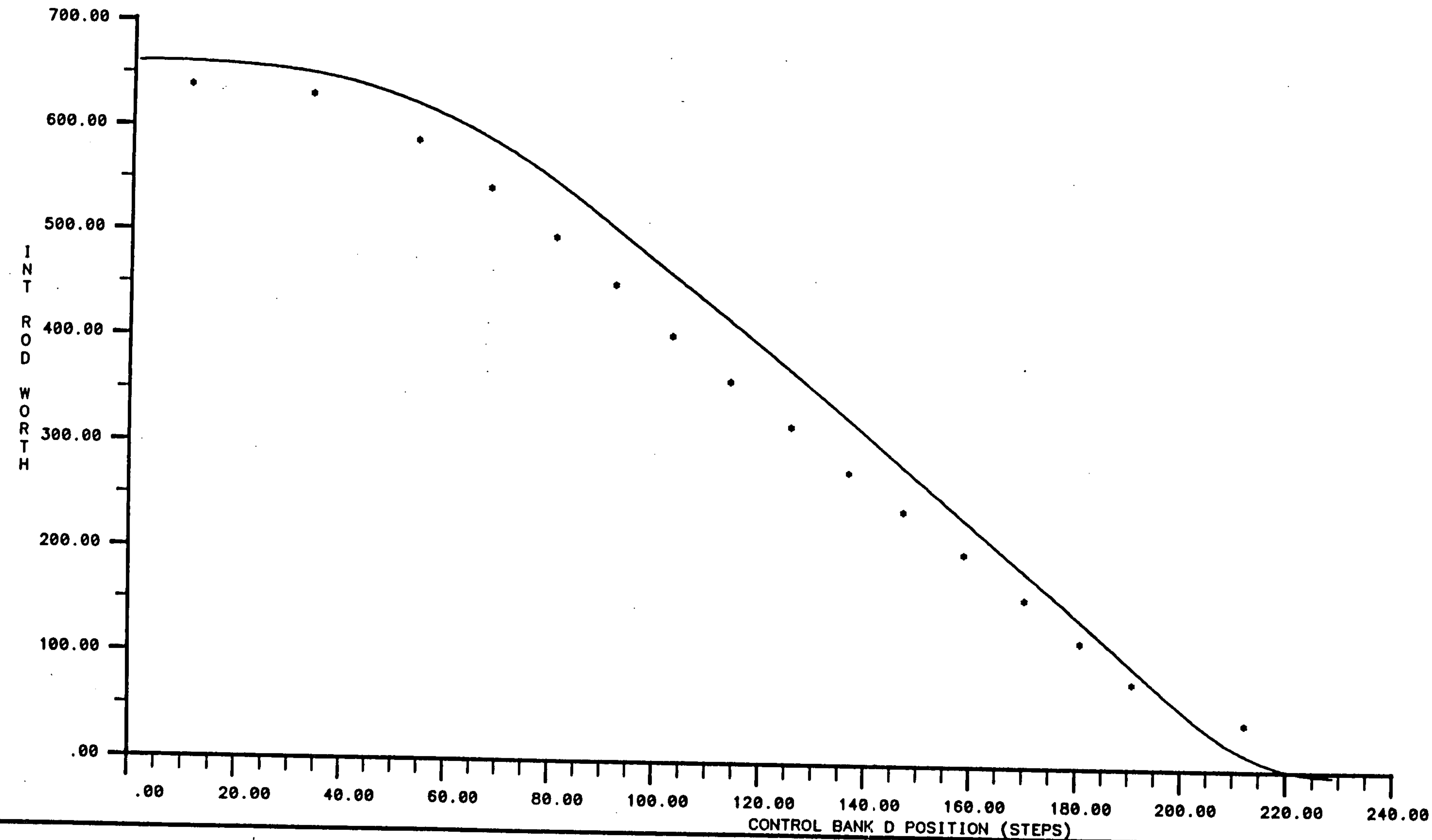
Figure 1.2

H. B. ROBINSON UNIT 2 -- CYCLE II

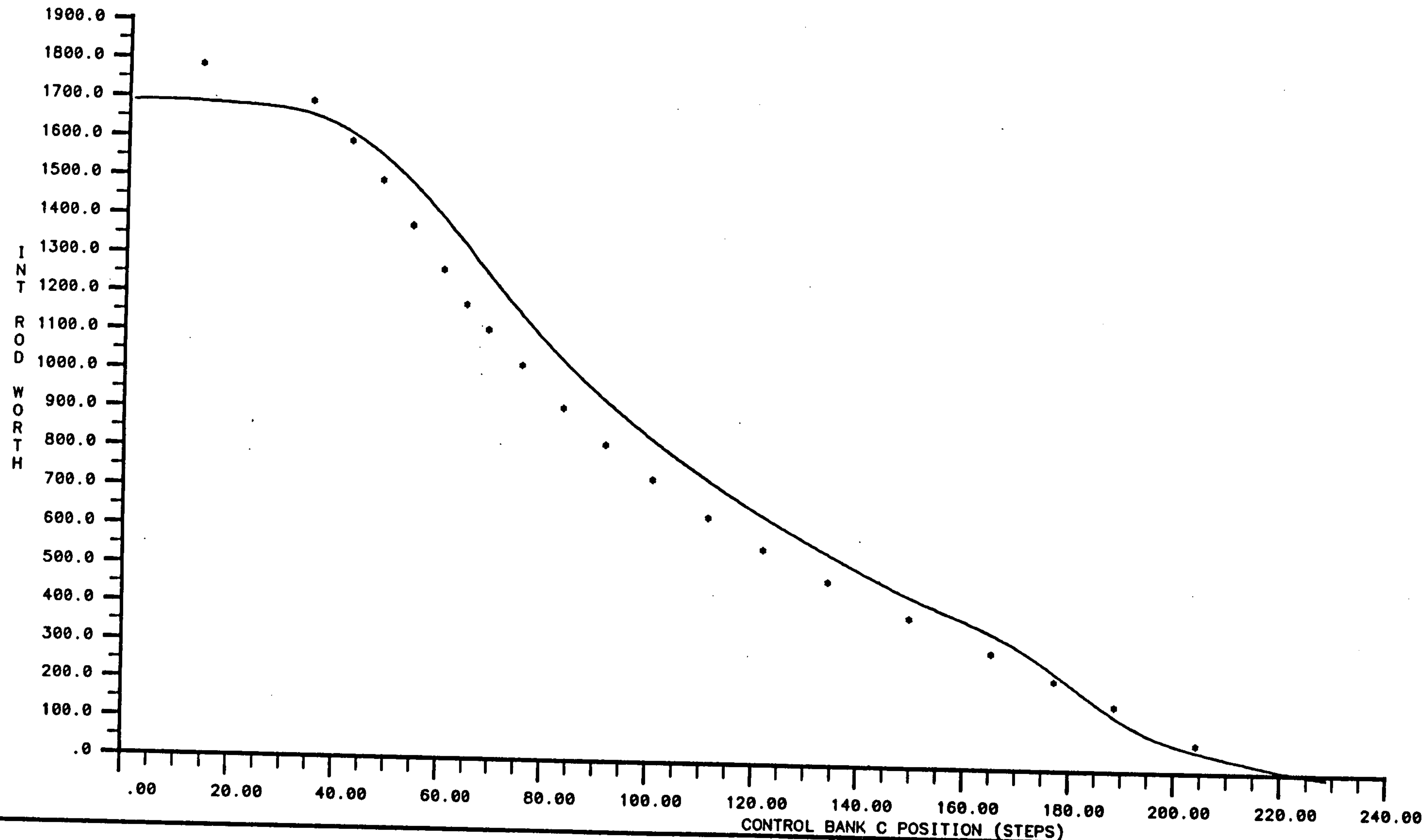
CONTROL ROD AND FLUX THIMBLE LOCATIONS



Code Version: EXXON XTG Run Date: 06/07/86 Resp. Engineer: JOSE GARCIA	H. B. ROBINSON UNIT 2 CYCLE 11 CONTROL BANK D INTEGRAL ROD WORTH (PCM) FIGURE 2.1	—— = XTG PREDICTION • = MEASURED



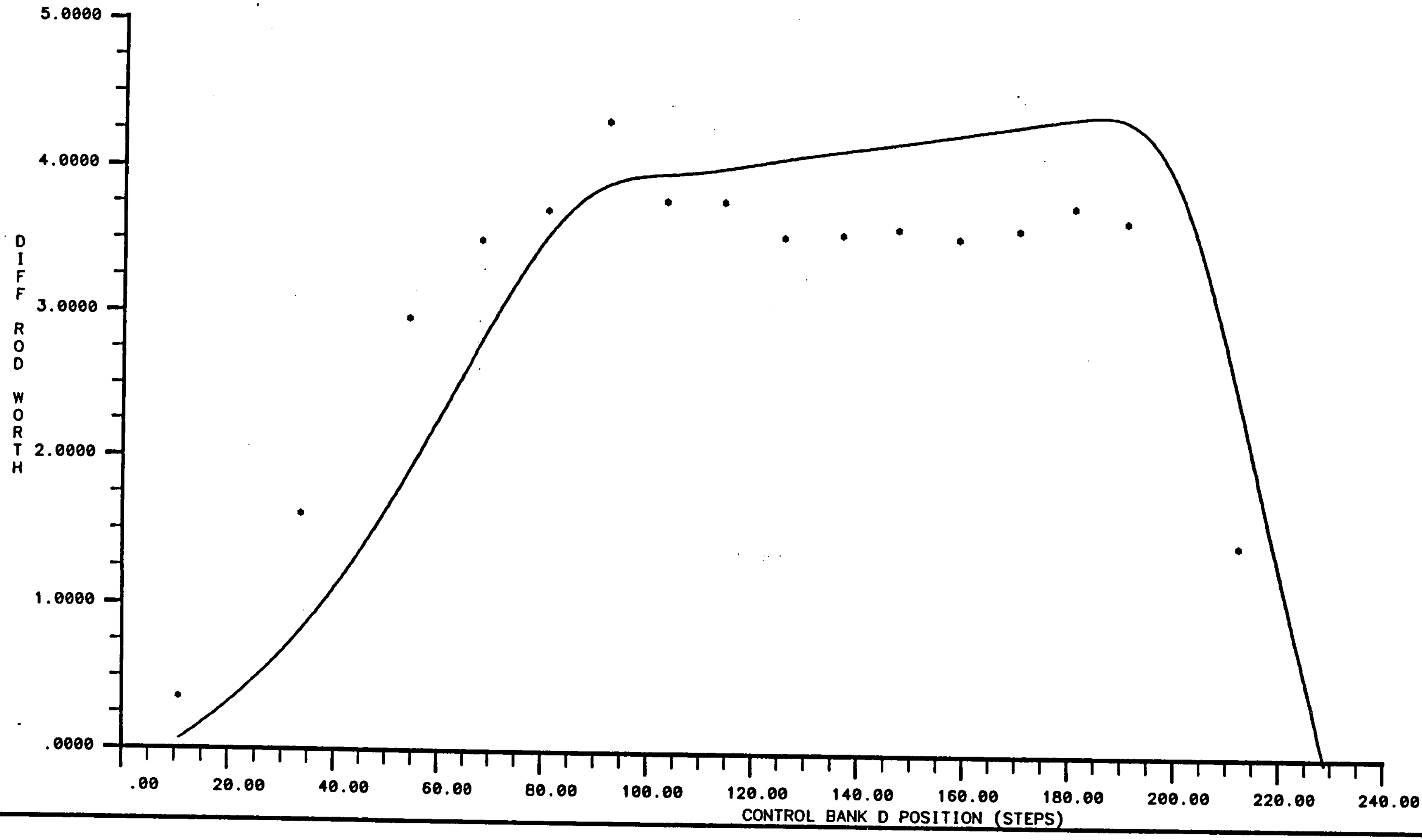
Code Version: EXXON XTG Run Date: 06/07/86 Resp. Engineer: JOSE GARCIA	H. B. ROBINSON UNIT 2 CYCLE 11 CONTROL BANK C INTEGRAL ROD WORTH (PCM) FIGURE 2.2	—— = XTG PREDICTION • = MEASURED



Code Version: EXXON XTG
Run Date: 06/07/86
Resp. Engineer: JOSE GARCIA

H. B. ROBINSON UNIT 2 CYCLE 11
BANK D DIFFERENTIAL ROD WORTH (PCM)
FIGURE 2.3

——— = XTG PREDICTION
• = MEASURED



Code Version:	EXXON XTG
Run Date:	06/07/86
Resp. Engineer:	JOSE GARCIA

H. B. ROBINSON UNIT 2 CYCLE 11
BANK C DIFFERENTIAL ROD WORTH (PCM)
FIGURE 2.4

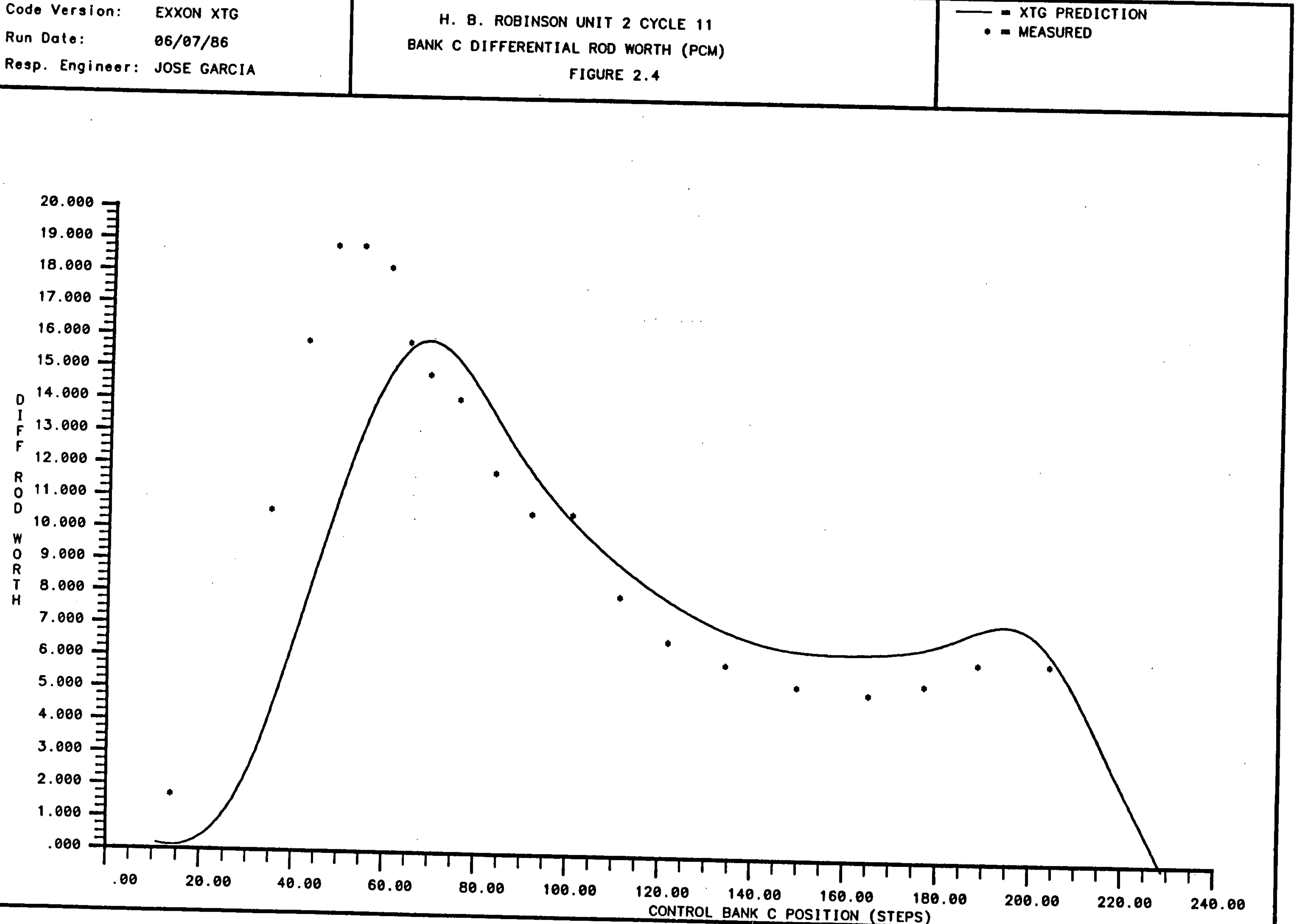


Figure 3.1

H. B. Robinson Unit 2, Cycle 11

Isothermal Temperature Coefficient

Cool Down

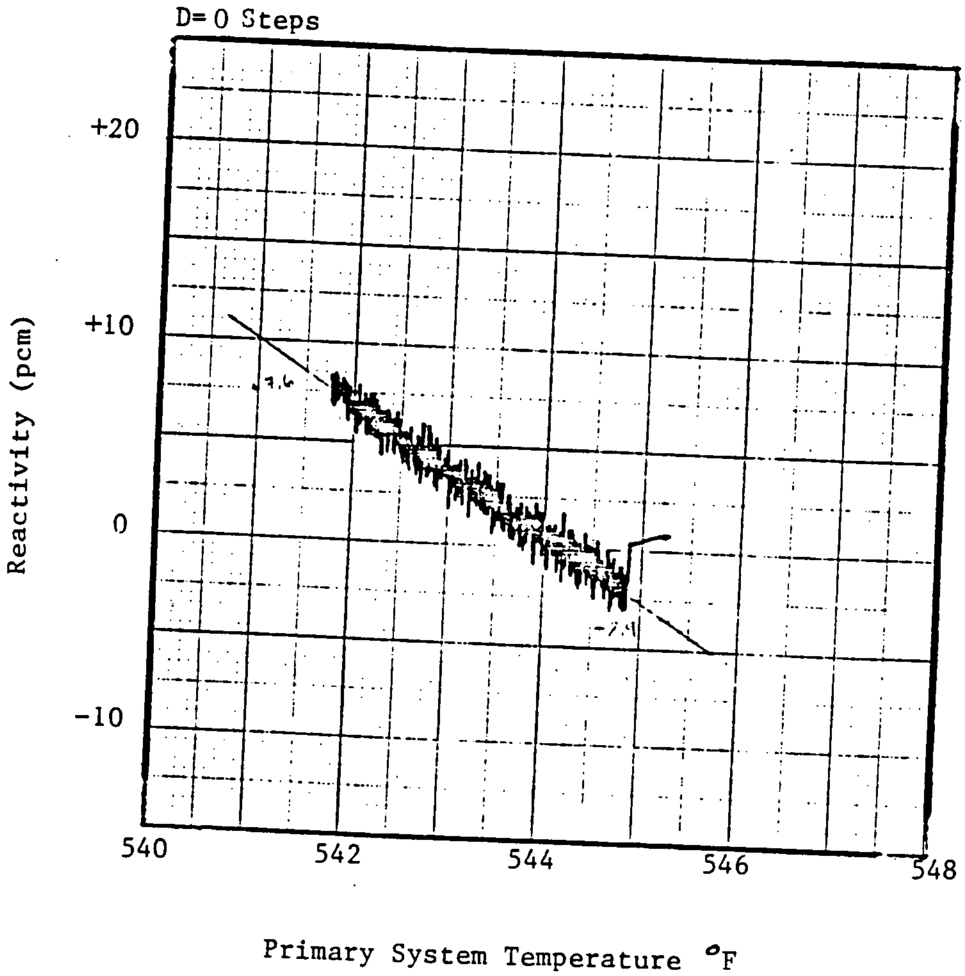


Figure 3.2

H. B. Robinson Unit 2, Cycle 11

Isothermal Temperature Coefficient

Heat-Up

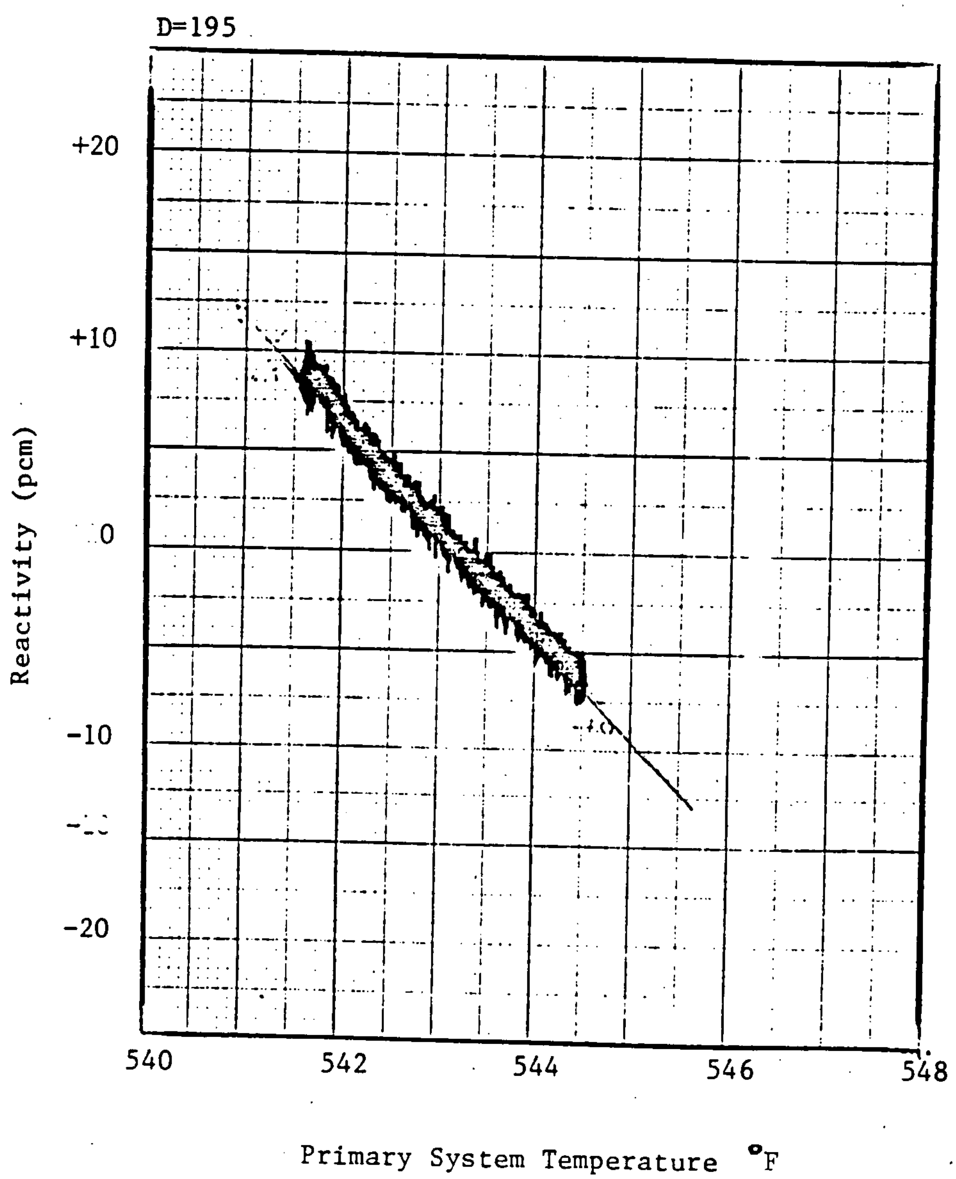


Figure 3.3

H. B. Robinson Unit 2, Cycle 11

Isothermal Temperature Coefficient

Cool Down

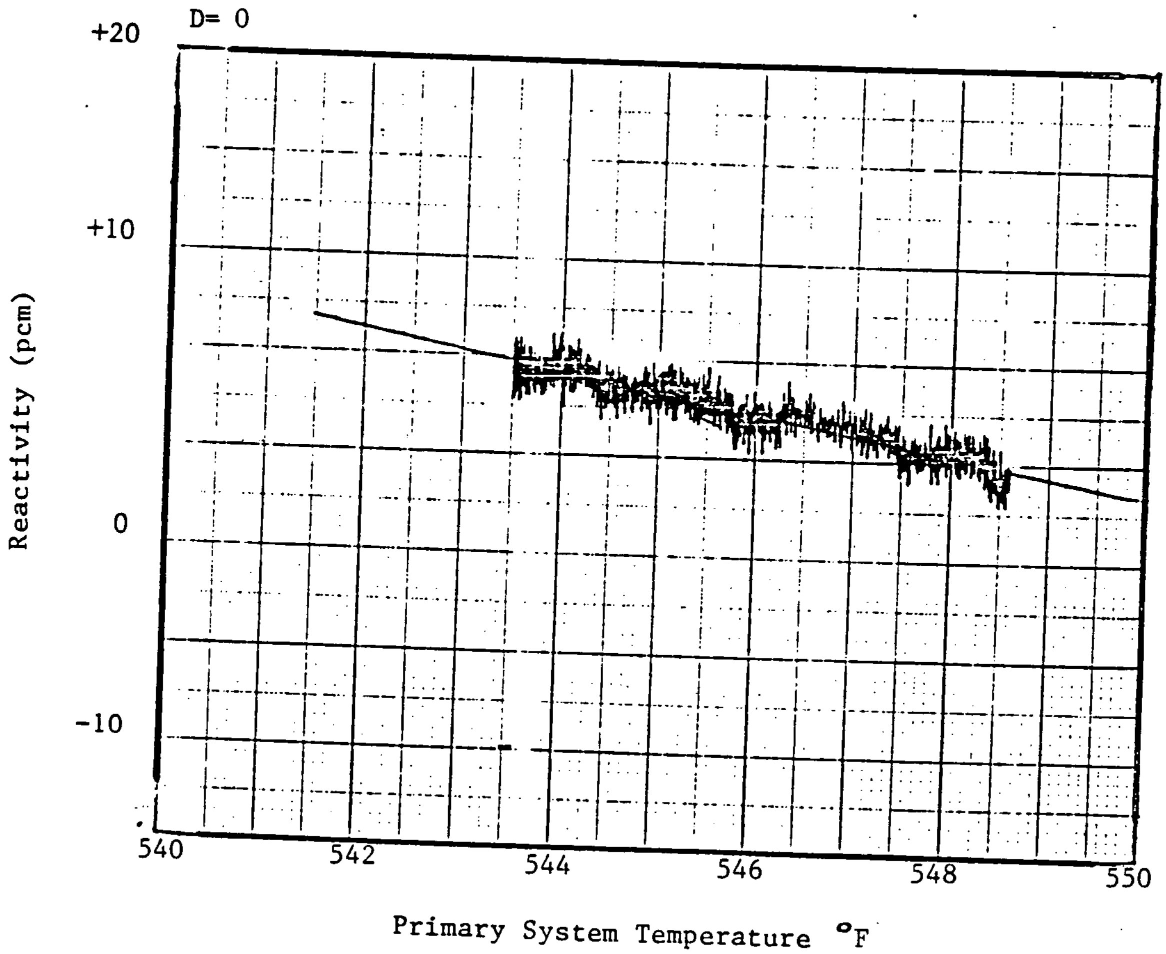
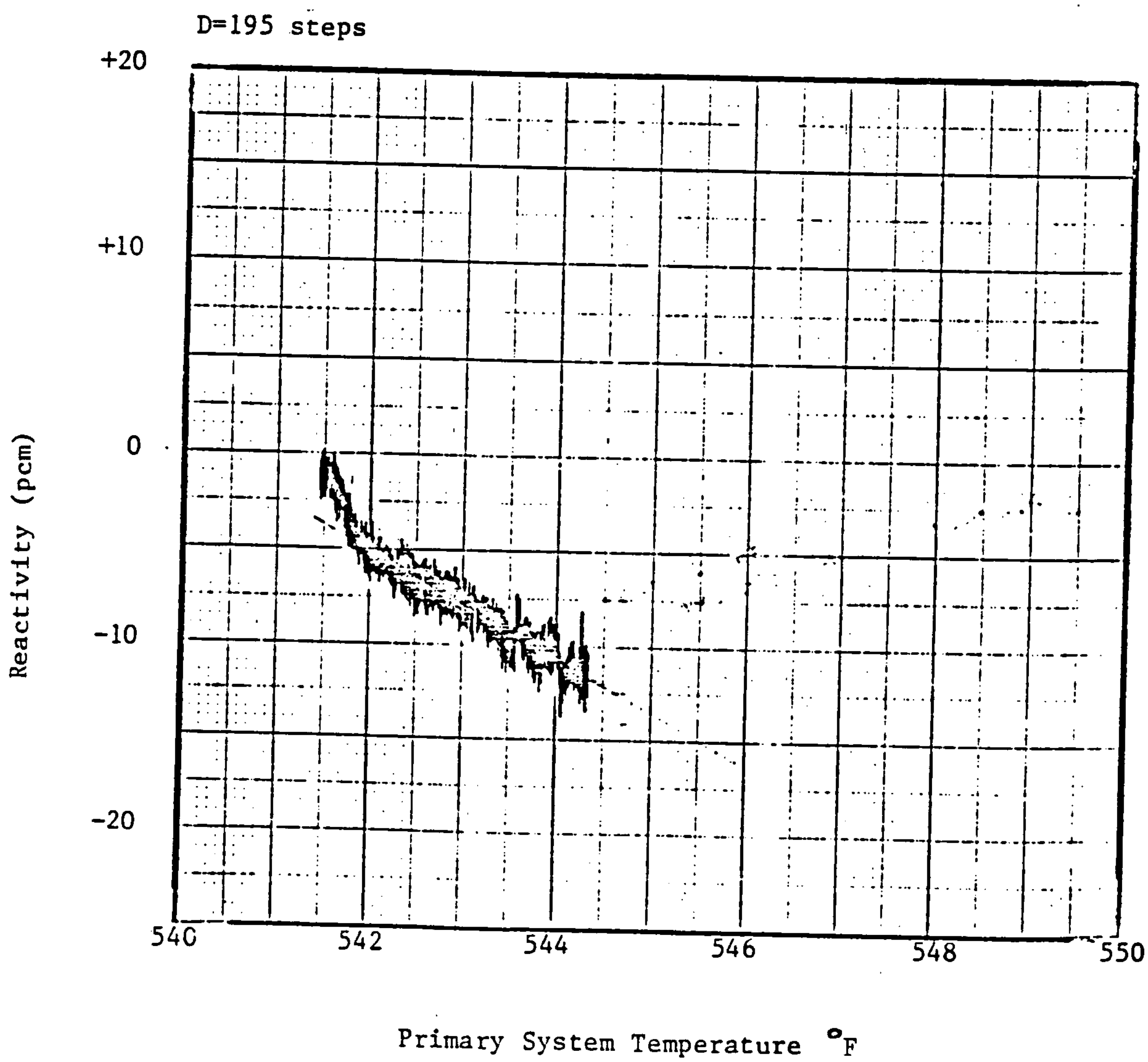


Figure 3.4

H. B. Robinson Unit 2, Cycle 11

Isothermal Temperature Coefficient

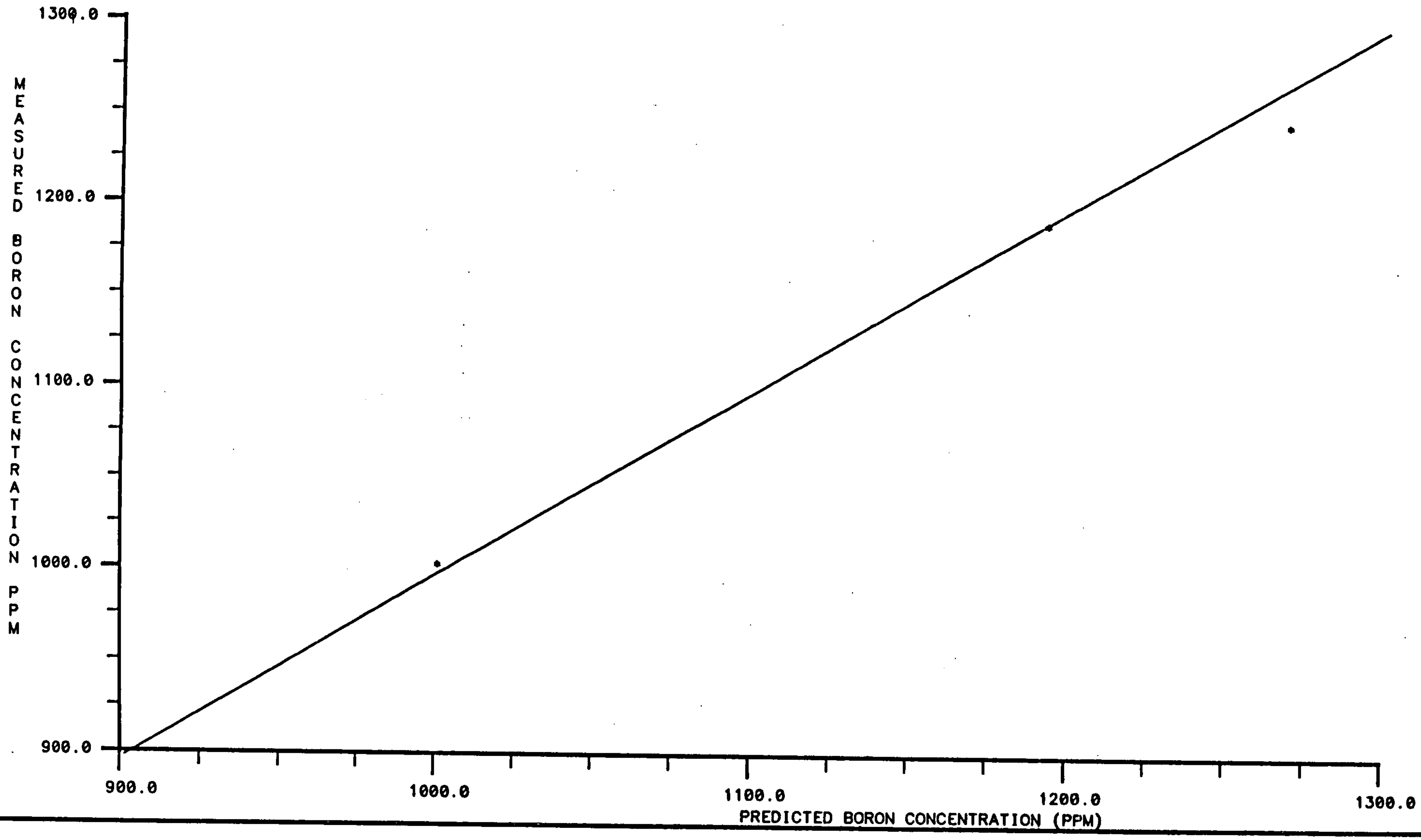
Heat-Up



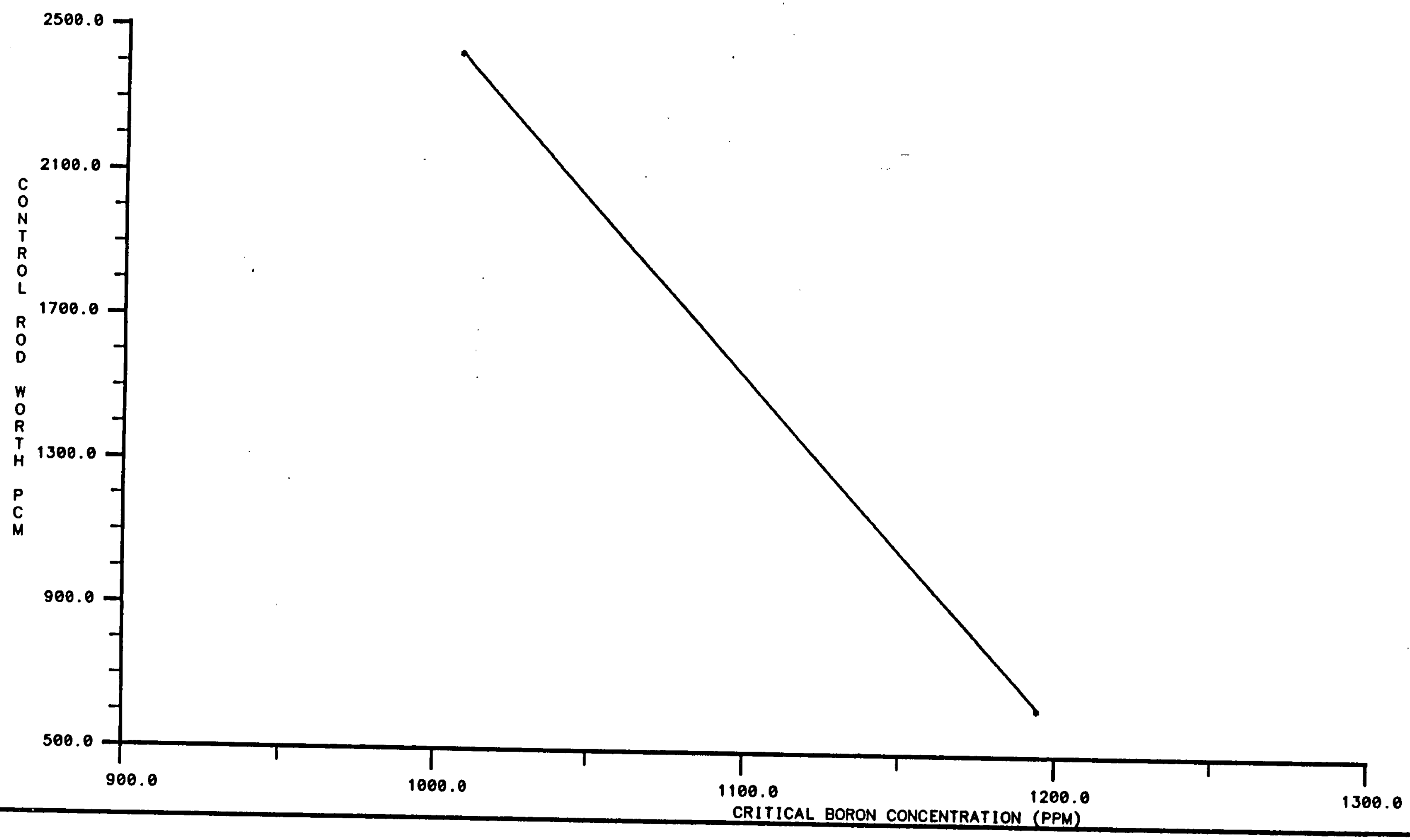
Code Version:	EXXON XTG
Run Date:	06/07/86
Resp. Engineer:	JOSE GARCIA

H. B. ROBINSON UNIT 2 CYCLE 11
MEASURED VS PREDICTED BORON END POINT
FIGURE 4.1

• = MEASURED
—— = PREDICTED



Code Version: EXXON XTG Run Date: 06/07/86 Resp. Engineer: JOSE GARCIA	H. B. ROBINSON UNIT 2 CYCLE 11 BOC HZP MEASURED BORON WORTH (PCM/PPM) FIGURE 4.2	BORON WORTH = -9.63 PCM/PPM



A QUARTER CORE AVERAGED ASSEMBLY RELATIVE POWER C11 MAP498 03/26/86 D-151 10MWD/MTU 32.52%HFP 54P B-1020

Row		H	G	F	E	D	C	B	A
1	PRED	0.864	1.021	1.205	0.984	0.859	1.216	0.939	0.234
	MES	0.817	0.986	1.199	0.971	0.858	1.241	0.962	0.241
	DIF	-5.399	-3.361	-0.505	-1.360	-0.116	2.067	2.526	3.008
2	PRED	1.018	0.832	0.949	1.357	1.256	1.023	1.122	0.205
	MES	0.988	0.803	0.927	1.351	1.260	1.040	1.156	0.210
	DIF	-2.953	-3.476	-2.455	-0.464	0.297	1.688	3.023	2.666
3	PRED	1.195	0.940	1.289	1.117	1.361	1.215	0.957	
	MES	1.175	0.910	1.258	1.093	1.361	1.249	0.999	
	DIF	-1.706	-3.145	-2.457	-2.183	0.008	2.827	4.359	
4	PRED	0.972	1.333	1.089	1.367	1.264	1.111	0.758	
	MES	0.948	1.303	1.055	1.350	1.268	1.147	0.792	
	DIF	-2.463	-2.217	-3.100	-1.378	0.251	3.218	4.473	
5	PRED	0.852	1.236	1.341	1.259	1.046	0.418		
	MES	0.830	1.213	1.309	1.252	1.065	0.425		
	DIF	-2.369	-1.850	-2.378	-0.569	1.743	1.737		
6	PRED	1.201	1.010	1.203	1.106	0.427			
	MES	1.210	1.006	1.211	1.136	0.433			
	DIF	0.808	-0.384	0.689	2.686	1.531			
7	PRED	0.927	1.110	0.948	0.754				
	MES	0.939	1.121	0.966	0.771				
	DIF	1.307	1.031	1.815	2.333				
8	PRED	0.231	0.202						
	MES	0.238	0.208						
	DIF	2.984	2.860						

Legend: PRED / MES / DIF

FORM 0113 (02/83)

H.B. Robinson Unit 2 Cycle 11

Figure 5.1

A QUARTER CORE AVERAGED ASSEMBLY RELATIVE POWER C11 MAP489 03/28/86 D-181 52MWD/MTU 72.38%HFP 53P B-977

	H	G	F	E	D	C	B	A	
1	0.942 0.926 -1.728	1.061 1.058 -0.247	1.226 1.239 1.133	1.009 1.010 0.075	0.915 0.921 0.577	1.226 1.250 1.877	0.931 0.949 1.927	0.229 0.235 2.286	1
2	1.058 1.052 -0.615	0.857 0.847 -1.139	0.964 0.957 -0.778	1.371 1.377 0.373	1.273 1.278 0.433	1.023 1.032 0.844	1.108 1.131 2.163	0.200 0.203 1.503	2
3	1.216 1.218 0.124	0.954 0.941 -1.384	1.292 1.272 -1.534	1.117 1.095 -2.006	1.352 1.342 -0.742	1.199 1.217 1.497	0.939 0.964 2.724		3
4	0.998 0.989 -0.846	1.348 1.337 -0.804	1.089 1.058 -2.774	1.354 1.331 -1.806	1.247 1.237 -0.858	1.089 1.109 1.897	0.741 0.763 2.994		4
5	0.909 0.899 -0.891	1.253 1.242 -0.888	1.333 1.308 -1.801	1.243 1.224 -1.454	1.026 1.036 0.957	0.411 0.415 0.913			5
6	1.212 1.220 0.683	1.012 1.006 -0.572	1.188 1.186 -0.183	1.084 1.096 1.080	0.420 0.424 1.010				6
7	0.920 0.925 0.564	1.096 1.103 0.634	0.930 0.940 1.022	0.737 0.746 1.258					7
8	0.226 0.229 1.088	0.198 0.200 1.282							8
	H	G	F	E	D	C	B	A	

PRED
MES
DIF

FORM 0113 (02/83)

H.B. Robinson Unit 2 Cycle 11

Figure 5.2

Figure 5.3

H.B. Robinson Unit 2 Cycle 11

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A QUARTER CORE AVERAGED ASSEMBLY RELATIVE POWER C11 MAP505 04/07/86 D-211 100MWD/MTU 89.37%HFP 48P B-872

	H	G	F	E	D	C	B	A	
1	1.080 1.057 -2.185	1.128 1.114 -1.234	1.259 1.254 -0.412	1.052 1.029 -2.197	1.021 1.006 -1.477	1.249 1.248 -0.073	0.922 0.925 0.379	0.231 0.233 0.949	1
2	1.125 1.106 -1.667	0.898 0.879 -2.116	0.986 0.968 -1.908	1.395 1.389 -0.462	1.301 1.296 -0.422	1.025 1.024 -0.075	1.086 1.101 1.358	0.201 0.203 1.159	2
3	1.250 1.237 -1.068	0.976 0.956 -2.127	1.294 1.278 -1.244	1.113 1.103 -0.933	1.335 1.341 0.457	1.172 1.193 1.862	0.908 0.935 2.963		3
4	1.042 1.016 -2.485	1.372 1.347 -1.825	1.086 1.072 -1.353	1.326 1.330 0.159	1.212 1.224 0.986	1.048 1.085 3.549	0.711 0.743 4.547		4
5	1.015 0.981 -3.086	1.283 1.258 -1.925	1.316 1.302 -1.028	1.208 1.208 0.010	0.989 1.017 2.885	0.397 0.411 3.701			5
6	1.236 1.226 -0.776	1.014 1.000 -1.353	1.160 1.160 -0.054	1.045 1.066 2.039	0.405 0.419 3.340				6
7	0.912 0.917 0.488	1.076 1.076 0.008	0.901 0.912 1.235	0.708 0.725 2.469					7
8	0.228 0.229 0.181	0.199 0.200 0.934							8
	H	G	F	E	D	C	B	A	

PRED
MES
DIF

FORM 0113 (02/83)

A QUARTER CORE AVERAGED ASSEMBLY RELATIVE POWER C11 MAP506 04/07/86 D-219 190MWD/MTU 94.80%HFP 46P B-827

Row		H	G	F	E	D	C	B	A
1	PRED	1.085	1.132	1.262	1.053	1.021	1.249	0.921	0.231
	MES	1.059	1.122	1.269	1.041	1.007	1.247	0.924	0.232
	DIF	-2.387	-0.874	0.528	-1.133	-1.326	-0.146	0.258	0.421
2	PRED	1.129	0.901	0.988	1.395	1.301	1.025	1.084	0.201
	MES	1.111	0.885	0.976	1.396	1.297	1.022	1.094	0.202
	DIF	-1.585	-1.822	-1.339	0.070	-0.327	-0.245	0.860	0.483
3	PRED	1.253	0.978	1.295	1.113	1.334	1.170	0.907	
	MES	1.246	0.958	1.276	1.101	1.340	1.188	0.928	
	DIF	-0.568	-2.054	-1.497	-1.107	0.424	1.484	2.406	
4	PRED	1.043	1.372	1.086	1.325	1.211	1.048	0.709	
	MES	1.022	1.349	1.060	1.321	1.222	1.078	0.735	
	DIF	-2.013	-1.721	-2.393	-0.472	0.903	2.885	3.639	
5	PRED	1.016	1.283	1.315	1.207	0.989	0.397		
	MES	0.988	1.261	1.299	1.203	1.013	0.407		
	DIF	-2.524	-1.703	-1.266	-0.291	2.479	2.546		
6	PRED	1.236	1.013	1.160	1.044	0.405			
	MES	1.232	1.006	1.165	1.067	0.416			
	DIF	-0.299	-0.767	0.483	2.171	2.501			
7	PRED	0.912	1.075	0.899	0.706				
	MES	0.920	1.081	0.917	0.724				
	DIF	0.803	0.582	1.920	2.572				
8	PRED	0.229	0.199						
	MES	0.230	0.203						
	DIF	0.606	2.147						

Key: PRED / MES / DIF

FORM 0113 (02/83)

H.B. Robinson Unit 2 Cycle 11

Figure 5.4

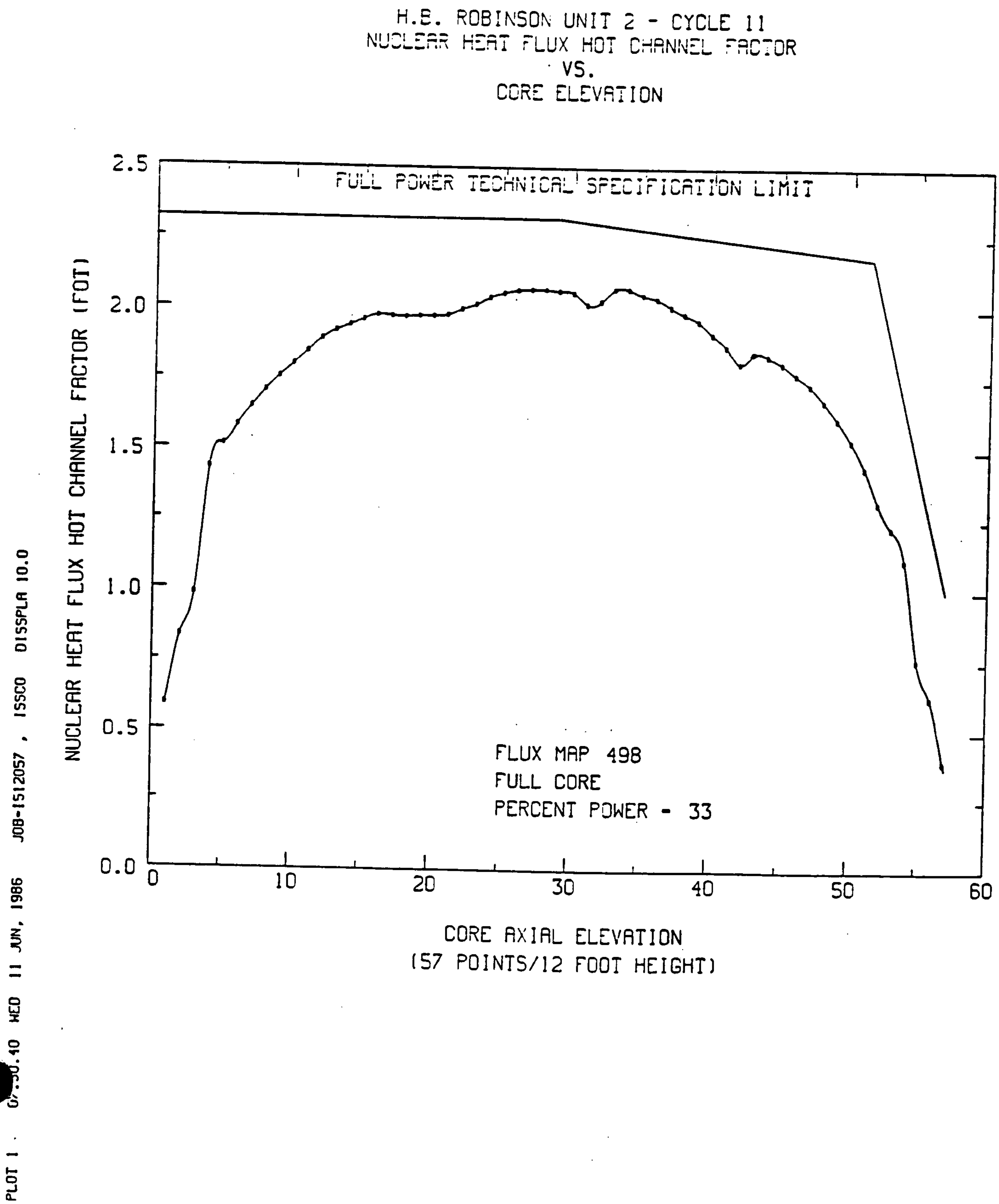
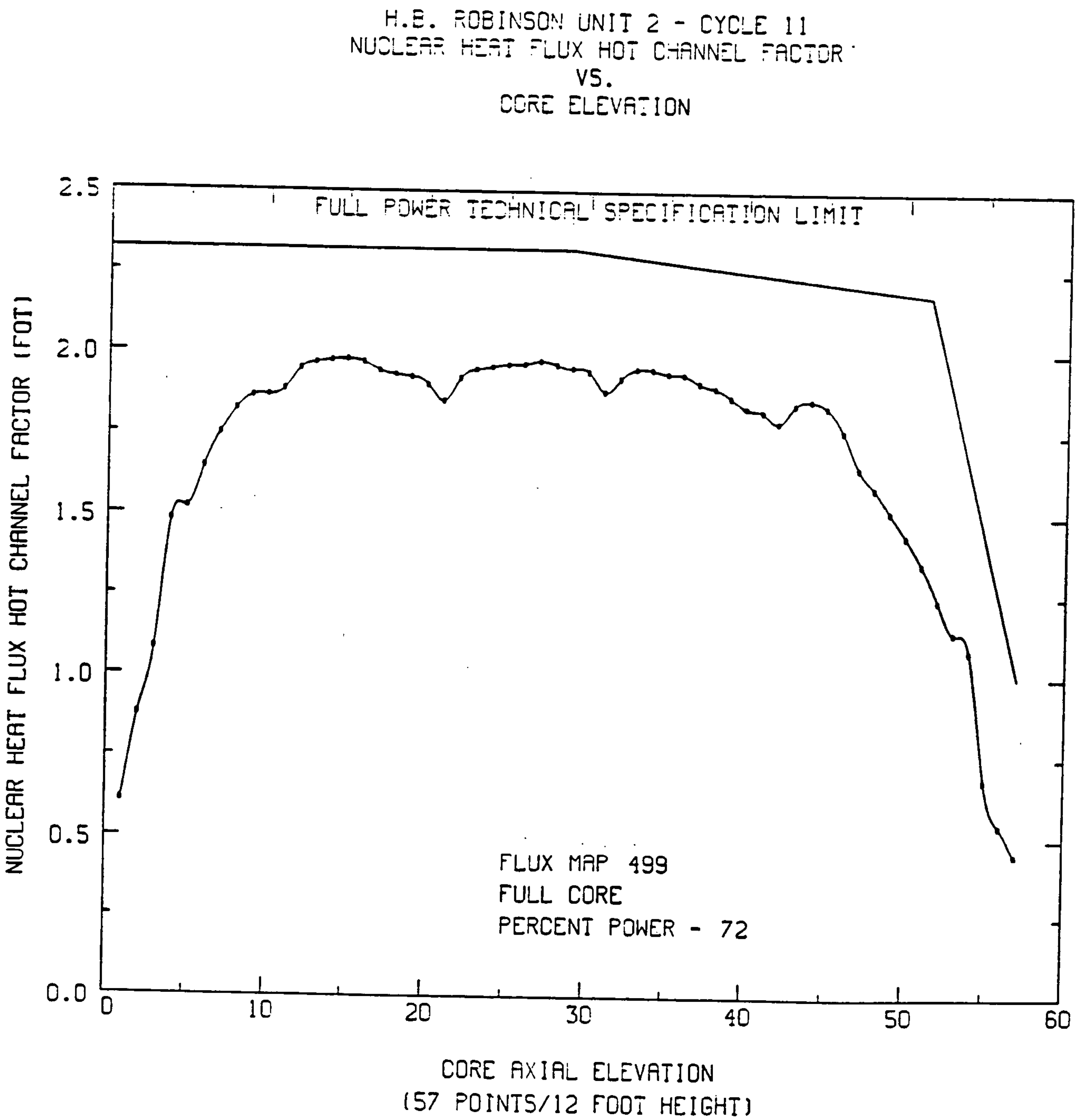

H.B. ROBINSON UNIT 2 - CYCLE 11
NUCLEAR HEAT FLUX HOT CHANNEL FACTOR
VS.
CORE ELEVATION
FULL POWER TECHNICAL SPECIFICATION LIMIT
NUCLEAR HEAT FLUX HOT CHANNEL FACTOR (FQT)
2.5
2.0
1.5
1.0
0.5
0.0
0
10
20
30
40
50
60
FLUX MAP 498
FULL CORE
PERCENT POWER - 33
CORE AXIAL ELEVATION
(57 POINTS/12 FOOT HEIGHT)
PLOT 1 . 07.30.40 WED 11 JUN, 1986 JOB-I512057 , ISSCO DISSPLA 10.0

Figure 5.6



PLOT 3 0.50.42 WED 11 JUN, 1986 JOB-1512057 , ISSCO DISSPLA 10.0

Figure 5.7

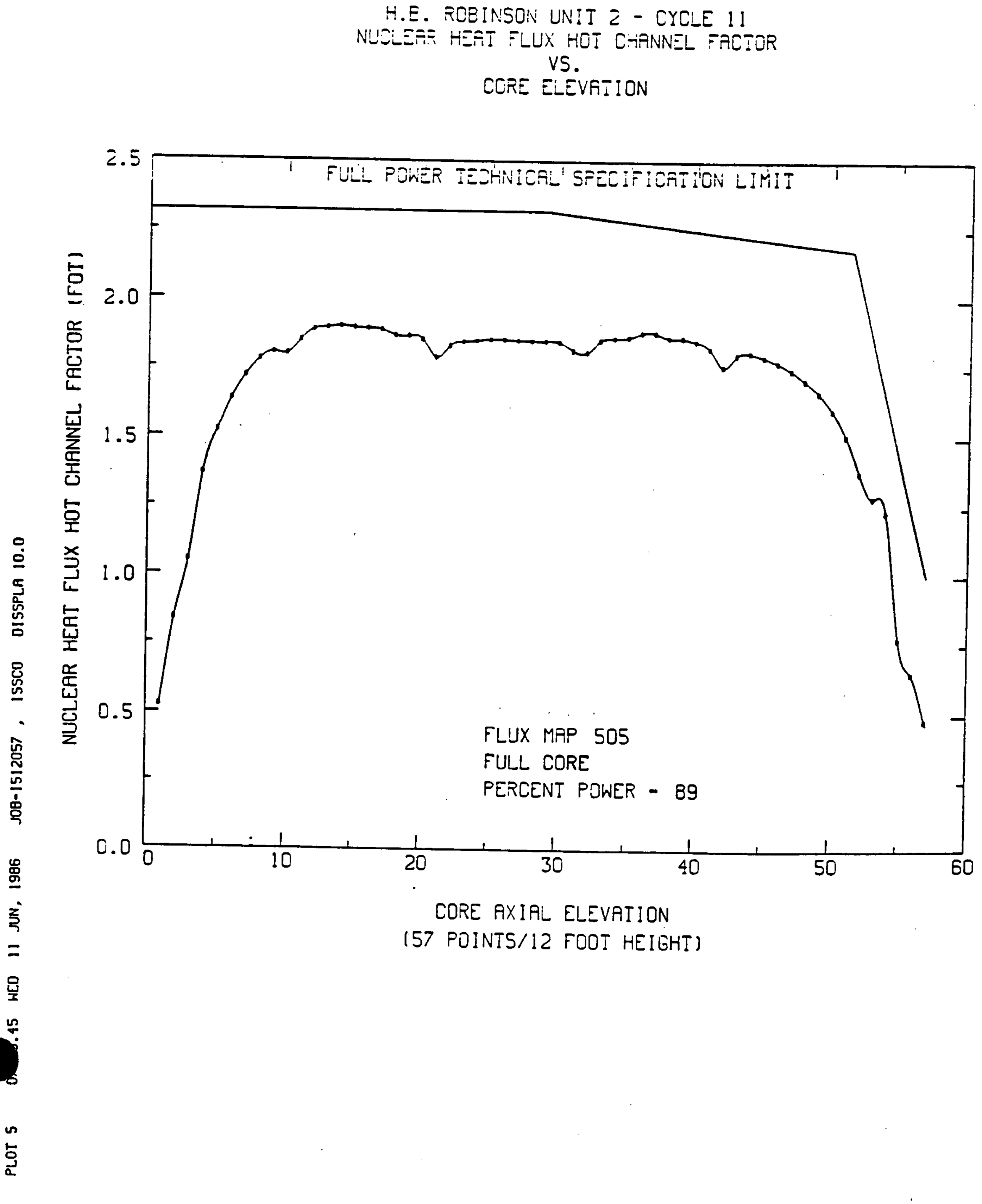

H.B. ROBINSON UNIT 2 - CYCLE 11
NUCLEAR HEAT FLUX HOT CHANNEL FACTOR
VS.
CORE ELEVATION
FULL POWER TECHNICAL SPECIFICATION LIMIT
NUCLEAR HEAT FLUX HOT CHANNEL FACTOR (FQT)
2.5
2.0
1.5
1.0
0.5
0.0
0
10
20
30
40
50
60
FLUX MAP 505
FULL CORE
PERCENT POWER - 89
CORE AXIAL ELEVATION
(57 POINTS/12 FOOT HEIGHT)
PLOT 5 WED 11 JUN, 1986 JOB-1512057 , ISSCO DISSPLA 10.0

Figure 5.8

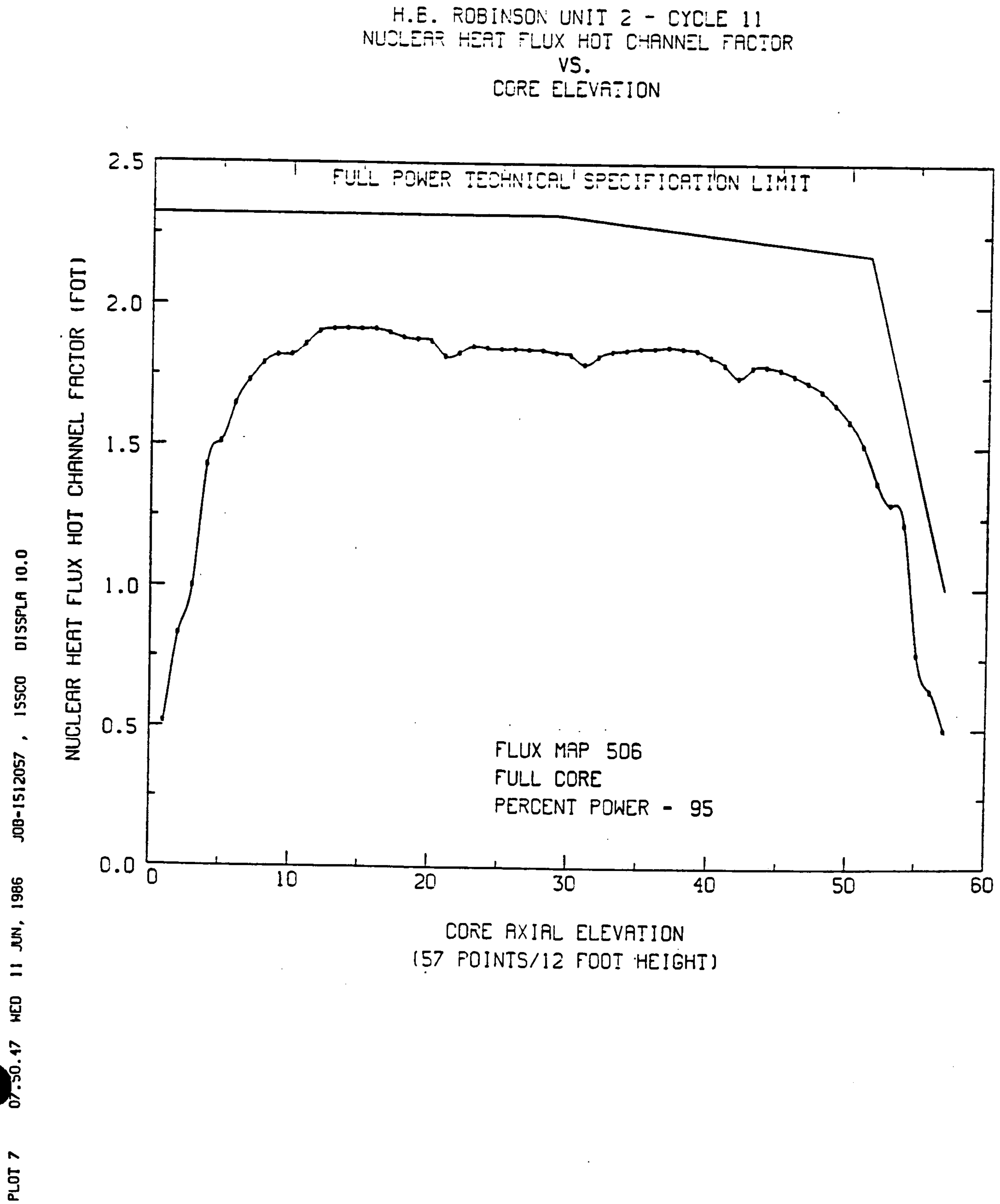

H.E. ROBINSON UNIT 2 - CYCLE 11
NUCLEAR HEAT FLUX HOT CHANNEL FACTOR
VS.
CORE ELEVATION
FULL POWER TECHNICAL SPECIFICATION LIMIT
NUCLEAR HEAT FLUX HOT CHANNEL FACTOR (FQT)
2.5
2.0
1.5
1.0
0.5
0.0
0
10
20
30
40
50
60
FLUX MAP 506
FULL CORE
PERCENT POWER - 95
CORE AXIAL ELEVATION
(57 POINTS/12 FOOT HEIGHT)
PLOT 7 07.50.47 WED 11 JUN, 1986 JOB-1512057 , ISSCO DISSPLA 10.0

Figure 5.9

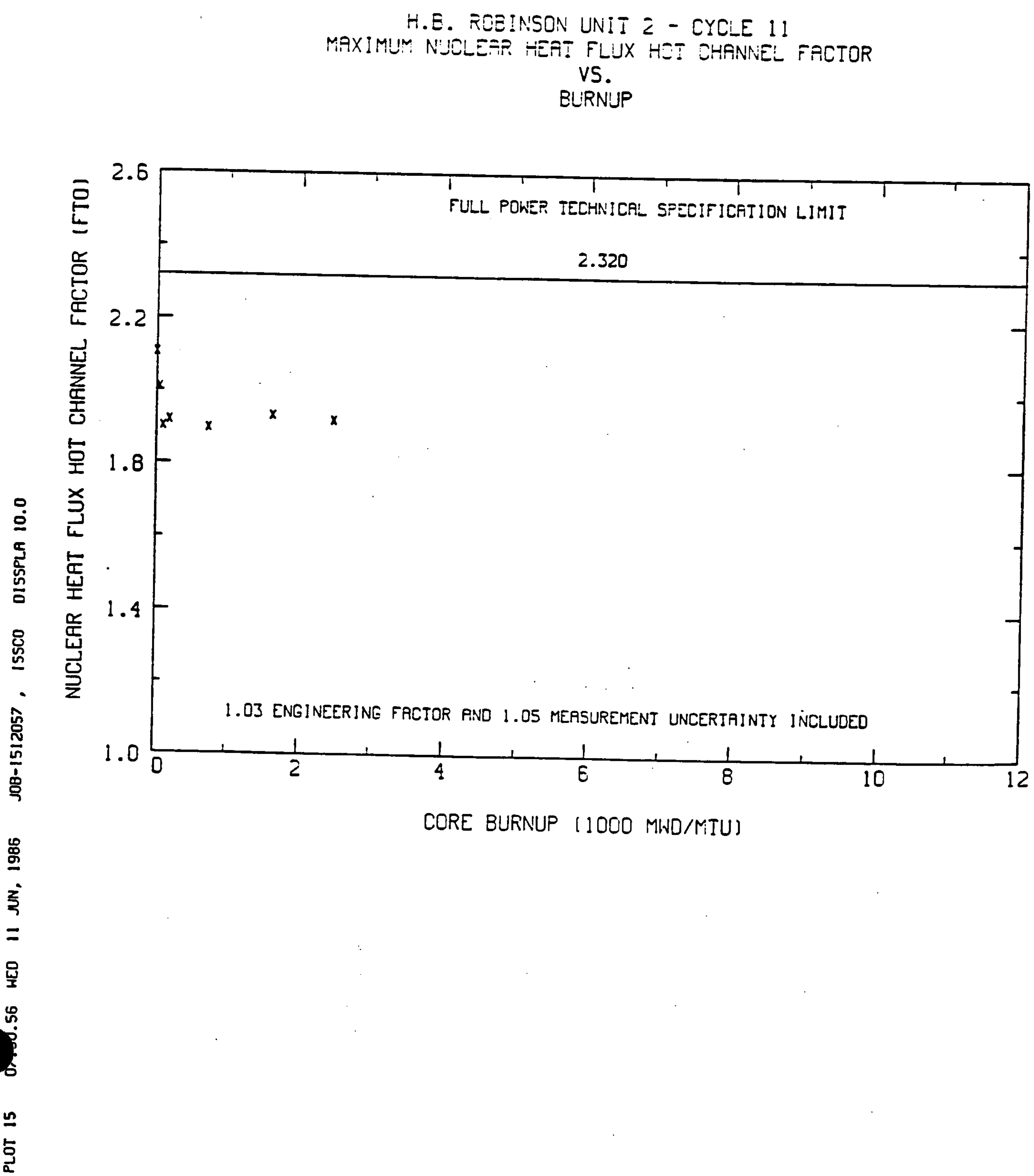
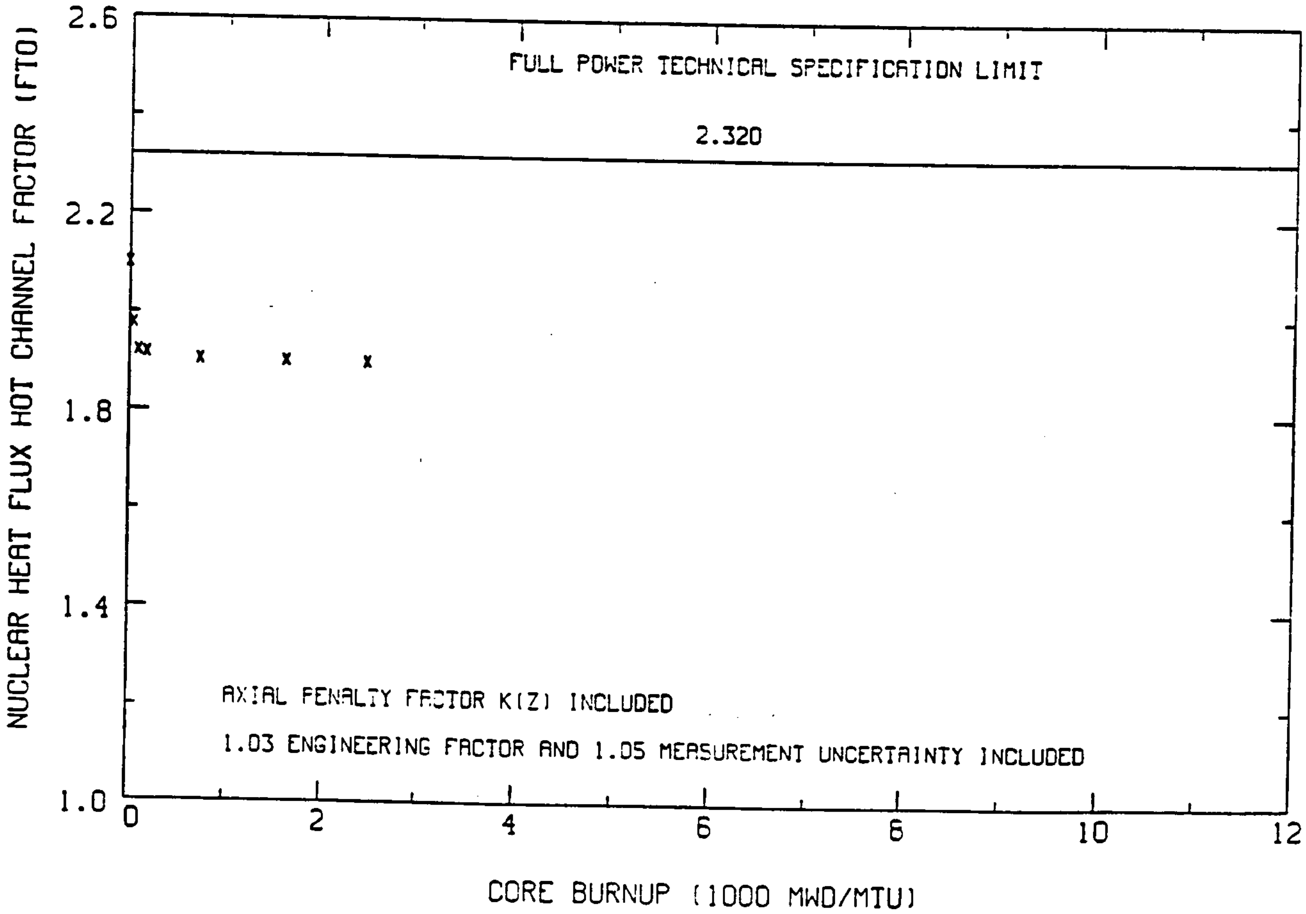

H.B. ROBINSON UNIT 2 - CYCLE 11
MAXIMUM NUCLEAR HEAT FLUX HOT CHANNEL FACTOR
VS.
BURNUP
NUCLEAR HEAT FLUX HOT CHANNEL FACTOR (FTQ)
2.6
2.2
1.8
1.4
1.0
FULL POWER TECHNICAL SPECIFICATION LIMIT
2.320
1.03 ENGINEERING FACTOR AND 1.05 MEASUREMENT UNCERTAINTY INCLUDED
0
2
4
6
8
10
12
CORE BURNUP (1000 MWD/MTU)
PLOT 15 07.50.56 WED 11 JUN, 1986 JOB-1512057 , ISSCO DISSPLA 10.0

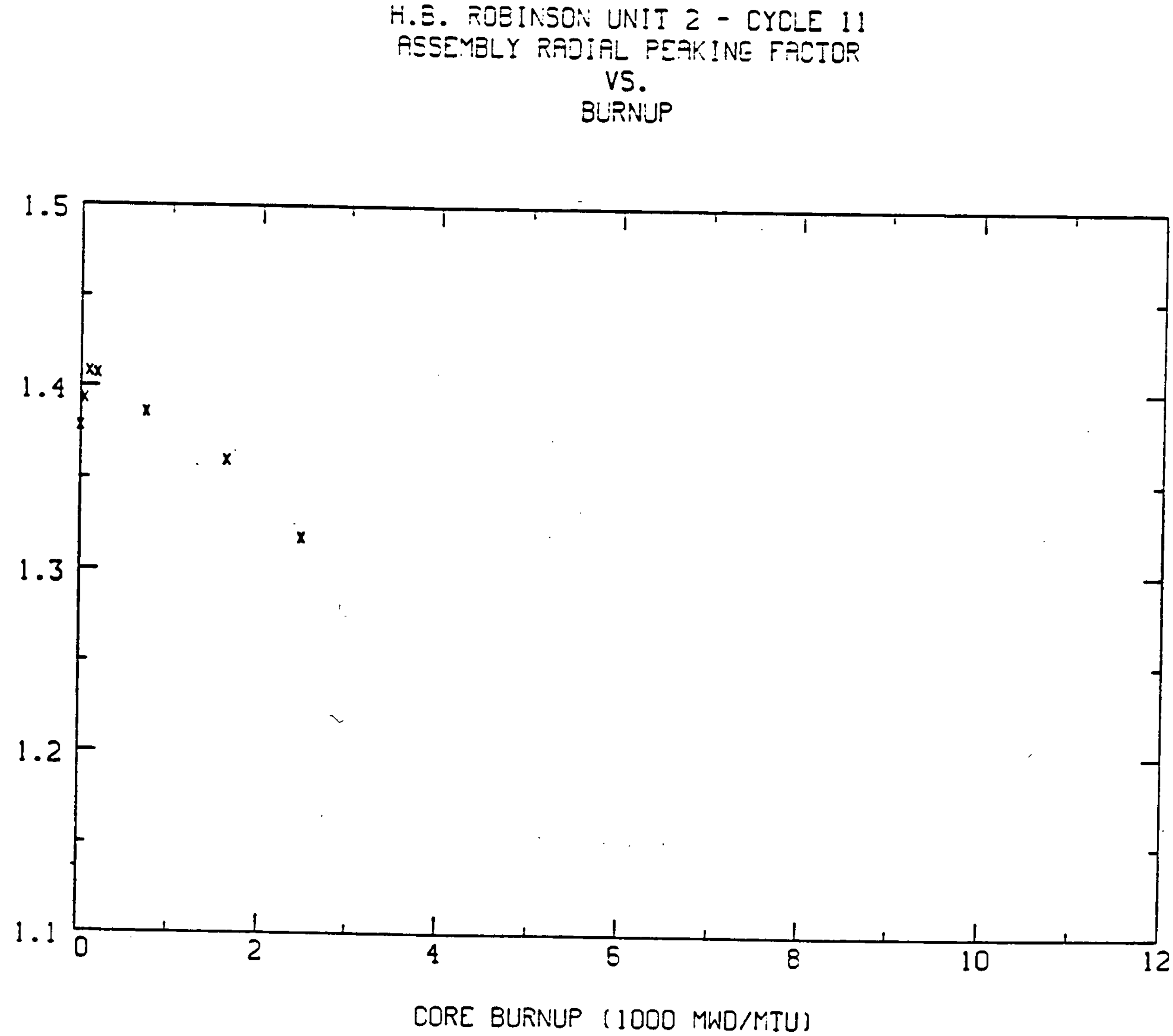
Figure 5.10

H.B. ROBINSON UNIT 2 - CYCLE 11
LIMITING NUCLEAR HEAT FLUX HOT CHANNEL FACTOR
VS.
BURNUP



PLOT 16 0...57 WED 11 JUN, 1986 JOB-1512057 , ISSCO DISSPLA 10.0

Figure 5.11



PLOT 22 07.51.00 WED 11 JUN, 1986 JOB-1512057 , ISSCO DISSPLA 10.0

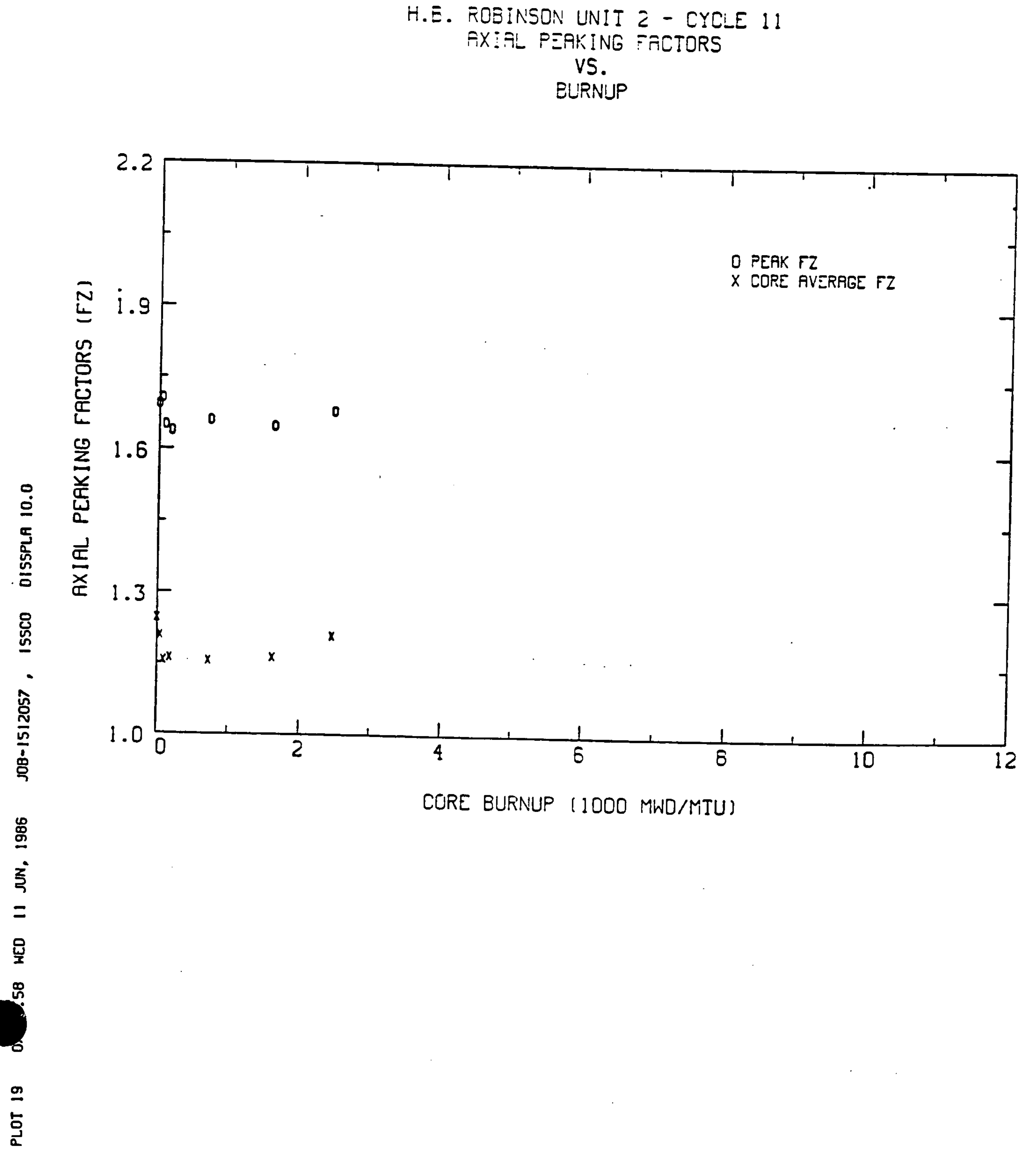
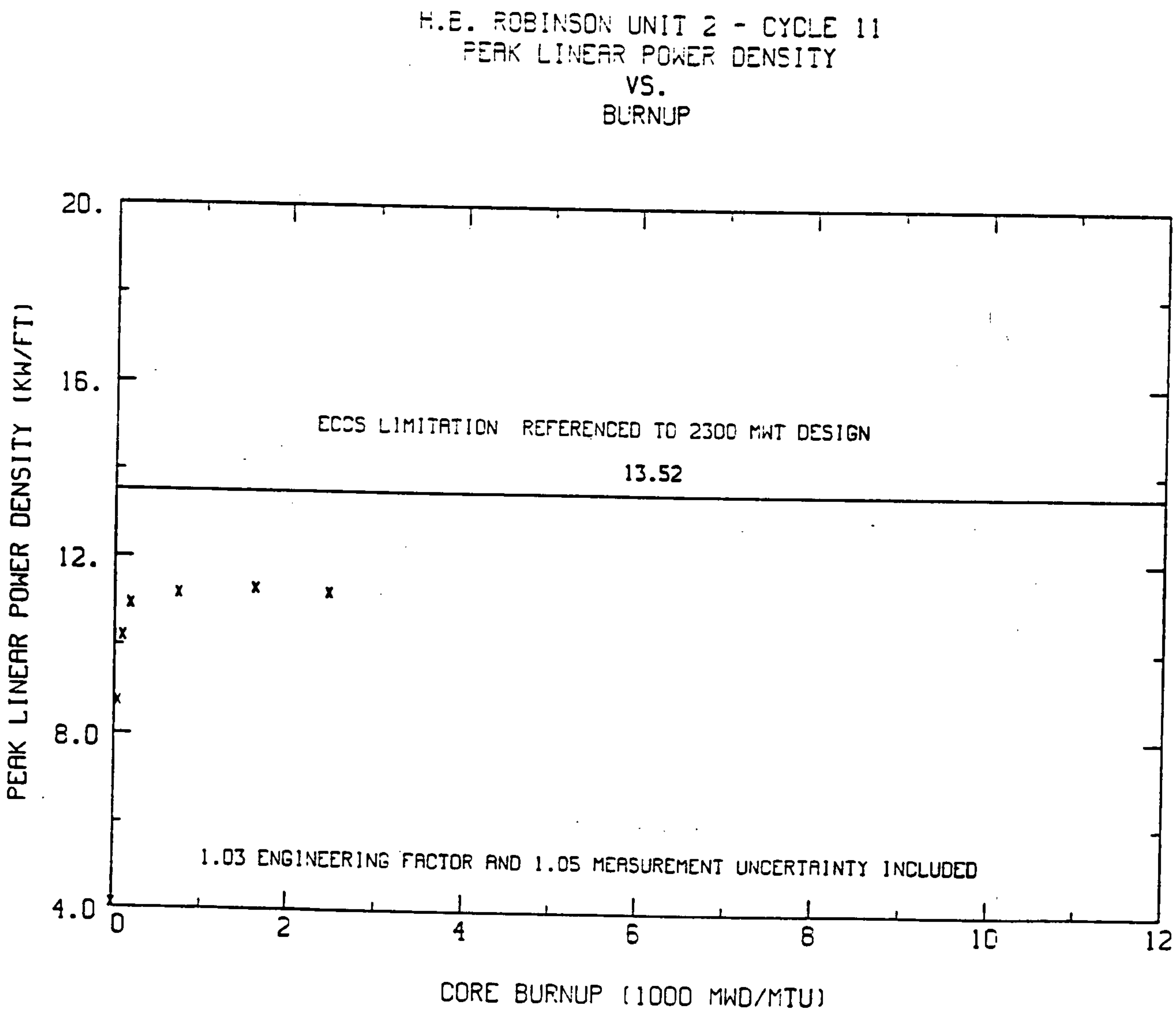
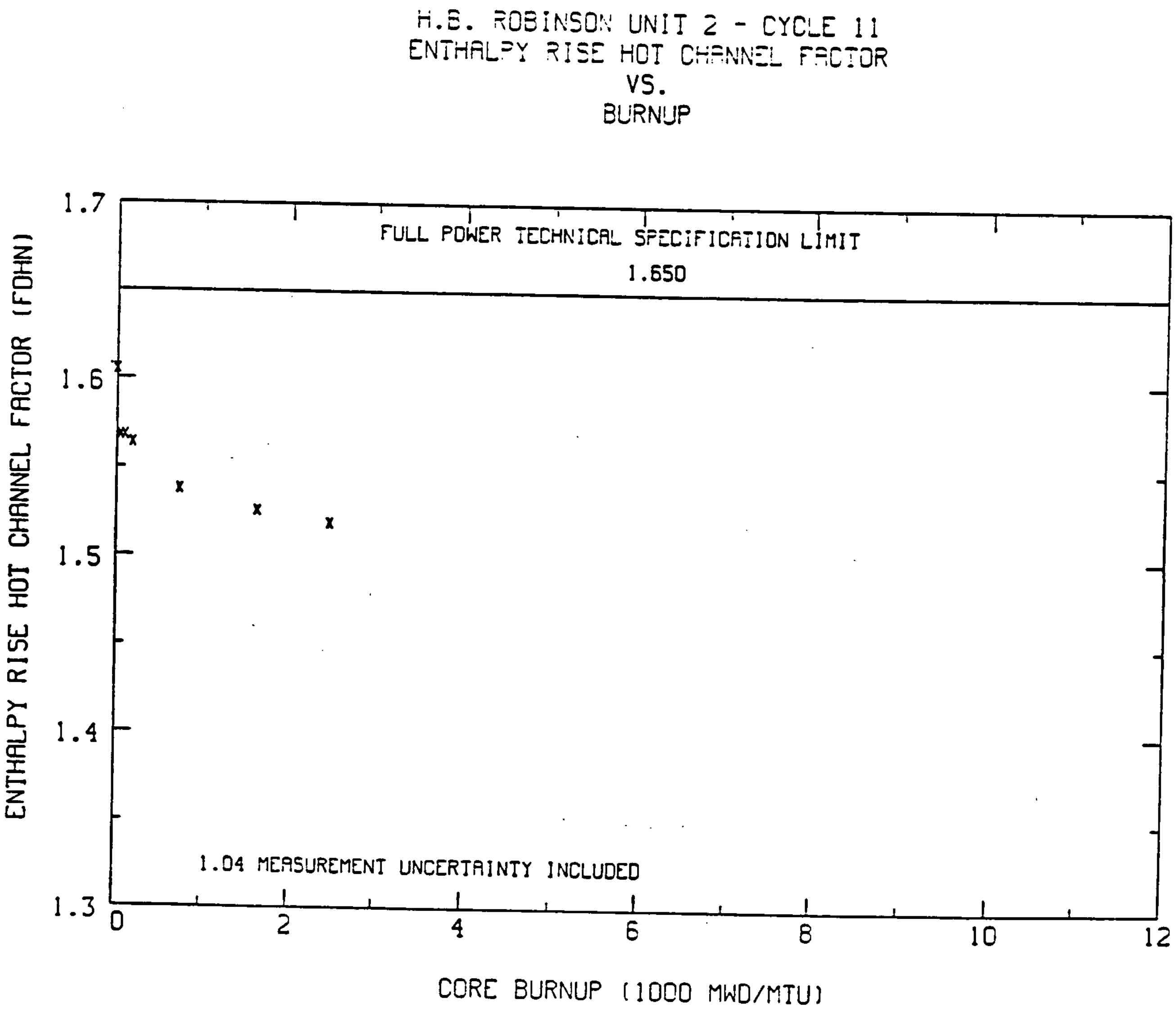

H.B. ROBINSON UNIT 2 - CYCLE 11
AXIAL PEAKING FACTORS
VS.
BURNUP
O PEAK FZ
X CORE AVERAGE FZ
AXIAL PEAKING FACTORS (FZ)
CORE BURNUP (1000 MWD/MTU)
2.2
1.9
1.6
1.3
1.0
0
2
4
6
8
10
12
PLOT 19 WED 11 JUN, 1986 JOB-1512057 , ISSCO DISSPLA 10.0

Figure 5.13



PLOT 20 0...59 WED 11 JUN, 1986 JOB-1512057 , ISSCO DISSPLA 10.0

Figure 5.14



PLOT 17 07.50.57 WED 11 JUN, 1986 JOB-1512057 , ISSCO DISSPLA 10.0

APPENDIX A

						0.202	0.231	0.202						
						0.203	0.237	0.209						
						0.32	2.74	3.47						
				0.754	0.948	1.110	0.927	1.110	0.948	0.754				
				0.773	0.941	1.116	0.939	1.141	0.976	0.768				
				2.52	-0.74	0.62	1.28	2.87	2.93	1.83				
			0.427	1.106	1.203	1.010	1.201	1.010	1.203	1.106	0.427			
			0.434	1.129	1.204	1.001	1.219	1.014	1.206	1.109	0.425			
			1.76	2.07	0.11	-0.94	1.56	0.40	0.29	0.20	-0.56			
		0.418	1.046	1.259	1.341	1.236	0.848	1.236	1.341	1.259	1.046	0.418		
		0.437	1.079	1.278	1.347	1.236	0.837	1.230	1.311	1.228	1.029	0.417		
		4.59	3.17	1.44	0.44	-0.02	-1.28	-0.44	-2.23	-2.50	-1.70	-0.13		
	0.758	1.111	1.264	1.367	1.089	1.333	0.972	1.333	1.089	1.374	1.264	1.111	0.758	
	0.810	1.188	1.294	1.360	1.081	1.336	0.970	1.327	1.062	1.338	1.226	1.119	0.788	
	6.93	6.89	2.37	-0.57	-0.76	0.22	-0.19	-0.42	-2.47	-2.66	-3.06	0.69	4.02	
	0.957	1.215	1.361	1.117	1.289	0.940	1.195	0.940	1.289	1.117	1.361	1.215	0.957	
	0.998	1.267	1.378	1.081	1.256	0.924	1.202	0.924	1.273	1.092	1.337	1.229	0.994	
	4.26	4.31	1.29	-3.26	-2.56	-1.70	0.58	-1.64	-1.30	-2.24	-1.76	1.11	3.83	
0.205	1.122	1.023	1.256	1.357	0.949	0.832	1.018	0.832	0.954	1.357	1.256	1.023	1.122	0.205
0.204	1.144	1.039	1.256	1.325	0.911	0.790	0.993	0.805	0.939	1.360	1.255	1.037	1.162	0.212
-0.38	1.92	1.61	0.02	-2.35	-4.05	-5.04	-2.52	-3.26	-1.57	0.16	-0.09	1.40	3.54	3.78
0.234	0.939	1.216	0.859	0.984	1.205	1.021	0.864	1.021	1.205	0.984	0.859	1.216	0.939	0.234
0.241	0.958	1.240	0.859	0.964	1.183	0.968	0.817	1.005	1.215	0.977	0.857	1.242	0.967	0.241
3.11	2.06	1.99	-0.03	-2.01	-1.81	-5.18	-5.40	-1.54	0.80	-0.71	-0.21	2.15	2.99	2.91
0.205	1.122	1.023	1.256	1.357	0.949	0.832	1.018	0.832	0.949	1.357	1.256	1.023	1.122	0.205
0.211	1.150	1.039	1.264	1.372	0.935	0.800	0.984	0.818	0.923	1.347	1.264	1.045	1.170	0.213
3.12	2.42	1.55	0.64	1.06	-1.47	-3.88	-3.39	-1.72	-2.72	-0.73	0.61	2.19	4.21	4.15
	0.957	1.215	1.361	1.117	1.289	0.940	1.195	0.940	1.289	1.117	1.361	1.215	0.957	
	0.985	1.250	1.370	1.118	1.275	0.903	1.148	0.890	1.226	1.081	1.358	1.252	1.018	
	2.96	2.88	0.69	0.07	-1.08	-3.94	-3.99	-5.30	-4.89	-3.30	-0.18	3.01	6.38	
	0.758	1.111	1.264	1.367	1.089	1.333	0.972	1.333	1.089	1.367	1.264	1.111	0.758	
	0.780	1.143	1.270	1.362	1.069	1.294	0.926	1.257	1.009	1.341	1.280	1.138	0.788	
	2.95	2.83	0.45	-0.38	-1.79	-2.96	-4.73	-5.71	-7.37	-1.90	1.24	2.46	3.99	
		0.418	1.046	1.259	1.341	1.236	0.852	1.236	1.341	1.259	1.046	0.418		
		0.427	1.062	1.250	1.332	1.220	0.823	1.166	1.246	1.253	1.088	0.419		
		2.20	1.51	-0.75	-0.66	-1.28	-3.46	-5.66	-7.06	-0.47	3.99	0.28		
			0.427	1.106	1.203	1.010	1.201	1.010	1.203	1.106	0.427			
			0.438	1.148	1.220	0.996	1.201	1.014	1.214	1.159	0.437			
			2.65	3.71	1.43	-1.39	0.05	0.40	0.92	4.77	2.28			
				0.754	0.948	1.110	0.927	1.110	0.948	0.754				
				0.783	0.985	1.102	0.940	1.124	0.960	0.762				
				3.85	3.89	-0.69	1.34	1.33	1.18	1.13				
						0.202	0.231	0.202						
						0.211	0.238	0.209						
						4.41	3.23	3.24						

Predicted
Measured
%Difference

H.B. Robinson Unit 2 Cycle 11
Flux Map 498 Assembly Relative Power

Figure A.1

H.B. Robinson Unit 2 Cycle 11
Flux Map 499 Assembly Relative Power

						0.198	0.226	0.198						
						0.194	0.228	0.202						
						-1.79	0.57	2.39						
				0.737	0.930	1.096	0.920	1.096	0.930	0.737				
				0.753	0.921	1.094	0.922	1.117	0.953	0.747				
				2.12	-1.04	-0.15	0.24	1.98	2.38	1.32				
			0.420	1.084	1.188	1.012	1.212	1.012	1.188	1.084	0.420			
			0.425	1.099	1.183	1.002	1.223	1.011	1.182	1.079	0.415			
			1.18	1.33	-0.38	-0.92	0.88	-0.06	-0.48	-0.47	-1.09			
		0.411	1.026	1.243	1.333	1.253	0.905	1.253	1.333	1.243	1.026	0.411		
		0.420	1.045	1.247	1.334	1.257	0.904	1.247	1.291	1.204	1.005	0.406		
		2.30	1.80	0.40	0.07	0.27	-0.04	-0.49	-3.15	-3.07	-2.08	-1.19		
	0.741	1.089	1.247	1.354	1.089	1.348	0.998	1.348	1.089	1.360	1.247	1.089	0.741	
	0.769	1.129	1.254	1.340	1.075	1.376	1.011	1.350	1.062	1.323	1.196	1.083	0.761	
	3.85	3.72	0.56	-1.02	-1.30	2.08	1.35	0.16	-2.51	-2.77	-4.12	-0.49	2.75	
	0.939	1.199	1.352	1.117	1.292	0.954	1.216	0.954	1.292	1.117	1.352	1.199	0.939	
	0.951	1.215	1.347	1.083	1.268	0.959	1.246	0.952	1.282	1.096	1.330	1.206	0.965	
	1.36	1.27	-0.40	-3.07	-1.83	0.48	2.50	-0.21	-0.80	-1.87	-1.60	0.55	2.87	
0.200	1.108	1.023	1.273	1.371	0.964	0.857	1.058	0.857	0.968	1.371	1.273	1.023	1.108	0.200
0.197	1.110	1.012	1.267	1.354	0.947	0.847	1.062	0.848	0.965	1.383	1.281	1.039	1.141	0.205
-1.63	0.24	-1.17	-0.47	-1.26	-1.71	-1.21	0.35	-1.09	-0.38	0.80	0.62	1.50	2.99	2.71
0.229	0.931	1.226	0.915	1.009	1.226	1.061	0.942	1.061	1.226	1.009	0.915	1.226	0.931	0.229
0.235	0.939	1.247	0.918	1.004	1.228	1.050	0.926	1.066	1.251	1.015	0.923	1.252	0.958	0.234
2.33	0.91	1.67	0.29	-0.46	0.23	-0.98	-1.73	0.49	2.04	0.61	0.86	2.09	2.94	2.24
0.200	1.108	1.023	1.273	1.371	0.964	0.857	1.058	0.857	0.964	1.371	1.273	1.023	1.108	0.200
0.205	1.132	1.039	1.290	1.393	0.960	0.837	1.042	0.858	0.958	1.377	1.276	1.039	1.143	0.205
2.36	2.23	1.49	1.34	1.55	-0.38	-2.34	-1.58	0.07	-0.64	0.39	0.24	1.56	3.19	2.57
	0.939	1.199	1.352	1.117	1.292	0.954	1.216	0.954	1.292	1.117	1.352	1.199	0.939	
	0.965	1.233	1.352	1.111	1.283	0.931	1.189	0.922	1.256	1.089	1.339	1.216	0.975	
	2.80	2.78	-0.02	-0.57	-0.71	-2.44	-2.25	-3.36	-2.78	-2.51	-0.95	1.40	3.87	
	0.741	1.089	1.247	1.354	1.089	1.348	0.998	1.348	1.089	1.354	1.247	1.089	0.741	
	0.761	1.117	1.240	1.328	1.070	1.327	0.967	1.295	1.030	1.333	1.256	1.107	0.760	
	2.76	2.65	-0.59	-1.93	-1.81	-1.55	-3.04	-3.91	-5.47	-1.51	0.71	1.70	2.62	
		0.411	1.026	1.243	1.333	1.253	0.909	1.253	1.333	1.243	1.026	0.411		
		0.419	1.034	1.213	1.322	1.249	0.893	1.216	1.289	1.233	1.061	0.413		
		1.98	0.75	-2.38	-0.81	-0.38	-1.74	-2.95	-3.31	-0.76	3.35	0.55		
			0.420	1.084	1.188	1.012	1.212	1.012	1.188	1.084	0.420			
			0.428	1.115	1.204	1.006	1.218	1.004	1.172	1.091	0.428			
			2.04	2.85	1.40	-0.53	0.48	-0.77	-1.28	0.61	1.92			
				0.737	0.930	1.096	0.920	1.096	0.930	0.737				
				0.759	0.959	1.096	0.928	1.103	0.927	0.726				
				3.01	3.09	0.05	0.89	0.66	-0.35	-1.41				
						0.198	0.226	0.198						
						0.203	0.230	0.201						
						2.89	1.61	1.63						

Predicted
Measured
%Difference

Figure A.2

Figure A.3

H.B. Robinson Unit 2 Cycle 11
Flux Map 505 Assembly Relative Power

						0.199	0.228	0.199						
						0.197	0.222	0.199						
						-0.85	-2.85	0.38						
				0.708	0.901	1.076	0.912	1.076	0.901	0.708				
				0.741	0.889	1.061	0.899	1.084	0.921	0.725				
				4.74	-1.31	-1.38	-1.51	0.72	2.27	2.48				
			0.405	1.045	1.160	1.014	1.236	1.014	1.160	1.045	0.405			
			0.421	1.073	1.153	0.993	1.213	0.996	1.160	1.057	0.414			
			3.81	2.74	-0.60	-2.06	-1.85	-1.74	-0.02	1.14	2.07			
		0.397	0.989	1.208	1.316	1.283	1.010	1.283	1.316	1.208	0.989	0.397		
		0.412	1.019	1.218	1.315	1.264	0.980	1.253	1.290	1.199	0.995	0.404		
		3.82	3.10	0.82	-0.09	-1.52	-3.02	-2.31	-1.98	-0.75	0.68	1.75		
	0.711	1.048	1.212	1.326	1.086	1.372	1.042	1.372	1.086	1.333	1.212	1.048	0.711	
	0.743	1.095	1.226	1.322	1.079	1.371	1.030	1.357	1.069	1.327	1.200	1.070	0.746	
	4.60	4.44	1.19	-0.33	-0.63	-0.10	-1.09	-1.06	-1.59	-0.46	-0.97	2.10	4.93	
	0.908	1.172	1.335	1.113	1.294	0.976	1.250	0.976	1.294	1.113	1.335	1.172	0.908	
	0.922	1.188	1.337	1.092	1.280	0.969	1.262	0.967	1.283	1.100	1.326	1.187	0.941	
	1.52	1.38	0.17	-1.90	-1.14	-0.79	0.91	-0.97	-0.90	-1.22	-0.66	1.35	3.69	
0.201	1.086	1.025	1.301	1.395	0.991	0.898	1.125	0.898	0.986	1.395	1.301	1.025	1.086	0.201
0.195	1.076	1.006	1.278	1.359	0.962	0.878	1.118	0.884	0.977	1.392	1.290	1.025	1.111	0.206
-2.67	-0.92	-1.85	-1.79	-2.62	-2.91	-2.24	-0.65	-1.53	-0.92	-0.23	-0.89	-0.03	2.32	2.71
0.231	0.922	1.249	1.021	1.052	1.259	1.128	1.080	1.128	1.259	1.052	1.021	1.249	0.922	0.231
0.229	0.916	1.244	1.002	1.014	1.237	1.105	1.057	1.123	1.271	1.044	1.009	1.253	0.935	0.237
-0.80	-0.67	-0.43	-1.83	-3.61	-1.73	-2.02	-2.18	-0.44	0.92	-0.78	-1.11	0.29	1.43	2.71
0.201	1.086	1.025	1.301	1.395	0.986	0.898	1.125	0.898	0.986	1.395	1.301	1.025	1.086	0.201
0.202	1.094	1.026	1.301	1.408	0.969	0.867	1.095	0.886	0.965	1.396	1.315	1.040	1.122	0.209
0.52	0.75	0.12	-0.03	0.91	-1.72	-3.40	-2.71	-1.31	-2.10	0.08	1.03	1.48	3.29	4.09
	0.908	1.172	1.335	1.113	1.294	0.976	1.250	0.976	1.294	1.113	1.335	1.172	0.908	
	0.922	1.188	1.345	1.110	1.281	0.943	1.212	0.943	1.269	1.110	1.357	1.211	0.955	
	1.51	1.40	0.72	-0.31	-1.03	-3.42	-3.10	-3.43	-1.96	-0.31	1.61	3.32	5.14	
	0.711	1.048	1.212	1.326	1.086	1.372	1.042	1.372	1.086	1.326	1.212	1.048	0.711	
	0.742	1.094	1.230	1.308	1.062	1.336	1.001	1.323	1.076	1.363	1.240	1.083	0.741	
	4.46	4.38	1.46	-1.35	-2.27	-2.60	-3.91	-3.57	-0.94	2.78	2.29	3.29	4.20	
		0.397	0.989	1.208	1.316	1.283	1.015	1.283	1.316	1.208	0.989	0.397		
		0.424	1.027	1.187	1.296	1.260	0.983	1.257	1.309	1.229	1.027	0.406		
		6.87	3.91	-1.76	-1.49	-1.82	-3.13	-2.05	-0.53	1.75	3.86	2.38		
			0.405	1.045	1.160	1.014	1.236	1.014	1.160	1.045	0.405			
			0.424	1.075	1.168	0.993	1.239	1.018	1.158	1.059	0.417			
			4.57	2.93	0.64	-2.01	C.31	0.42	-0.23	1.35	2.94			
				0.708	0.901	1.076	0.912	1.076	0.901	0.708				
				0.729	0.928	1.060	0.935	1.100	0.909	0.705				
				3.05	3.00	-1.51	2.50	2.21	0.99	-0.38				
						0.199	0.228	0.199						
						0.201	0.236	0.205						
						1.00	3.22	3.22						

Predicted
Measured
%Difference

Figure A.4

H.B. Robinson Unit 2 Cycle 11
Flux Map 506 Assembly Relative Power

						0.199	0.229	0.199						
						0.198	0.226	0.205						
						-0.08	-1.06	3.12						
				0.706	0.899	1.075	0.912	1.075	0.899	0.706				
				0.738	0.897	1.072	0.909	1.099	0.935	0.725				
				4.57	-0.27	-0.26	-0.33	2.24	3.90	2.69				
			0.405	1.044	1.160	1.013	1.236	1.013	1.160	1.044	0.405			
			0.419	1.071	1.160	1.004	1.227	1.008	1.174	1.055	0.405			
			3.46	2.59	0.01	-0.96	-0.72	-0.57	1.23	1.00	-0.04			
		0.397	0.989	1.207	1.315	1.283	1.011	1.283	1.315	1.207	0.989	0.397		
		0.410	1.016	1.215	1.318	1.273	0.989	1.265	1.300	1.197	0.990	0.402		
		3.21	2.76	0.68	0.17	-0.83	-2.20	-1.42	-1.16	-0.82	0.09	1.24		
	0.709	1.048	1.211	1.325	1.086	1.372	1.043	1.372	1.086	1.332	1.211	1.048	0.709	
	0.735	1.085	1.223	1.323	1.080	1.373	1.038	1.368	1.073	1.327	1.204	1.073	0.744	
	3.67	3.54	0.95	-0.17	-0.59	0.06	-0.46	-0.31	-1.20	-0.38	-0.54	2.37	4.97	
	0.907	1.170	1.334	1.113	1.295	0.978	1.253	0.978	1.295	1.113	1.334	1.170	0.907	
	0.919	1.185	1.337	1.097	1.283	0.974	1.276	0.972	1.286	1.101	1.326	1.186	0.939	
	1.33	1.22	0.26	-1.43	-0.96	-0.43	1.76	-0.60	-0.74	-1.11	-0.60	1.34	3.53	
0.201	1.084	1.025	1.301	1.395	0.988	0.901	1.129	0.901	0.992	1.395	1.301	1.025	1.084	0.201
0.197	1.078	1.011	1.286	1.373	0.965	0.882	1.125	0.886	0.988	1.397	1.285	1.023	1.104	0.205
-2.04	-0.62	-1.35	-1.14	-1.56	-2.33	-2.07	-0.36	-1.66	-0.46	0.13	-1.19	-0.19	1.83	1.96
0.231	0.921	1.249	1.021	1.053	1.262	1.132	1.085	1.132	1.262	1.053	1.021	1.249	0.921	0.231
0.229	0.917	1.243	1.008	1.029	1.248	1.111	1.059	1.133	1.289	1.053	1.007	1.251	0.931	0.236
-1.11	-0.52	-0.44	-1.30	-2.29	-1.09	-1.87	-2.39	0.12	2.14	0.02	-1.35	0.14	1.03	1.95
0.201	1.084	1.025	1.301	1.395	0.988	0.901	1.129	0.901	0.988	1.395	1.301	1.025	1.084	0.201
0.199	1.087	1.021	1.301	1.407	0.974	0.870	1.098	0.899	0.976	1.407	1.314	1.034	1.106	0.207
-0.96	0.24	-0.35	0.03	0.86	-1.41	-3.40	-2.81	-0.17	-1.15	0.85	1.00	0.91	1.99	2.96
	0.907	1.170	1.334	1.113	1.295	0.978	1.253	0.978	1.295	1.113	1.334	1.170	0.907	
	0.913	1.177	1.339	1.110	1.282	0.945	1.217	0.941	1.253	1.095	1.356	1.203	0.944	
	0.66	0.57	0.35	-0.30	-1.02	-3.34	-2.90	-3.83	-3.26	-1.58	1.68	2.81	4.10	
	0.709	1.048	1.211	1.325	1.086	1.372	1.043	1.372	1.086	1.325	1.211	1.048	0.709	
	0.726	1.072	1.216	1.312	1.064	1.339	1.005	1.314	1.024	1.321	1.245	1.083	0.734	
	2.41	2.29	0.38	-1.01	-2.04	-2.41	-3.57	-4.23	-5.74	-0.33	2.81	3.33	3.51	
		0.397	0.989	1.207	1.315	1.283	1.016	1.283	1.315	1.207	0.989	0.397		
		0.410	1.009	1.190	1.299	1.262	0.987	1.246	1.279	1.211	1.039	0.407		
		3.36	1.99	-1.38	-1.27	-1.64	-2.85	-2.92	-2.80	0.36	5.07	2.37		
			0.405	1.044	1.160	1.013	1.236	1.013	1.160	1.044	0.405			
			0.417	1.076	1.169	0.995	1.237	1.017	1.158	1.066	0.420			
			2.88	3.06	0.79	-1.84	0.12	0.31	-0.10	2.04	3.72			
				0.706	0.899	1.075	0.912	1.075	0.899	0.706				
				0.729	0.929	1.060	0.930	1.093	0.907	0.705				
				3.22	3.24	-1.38	1.94	1.72	0.81	-0.20				
						0.199	0.229	0.199						
						0.205	0.234	0.203						
						3.26	2.28	2.28						

Predicted
Measured
%Difference