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H. B. ROBINSON UNIT 2, CYCLE 12

STARTUP TEST REPORT

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I. Introduction and Cycle Description

This report will document the startup test results for H. B. Robinson Unit 2 Cycle 12. The report will focus primarily on the results obtained from the various startup physics tests and on a comparison between measured and predicted data supplied by Advanced Nuclear Fuels Corporation. Note that this report is not intended to be a diary of the startup test; for detailed documentation of the tests, refer to EST-48, EST-49, and EST-50.

Specifically the following items will be addressed:

- Control Rod Drop Times
- Control Rod Bank Worth Measurements
- Boron Worth and Endpoint Measurements
- Isothermal Temperature Coefficients
- Power Distribution
- Conclusions

Among the items discussed for each of the topics above will be measured data, comparison to predicted data, and applicable acceptance criteria which must be satisfied for the successful completion of the tests.

H. B. Robinson Unit 2 is a three-loop Westinghouse PWR reactor currently in its twelveth cycle of operation at a rated thermal power of 2300 MW. The reactor core consists of 157 assemblies grouped into 5 regions for Cycle 12, with 48 fresh reload assemblies, 89 carryovers, 12 PLSA, and 8

reinserts. Tables 1.1 and 1.2 provide a review of the Cycle 12 core design parameters and a description of each fuel type. Figures 1.1 and 1.2 provide the core loading pattern and the thimble and control rod locations, respectively.

Cycle 12 initial criticality was achieved on June 16, 1987. Following initial criticality, checkout of the reactivity computer was performed by comparing periodic measurements to the startup rate indicated by the computer using the N-44 excore detector for the input signal. The six-group constants input to the reactimeter were provided by Advanced Nuclear Fuels and are listed in Table 1.3. After confirming correct operation of the reactivity computer, startup physics testing continued in accordance with established procedures. The results of the tests and the applicable acceptance criteria are provided in tables 1.4 and 1.5.

2.0 Control Rod Drop Times

Control rod drop tests were performed in accordance with plant startup procedure EST-48 at cold and hot full coolant flow conditions. Briefly, a control bank was selected and pulled to the fully withdrawn position. Individual rods were then dropped by removing the stationary gripper coil fuse thus interrupting the current. A trace of each rod's fall was recorded with a visicorder with a corresponding 60 H_Z timing trace as a scaling reference.

Technical specifications require that the rod drop time from the beginning of the drop to dash pot entry be no greater than 1.8 seconds at full core flow and operating temperatures. For Cycle 12, all rods easily meet the acceptance criteria.

Summarized results of the rod drop test are presented in Tables 2.1 and 2.2.

3.0 Control Rod Bank Worth Measurements

Control rod bank worth measurements were performed in accordance with EST-50 and Appendix D to EST-50. Procedures require that at a minimum, the integral rod worths of banks D and C must be measured and their individual and cumulative integral worths must fall within acceptance criteria. If the acceptance criteria cannot be met, the individual integral rod worths of banks B and A must be measured, the cumulative worths of D+C+B+A calculated and the acceptance criteria must be met for B, A, and the sum of A+B+C+D. If acceptance criteria are not met, shutdown bank B must be measured. If shutdown bank B acceptance criteria are not met, shutdown bank A and the N-1 rod worth must be measured. The N-1 rod worth must be greater than 95% of predicted, otherwise, PNSC approval is required before power escalation can begin.

The acceptance criteria at each step are met if the individual rod integral worths are within ±15% of predicted and the cumulative integral worths are within ±10% of predicted.

Tables 3.1 and 3.2 presents the predicted and measured integral and differential worths of banks D and C; the ±10 and ±15 percent acceptance criteria were met and no further banks were measured. Figures 3.1 - 3.4 graphically compare the predicted and measured integral and differential rod worths for D and C.

4.0 Boron Worth and Endpoint Measurements

Boron endpoint measurements were performed in accordance with procedures outlined in EST-50 and Appendix B to EST-50 for several bank configurations. The acceptance criteria for boron endpoint measurements require the ARO endpoint to be within ±50 ppm of ANF predictions and the other measurements are accepted at the lead engineers discretion. Note that if acceptance criteria are not met for the ARO measurement PNSC approval is required before continuing.

For Cycle 12, the ARO boron endpoint was 77 ppm less than predicted (1398 measured). PNSC review of the situation was required and approval was given to proceed based on the indication that the core was apparently less reactive than predicted and would therefore present no safety concerns. NFS was requested to review the situation and concurred with the plant personnel's decision. Subsequent flux map data indicated a radial in-out power tilt where the core center measured less reactive than predicted, which was consistent with the low boron endpoint. Several possible causes are under investigation including core leakage underprediction, residual gadolinia modeling errors, and incorrect modeling of the higher gadolinia w/o's which are being used for the first time at HBR2.

Table 4.1 contains the boron endpoint measurements and Figure 4.1 plots the measured and predicted boron endpoints and worths. Refer to Table 1.4 for additional information.

5.0 Isothermal Temperature Coefficients

Isothermal Temperature Coefficient measurements were taken to insure that technical specification requirements limiting the moderator temperature coefficient to +5 pcm/°F at HZP and less than 0.0 pcm/°F at HFP are met. Should the MTC exceed +5 pcm/°F at HZP, ARO conditions rod withdrawal limits for startup or power ascension must be established. The ITC is measured at HZP and operating pressure for ARO and D-in rod positions.

The coefficients are obtained by uniform heatup/cooldowns of the primary system and the subsequent reactivity changes are monitored by the reactivity computer and recorded on the X-Y plotter. All measurements are made below the nuclear heating range to minimize Doppler feedback effects. Over the temperature range used (530 to 547°F) the reactivity versus temperature relationship is approximately linear. As such, the coefficients were measured as the slope of the reactivity change vs. temperature change provided on the X-Y plotter. Note that ITC measurements were taken for heatup and cooldown and the results averaged to find the MTC. This was done in order to minimize the effect of boron additions to the system during cooldown (boron additions are caused by concentration mismatches between the primary and pressurizer). Calculation of the MTC from the measured ITC is done using the equation below and assuming a Doppler coefficient of -1.66 pcm/°F (provided in the ANF HBR 2 Cycle 12 Startup and Operations Report)

$$\alpha_T \text{ iso} = \alpha_T \text{ mod} + \alpha_T \text{ doppler}$$

Results of the ITC/MTC measurements are presented in Tables 5.1 and 5.2 and the actual test data is provided graphically (obtained from Cycle 12 EST-50 records) as Figures 5.1-5.4. The results indicated a negative MTC of -0.745 at HZP, ARO conditions indicating no rod withdrawal limits would be necessary and that the MTC at 100 percent power was less than zero.

6.0 Power Distribution

The core power distribution measurements are taken to insure correct core loading and to verify compliance with tech spec requirements/limits on hot channel factors, quadrant tilts, power density, and allowable power limits.

Core power distribution is measured by processing moveable detector data using the INCORE code which evaluates the map quality, flux trace validity, hot channel factors and locations, and allowable power limits.

Tables 6.1 and 6.2 provide pertinent statistics for evaluating map quality and summarized core parameters which must be monitored. Flux maps were taken at power levels of 34, 69, 90, and 98% (Maps 524, 531, 532, and 533 respectively). Statistics for these maps were in general less satisfactory than comparable Cycle 11 maps due to significant mechanical problems experienced with the in-core detector system at the beginning of Cycle 12. Because of the problems, an additional map (533) was necessary before the plant could operate at 100% power within ±5% operating bands, and Map 525 (statistics not included in this report) was declared unacceptable. Additionally, two thimble locations are inoperable and cannot be fixed until the next refueling outage. By Map 533 the in-core detector system had been repaired and the map statistics were very good.

Figures 6.1-6.23 provide pertinent INCORE and MAPLOT results for the four maps. Tech spec limits and margins are met for each map.

7.0 Conclusions

The data obtained during the Cycle 12 startup physics testing shows acceptable agreement between measured and predicted HZP, ARO critical boron concentration. The lower than expected HZP critical boron indicated that the core was less reactive than predicted and the flux maps tended to confirm this by indicating that the center of the core was producing less power than predicted. However, the predictions overall were acceptable, yielding good confidence in the ANF data and CP&L's ability to predict Cycle 12 core behavior and responses.

References

1. "H. B. Robinson Unit 2, Cycle 12 Startup and Operations Report": XN-NF-87-30(P); March 1987; Advanced Nuclear Fuels Corporation; Richland, Washington.

2. H. B. Robinson Unit 2 Engineering Surveillance Tests EST-48, EST-49, and EST-50.

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Appendix

Table 1.1

H. B. Robinson Unit 2
Core Design Parameters
Cycle 11 and 12

	Cycle 11	Cycle 12
Power Rating (Mwt)	2300	2300
As-Built Zero Burnup Loading (MTU)		
Region 11, 4 F/A	1.73	
Region 12, 40 F/A	17.24	
Region 12A, 1 F/A	0.43	
Region 12B, 8 F/A	3.46	
Region 12R, 8 F/A		3.45*
Region 13, 12 F/A	3.66	3.66
Region 13A, 41 F/A	18.89	17.6
Region 14, 48 F/A	20.81	20.81
Region 15, 48 F/A	———	20.73
Total	66.22	66.25
System Pressure (psia)	2250	2250
Core Average Moderator Temperature (HZP/HFP °F)	547/575	547/575
Core Dimensions		
Equivalent Diameter (in.)	119.7	119.7
Fuel Pellet Stack Height Cold (in.)	144	144
Maximum Thermal Output for Normal Operation Based On ECCS Limitation (kw/ft)	13.52	13.52
Average Thermal Output (kw/ft)	5.98	5.98
Core Power Density (kw/liter)	86.35	86.35
Number of Burnable Poison Rods	384	336

*Reinserted fuel assemblies

Table 1.2
H. B. Robinson Unit 2, Cycle 12
Fuel Specifications

Region	Nominal/As Design/Loaded	Weight Percent U_{235} In $UO_2Gd_2O_2$	Gadolinia Pins No. 4 w/o	6 w/o	10 w/o
12	2.85/2.850	--	--	--	--
13+	1.24/1.240	--	--	--	--
13A	3.12/3.120	--	--	--	--
13A	3.09/3.090	2.37	8	--	--
13A	3.02/3.020	2.37	12	--	--
14	3.48/3.480	--	--	--	--
14	3.48/3.480	2.60	4	--	--
14	3.43/3.430	2.60	8	--	--
14	3.41/3.410	2.60	12	--	--
14	3.41/3.410	2.60	--	12	--
15	3.59/3.590	--	--	--	--
15++	3.57/3.570	2.70	2	--	--
15++	3.54/3.540	2.70	4	--	--
15	3.52/3.520	2.70	12	--	--
15	3.52/3.520	2.70	8	4	--
15	3.51/3.510	2.70	--	8	4

\+ PLSA lower 42 inches of assembly is 304 stainless steel
++ Gadolinia asymmetrically loaded

Fuel Rod Specifications

Fuel Rod O.D. - 0.424 in.
Clad Material - Zircaloy - 4
Clad Thickness - 0.0290 in.
Percent Theoretical Density - 94.0
Pellet O.D. (inches) - 0.3565
Gas Fill - He

Table 1.3

H. B. Robinson Unit 2, Cycle 12, Input Parameters to Reactivity Computer

Prompt Neutron Lifetime, ℓ^* = 22.0 μsec.

Delayed Neutron Importance, I = 0.965

All Rod Out - Use for unrodded measurements

Precursor Data	$I^*\beta_i$ † Decimal	λ_i Decimal
Group 1	0.000202	0.012538
2	0.001267	0.030785
3	0.001144	0.117509
4	0.002456	0.315325
5	0.000899	1.259613
6	0.000218	3.457345
	0.006187	3.457345

$\bar{\beta} / \bar{\lambda}$ = 0.078292

Bank D In - Use for Bank D Measurements

Precursor Data	$I^*\beta_i$ † Decimal	λ_i Decimal
Group 1	0.000204	0.012535
2	0.001274	0.030786
3	0.001151	0.117366
4	0.002473	0.314999
5	0.000902	1.257624
6	0.000218	3.454175
	0.006223	

$\bar{\beta} / \bar{\lambda}$ = 0.078839

† 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	$I^*\beta_i$ † Decimal	λ_i Decimal
Group 1	0.000205	0.012533
2	0.001277	0.030785
3	0.001154	0.117308
4	0.002800	0.314866
5	0.000904	1.256730
6	0.000219	3.452662
	0.006238	

$\bar{\beta} / \bar{\lambda} = 0.079058$

Precursor Data	$I^*\beta_i$ † Decimal	λ_i Decimal
Group 1	0.000199	0.012540
2	0.001255	0.030778
3	0.001133	0.117631
4	0.002426	0.315586
5	0.000890	1.260562
6	0.000216	3.455515
	0.006119	

$\bar{\beta} / \bar{\lambda} = 0.077449$

Table 1.3 (Continued)

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

Precursor Data	$I^*\beta_i$ † Decimal	λ_i Decimal
Group 1	0.000203	0.012536
2	0.001266	0.030782
3	0.001144	0.117437
4	0.002455	0.315146
5	0.000896	1.258085
6	0.000217	3.453047
	0.006181	

$\bar{\beta} / \bar{\lambda} = 0.078318$

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

Precursor Data	$I^*\beta_i$ † Decimal	λ_i Decimal
Group 1	0.000205	0.012533
2	0.001275	0.030784
3	0.001152	0.117305
4	0.002474	0.314837
5	0.000901	1.256216
6	0.000218	3.451374
	0.006224	

$\bar{\beta} / \bar{\lambda} = 0.078922$

Table 1.3 (Continued)

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

Precursor Data	$\lvert 1^{*}\beta_i \rvert$ Decimal	λ_i Decimal
Group 1	0.000205	0.012532
2	0.001276	0.030783
3	0.001152	0.117262
4	0.002475	0.314740
5	0.000901	1.255611
6	0.000218	3.449399
	0.006227	

$\bar{\beta} / \bar{\lambda} = 0.078999$

Table 1.4

H. B. ROBINSON UNIT 2, CYCLE 12
STARTUP TEST SUMMARY

Boron Endpoint (ppm)

Configuration	Measured	ANF Predicted	Difference
ARO	1398	1475	77
D-In	1339	1397	58
D + C	1202	1244	42

Control Rod Worths (pcm)

Bank	Measured	ANF Predicted	Percent Difference
D	549	636	-13.7
C	1296 (D Inserted)	1252	-3.4
C + D	1845 (In Overlap)	1888	-2.3

Moderator Temperature Coefficient (pcm/°F)

Configuration	Measured	ANF Predicted	Difference
ARO	-0.745	+0.7	-1.445
D-In	-2.880	-1.4	-1.48

Differential Boron Worth (pcm/ppm)

Configuration	Measured	ANF Predicted	Percent Difference
D-In	9.31	8.15	14.2%
D + C - IN	9.46	8.18	15.6%

Power Distribution at HFP

	Measured*	ANF Predicted***	Percent Difference
F_Q^T**	2.27	2.29	0.87
$F\Delta_H^N$	1.56	1.55	0.65

*Values at 202 MWD/MT and 89.73 percent power.
**Include V(z) for ±3 percent bands.
***Values at 100 MWD/MT and 100 percent power.

Table 1.5

H. B. ROBINSON UNIT 2, CYCLE 12
STARTUP PHYSICS TEST PROCEDURES
ACCEPTANCE CRITERIA

Test	Criteria
Boron Endpoint	ARO boron centration is within ±50 ppm of predicted. (If not, PNSC approval is required to continue.)
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 within 95 percent of measured or PNSC approval is required before continuing.
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. $F\Delta^N_H \leq 1.65 * \underline{1 + 0.2\ (1 - P)}$
	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 in Cycle 11.

Figure 1.1

H. B. ROBINSON UNIT 2 CYCLE 12

LOADING PATTERN

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A	
01							N45 7898 13	N49 9466 13	N53 7892 13							01
02					S01 0 15	S35 0 15	S45 0 15	P30 14752 14	S46 0 15	S36 0 15	S02 0 15					02
03				N29 25764 13A	S22 0 15	P33 11583 14	N03 21981 13A	S14 0 15	N04 21584 13A	P34 11707 14	S23 0 15	N10 27870 13A				03
04			N13 26883 13A	P12 13115 14	P01 9136 14	N43 26091 13A	P41 13111 14	N27 25143 13A	P42 13176 14	N44 25610 13A	P02 9031 14	P13 13145 14	N14 27771 13A			04
05		S05 0 15	S18 0 15	P05 8969 14	M05 21234 12R	S25 0 15	P20 13893 14	N19 24765 13A	P21 13687 14	S26 0 15	M06 21640 12R	P06 9059 14	S19 0 15	S06 0 15		05
06		S34 0 15	P37 11517 14	N35 26357 13A	S31 0 15	M20 23786 12R	N37 26365 13A	S10 0 15	N38 26609 13A	M21 23162 12R	S29 0 15	N36 26555 13A	P38 11739 14	S37 0 15		06
07	N56 7864 13	S42 0 15	N07 21944 13A	P45 13130 14	P10 13714 14	N32 25685 13A	P26 14625 14	P17 15245 14	P25 14877 14	N22 25216 13A	P11 13669 14	P46 13130 14	N08 22410 13A	S47 0 15	N46 7645 13	07
08	N52 9446 13	P28 14699 14	S13 0 15	N26 24776 13A	N18 25326 13A	S09 0 15	P16 15058 14	N21 25379 13A	P18 15251 14	S11 0 15	N20 24764 13A	N28 25460 13A	S15 0 15	P29 14810 14	N50 9158 13	08
09	N48 8015 13	S41 0 15	N06 21967 13A	P48 12985 14	P09 13703 14	N24 25907 13A	P31 14706 14	P19 14884 14	P27 14170 14	N30 25335 13A	P24 13712 14	P47 13175 14	N05 21862 13A	S48 0 15	N54 7761 13	09
10		S33 0 15	P40 11492 14	N34 25988 13A	S28 0 15	M19 23656 12R	N40 26609 13A	S12 0 15	N39 25893 13A	M18 23603 12R	S30 0 15	N33 26112 13A	P39 11789 14	S38 0 15		10
11		S07 0 15	S17 0 15	P08 8953 14	M08 21316 12R	S27 0 15	P23 13686 14	N17 25414 13A	P22 13770 14	S32 0 15	M07 21137 12R	P07 9016 14	S20 0 15	S08 0 15		11
12			N16 27571 13A	P15 12876 14	P04 8994 14	N42 26507 13A	P44 13173 14	N25 25616 13A	P43 13026 14	N41 25820 13A	P03 8927 14	P14 13163 14	N15 27594 13A			12
13				N12 27552 13A	S21 0 15	P36 11620 14	N02 21885 13A	S16 0 15	N01 21798 13A	P35 11555 14	S24 0 15	N11 26800 13A	ASSEMBLY ID BOC EXPOSURE REGION			13
14					S03 0 15	S40 0 15	S44 0 15	P32 14737 14	S43 0 15	S39 0 15	S04 0 15					14
15							N55 7695 13	N51 9202 13	N47 7716 13							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 12

CONTROL ROD AND FLUX THIMBLE LOCATIONS

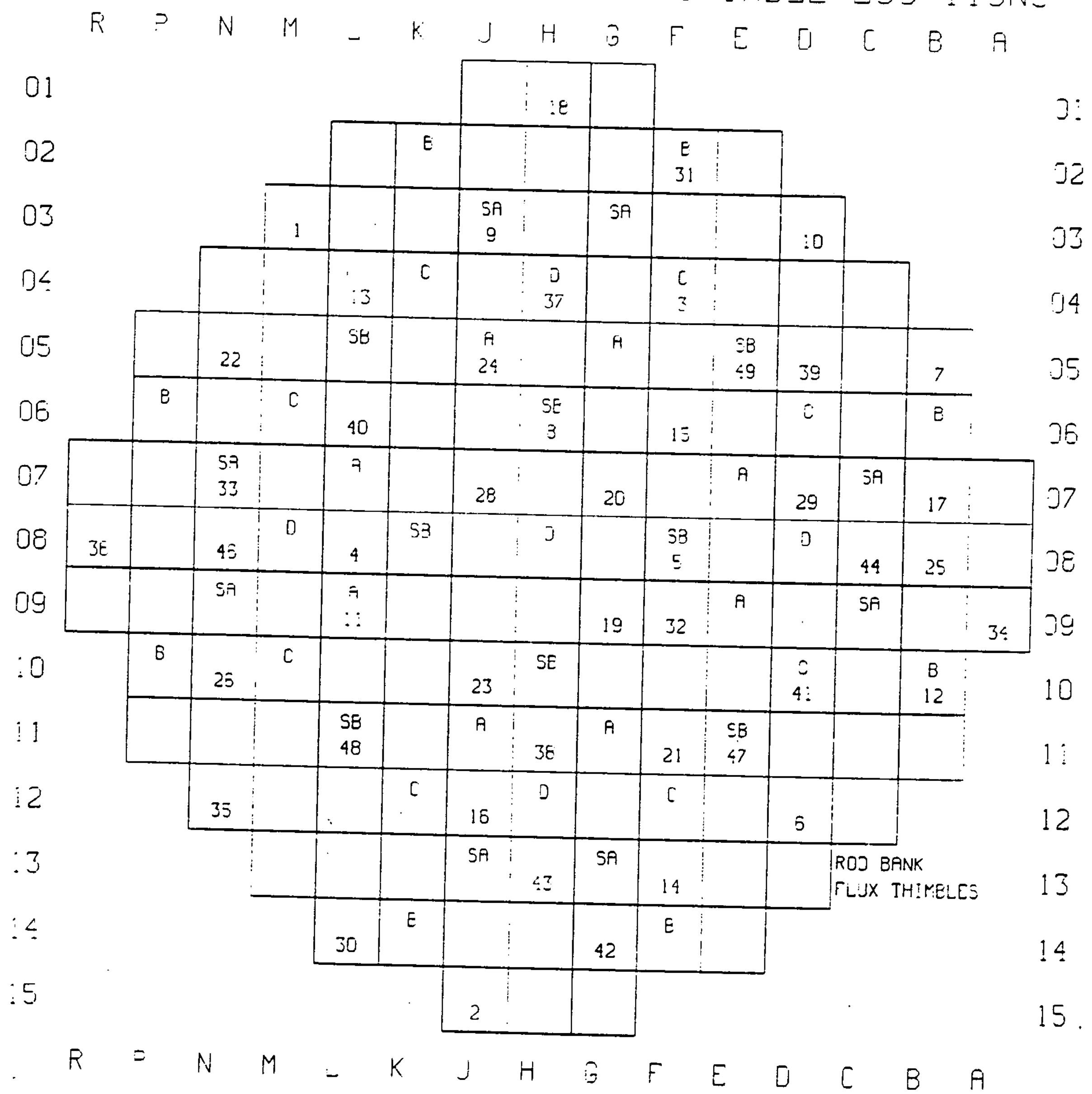


Table 2.1

H. B. Robinson Unit 2, Cycle 12
Cold Control Rod Drop Times

RCCA BANK NUMBER	RCCA GRID LOCATION	DROP TIME TO DASH POT (t_1) (SECONDS)	DASH POT TO RED 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	1.24	0.52	1.76	186	120	361
	C-9	1.31	0.55	1.86	186	120	361
	J-13	1.24	0.53	1.77	186	120	361
	N-7	1.25	0.56	1.81	186	120	361
	J-3	1.31	0.55	1.86	186	120	361
	C-7	1.25	0.55	1.80	183	120	361
	G-13	1.24	0.53	1.77	183	120	361
	N-9	1.24	0.57	1.81	183	120	361
SBD	E-5	1.31	0.53	1.84	187	120	361
	E-11	1.30	0.55	1.85	187	120	361
	L-11	1.22	0.53	1.75	187	120	361
	L-5	1.34	0.57	1.91	187	120	361
	H-6	1.19	0.54	1.73	187	120	361
	F-8	1.25	0.55	1.80	187	120	361
	H-10	1.25	0.57	1.82	187	120	361
	K-8	1.27	0.55	1.82	187	120	360
CA	G-5	1.21	0.56	1.77	188	120	360
	E-9	1.21	0.55	1.76	188	120	360
	J-11	1.29	0.56	1.85	188	120	360
	L-7	1.21	0.56	1.77	188	120	360
	J-5	1.29	0.74	2.03	188	120	360
	E-7	1.24	0.53	1.77	188	120	360
	G-11	1.30	0.61	1.91	188	120	360
	L-9	1.27	0.54	1.81	188	120	360
CB	F-2	1.23	0.56	1.79	190	120	360
	B-10	1.31	0.56	1.87	190	120	360
	K-14	1.31	0.55	1.86	190	120	360
	P-6	1.26	0.55	1.81	190	120	360
	K-2	1.32	0.56	1.88	190	120	360
	B-6	1.21	0.56	1.77	190	120	360
	F-14	1.26	0.55	1.81	190	120	360
	P-10	1.27	0.61	1.88	190	120	360

Table 2.1 (Continued)

RCCA BANK NUMBER	RCCA GRID LOCATION	DROP TIME TO DASH POT (t_1) (SECONDS)	DASH POT TO RED 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	1.23	0.53	1.76	189	120	365
	D-10	1.32	0.59	1.91	189	120	365
	K-12	1.24	0.55	1.79	189	120	365
	M-6	1.35	0.53	1.88	189	120	365
	K-4	1.26	0.52	1.78	189	120	365
	D-6	1.24	0.58	1.82	189	120	365
	F-12	1.32	0.55	1.87	189	120	365
	M-10	1.25	0.54	1.79	189	120	365
CD	D-8	1.18	0.56	1.74	181	120	365
	M-8	1.32	0.56	1.88	181	120	365
	H-4	1.23	0.53	1.76	181	120	365
	H-12	1.26	0.55	1.81	181	120	365
	H-8	1.24	0.63	1.87	181	120	365

Table 2.2

H. B. Robinson Unit 2, Cycle 12
Hot Control Rod Drop Times

RCCA BANK NUMBER	RCCA GRID LOCATION	DROP TIME TO DASH POT (t_1) (SECONDS)	DASH POT TO RED BOTTOM TIME (t_2) (SECONDS)	TOTAL DROP TIME ($t_1 + t_2$) (SECONDS)	RCS Tavg (°F)	RCS FLOW (PERCENT	RCS PRESSURE (PSIG)
CB	F-2	1.24	0.53	1.77	546	105	2225
	B-10	1.35	0.55	1.90	546	105	2225
	K-14	1.35	0.56	1.91	546	105	2225
	P-6	1.23	0.54	1.77	546	105	2225
	K-2	1.33	0.56	1.89	546	105	2225
	B-6	1.31	0.55	1.86	546	105	2225
	F-14	1.27	0.55	1.82	546	105	2225
	P-10	1.33	0.60	1.93	546	105	2225
CC	F-4	1.24	0.55	1.79	548	105	2200
	D-10	1.37	0.58	1.95	548	105	2200
	K-12	1.23	0.55	1.78	548	105	2200
	M-6	1.37	0.56	1.93	548	105	2200
	K-4	1.24	0.53	1.77	548	105	2200
	D-6	1.25	0.62	1.87	548	105	2200
	F-12	1.32	0.56	1.88	548	105	2200
	M-10	1.30	0.57	1.87	548	105	2200
CD	D-8	1.30	0.56	1.86	548	105	2230
	M-8	1.38	0.54	1.92	548	105	2230
	H-4	1.29	0.50	1.79	548	105	2230
	H-12	1.27	0.55	1.82	548	105	2230
	H-8	1.40	0.54	1.94	548	105	2230
SDA	G-3	1.27	0.52	1.79	547	105	2235
	C-9	1.34	0.55	1.89	547	105	2235
	J-13	1.33	0.54	1.87	547	105	2235
	N-7	1.27	0.55	1.82	547	105	2235
	J-3	1.33	0.56	1.89	547	105	2235
	C-7	1.28	0.54	1.82	547	105	2235
	G-13	1.25	0.51	1.76	547	105	2235
	N-9	1.28	0.61	1.89	547	105	2235
SDB	E-5	1.34	0.54	1.88	546	105	2235
	E-11	1.34	0.55	1.89	546	105	2235
	L-11	1.25	0.53	1.78	546	105	2235
	L-5	1.38	0.56	1.94	546	105	2235
	H-6	1.27	0.53	1.80	546	105	2235
	F-8	1.34	0.55	1.89	546	105	2235
	H-10	1.36	0.55	1.91	546	105	2235
	K-8	1.36	0.54	1.90	546	105	2235

Table 2.2 (Continued)

RCCA BANK NUMBER	RCCA GRID LOCATION	DROP TIME TO DASH POT (t_1) (SECONDS)	DASH POT TO RED BOTTOM TIME (t_2) (SECONDS)	TOTAL DROP TIME ($t_1 + t_2$) (SECONDS)	RCS Tavg (°F)	RCS FLOW (PERCENT	RCS PRESSURE (PSIG)
CA	G-5	1.27	0.58	1.85	546	105	2235
	E-9	1.26	0.58	1.84	546	105	2235
	J-11	1.35	0.56	1.91	546	105	2235
	L-7	1.26	0.60	1.86	546	105	2235
	J-5	1.33	0.81	2.14	546	105	2235
	E-7	1.26	0.54	1.80	546	105	2235
	G-11	1.38	0.59	1.97	546	105	2235
	L-9	1.27	0.53	1.80	546	105	2235

Table 3.1

H. B. Robinson Unit 2, Cycle 12
Control Bank D Rod Worth
Measurements

RCCS Position (Steps Withdrawn)			Difference	Reactivity (pcm)		
Initial	Final	Average		Δρ	Δρ/h	ΣΔρ
228	172	200	56	109	1.95	109
172	166	169	6	22.5	3.75	131.5
166	160	163	6	22.5	3.75	154
160	154	157	6	24.0	4.0	178
154	148	151	6	23.5	3.92	201.5
148	142	145	6	22.5	3.75	224
142	137	139.5	5	19.0	3.8	243
137	132	134.5	5	19.5	3.9	262.5
132	127	129.5	5	19.0	3.8	281.5
127	122	124.5	5	18.5	3.7	300.0
122	117	119.5	5	20.0	4.0	320.0
117	112	114.5	5	19.5	3.9	339.5
112	107	109.5	5	19.5	3.9	359.0
107	102	104.5	5	18.0	3.6	377.0
102	97	99.5	5	16.5	3.3	393.5
97	92	94.5	5	16.0	3.2	409.5
92	87	89.5	5	16.0	3.2	425.5
87	81	84.0	6	18.5	3.08	444.0
75	69	72.0	6	15.0	2.50	476.0
69	63	66.0	6	12.5	2.08	488.5
63	56	59.5	7	14.5	2.07	503.0
56	48	52.0	8	13.0	1.63	516.0
48	38	43.0	10	12.0	1.20	528.0
38	23	30.5	15	11.5	0.77	539.5
23	0	11.5	23	9.0	0.39	548.5

Bank D Measured	Bank D Predicted	Percent Difference	Acceptance Criteria
548.5 pcm	636 pcm	-13.8	±15%

Table 3.2

H. B. Robinson Unit 2, Cycle 12
Control Bank C Rod Worth
Measurements

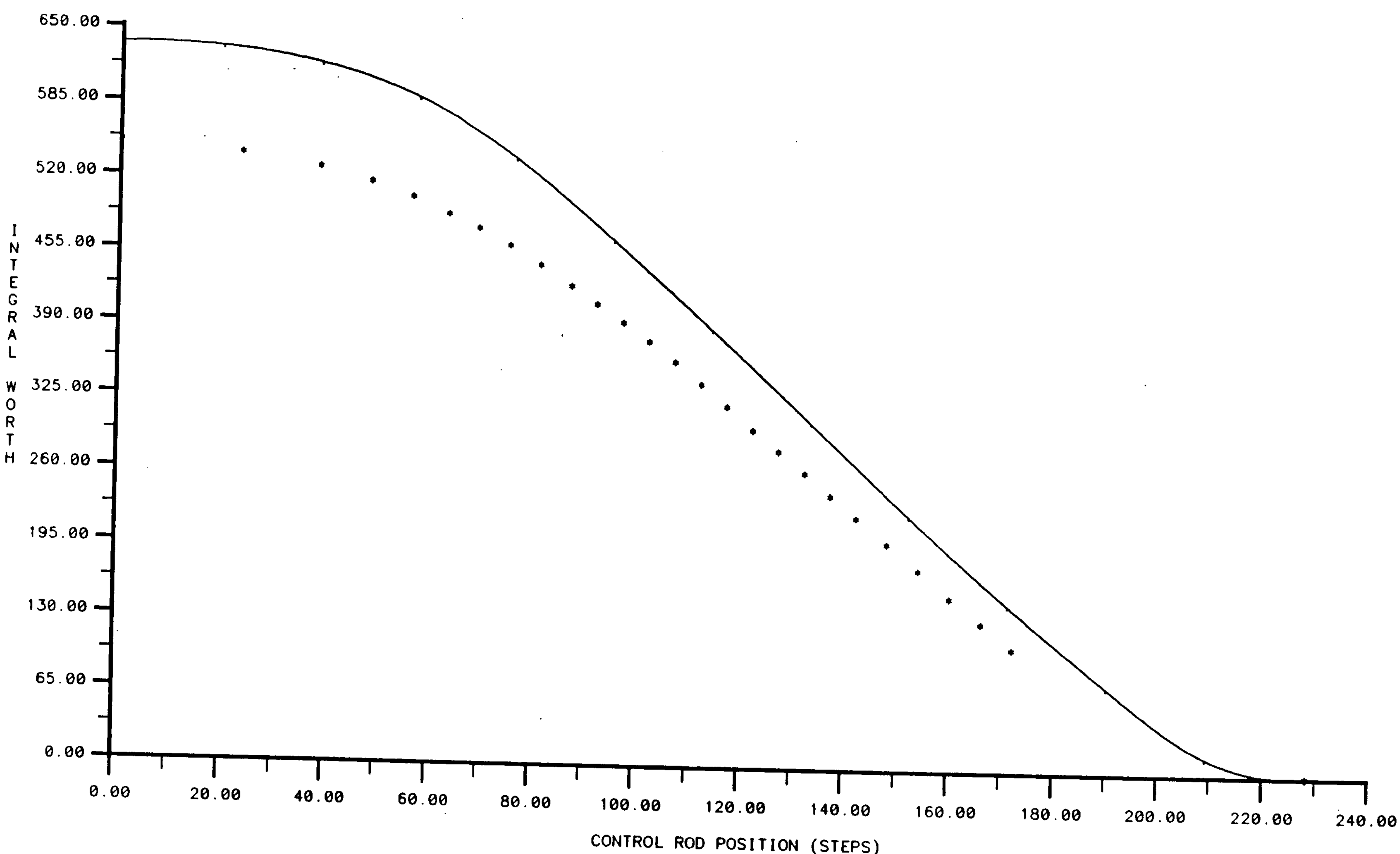
RCCS Position (Steps Withdrawn)			Difference	Reactivity (PCM)		
Initial	Final	Average	(Δh)	Δρ	Δρ/Δh	ΣΔρ
228	202	215	26	45	1.73	45
202	198	200	4	21	5.25	66
198	194	196	4	23	5.75	89
194	188	191	6	35	5.83	124
188	182	185	6	37	6.17	161
182	176	179	6	36	6.00	197
176	170	173	6	36	6.00	233
170	164	167	6	37	6.17	270
164	158	161	6	38	6.33	308
158	152	155	6	39	6.50	347
152	146	149	6	40	6.67	387
146	140	143	6	40	6.67	427
140	134	137	6	43	7.17	470
134	128	131	6	44	7.33	514
128	123	125.5	5	38	7.60	552
123	118	120.5	5	39	7.80	591
118	113	115.5	5	40	8.00	631
113	108	110.5	5	43	8.60	674
108	103	105.5	5	43	8.60	717
103	98	100.5	5	44	8.80	761
98	93	95.5	5	45	9.00	806
93	88	90.5	5	47	9.40	853
88	83	85.5	5	48	9.60	901
83	78	80.5	5	48	9.60	949
78	73	75.5	5	49	9.80	998
73	69	71	4	39	9.75	1037
69	65	67	4	38	9.50	1075
65	60	62.5	5	43	8.60	1118
60	55	57.5	5	42	8.40	1160
55	50	52.5	5	31	6.20	1191
50	42	46	8	41	5.13	1232
42	32	37	10	32	3.20	1264
32	12	22	20	28	1.40	1292
12	0	6	12	4	0.33	1296

Bank	Measured Worth	Predicted Worth	Percent Difference	Acceptance Criteria
C	1296 pcm	1252 pcm	+3.5	±15%
D+C	1844.5 pcm	1888 pcm	+2.3	±10%

Data Source: ANF AND EST-50
Run Date: 8/06/87
Resp. Engineer: Roger L. Thomas, Jr.

H. B. ROBINSON UNIT 2 CYCLE 12
CONTROL BANK D INTEGRAL WORTHS (PCM)
FIGURE 3.1

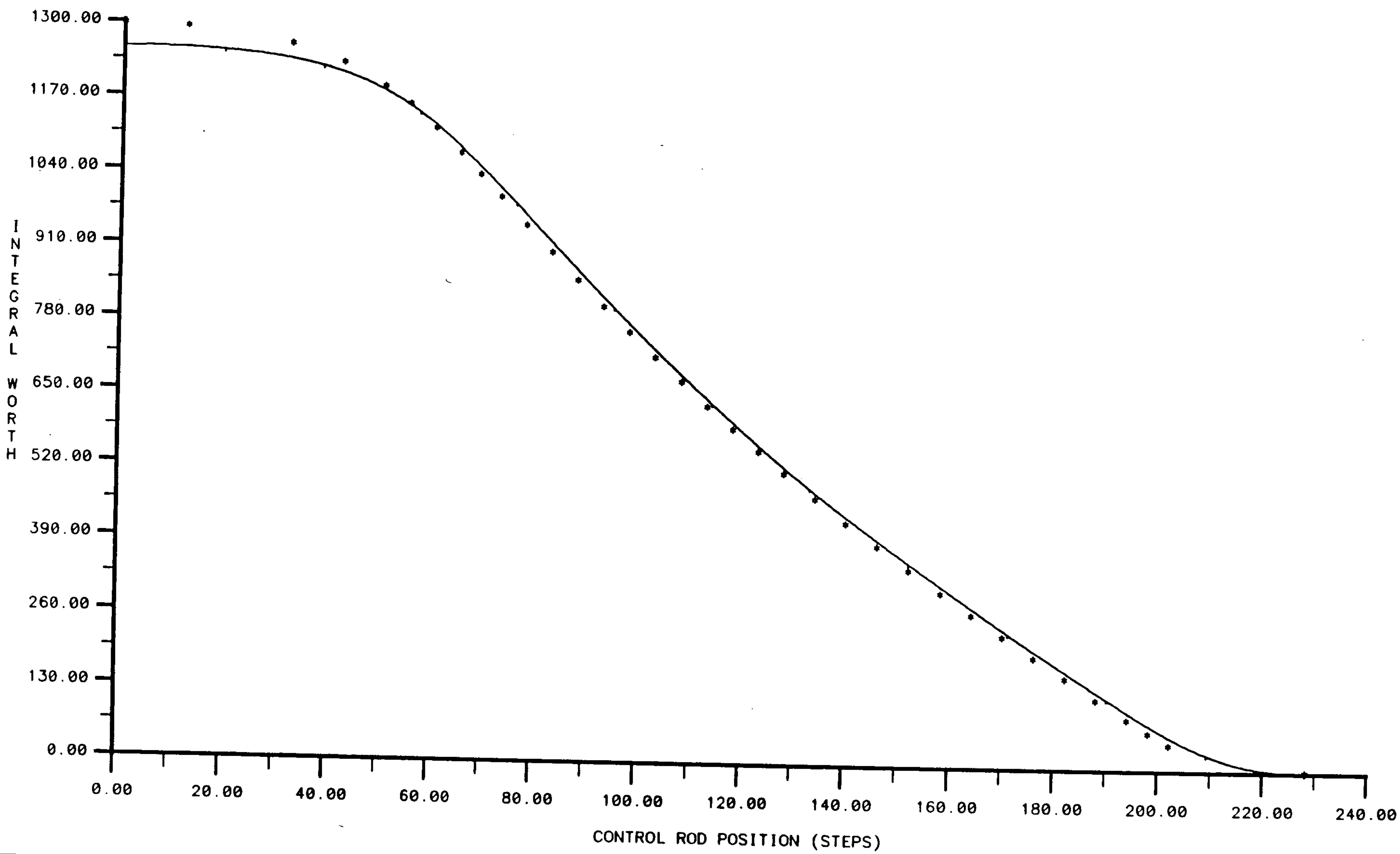
——— = ANF PREDICTION
* = MEASURED



Data Source: ANF AND EST-50
Run Date: 8/06/87
Resp. Engineer: Roger L. Thomas, Jr.

H. B. ROBINSON UNIT 2 CYCLE 12
CONTROL BANK C INTEGRAL WORTHS (PCM)
FIGURE 3.2

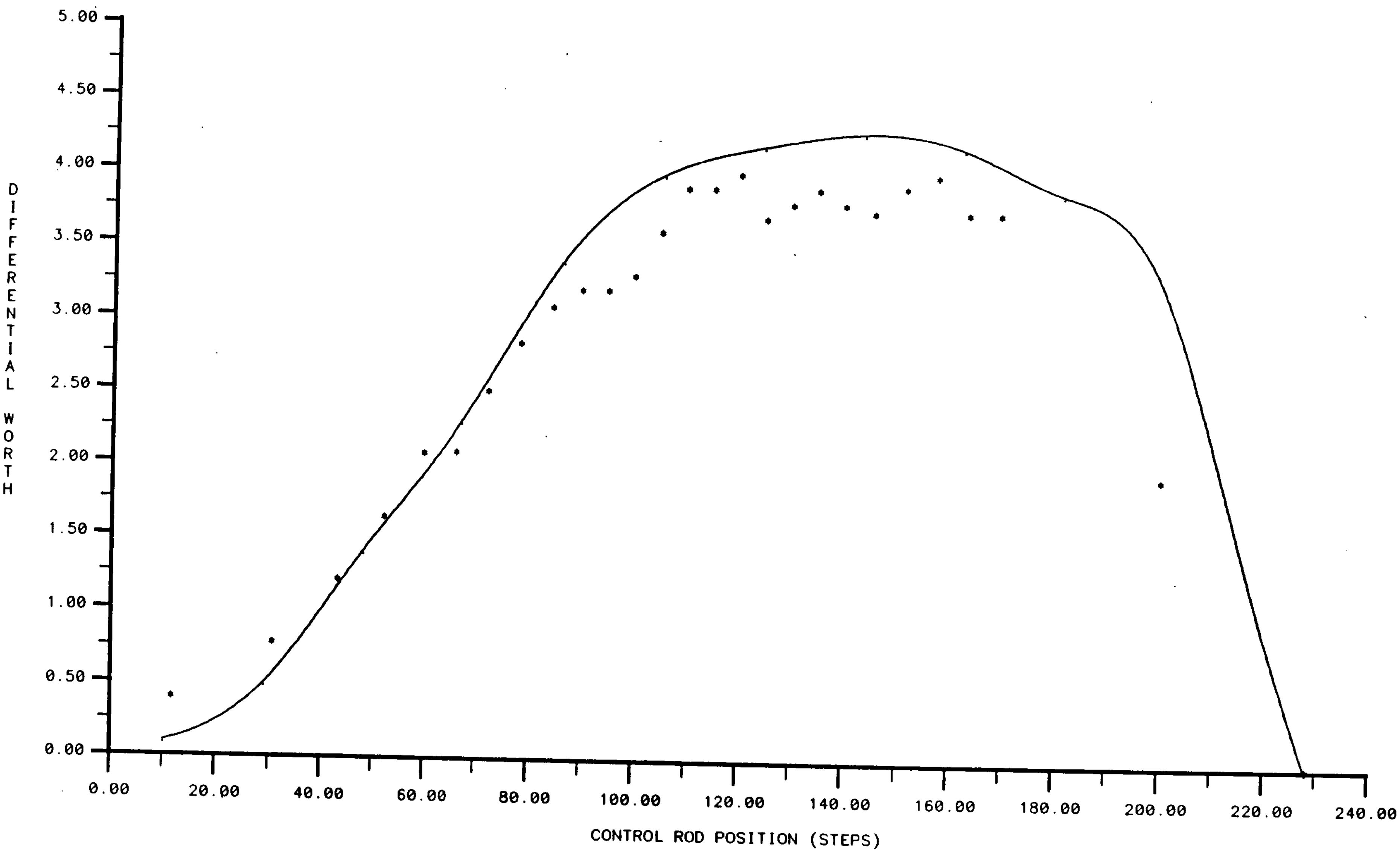
—— = ANF PREDICTION
* = MEASURED



Data Source: ANF AND EST-50
Run Date: 8/06/87
Resp. Engineer: Roger L. Thomas, Jr.

H. B. ROBINSON UNIT 2 CYCLE 12
CONTROL BANK D DIFFERENTIAL WORTHS (PCM/PPM)
FIGURE 3.3

——— = ANF PREDICTION
* = MEASURED



Data Source: ANF AND EST-50
Run Date: 8/06/87
Resp. Engineer: Roger L. Thomas, Jr.

H. B. ROBINSON UNIT 2 CYCLE 12
CONTROL BANK C DIFFERENTIAL WORTHS (PCM/PPM)
FIGURE 3.4

——— = ANF PREDICTION
* = MEASURED

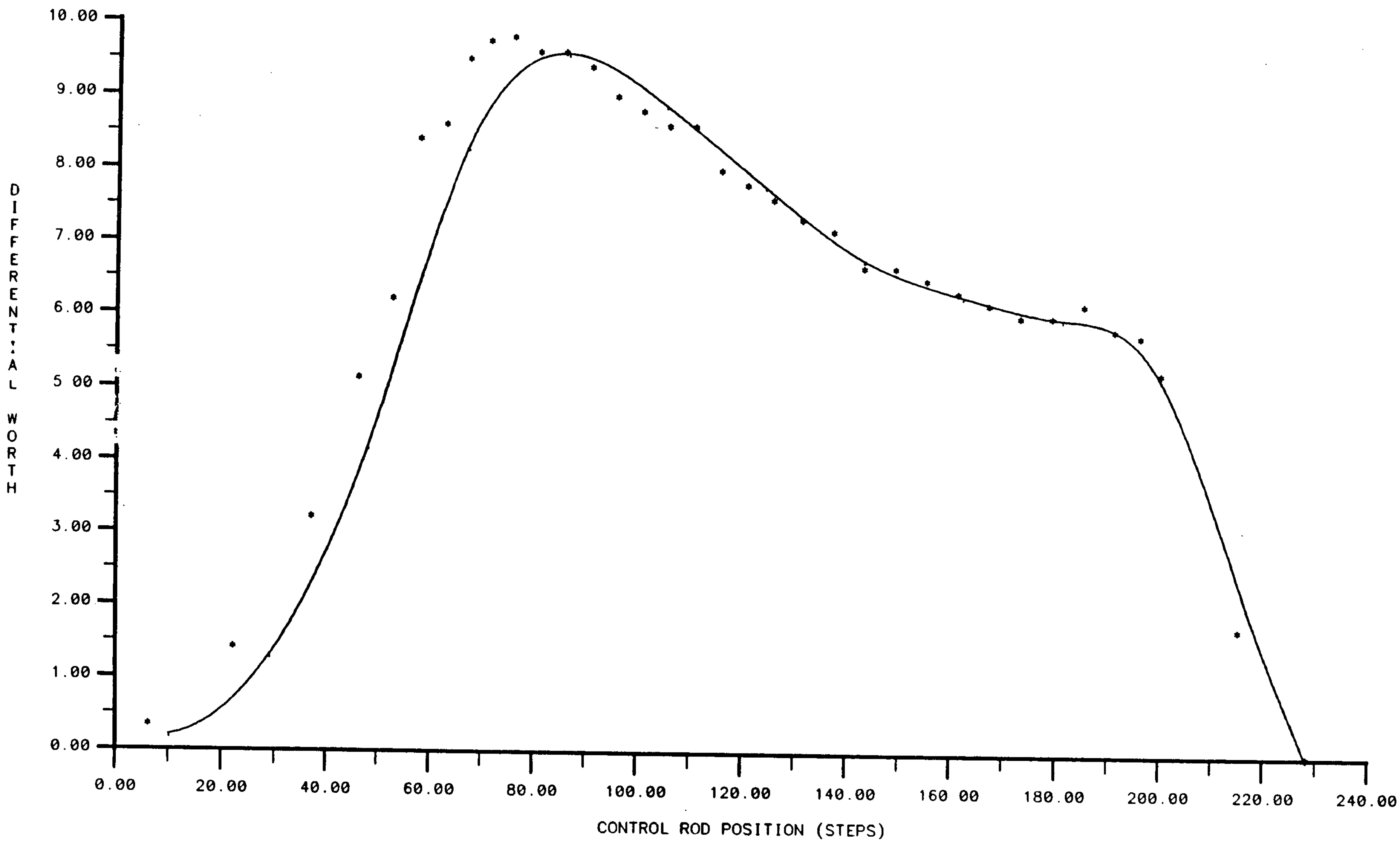


Table 4.1

H. B. Robinson Unit 2, Cycle 12
Boron Endpoints and Worths

RCCS Position	Boron Concentration	Boron Worth
ARO	1398 ppm	
D-In	1339 ppm	9.3 pcm/ppm
D+C+In	1202 ppm	9.46 pcm/ppm

Data Source: ANF AND EST-50
Run Date: 5/19/87
Resp. Engineer: Roger L. Thomas, Jr.

H. B. ROBINSON UNIT 2 CYCLE 12
MEASURED AND PREDICTED BORON WORTHS VS. CONCENTRATION
FIGURE 4.1

1) M = MEASURED (EST-50)
2) P = PREDICTED (ANF)

• HZP CONDITIONS

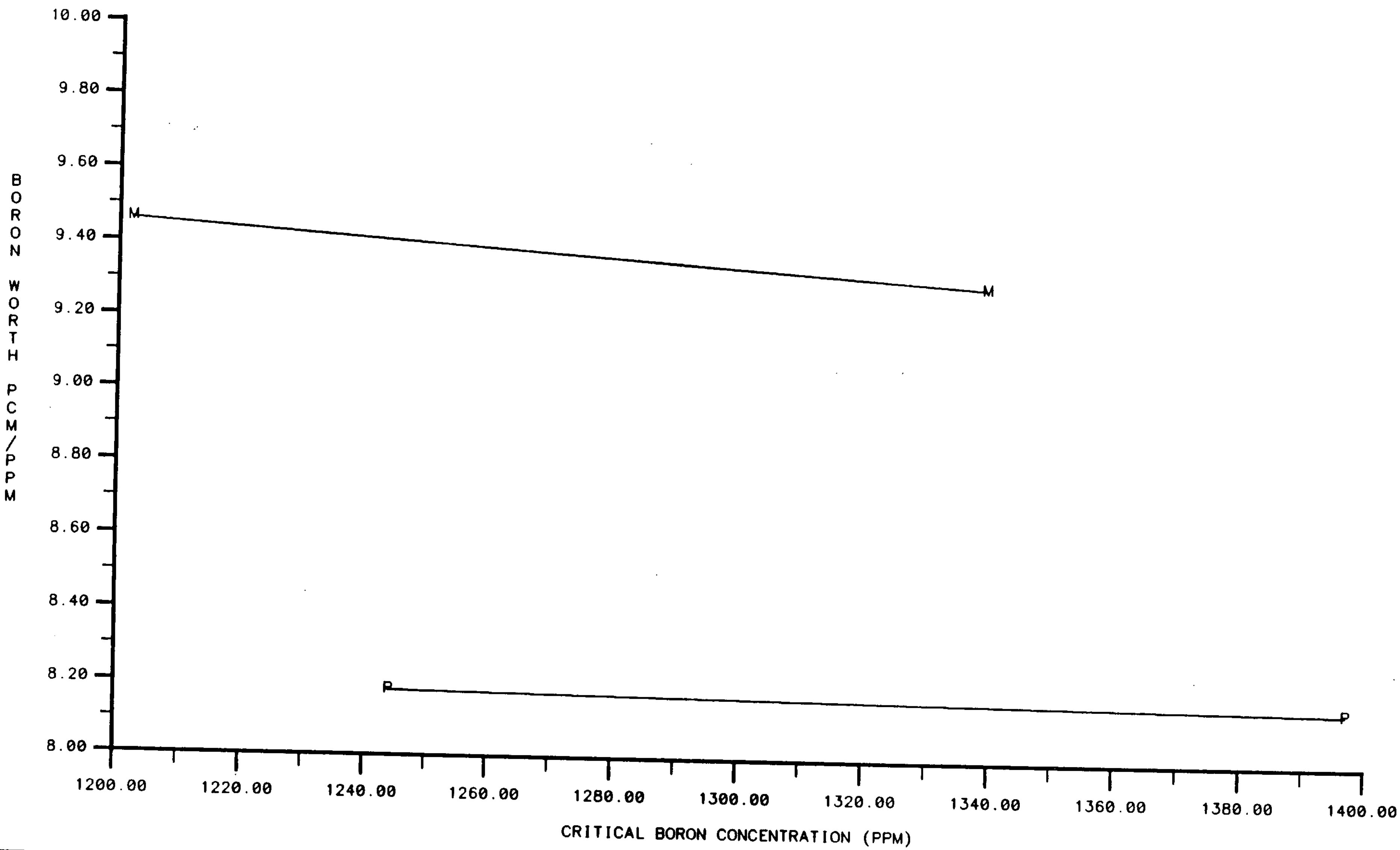


Table 5.1

H. B. Robinson Unit 2, Cycle 12
Isothermal Temperature Coefficient
Summary

Configuration		ITC Measured (pcm/°F)			ANF Predicted (pcm/°F)	Difference Average Predicted
D-Steps	C-Steps	Heat-up	Cooldown	Avg.		
172	228	-2.37	-2.44	-2.41	-1.0	-1.41
0	228	-4.53	-4.55	-4.54	-3.1	-1.44

Table 5.2

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
12	1,398	-0.745	1,339	-2.88

Figure 5.1

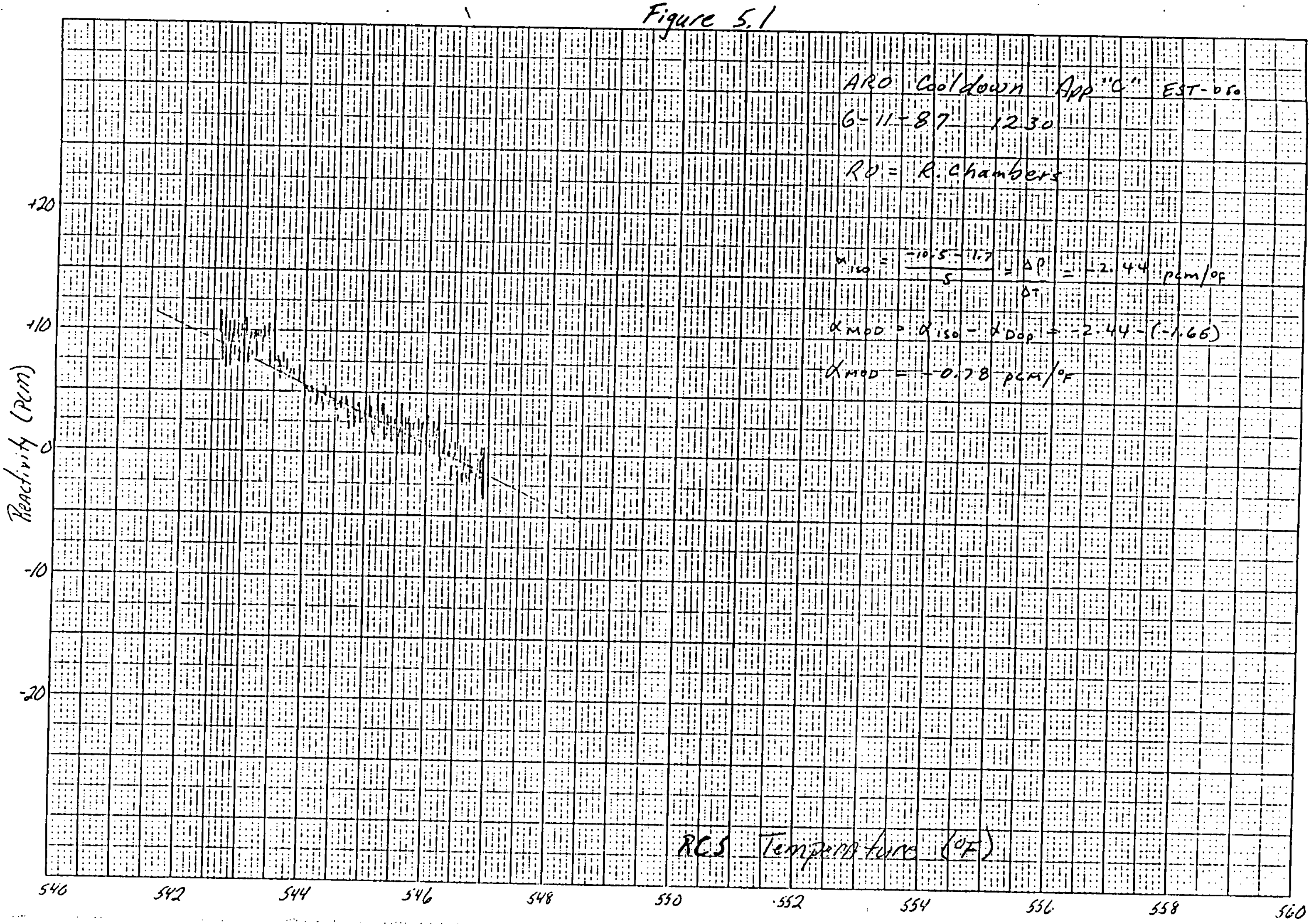
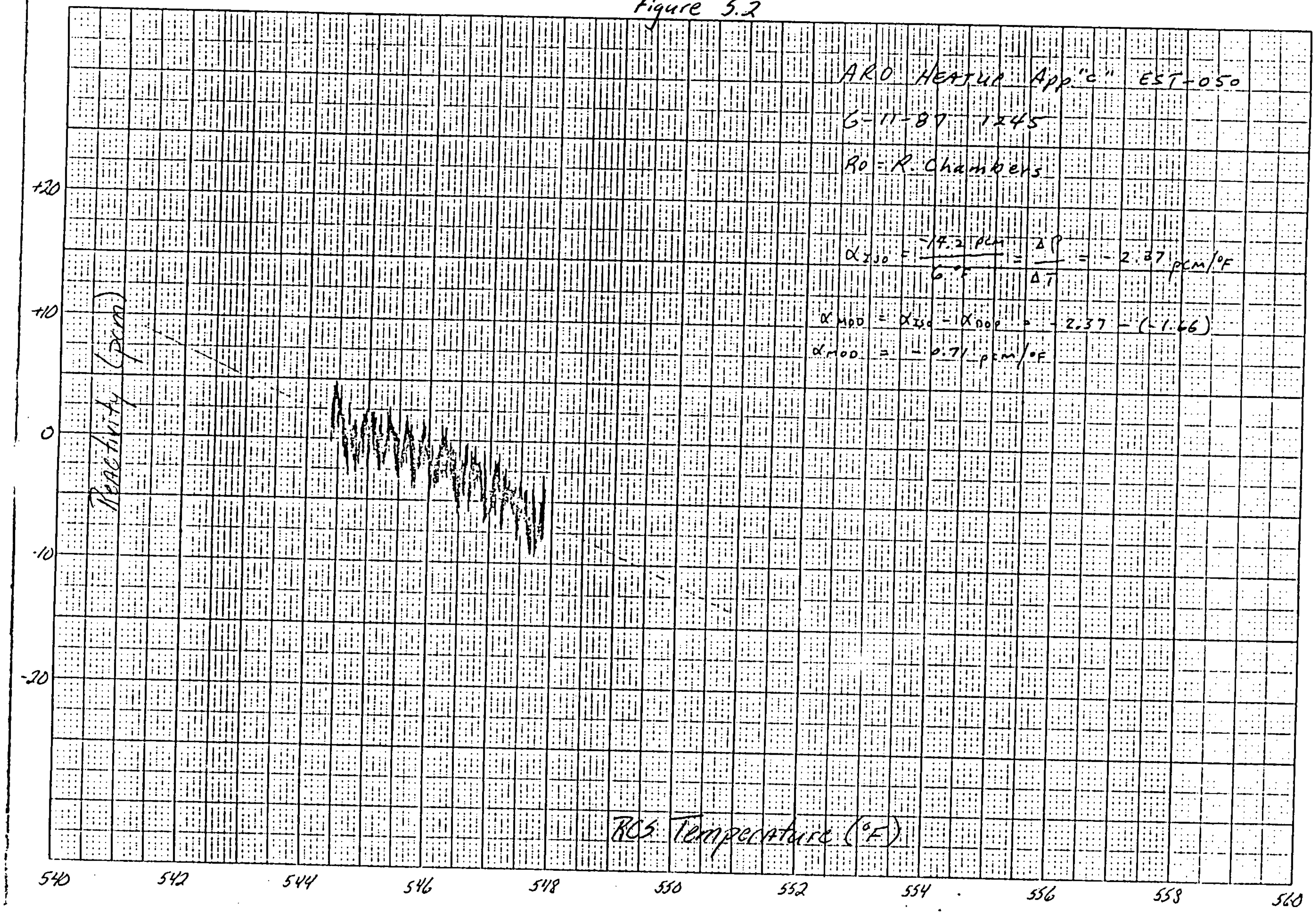

ARO Cooldown App "C" EST-050
6-11-87 1230
RO = R. Chambers
$\alpha_{iso} = \frac{-10.5 - 1.7}{5} = \frac{\Delta\rho}{\Delta T} = -2.44$ pcm/°F
$\alpha_{MOD} = \alpha_{iso} - \alpha_{Dop} = -2.44 - (-1.66)$
$\alpha_{MOD} = -0.78$ pcm/°F
Reactivity (PCM)
+20
+10
0
-10
-20
RCS Temperature (°F)
540
542
544
546
548
550
552
554
556
558
560

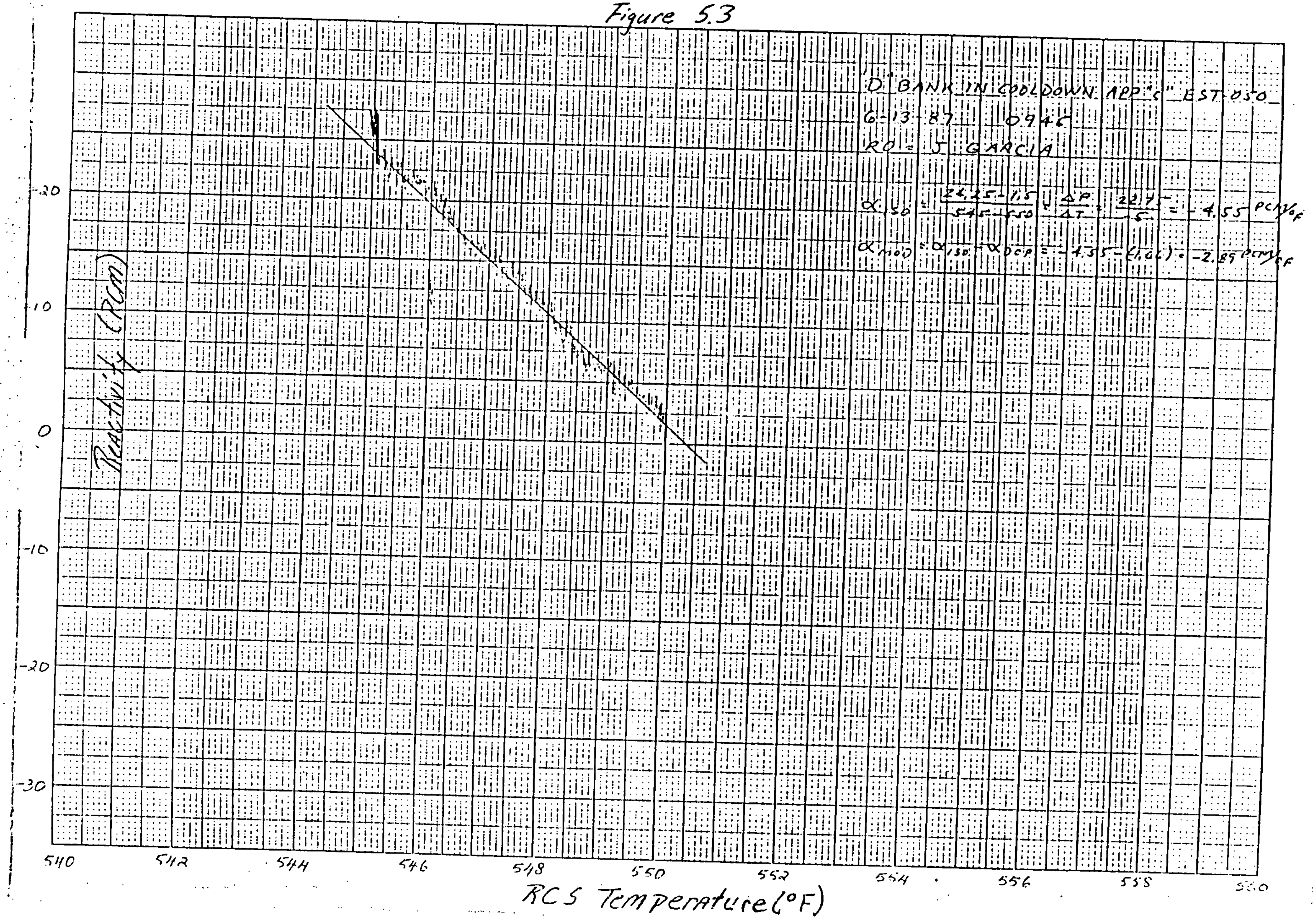
Figure 5.2


ARO HEATUP App "c" EST-050
6-11-87 1245
RO = R. Chambers
α230 = -14.2 pcm / 6 °F = Δρ / ΔT = -2.37 pcm/°F
α MOD = α230 - α DOP = -2.37 - (-1.66)
α MOD = -0.71 pcm/°F
Reactivity (pcm)
+20
+10
0
-10
-20
RCS Temperature (°F)
540
542
544
546
548
550
552
554
556
558
560

K+E 20 X 20 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 1240

Figure 5.3



K&E 20 X 20 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

46 1240

Figure 5.4

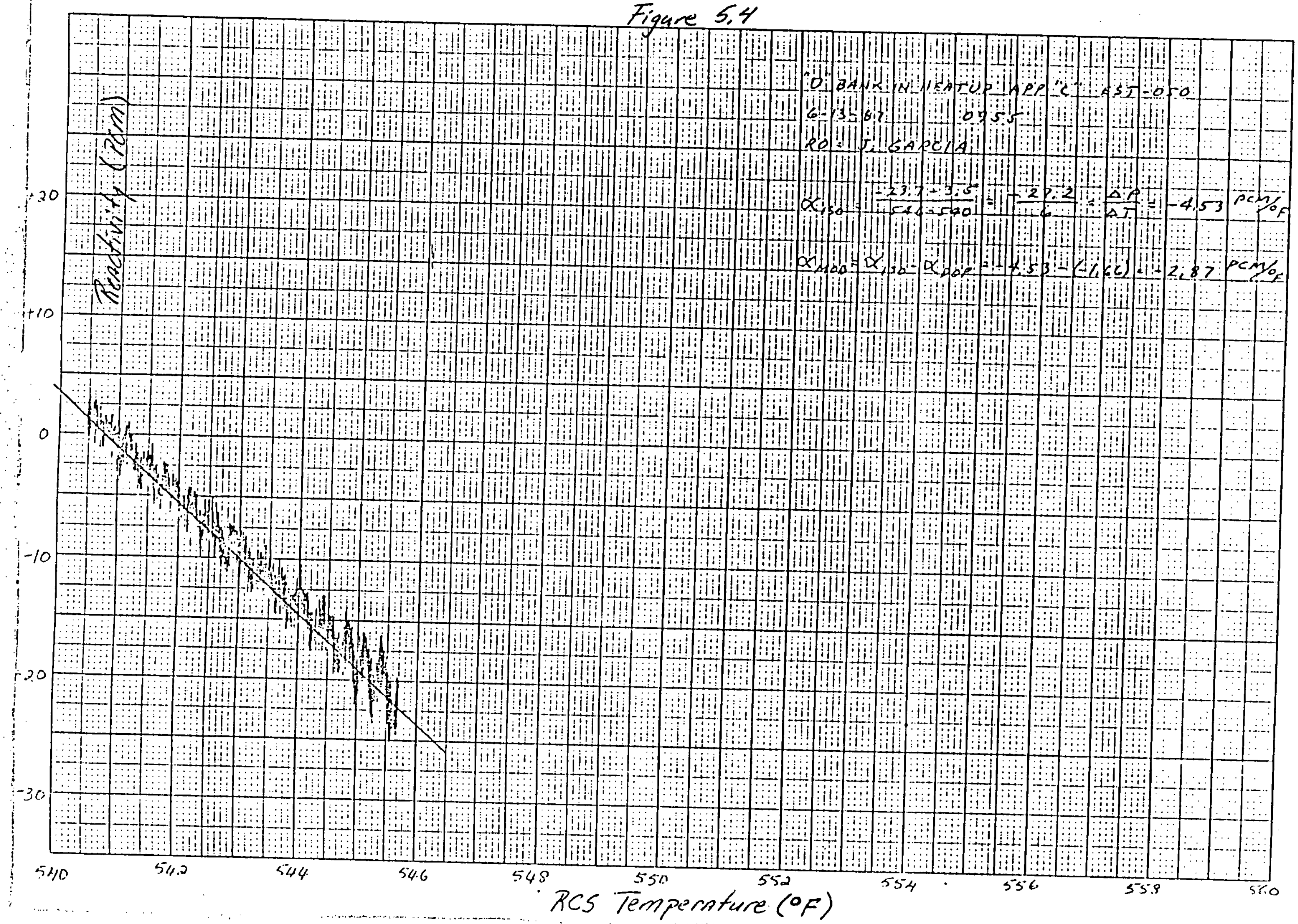


Table 6.1

H.B. ROBINSON UNIT 2 - CYCLE 12
FLUX MAP SUMMARY

MAP NO	MWD/ MT	DATE	PWR %	D BANK	CORE AVG AO	CORE AVG FZ	F_H	LOC F_H	KW/ FT	LIM F_Q	F_Q	LOC FQ	F_R	APL 3% BAND	APL 5% BAND	F_Z	LOC FZ
524	19	61787	34	178	4.70	1.327	1.627	L13	4.73	2.360	2.351	G 2	1.400	91.02	88.56	1.763	J15
531	130	62387	69	195	5.82	1.296	1.590	G 2	9.35	2.285	2.249	P 7	1.364	94.01	91.47	1.729	A 7
532	202	62587	90	202	0.62	1.243	1.562	L13	11.42	2.097	2.119	G 2	1.330	102.42	99.65	1.763	G15
533	324	62987	99	213	-0.40	1.230	1.558	L13	12.44	2.086	2.102	G 2	1.313	103.00	100.22	1.752	J15

F_Q INCLUDES 1.03 ENGINEERING FACTOR AND ,1.05 MEASUREMENT UNCERTAINTY

F_H INCLUDES 1.04 MEASUREMENT UNCERTAINTY

KW/FT INCLUDES 1.03 ENGINEERING FACTORAND 1.05 MEASUREMENT UNCERTAINTY

MAP NO	QUADRANT TILT NW	NE	SW	SE	POWER FRACTION 15	14	12R	13A	13	STANDARD DEVIATION 15	14	12R	13A	13
524	1.005	0.997	1.006	0.992	1.150	1.178	0.960	0.849	0.228	4.663	3.552	4.643	3.354	5.388
531	1.006	0.994	1.004	0.996	1.121	1.187	0.973	0.869	0.230	4.522	3.625	4.229	3.406	7.759
532	1.002	0.997	1.006	0.995	1.117	1.189	0.985	0.874	0.214	3.549	2.199	3.126	2.308	3.129
533	1.001	1.000	1.003	0.996	1.115	1.190	0.981	0.877	0.212	3.498	2.090	3.583	2.094	3.005

Table 6.2

H. B. Robinson Unit 2, Cycle 12

Flux Map Thimble Statistics

Map No.	No. of Useable Thimble Traces	Reaction Rate Percent Difference: Axial Plane B*	Reaction Rate Percent Difference: Axial Plane C*
524	41	5.15	3.97
531	37	3.82	6.24
532	41	2.69	3.37
533	43	2.53	3.79

*Statistics for unrodded regions

A QUARTER CORE AVERAGED ASSEMBLY RELATIVE POWER C12 MAP524 06/17/87 D-178 19MWD/MTU 33.5%HFP 53P 1 B-1227 30% MAP

	H	G	F	E	D	C	B	A	
1	0.879 0.818 -6.908	1.092 1.040 -4.813	1.121 1.082 -3.427	0.875 0.844 -3.478	0.892 0.902 1.183	1.261 1.319 4.625	1.009 1.060 5.020	0.227 0.239 5.259	1
2	1.091 1.037 -4.971	1.055 1.003 -4.919	0.852 0.812 -4.638	1.144 1.096 -4.162	1.212 1.218 0.457	1.075 1.116 3.781	1.230 1.293 5.120	0.211 0.221 4.716	2
3	1.114 1.079 -3.073	0.842 0.808 -4.320	0.851 0.808 -5.139	1.272 1.219 -4.129	1.022 1.014 -0.803	1.309 1.355 3.501	1.112 1.172 5.381		3
4	0.869 0.845 -2.707	1.139 1.094 -3.927	1.270 1.208 -4.856	1.149 1.113 -3.142	1.357 1.352 -0.389	1.142 1.180 3.265	0.812 0.857 5.503		4
5	0.891 0.877 -1.629	1.214 1.197 -1.397	1.033 1.004 -2.464	1.366 1.336 -2.198	1.038 1.030 -0.814	0.440 0.445 1.082			5
6	1.267 1.291 1.905	1.082 1.106 2.259	1.319 1.356 2.843	1.154 1.173 1.581	0.460 0.459 -0.049				6
7	1.015 1.058 4.186	1.237 1.294 4.588	1.120 1.177 5.119	0.820 0.847 3.298					7
8	0.228 0.240 5.056	0.213 0.224 5.167							8
	H	G	F	E	D	C	B	A	

PRED
MES
DIF

FORM 0113 (02/83)

H. B. Robinson Unit 2 Cycle 12

Figure 6.1

A QUARTER CORE AVERAGED ASSEMBLY RELATIVE POWER C12 MAP531 06/23/87 D-195 130MWD/MTU 69.25%HFP 43P 1 B-994 70% MAP

		H	G	F	E	D	C	B	A	
1	PRED	1.016	1.196	1.192	0.930	0.968	1.263	0.986	0.225	1
	MES	0.945	1.150	1.154	0.903	0.969	1.271	1.047	0.240	
	DIF	-6.977	-3.827	-3.180	-2.846	0.009	0.619	6.143	6.448	
2	PRED	1.196	1.142	0.903	1.185	1.238	1.066	1.185	0.208	2
	MES	1.132	1.086	0.863	1.144	1.232	1.112	1.257	0.222	
	DIF	-5.319	-4.899	-4.428	-3.436	-0.493	4.282	6.126	6.710	
3	PRED	1.185	0.894	0.883	1.277	1.016	1.266	1.057		3
	MES	1.141	0.855	0.839	1.231	1.009	1.314	1.118		
	DIF	-3.705	-4.681	-5.024	-3.537	-0.721	3.813	5.785		
4	PRED	0.923	1.179	1.274	1.134	1.314	1.093	0.770		4
	MES	0.895	1.134	1.224	1.107	1.325	1.122	0.814		
	DIF	-3.050	-3.775	-3.945	-2.318	0.793	2.583	5.677		
5	PRED	0.967	1.238	1.026	1.321	1.003	0.428			5
	MES	0.949	1.218	1.009	1.313	1.015	0.435			
	DIF	-1.802	-1.631	-1.268	-0.626	1.187	1.773			
6	PRED	1.268	1.071	1.274	1.104	0.446				6
	MES	1.275	1.079	1.281	1.111	0.453				
	DIF	0.571	0.692	0.542	0.650	1.596				
7	PRED	0.992	1.192	1.064	0.777					7
	MES	1.043	1.259	1.094	0.804					
	DIF	5.140	5.644	2.825	3.482					
8	PRED	0.227	0.210							8
	MES	0.245	0.226							
	DIF	7.768	7.564							
		H	G	F	E	D	C	B	A	

Legend: PRED / MES / DIF

FORM 0113 (02/83)

H. B. Robinson Unit 2 Cycle 12

Figure 6.2

A QUARTER CORE AVERAGED ASSEMBLY RELATIVE POWER C12 MAP532 06/25/87 D-202 202MWD/MTU 89.73%HFP 52P 1 B-953 90% MAP

Row		H	G	F	E	D	C	B	A
1	PRED	1.020	1.201	1.196	0.933	0.971	1.263	0.983	0.219
	MES	0.981	1.164	1.175	0.920	0.978	1.299	1.011	0.225
	DIF	-3.825	-3.010	-1.804	-1.396	0.699	2.832	2.882	2.395
2	PRED	1.199	1.147	0.907	1.188	1.240	1.066	1.180	0.203
	MES	1.161	1.110	0.882	1.160	1.239	1.091	1.220	0.208
	DIF	-3.219	-3.226	-2.740	-2.319	-0.142	2.363	3.403	2.552
3	PRED	1.189	0.897	0.886	1.278	1.017	1.266	1.054	
	MES	1.164	0.873	0.855	1.240	1.008	1.292	1.096	
	DIF	-2.050	-2.982	-3.533	-2.913	-0.941	2.075	3.989	
4	PRED	0.926	1.181	1.275	1.135	1.315	1.093	0.768	
	MES	0.912	1.152	1.235	1.115	1.312	1.112	0.801	
	DIF	-1.504	-2.493	-3.162	-1.771	-0.203	1.701	4.357	
5	PRED	0.969	1.240	1.026	1.321	1.004	0.429		
	MES	0.960	1.227	1.010	1.309	1.007	0.434		
	DIF	-0.942	-1.084	-1.212	-0.935	0.288	1.216		
6	PRED	1.267	1.070	1.273	1.103	0.447			
	MES	1.267	1.077	1.299	1.131	0.453			
	DIF	0.016	0.646	2.022	2.467	1.512			
7	PRED	0.988	1.186	1.060	0.774				
	MES	0.997	1.211	1.103	0.805				
	DIF	0.875	2.079	4.053	4.063				
8	PRED	0.221	0.204						
	MES	0.222	0.211						
	DIF	0.100	3.094						

PRED
MES
DIF

FORM 0113 (02/83)

H. B. Robinson Unit 2 Cycle 12

Figure 6.3

A QUARTER CORE AVERAGED ASSEMBLY RELATIVE POWER C12 MAP533 06/29/87 D-213 324MWD/MTU 98.55%HFP 53P ! B-905 98% MAP

	H	G	F	E	D	C	B	A	
1	1.026 0.991 -3.459	1.207 1.179 -2.275	1.201 1.187 -1.143	0.936 0.930 -0.624	0.973 0.983 0.982	1.263 1.298 2.774	0.982 1.011 3.024	0.218 0.222 2.021	1
2	1.205 1.170 -2.879	1.153 1.121 -2.766	0.911 0.891 -2.202	1.190 1.168 -1.838	1.242 1.244 0.175	1.065 1.090 2.342	1.175 1.212 3.191	0.201 0.205 2.132	2
3	1.193 1.173 -1.667	0.901 0.880 -2.602	0.889 0.857 -3.593	1.278 1.236 -3.263	1.018 1.006 -1.138	1.264 1.292 2.194	1.049 1.089 3.773		3
4	0.929 0.921 -0.919	1.183 1.158 -2.113	1.275 1.230 -3.524	1.136 1.104 -2.829	1.314 1.301 -0.958	1.092 1.115 2.115	0.765 0.797 4.239		4
5	0.971 0.970 -0.108	1.241 1.232 -0.683	1.026 1.005 -1.688	1.321 1.293 -2.099	1.005 0.999 -0.584	0.429 0.434 1.062			5
6	1.266 1.276 0.806	1.070 1.081 1.065	1.271 1.292 1.720	1.102 1.124 2.042	0.448 0.452 0.970				6
7	0.986 1.005 1.906	1.180 1.212 2.706	1.054 1.097 4.017	0.770 0.798 3.633					7
8	0.220 0.222 1.212	0.202 0.209 3.062							8
	H	G	F	E	D	C	B	A	

PRED
MES
DIF

H. B. Robinson Unit 2 Cycle 12

Figure 6.4

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ASM"Y RELATIVE POWER   EXPECTED /MEASURED/ % DIFF   SUMS: 156.9913 / 156.9946 / 40.6203

						0.213	0.228	0.213						
						0.221	0.237	0.226						
						3.66	3.68	5.87						
				0.820	1.120	1.237	1.015	1.237	1.120	0.820				
				0.838	1.165	1.288	1.057	1.315	1.189	0.844				
				2.15	4.04	4.08	4.06	6.26	6.15	2.88				
			0.460	1.154	1.319	1.082	1.267	1.082	1.319	1.154	0.460			
			0.467	1.160	1.344	1.118	1.284	1.086	1.333	1.151	0.449			
			1.69	0.49	1.91	3.29	1.31	0.35	1.05	-0.32	-2.30			
		0.440	1.038	1.366	1.028	1.214	0.891	1.214	1.028	1.366	1.038	0.440		
		0.460	1.058	1.354	1.024	1.209	0.874	1.182	0.987	1.324	1.016	0.449		
		4.52	1.86	-0.84	-0.43	-0.44	-1.92	-2.59	-4.00	-3.08	-2.12	1.85		
	0.812	1.142	1.357	1.149	1.270	1.139	0.869	1.139	1.270	1.149	1.357	1.142	0.812	
	0.864	1.215	1.365	1.101	1.224	1.103	0.850	1.104	1.208	1.101	1.344	1.189	0.882	
	6.44	6.33	0.58	-4.22	-3.64	-3.16	-2.20	-3.07	-4.87	-4.24	-1.01	4.10	8.58	
	1.112	1.309	1.022	1.272	0.851	0.847	1.114	0.847	0.851	1.272	1.022	1.309	1.112	
	1.176	1.383	1.025	1.188	0.806	0.822	1.092	0.809	0.800	1.224	1.000	1.346	1.191	
	5.78	5.62	0.21	-6.54	-5.28	-2.92	-1.96	-4.49	-5.99	-3.76	-2.19	2.83	7.08	
0.211	1.230	1.075	1.212	1.144	0.852	1.055	1.091	1.055	0.852	1.144	1.212	1.075	1.230	0.211
0.222	1.299	1.129	1.234	1.068	0.808	1.014	1.046	0.996	0.811	1.106	1.191	1.101	1.294	0.223
5.14	5.65	4.98	1.77	-6.67	-5.11	-3.89	-4.14	-5.62	-4.81	-3.30	-1.74	2.44	5.27	5.76
0.227	1.009	1.261	0.892	0.875	1.121	1.092	0.879	1.092	1.121	0.875	0.892	1.261	1.009	0.227
0.238	1.068	1.335	0.911	0.841	1.078	1.044	0.818	1.035	1.087	0.847	0.893	1.304	1.051	0.239
5.08	5.85	5.87	2.19	-3.78	-3.83	-4.39	-6.91	-5.23	-3.03	-3.17	0.18	3.38	4.19	5.44
0.211	1.230	1.075	1.212	1.144	0.852	1.055	1.091	1.055	0.852	1.144	1.212	1.075	1.230	0.211
0.219	1.296	1.129	1.227	1.103	0.819	1.010	1.028	0.993	0.810	1.108	1.219	1.103	1.281	0.220
3.80	5.41	5.07	1.21	-3.55	-3.79	-4.26	-5.80	-5.92	-4.84	-3.14	0.58	2.63	4.15	4.17
	1.112	1.309	1.022	1.272	0.851	0.842	1.114	0.842	0.851	1.272	1.022	1.309	1.112	
	1.161	1.364	1.024	1.234	0.822	0.809	1.067	0.793	0.802	1.230	1.009	1.327	1.160	
	4.36	4.19	0.10	-2.95	-3.46	-3.94	-4.19	-5.93	-5.83	-3.26	-1.33	1.35	4.30	
	0.812	1.142	1.357	1.149	1.270	1.139	0.869	1.139	1.270	1.149	1.357	1.142	0.812	
	0.834	1.173	1.362	1.123	1.231	1.100	0.841	1.070	1.170	1.129	1.337	1.142	0.847	
	2.73	2.66	0.38	-2.30	-3.05	-3.43	-3.21	-6.05	-7.87	-1.80	-1.51	-0.03	4.26	
		0.440	1.038	1.366	1.028	1.214	0.891	1.214	1.033	1.366	1.038	0.440		
		0.444	1.035	1.332	1.002	1.208	0.879	1.188	1.003	1.333	1.011	0.427		
		0.94	-0.36	-2.48	-2.52	-0.47	-1.33	-2.09	-2.89	-2.38	-2.64	-2.98		
			0.460	1.154	1.319	1.082	1.267	1.082	1.319	1.154	0.460			
			0.475	1.225	1.400	1.105	1.299	1.117	1.349	1.155	0.446			
			3.40	6.13	6.14	2.15	2.50	3.24	2.27	0.02	-2.98			
				0.820	1.120	1.237	1.015	1.237	1.120	0.820				
				0.871	1.190	1.269	1.059	1.305	1.165	0.836				
				6.24	6.29	2.54	4.31	5.47	4.00	1.93				
						0.213	0.228	0.213						
						0.223	0.243	0.227						

FORM 0113 (02/83)

H. B. Robinson Unit 2 Cycle 12 - Flux Map 524

Figure 6.5

ASM"Y RELATIVE POWER   EXPECTED /MEASURED/ % DIFF   SUMS: 157.0014 / 156.9950 / 82.7300

						0.210	0.227	0.210						
						0.225	0.244	0.225						
						7.21	7.27	7.21						
				0.777	1.064	1.192	0.992	1.192	1.064	0.777				
				0.808	1.095	1.250	1.052	1.287	1.042	0.786				
				4.05	2.90	4.90	6.03	8.00	-2.11	1.28				
			0.446	1.104	1.274	1.071	1.268	1.071	1.274	1.104	0.446			
			0.462	1.129	1.298	1.095	1.269	1.044	1.246	1.103	0.451			
			3.61	2.23	1.88	2.22	0.06	-2.54	-2.23	-0.13	1.11			
		0.428	1.003	1.321	1.021	1.238	0.967	1.238	1.021	1.321	1.003	0.428		
		0.451	1.035	1.331	1.019	1.222	0.943	1.206	0.997	1.303	0.998	0.428		
		5.33	3.20	0.76	-0.19	-1.27	-2.49	-2.55	-2.32	-1.39	-0.53	0.05		
	0.770	1.093	1.314	1.134	1.274	1.179	0.923	1.179	1.274	1.134	1.314	1.093	0.770	
	0.820	1.163	1.331	1.100	1.234	1.136	0.894	1.141	1.232	1.106	1.299	1.084	0.816	
	6.46	6.37	1.26	-2.99	-3.17	-3.64	-3.12	-3.20	-3.33	-2.46	-1.17	-0.88	5.98	
	1.057	1.266	1.016	1.277	0.883	0.899	1.185	0.899	0.883	1.277	1.016	1.266	1.057	
	1.126	1.346	1.005	1.204	0.836	0.870	1.151	0.855	0.838	1.236	1.000	1.297	1.121	
	6.46	6.33	-1.07	-5.68	-5.36	-3.23	-2.87	-4.83	-5.11	-3.16	-1.61	2.46	5.99	
0.208	1.185	1.066	1.238	1.185	0.903	1.142	1.196	1.142	0.903	1.185	1.238	1.066	1.185	0.208
0.227	1.282	1.133	1.191	1.140	0.868	1.115	1.142	1.075	0.857	1.133	1.270	1.109	1.249	0.217
8.99	8.22	6.26	-3.82	-3.83	-3.90	-2.40	-4.52	-5.91	-5.19	-4.36	2.60	4.04	5.48	4.27
0.225	0.986	1.263	0.968	0.930	1.192	1.196	1.016	1.196	1.192	0.930	0.968	1.263	0.986	0.225
0.246	1.068	1.240	0.945	0.909	1.164	1.173	0.945	1.127	1.145	0.897	0.992	1.302	1.025	0.234
9.06	8.33	-1.85	-2.46	-2.18	-2.37	-1.91	-6.98	-5.74	-3.99	-3.51	2.48	3.09	3.95	3.84
0.208	1.185	1.066	1.238	1.185	0.903	1.142	1.196	1.142	0.903	1.185	1.238	1.066	1.185	0.208
0.227	1.258	1.111	1.229	1.150	0.874	1.091	1.122	1.064	0.855	1.154	1.237	1.094	1.239	0.218
8.99	6.22	4.21	-0.70	-2.96	-3.22	-4.46	-6.12	-6.82	-5.41	-2.59	-0.06	2.63	4.59	4.59
	1.057	1.266	1.016	1.277	0.883	0.894	1.185	0.894	0.883	1.277	1.016	1.266	1.057	
	1.102	1.320	1.029	1.237	0.847	0.856	1.131	0.838	0.834	1.248	1.001	1.294	1.125	
	4.26	4.25	1.31	-3.10	-4.11	-4.33	-4.54	-6.33	-5.53	-2.21	-1.51	2.22	6.43	
	0.770	1.093	1.314	1.134	1.274	1.179	0.923	1.179	1.274	1.134	1.314	1.093	0.770	
	0.800	1.136	1.364	1.096	1.241	1.146	0.895	1.114	1.189	1.128	1.305	1.104	0.819	
	3.88	3.85	3.82	-3.33	-2.59	-2.74	-2.98	-5.52	-6.69	-0.49	-0.74	1.00	6.39	
		0.428	1.003	1.321	1.021	1.238	0.967	1.238	1.026	1.321	1.003	0.428		
		0.442	1.037	1.312	1.012	1.228	0.956	1.215	1.008	1.306	0.990	0.421		
		3.36	3.39	-0.71	-0.83	-0.83	-1.12	-1.88	-1.73	-1.15	-1.31	-1.65		
			0.446	1.104	1.274	1.071	1.268	1.071	1.274	1.104	0.446			
			0.461	1.097	1.265	1.070	1.282	1.105	1.315	1.117	0.438			
			3.33	-0.66	-0.69	-0.08	1.08	3.17	3.20	1.16	-1.66			
				0.777	1.064	1.192	0.992	1.192	1.064	0.777				
				0.821	1.126	1.239	1.034	1.259	1.114	0.799				
				5.67	5.84	4.00	4.25	5.67	4.66	2.94				
						0.210	0.227	0.210						
						0.230	0.246	0.224						

FORM 0113 (02/83)

H. B. Robinson Unit 2 Cycle 12 - Flux Map 531

Figure 6.6

ASM*Y RELATIVE POWER   EXPECTED /MEASURED/ % DIFF   SUMS: 157.0008 / 156.9953 / 36.8260

						0.204	0.221	0.204						
						0.207	0.224	0.213						
						1.28	1.30	4.21						
				0.774	1.060	1.186	0.988	1.186	1.060	0.774				
				0.801	1.079	1.209	1.007	1.246	1.113	0.800				
				3.47	1.84	1.91	1.89	5.04	4.97	3.40				
			0.447	1.103	1.273	1.070	1.267	1.070	1.273	1.103	0.447			
			0.460	1.122	1.285	1.085	1.270	1.073	1.288	1.115	0.450			
			3.01	1.65	0.97	1.36	0.24	0.27	1.14	1.08	0.84			
		0.429	1.004	1.321	1.021	1.240	0.969	1.240	1.021	1.321	1.004	0.429		
		0.447	1.029	1.324	1.016	1.229	0.956	1.216	0.995	1.300	0.996	0.427		
		4.31	2.45	0.20	-0.52	-0.89	-1.32	-1.95	-2.60	-1.66	-0.84	-0.34		
	0.768	1.093	1.315	1.135	1.275	1.181	0.926	1.181	1.275	1.135	1.315	1.093	0.768	
	0.808	1.149	1.322	1.098	1.238	1.149	0.908	1.155	1.238	1.106	1.293	1.078	0.802	
	5.19	5.09	0.59	-3.28	-2.90	-2.68	-1.96	-2.22	-2.93	-2.56	-1.61	-1.38	4.41	
	1.054	1.266	1.017	1.278	0.886	0.902	1.189	0.902	0.886	1.278	1.017	1.266	1.054	
	1.098	1.317	1.015	1.207	0.846	0.880	1.168	0.874	0.853	1.246	0.999	1.272	1.100	
	4.16	4.03	-0.25	-5.52	-4.49	-2.44	-1.70	-3.09	-3.69	-2.48	-1.80	0.47	4.41	
0.203	1.180	1.066	1.240	1.188	0.907	1.147	1.199	1.147	0.907	1.188	1.240	1.066	1.180	0.203
0.209	1.218	1.098	1.244	1.151	0.879	1.116	1.167	1.105	0.878	1.163	1.228	1.085	1.227	0.209
3.01	3.26	3.00	0.29	-3.11	-3.08	-2.68	-2.73	-3.63	-3.18	-2.10	-1.03	1.83	4.02	3.06
0.219	0.983	1.263	0.971	0.933	1.196	1.201	1.020	1.201	1.196	0.933	0.971	1.263	0.983	0.219
0.223	1.015	1.302	0.979	0.924	1.177	1.166	0.981	1.162	1.173	0.916	0.977	1.295	1.008	0.226
1.71	3.20	3.12	0.80	-0.92	-1.64	-2.84	-3.82	-3.18	-1.97	-1.87	0.60	2.55	2.57	3.08
0.203	1.180	1.066	1.240	1.188	0.907	1.147	1.199	1.147	0.907	1.188	1.240	1.066	1.180	0.203
0.204	1.215	1.096	1.246	1.166	0.890	1.116	1.155	1.102	0.882	1.162	1.237	1.085	1.219	0.210
0.69	3.01	2.82	0.42	-1.86	-1.92	-2.71	-3.71	-3.89	-2.78	-2.21	-0.25	1.80	3.33	3.46
	1.054	1.266	1.017	1.278	0.886	0.897	1.189	0.897	0.886	1.278	1.017	1.266	1.054	
	1.083	1.300	1.019	1.256	0.866	0.874	1.160	0.863	0.854	1.252	0.998	1.279	1.103	
	2.76	2.72	0.20	-1.67	-2.31	-2.58	-2.39	-3.81	-3.63	-1.98	-1.91	1.08	4.63	
	0.768	1.093	1.315	1.135	1.275	1.181	0.926	1.181	1.275	1.135	1.315	1.093	0.768	
	0.793	1.128	1.330	1.122	1.258	1.166	0.916	1.136	1.205	1.135	1.301	1.092	0.803	
	3.22	3.17	1.20	-1.20	-1.35	-1.26	-1.05	-3.81	-5.47	-0.05	-1.00	-0.08	4.62	
		0.429	1.004	1.321	1.021	1.240	0.969	1.240	1.026	1.321	1.004	0.429		
		0.444	1.021	1.304	1.015	1.237	0.964	1.224	1.015	1.309	0.983	0.417		
		3.51	1.64	-1.30	-0.64	-0.23	-0.56	-1.27	-1.09	-0.98	-2.10	-2.62		
			0.447	1.103	1.273	1.070	1.267	1.070	1.273	1.103	0.447			
			0.468	1.173	1.313	1.068	1.264	1.084	1.309	1.112	0.435			
			4.82	6.35	3.11	-0.26	-0.21	1.22	2.86	0.78	-2.63			
				0.774	1.060	1.186	0.988	1.186	1.060	0.774				
				0.824	1.129	1.185	0.987	1.203	1.091	0.797				
				6.46	6.50	-0.06	-0.14	1.42	2.91	2.93				
						0.204	0.221	0.204						
						0.217	0.219	0.206						

FORM 0113 (02/83)

H. B. Robinson Unit 2 Cycle 12 - Flux Map 532

Figure 5.7

ASM'Y RELATIVE POWER .EXPECTED /MEASURED/ % DIFF SUMS: 156.9993 / 156.9954 / 36.9903

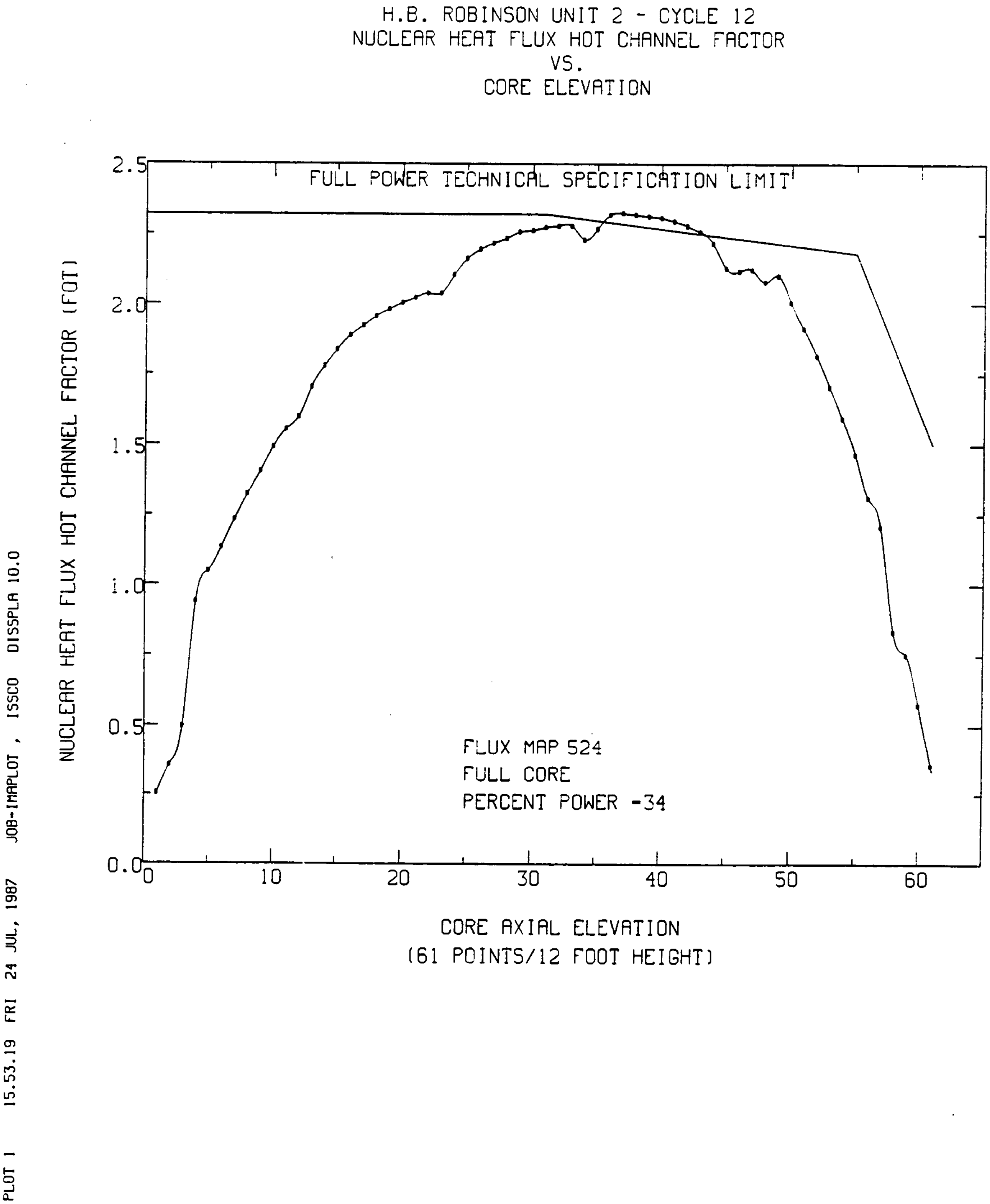
						0.202	0.220	0.202						
						0.201	0.219	0.211						
						-0.43	-0.42	4.41						
				0.770	1.054	1.180	0.986	1.180	1.054	0.770				
				0.795	1.072	1.199	1.002	1.240	1.107	0.794				
				3.21	1.64	1.63	1.56	5.09	5.00	3.09				
			0.448	1.102	1.271	1.070	1.266	1.070	1.271	1.102	0.448			
			0.460	1.114	1.278	1.084	1.278	1.079	1.287	1.111	0.448			
			2.67	1.09	0.56	1.38	0.95	0.88	1.29	0.80	-0.01			
		0.429	1.005	1.321	1.021	1.241	0.971	1.241	1.021	1.321	1.005	0.429		
		0.445	1.023	1.313	1.013	1.238	0.971	1.228	0.997	1.296	0.992	0.435		
		3.61	1.79	-0.60	-0.80	-0.26	-0.04	-1.03	-2.35	-1.83	-1.34	1.29		
	0.765	1.092	1.314	1.136	1.275	1.183	0.929	1.183	1.275	1.136	1.314	1.092	0.765	
	0.797	1.137	1.313	1.094	1.237	1.158	0.918	1.163	1.238	1.106	1.288	1.115	0.812	
	4.20	4.11	-0.09	-3.72	-2.96	-2.16	-1.20	-1.72	-2.90	-2.68	-2.00	2.10	6.12	
	1.049	1.264	1.018	1.278	0.889	0.905	1.193	0.905	0.889	1.278	1.018	1.264	1.049	
	1.088	1.308	1.012	1.207	0.853	0.889	1.178	0.878	0.855	1.247	1.001	1.286	1.099	
	3.64	3.51	-0.56	-5.57	-4.06	-1.82	-1.31	-3.02	-3.89	-2.44	-1.62	1.71	4.73	
0.201	1.175	1.065	1.242	1.190	0.911	1.153	1.205	1.153	0.911	1.190	1.242	1.065	1.175	0.201
0.207	1.214	1.097	1.247	1.157	0.889	1.134	1.178	1.112	0.884	1.172	1.239	1.084	1.213	0.205
3.09	3.29	2.97	0.47	-2.74	-2.39	-1.65	-2.22	-3.51	-2.98	-1.53	-0.20	1.81	3.22	2.09
0.218	0.982	1.263	0.973	0.936	1.201	1.207	1.026	1.207	1.201	0.936	0.973	1.263	0.982	0.218
0.222	1.014	1.304	0.984	0.934	1.189	1.186	0.991	1.173	1.185	0.926	0.982	1.292	1.009	0.222
1.95	3.28	3.25	1.10	-0.24	-0.94	-1.73	-3.46	-2.82	-1.34	-1.01	0.86	2.29	2.76	2.09
0.201	1.175	1.065	1.242	1.190	0.911	1.153	1.205	1.153	0.911	1.190	1.242	1.065	1.175	0.201
0.202	1.210	1.095	1.250	1.171	0.898	1.128	1.163	1.110	0.893	1.172	1.239	1.084	1.213	0.207
0.59	3.02	2.83	0.65	-1.61	-1.47	-2.15	-3.54	-3.74	-1.96	-1.48	-0.22	1.77	3.23	2.76
	1.049	1.264	1.018	1.278	0.889	0.901	1.193	0.901	0.889	1.278	1.018	1.264	1.049	
	1.077	1.296	1.010	1.237	0.863	0.883	1.169	0.869	0.858	1.254	1.001	1.277	1.092	
	2.61	2.56	-0.73	-3.17	-2.94	-2.04	-2.03	-3.53	-3.49	-1.87	-1.64	1.00	4.11	
	0.765	1.092	1.314	1.136	1.275	1.183	0.929	1.183	1.275	1.136	1.314	1.092	0.765	
	0.784	1.119	1.306	1.086	1.242	1.172	0.923	1.140	1.203	1.131	1.298	1.090	0.796	
	2.54	2.49	-0.57	-4.42	-2.59	-0.93	-0.64	-3.64	-5.64	-0.50	-1.17	-0.23	4.09	
		0.429	1.005	1.321	1.021	1.241	0.971	1.241	1.026	1.321	1.005	0.429		
		0.439	1.002	1.261	1.002	1.239	0.970	1.225	1.009	1.301	0.981	0.417		
		2.29	-0.35	-4.48	-1.91	-0.15	-0.18	-1.29	-1.69	-1.49	-2.43	-2.94		
			0.448	1.102	1.271	1.070	1.266	1.070	1.271	1.102	0.448			
			0.466	1.171	1.309	1.070	1.274	1.091	1.296	1.102	0.434			
			4.16	6.29	3.06	0.04	0.67	1.97	1.98	-0.01	-2.94			
				0.770	1.054	1.180	0.986	1.180	1.054	0.770				
				0.819	1.122	1.185	1.008	1.223	1.086	0.784				
				6.41	6.42	0.44	2.25	3.67	3.00	1.82				
						0.202	0.220	0.202						
						0.213	0.226	0.208						

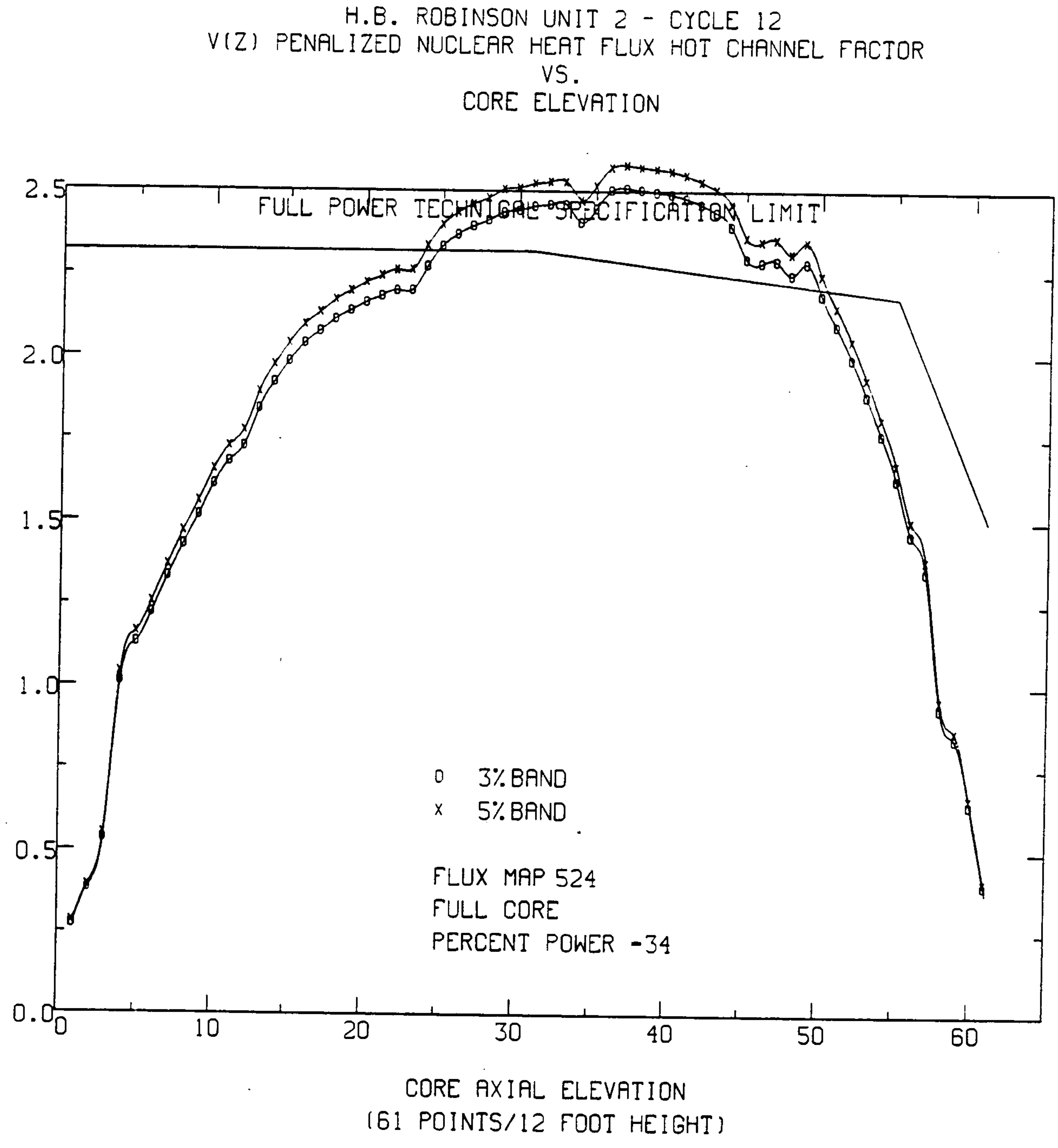
FORM 0113 (02/83)

H. B. Robinson Unit 2 Cycle 12 - Flux Map 533

Figure 6.8

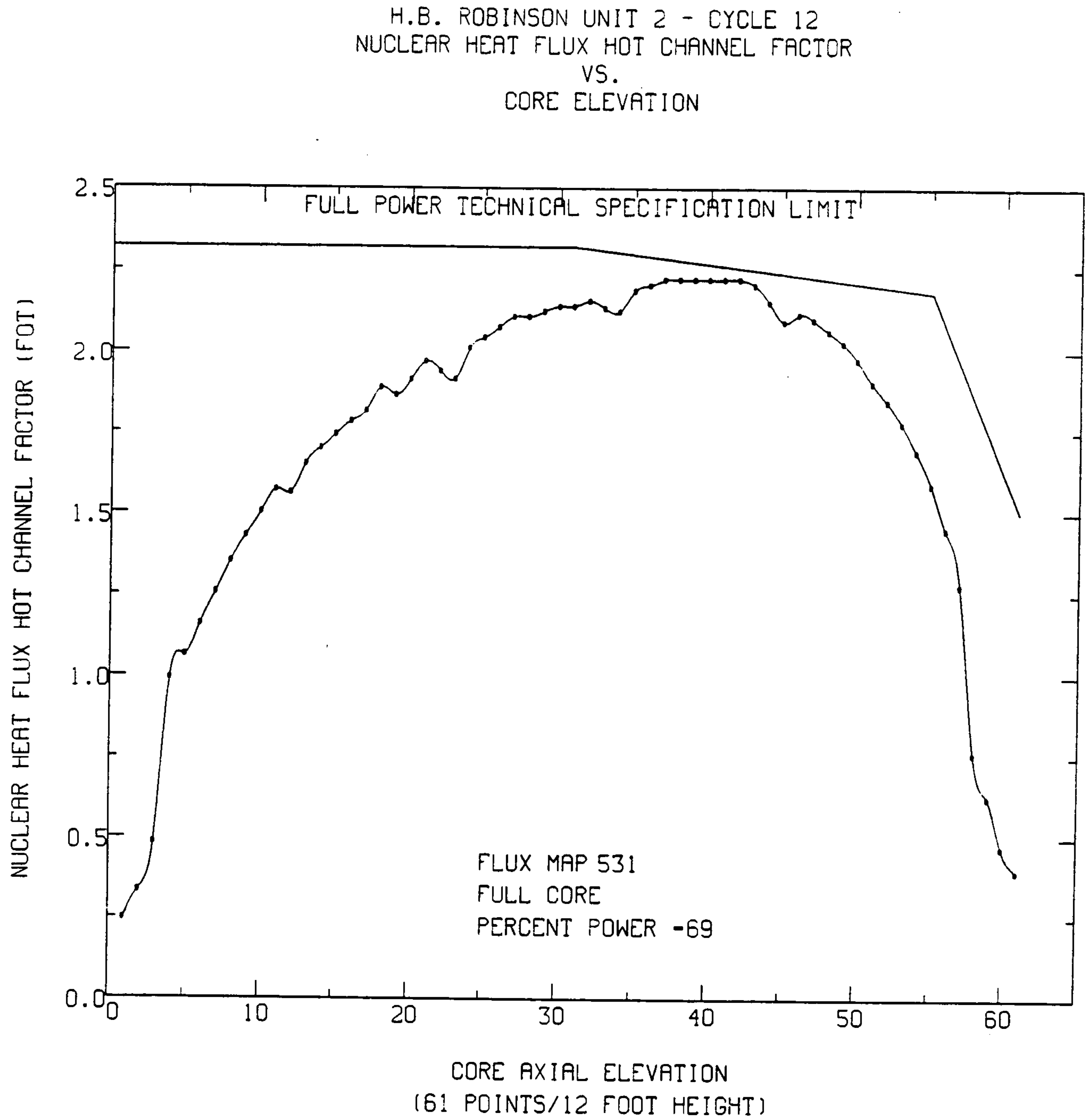
Figure 6.9


H.B. ROBINSON UNIT 2 - CYCLE 12
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 524
FULL CORE
PERCENT POWER -34
CORE AXIAL ELEVATION
(61 POINTS/12 FOOT HEIGHT)
PLOT 1 15.53.19 FRI 24 JUL, 1987 JOB-IMAPLOT , ISSCO DISSPLA 10.0



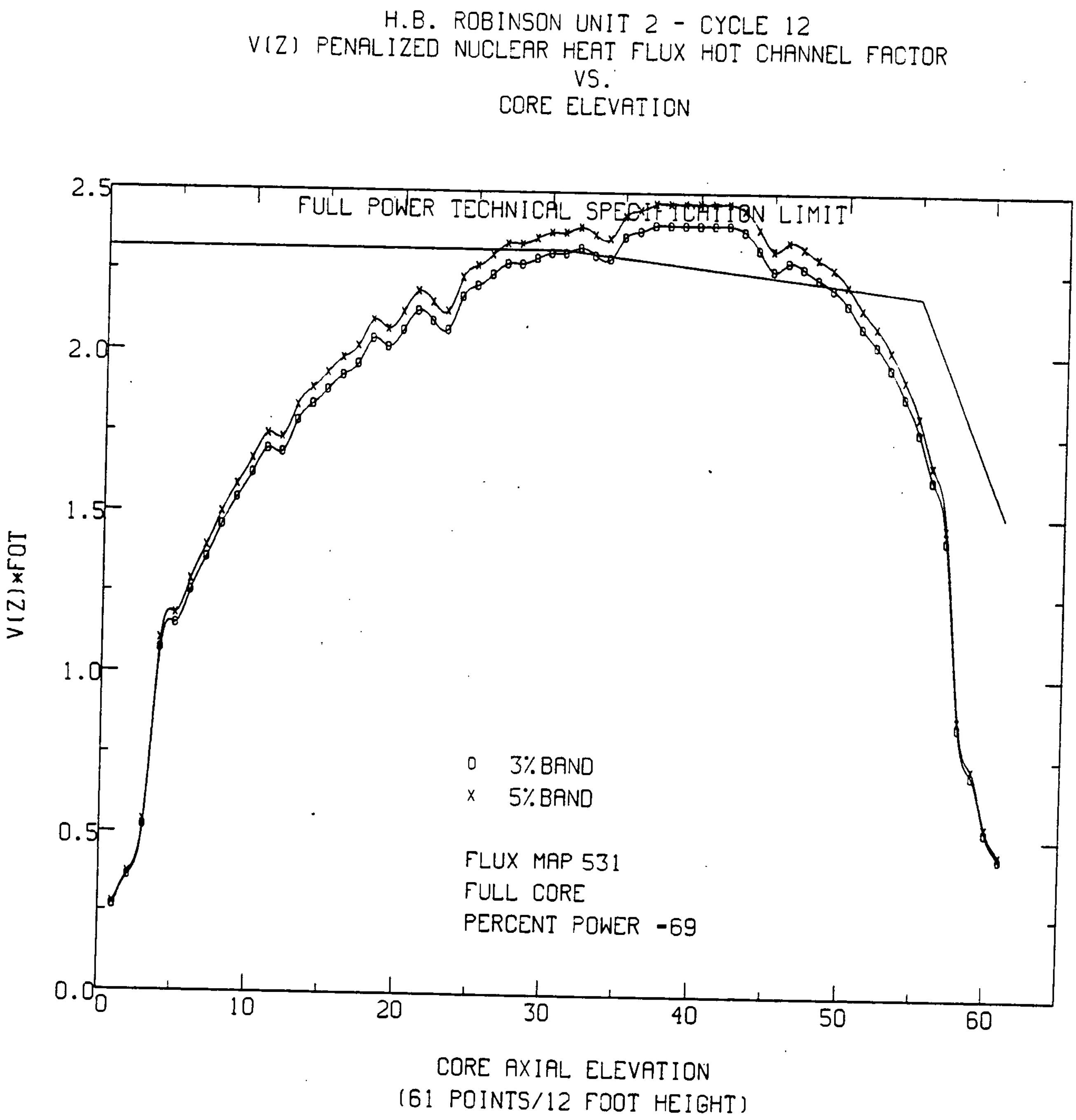
PLOT 2 15.53.20 FRI 24 JUL, 1987 JOB-IMAPLOT , ISSCO DISSPLA 10.0

Figure 6.11



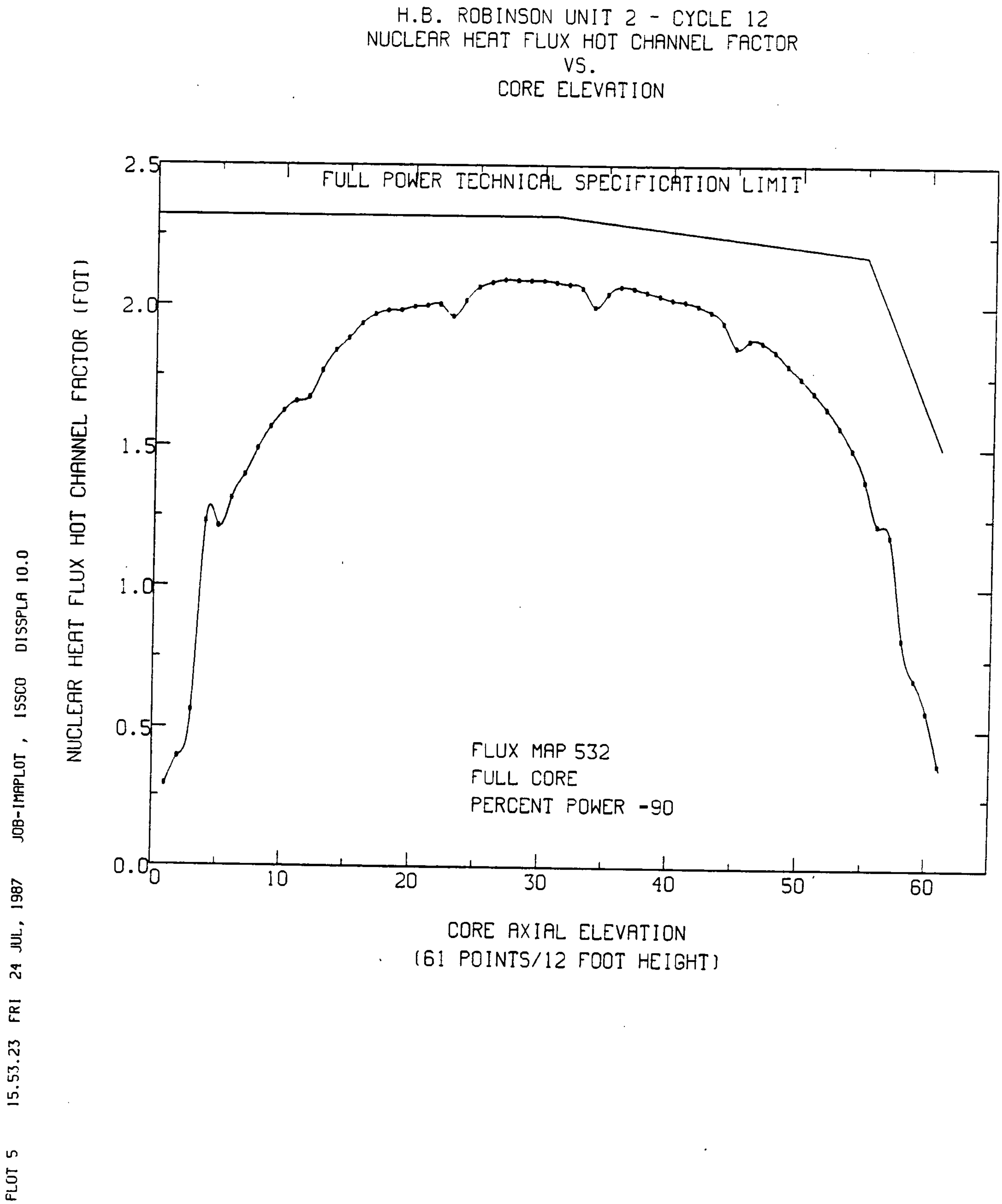
PLOT 3 15.53.21 FRI 24 JUL, 1987 JOB-IMAPLOT , ISSCO DISSPLA 10.0

Figure 6.12

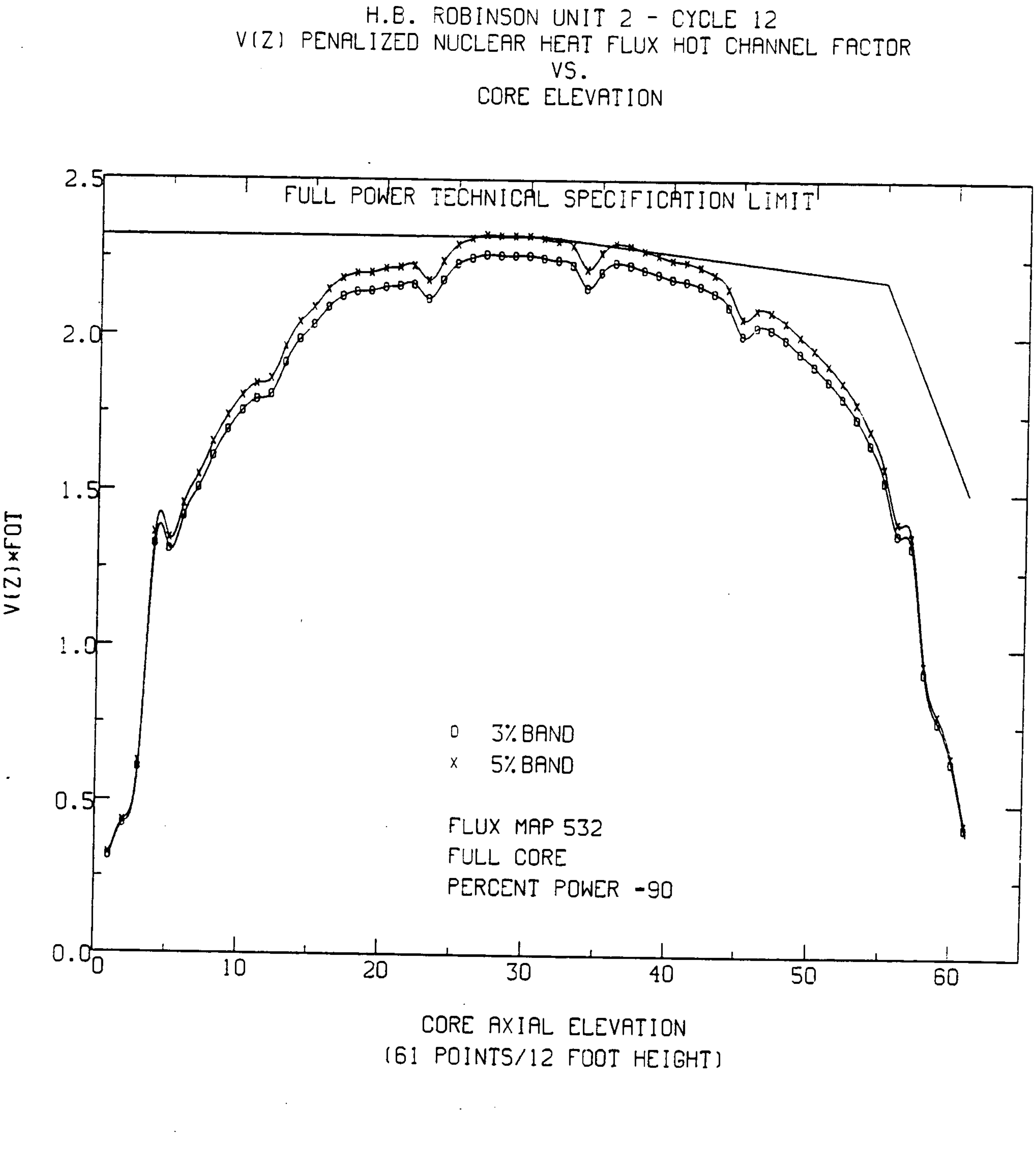


PLOT 4 15.53.22 FRI 24 JUL, 1987 JOB-IMAPLOT , ISSCO DISSPLA 10.0

Figure 6.13

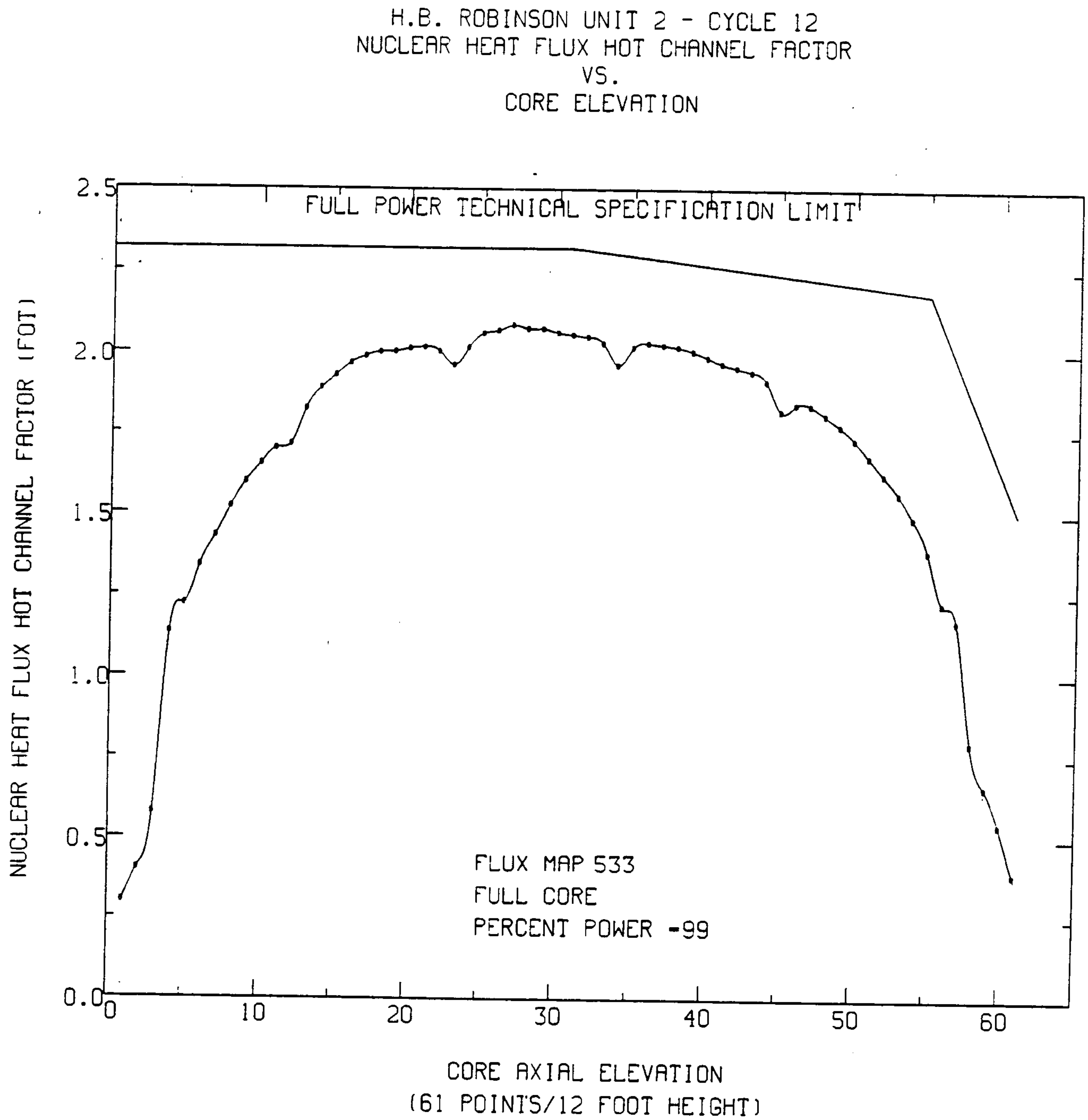


H.B. ROBINSON UNIT 2 - CYCLE 12
NUCLEAR HEAT FLUX HOT CHANNEL FACTOR
VS.
CORE ELEVATION
FULL POWER TECHNICAL SPECIFICATION LIMIT
FLUX MAP 532
FULL CORE
PERCENT POWER -90
NUCLEAR HEAT FLUX HOT CHANNEL FACTOR (FQT)
0.0
0.5
1.0
1.5
2.0
2.5
0
10
20
30
40
50
60
CORE AXIAL ELEVATION
(61 POINTS/12 FOOT HEIGHT)
PLOT 5 15.53.23 FRI 24 JUL, 1987 JOB-IMAPLOT , ISSCO DISSPLA 10.0



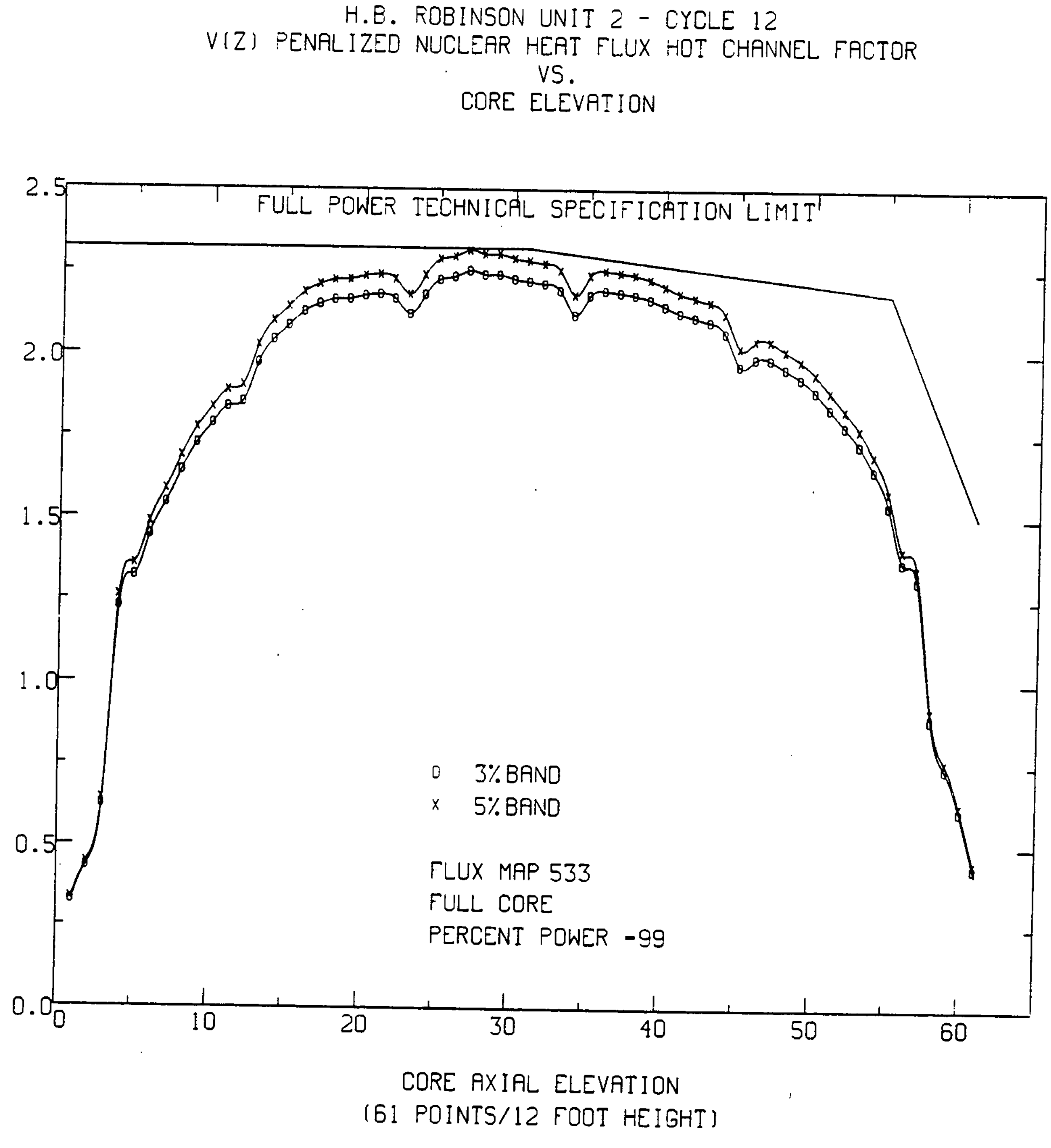
PLOT 6 15.53.24 FRI 24 JUL, 1987 JOB-IMAPLOT , ISSCO DISSPLA 10.0

Figure 6.15



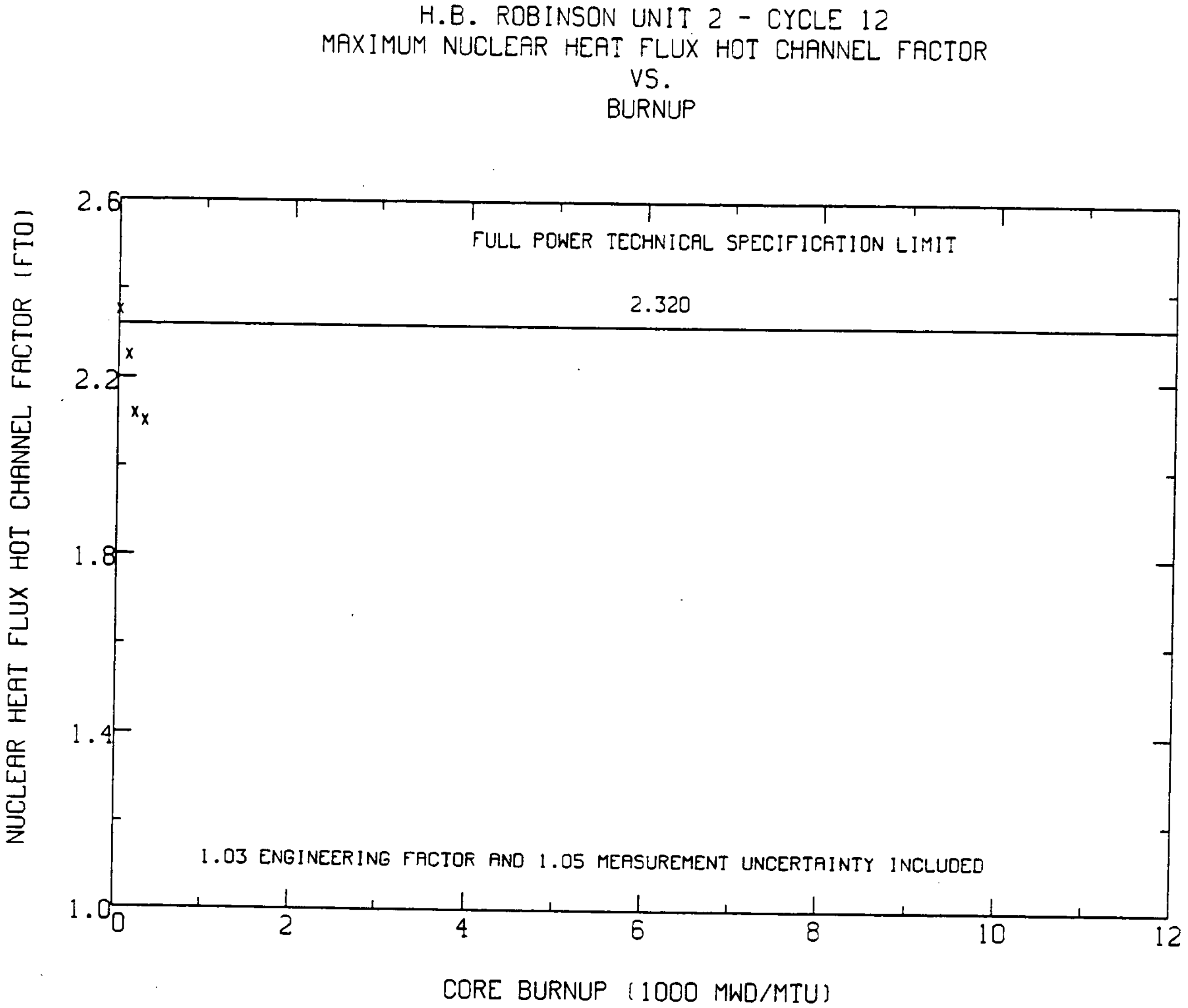
PLOT 7 15.53.24 FRI 24 JUL, 1987 JOB-IMAPLOT , ISSCO DISSPLA 10.0

Figure 6.16



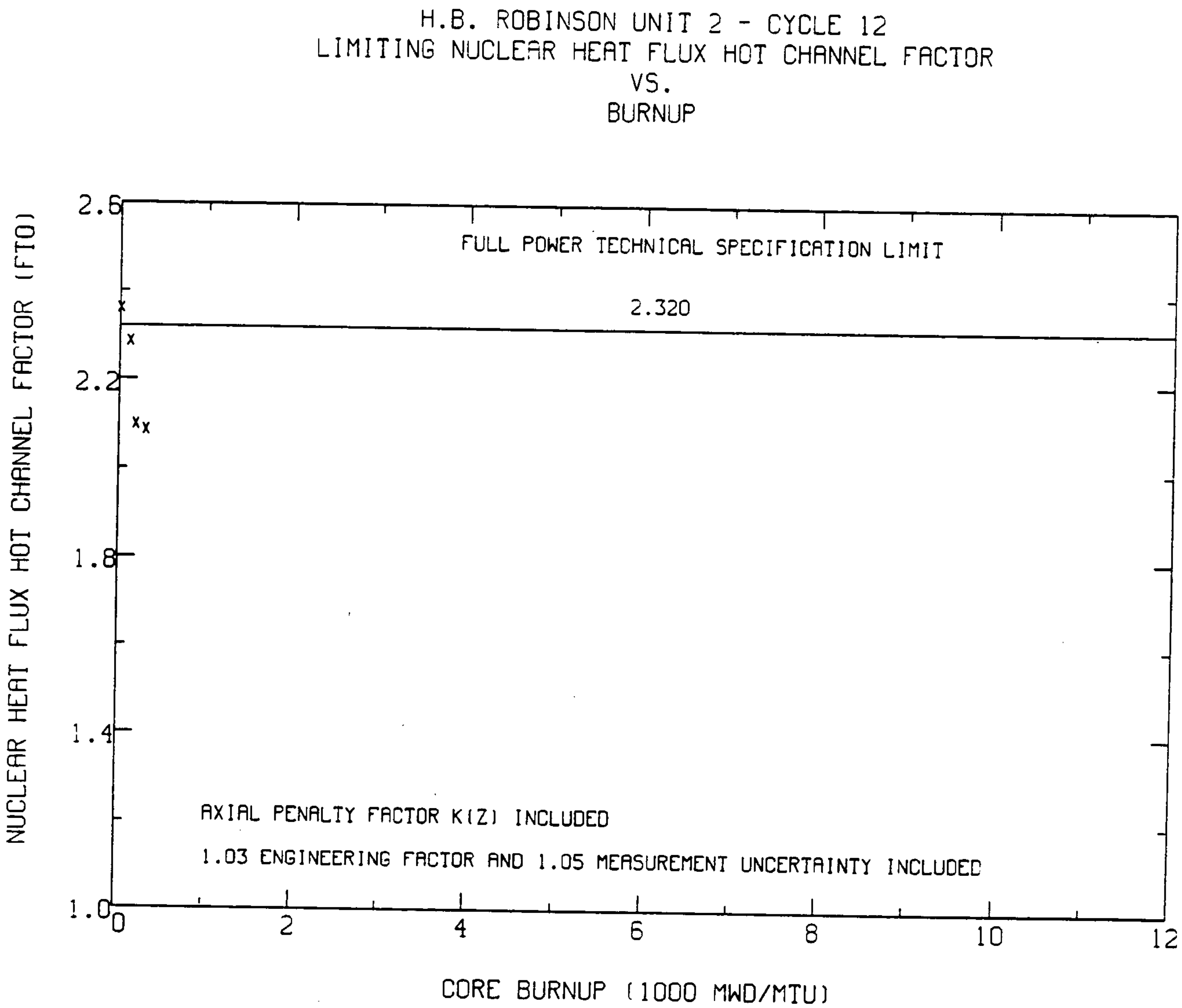
PLOT 8 15.53.26 FRI 24 JUL, 1987 JOB-IMAPLOT , ISSCO DISSPLA 10.0

Figure 6.17



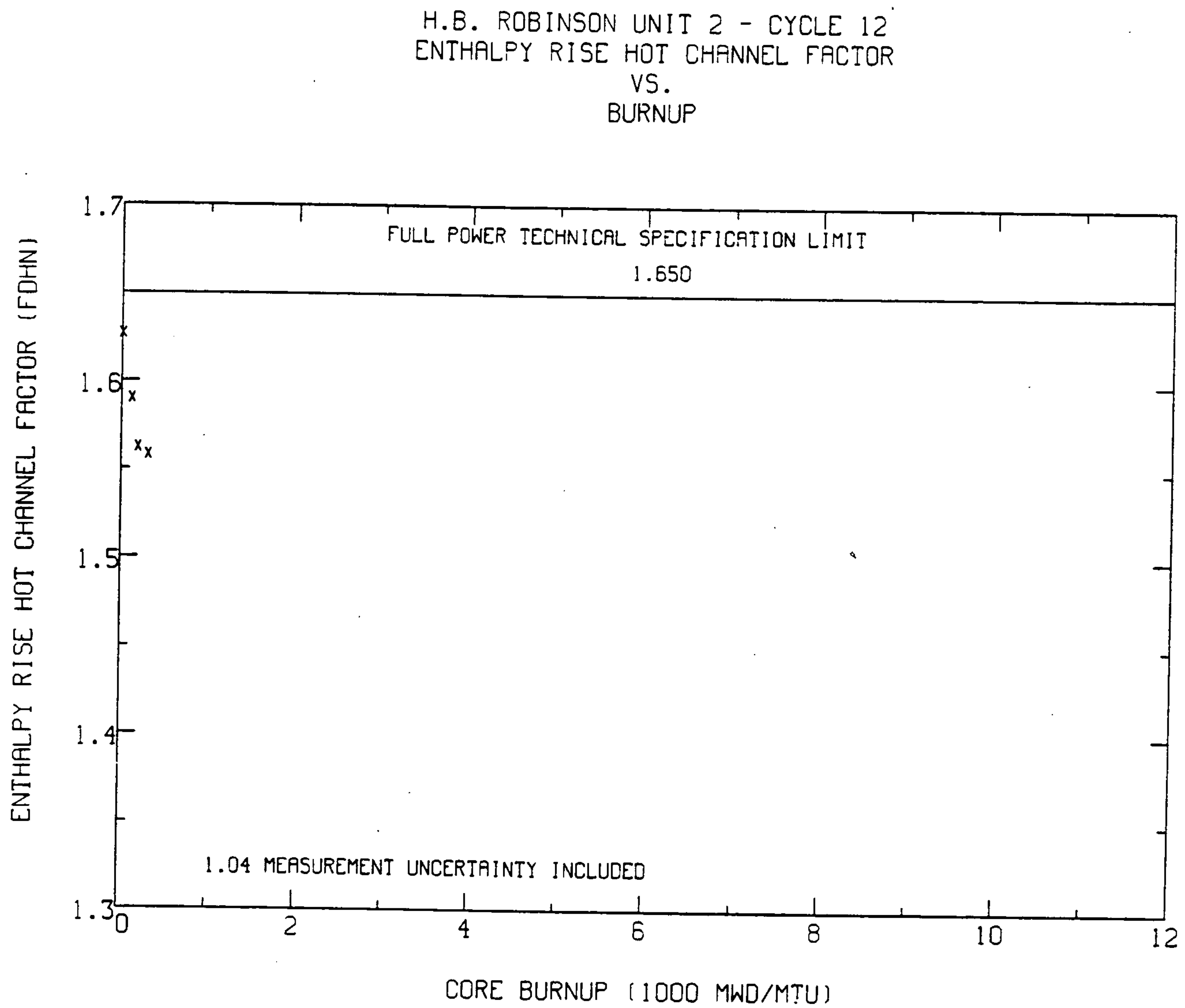
PLOT 9 15.53.26 FRI 24 JUL, 1987 JOB-IMAPLOT , ISSCO DISSPLA 10.0

Figure 6.18



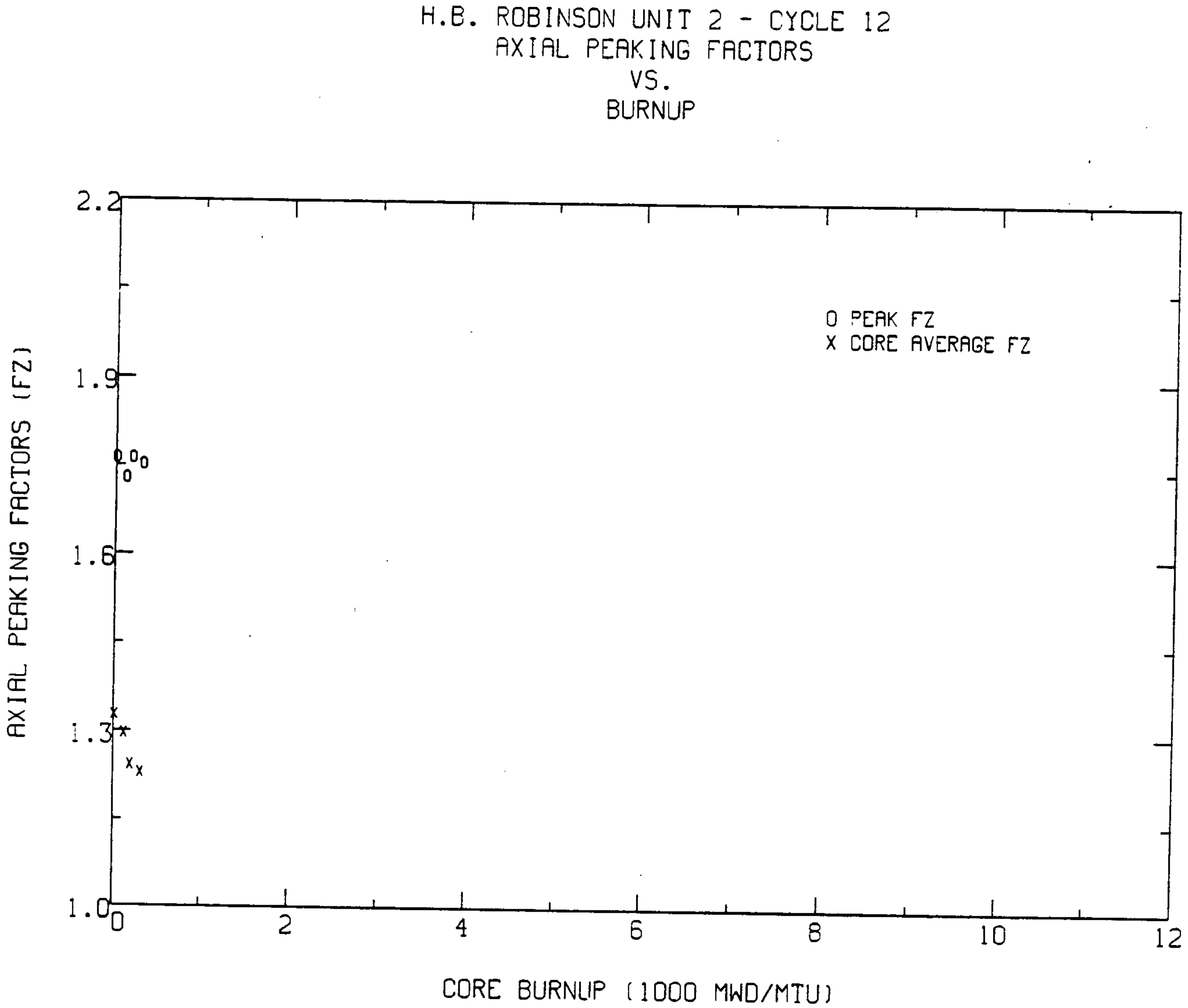
PLOT 10 15.53.27 FRI 24 JUL, 1987 JOB-IMAPLOT , ISSCO DISSPLA 10.0

Figure 6.19



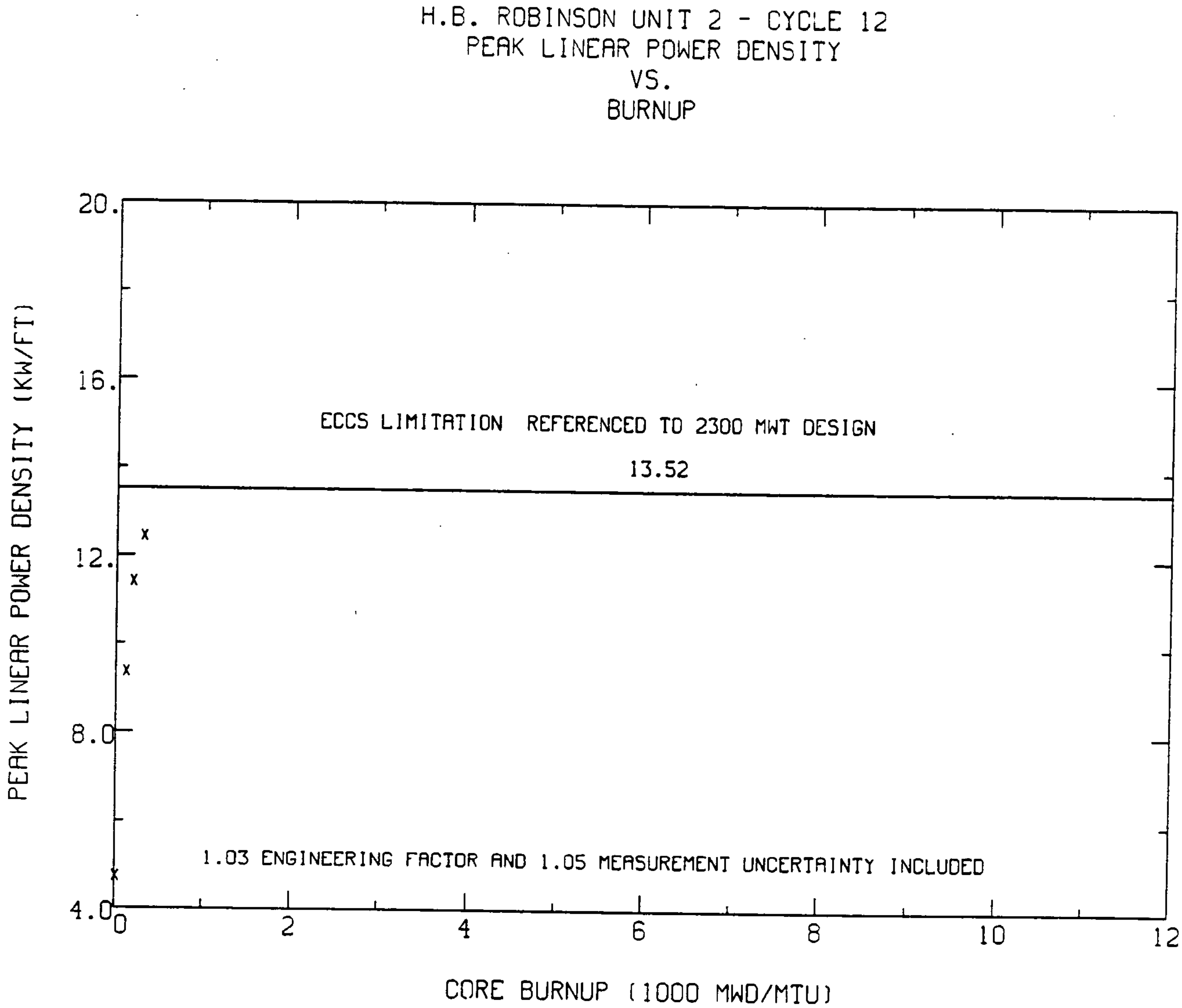
PLOT 11 15.53.27 FRI 24 JUL, 1987 JOB-IMAPLOT , ISSCO DISSPLA 10.0

Figure 6.20



PLOT 13 15.53.28 FRI 24 JUL, 1987 JOB-IMAPLOT , ISSCO DISSPLA 10.0

Figure 6.21



PLOT 14 15.53.28 FRI 24 JUL, 1987 JOB-IMAPLOT , ISSCO DISSPLA 10.0

Figure 6.22

H.B. ROBINSON UNIT 2 - CYCLE 12
ASSEMBLY RADIAL PEAKING FACTOR
VS.
BURNUP

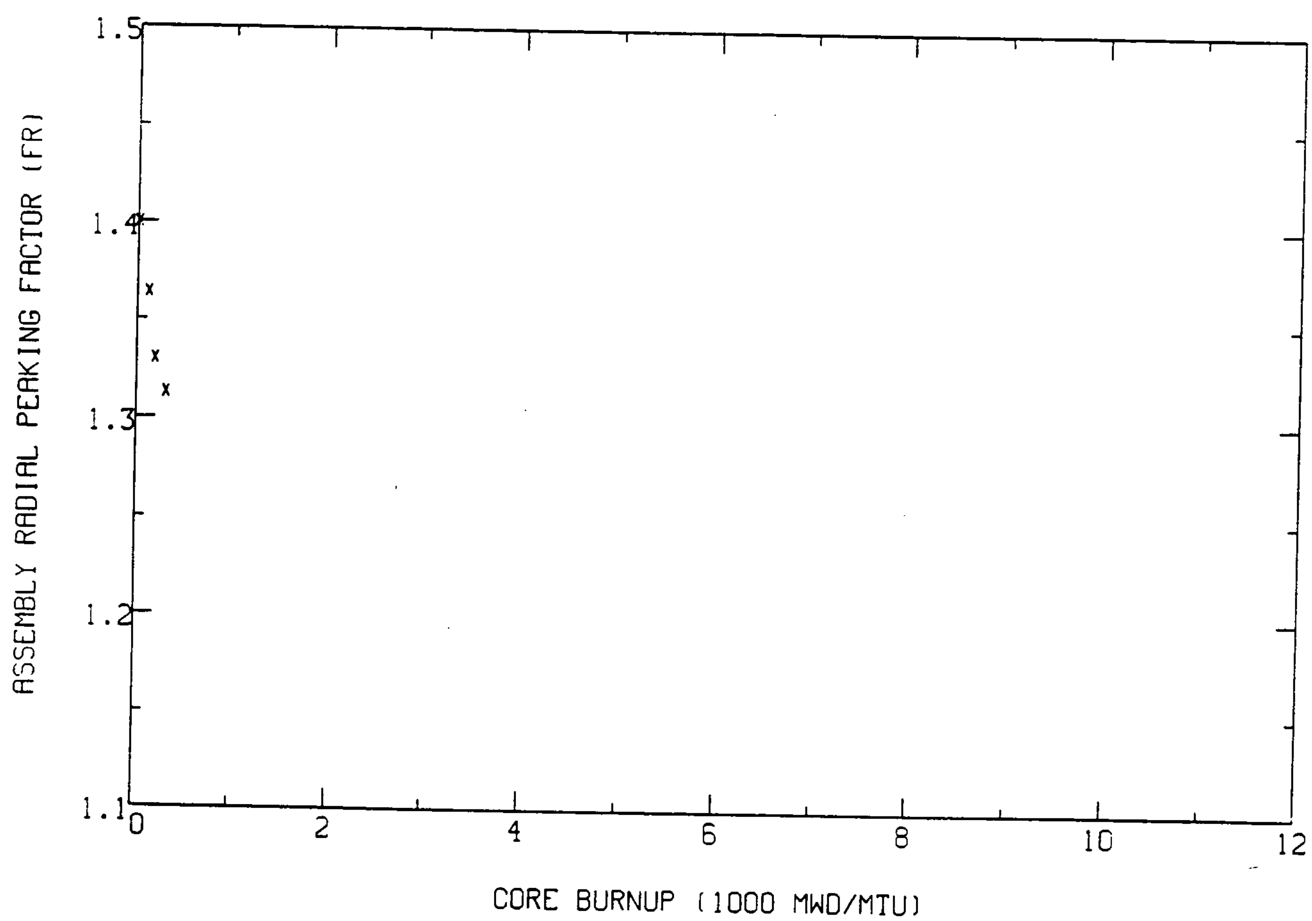
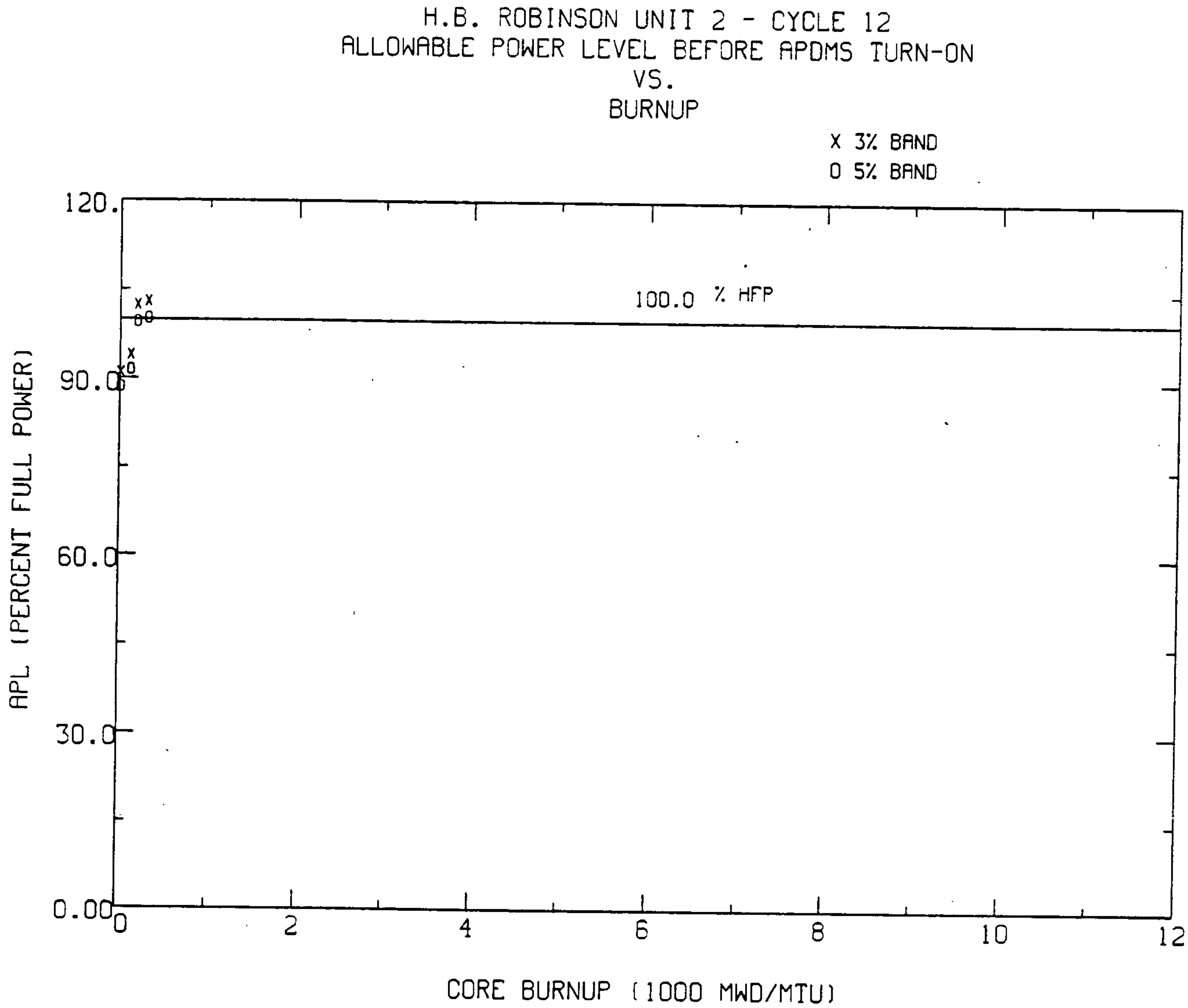


Figure 6.23


H.B. ROBINSON UNIT 2 - CYCLE 12
ALLOWABLE POWER LEVEL BEFORE APDMS TURN-ON
VS.
BURNUP
X 3% BAND
O 5% BAND
120.
90.0
60.0
30.0
0.00
100.0 % HFP
APL (PERCENT FULL POWER)
0
2
4
6
8
10
12
CORE BURNUP (1000 MWD/MTU)

H. B. Robinson Unit 2, Cycle 12
Startup Test Report
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