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ESPONSE TO NRC REQUEST OF 01/16/78. . FORWARDING SUMMARY REPT ON SUBJECT
ACILITY"S 2 CYCLE 6 STARTUP PHYSICS TESTING PROGRAM.

LANT NAME: H B ROBINSON - UNIT 2 REVIEWER INITIAL: XJM
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50 05/22/78 ACCESSION NBR: 78153-0188 TASK NBR
515 DOCUMENT TYPE: OTHERS FICHE NB
C DOCUMENT SIZE: 1P+2P NOTARIZE
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EVALUATION REPT; AND STATEMENT
GITTELMAN. W/ENCL AS STATED.

50 05/25/78 ACCESSION NBR: 78156-0241 TASK NBR
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C DOCUMENT SIZE: 1P NOTARIZE
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Carolina Power & Light Company

June 23, 1978 Serial: GD-78-1727

FILE: NG 3514 (R)

Office of Nuclear Reactor Regulation
Division of Operating Reactors
ATTENTION: Mr. A. Schwencer, Chief
Operating Reactors Branch No. 1
United States Nuclear Regulatory Commission
Washington, D. C. 20555

H. B. ROBINSON UNIT NO. 2
DOCKET NO. 50-261
OPERATING LICENSE NO. DPR-23
SUMMARY REPORT OF CYCLE 6 STARTUP PHYSICS TESTS

Dear Mr. Schwencer:

In your letter dated January 16, 1978, you requested that we provide a summary report of the startup physics tests for Cycle 6. In accordance with your request, we are submitting, as an attachment to this letter, a summary report on the H. B. Robinson Unit No. 2 Cycle 6 Startup Physics Testing Program.

Yours very truly,

E. E. Utley
Senior Vice President
Power Supply

FJH:CSB/mf(427-497)
Attachment

336 Fayetteville Street • P. O. Box 1551 • Raleigh, N. C. 27602

A001 S 1 7

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I. INTRODUCTION:

In accordance with your request in letter dated January 16, 1978, a summary report of the H. B. Robinson Unit No. 2 Physics Startup Testing for Cycle-6 is being submitted.

II. SUMMARY:

This report documents the startup tests results for Cycle 6 of H. B. Robinson Unit No. 2. The startup tests are a Technical Specification requirement, performed to verify proper core loading along with various calculated parameters relating to reactor safety and performance. The report is not intended to discuss the detailed startup procedures or to present the detailed data which are on file at the Robinson Plant.

Items to be specifically addressed include core design parameters, fuel specifications, and startup test results including: control rod bank worths, moderator temperature coefficients, boron worth and endpoints, and power distributions. The measurements were compared to Exxon predictions during startup to determine if the acceptance criteria were met. All acceptance criteria were met.

A discussion of control rod drop times is also included. The drop times verified the sufficiency of the Exxon low parasitic 15 x 15 PWR guide tube design. All drop times met the appropriate acceptance criteria.

III. CYCLE DESCRIPTION:

H. B. Robinson Unit No. 2 is a three-loop Westinghouse pressurized water reactor currently operating at 2200 MWT with a pending uprate to 2300 MWT. The core is designed for 157 (15 x 15) fuel assemblies with 45 full-length and 8 part-length control rods. Each fuel assembly consists of 204 fuel

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rods, 20 RCC guide tubes, and 1 instrumentation tube. On January 27, 1978, the unit was shut down for its fifth refueling. Cycle 5 contained 53 Westinghouse fuel assemblies and 104 Exxon assemblies designated in terms of four regions: 6A, 5, 7, and 8.

Fifty-three assemblies (Region 6A plus 52 elements of Region 5) were replaced with Exxon Nuclear Company fuel, making the core now totally Exxon fuel. Cycle 6 fuel regions are delineated 9A, 7, 8, and 9. The core is now essentially on an equilibrium cycle, since all regions consist of nominal 2.9 w/o fuel, except region 9A (which consists of one nominal 2.0 w/o assembly occupying the center core position). The Cycle 6 full core loading pattern is depicted in Figure 1.1 with the previous Cycle 5 locations indicated for partially depleted assemblies along with each assembly's BOC6 burnup. Assembly ID's (J-XX) are indicated for the reload region. Tables 1.1 and 1.2 contain appropriate core design parameters for 2300 MWT operation and appropriate fuel specifications, respectively.

The various control rod banks and their locations are pictured in Figure 1.2. As in previous cycles, part-length rods are not planned to be utilized in Cycle 6. Startup source spider assemblies with depleted Cycle 1 burnable poison rods are positioned at core locations H-3 and H-13. These source assemblies have remained in the same locations for each cycle. New secondary sources were inserted at locations C-8 and N-8. Burnable poison rods are not required in Cycle 6.

IV. PHYSICS STARTUP TESTS:

Physics startup test procedures are listed in Table 2.1 and the acceptance criteria associated with testing is shown in Table 2.2.

A. REFUELING STARTUP PROCEDURES (CPL-R-6.0):

This procedure encompasses all the startup procedures giving the testing program direction for proper sequence and hold points.

B. INITIAL CRITICALITY (CPL-R-6.0, APPENDIX A):

The purposes of this procedure are to achieve initial criticality, to establish the upper limit of the neutron flux level for all zero power physics measurements and to verify the proper operation of the reactivity computer.

Initial criticality was achieved by withdrawing all control rods while checking at 50 step intervals the inverse count rate ratio (ICRR) for approaching criticality. All rods were fully withdrawn except control bank "D" which had a remaining inserted worth of approximately 50 pcm. Dilution to a ICRR of 0.05 was performed and then control bank "D" withdrawn to achieve criticality. Cycle 6 initial criticality was achieved at 0530 April 10, 1978.

The upper limit of the neutron flux level for all zero power physics testing was established by achieving a super critical condition and allowing the flux level to increase until nuclear heating occurred.

Verification of reactivity computer measurements were performed by going super critical producing various reactivity gains. The reactor periods from these exercises were compared to the reactivity equivalent periods obtained from design report curves. Thus, the reactivity computer was assured to function correctly to respond to the reactivity insertions during physics testing.

C. BORON ENDPOINT MEASUREMENTS (CPL-R-6.0, APPENDIX B):

The boron endpoint measurements were used to determine the all rods out (ARO) boron concentration at the just critical condition and the rod configuration endpoints during the control rod worth measurements.

Table 3.1 presents the endpoint measured versus predicted worth for the designated control bank positions.

D. MODERATOR TEMPERATURE COEFFICIENT MEASUREMENTS (CPL-R-6.0, APPENDIX C):

The isothermal temperature coefficient was measured during zero power physics tests to ensure a negative moderator temperature coefficient as required by technical specifications. The coefficient was obtained by heating up/cooling down the primary system uniformly and recording the resultant reactivity (as obtained from the reactivity computer) on an X-Y recorder versus temperature (as obtained from the auctioneered T_{AVG} signal). All measurements were performed below the nuclear heat range to ensure maintaining the moderator and fuel at approximately the same temperature to preclude Doppler feedback. Over the temperature range of interest ($540^{o}F$ to $550^{o}F$), 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 heatup/cooldown coefficients was used to negate the effects of any inadvertent reactivity additions through boron concentration mismatches between the RCS, pressurizer, or volume control tank.

The isothermal temperature coefficient was measured with control bank "D" nearly withdrawn, fully inserted, and at intermediate positions. One measurement with D, C, B, and A banks inserted was made. Table 4.1 gives the predicted and measured isothermal temperature coefficients for the configurations and also includes the measured moderator coefficient assuming a -1.66 pcm/^{o}F Doppler coefficient.

E. CONTROL ROD REACTIVITY WORTH MEASUREMENTS (CPL-R-6.0, APPENDIX D):

Differential and integral control rod bank worths were obtained using the reactivity computer in accordance with Startup Procedure CPL-R-6.0, Appendix D, with the reactor at hot zero power. With the reactor just critical, the controlling bank was diluted into the core with a fairly constant boron dilution rate. The reactivity computer continuously recorded the reactivity change associated with the bank movement and the accompanying boron compensation. The reactivity computer trace was used to determine the differential rod worth which was defined as the ratio of the change in reactivity to the associated change in bank position about the average bank position. The integral rod worth was simply the cumulative sum of the differential rod worths between selected rod positions.

Startup Procedure CPL-R-6.0 required that the individual worths of control banks D, C, B, and A be determined in the insertion sequence, not in overlap. The acceptance criteria required that each bank's integral worth measurement be within $\pm$15% of predicted and that the total integral worth of D, C, B, and A be within $\pm$10% of predicted. If the above criteria were not met, the worth of the next bank, shutdown B, was to be determined. If the total measured integral worth of D, C, B, A, and shutdown B was not within $\pm$10% of predicted or the integral worth of shutdown B was not within $\pm$ 15%, shutdown bank A and the most reactive stuck rod (F-14) worths were to be determined.

Figures 5.1 through 5.5 illustrate the differential and integral rod worth curves predicted by Exxon and measured data points.

Table 5.1 presents a summary of the predicted control rod bank worths supplied by Exxon Nuclear and the corresponding worths measured during the startup program. The acceptance criteria, based on reactivity worth, were met for control rod banks D, C, B, and A measurements. The control banks' total worth was 5003 pcm, conservatively exceeding the predicted 4898 pcm by 2.1% $\Delta\rho$.

F. POWER DISTRIBUTION MAPS (CPL-R-9.4):

The core power distribution was verified to ensure proper core loading and compliance with technical specification limits relating to hot channel factors, thermal-hydraulic constraints, and power density. The necessary data for this verification were obtained from the INCORE code which processes the moveable incore detector data. Table 6.1 summarizes the pertinent startup test flux maps.

Operation of the Axial Power Distribution Monitoring System is normally required at H. B. Robinson No. 2 at operation above 94% power (since the limiting F_Q is 2.2 or 94% of 2.32). However, APDMS must be operated at even lower powers since F_{xy} exceeds 1.435. Operation of APDMS must begin at (94%) X $1.435/F_{xy}$. Hence, following Map 279--which has an F_{xy} value of 1.469--APDMS surveillance was initiated at 92% power.

Acceptance criteria were met for all power distribution maps.

V. CONTROL ROD DROP TESTS (CPL-R-4.10.2):

The control rod drop test (refer to Startup Test CPL-R-4.10.2) was performed to determine the drop time of each full-length control rod in the cold and hot full flow conditions. Technical specifications require that the rod drop time of each full-length control rod be no greater than 1.8 seconds at full flow and operating temperature from the beginning of rod motion to dash pot entry.

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 circuit. A trace of the falling rod was obtained on a visicorder from the LVDT output. Using an accompanying AC timing trace, the drop times to dash pot and dash pot to rod bottom were determined.

Tables 7.1 and 7.2 tabularize the drop time results for each control rod in the cold and hot condition, respectively. All drop time results were within the acceptance criteria.

VI. CONCLUSION:

All physics startup tests met their acceptance criteria and Exxon Nuclear predictions were in good comparison with the measured values.

TABLE 1.1

H. B. ROBINSON UNIT 2 -- CYCLE 6

CORE DESIGN PARAMETERS

	Cycle 5	Cycle 6
Power rating (MWt)	2300	2300
As built zero burnup loading (MTU)		
Region 5	23.71	
Region 6A	.46	
Region 7	22.30	22.30
Region 8	22.23	22.23
Region 9		22.28
Region 9A		.43
Total	68.70	67.24
System Pressure (psia)	2250	2250
Core average moderator temperature @HZP (^{o}F)	547	547
Core average moderator temperature @HFP (^{o}F) (a)	577.8	577.8
Core size:		
Equivalent diameter (in.)	119.7	119.7
Fuel pellet stack height cold (in.)	144.0	144.0
Average thermal output (kw/ft)	5.83	5.83
Max. thermal output for normal operation based on ECCS limitation (kw/ft)	12.8	12.8
Core power density (kw/liter)	86.35	86.35
Number of burnable poison rods	0	0

(a) The average moderator temperature varies linearly with power.

TABLE 1.2

H. B. ROBINSON UNIT 2 -- CYCLE 6

FUEL SPECIFICATIONS

REGION	INITIAL U-235 W/O NOMINAL DESIGN	INITIAL U-235 W/O AS-LOADED	% THEORETICAL DENSITY	PELLET O.D. (IN.)	GAS FILL
9A	2.0	2.013	94.0	.3565	HE
7	2.90	2.891	94.0	.3565	HE
8	2.90	2.892	94.0	.3565	HE
9	2.90	2.898	94.0	.3565	HE

FUEL ROD SPECIFICATIONS

FOR ALL REGIONS:

FUEL ROD O.D. = 0.424 in. (ALL EXXON REGIONS)

CLAD MATERIAL = ZIRCALOY-4

CLAD THICKNESS = 0.0290 in. min. (EXXON)

TABLE 2.1

H. B. ROBINSON UNIT 2--CYCLE 6
START-UP PHYSICS TEST PROCEDURES

Procedure	Number	Revision
Refueling Start-up Procedures	CPL-R-6.0	5.0
Initial Criticality	CPL-R-6.0, Appendix A	
Boron Endpoint Measurement	CPL-R-6.0, Appendix B	
Moderator Temperature Coefficient	CPL-R-6.0, Appendix C	
Control Rod Reactivity Worth Measurement	CPL-R-6.0, Appendix D	
Power Distribution Maps	CPL-R-9.4	2.0
Control Rod Drop Test	CPL-R-4.10.2	1.0

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TABLE 2.2
H. B. ROBINSON UNIT 2--CYCLE 6
START-UP PHYSICS TEST PROCEDURES
ACCEPTANCE CRITERIA

Test	Criteria
Boron Endpoint	ARO Boron Concentration within $\pm$50 PPM of predicted.
Moderator Temperature Coeff.	a. HZP Temperature coeffieient with D-bank inserted is negative. b. Moderator temperature coefficient during power escalation is negative.
Control Rod Worth	a. D, C, B, A each within $\pm$15% of predicted worth. b. D+C+B+A within $\pm$10% of predicted total c. If not (a) and (b), include SB; if still not include SA
Power Distribution Maps	HZP Map a. Assembly-wise $F_{\Delta H}$ < 1.08 predicted if $F_{\Delta H}$ predicted $\geq$ 1.0. Assembly-wise, $F_{\Delta H}$ < 1.15 predicted if $F_{\Delta H}$ predicted < 1.0 b. Quadrant tilts < 1.02 Power Maps a. $F_Q(Z) \leq 2.2/P$, P = fraction full power b. $F^N_{\Delta H} < 1.55 \left[\frac{1 + 0.2\ (1 - P)}{1.04} \right]$ c. Quandrant tilts < 1.02
Control Rod Drop	Drop time to dashpot under hot conditions < 1.8 seconds

TABLE 3.1

H. B. ROBINSON UNIT NO. 2--CYCLE 6 BORON ENDPOINT MEASUREMENTS

Control ROD Configuration	Predicted	Measured	PPM Difference	% Difference	Acceptance Criteria
All Rods Out	1300	1279	21	1.6	± 50 ppm
D IN	1224	1201	23	1.9	-
(D+C) IN	1069	1066	3	0.2	-
(D+C+B) IN	953	967	14	-1.5	-
(D+C+B+A) IN	814	829	15	-1.8	-

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TABLE 4.1

H. B. ROBINSON UNIT 2 -- CYCLE 6

SUMMARY OF ISOTHERMAL TEMPERATURE COEFFICIENTS

CONFIGURATION D-STEPS	CONFIGURATION C-STEPS	BORON CONCENTRATION	MEASURED ISOTHERMAL (PCM/°F) COOLDOWN	HEATUP	AVG.	*MODERATOR PCM/°F
214	228	1278	1.67	1.67	1.67	3.33
192	228	1270	1.51	1.67	1.59	3.25
0	205	1194	-0.70	-0.94	-0.82	0.84
58	186	1202	-0.47	-0.40	-0.43	1.23
50	178	1195	-0.85	-0.43	-0.64	1.02
33	161	1186	-0.80	-0.76	-0.78	0.88
21	149	1178	-1.70	-1.06	-1.38	0.28
11	139	1169	-1.81	-1.61	-1.71	-0.05
6	134	1165	-1.82	-1.78	-1.80	-0.14
A, B, C, D,@ 0, SB @ 196		823		-10.0	-10.0	-8.34

CONFIGURATION D-STEPS	CONFIGURATION C-STEPS	BORON CONCENTRATION	PREDICTED TEMPERATURE COEFFICIENTS (PCM/°F) ISOTHERMAL	DIFFERENCE FROM MEAS.	MODERATOR	DIFFERENCE FROM MEAS.
228	228	1300	+ .84	0.83	2.5*	0.83
0	228	1224	-1.67	0.85	-0.01*	0.85

*Doppler Coefficient of -1.66 PCM/°F Assumed

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TABLE 5.1

H. B. ROBINSON UNIT 2 -- CYCLE 6

CONTROL ROD BANK WORTH SUMMARY

BANK	MEASURED WORTH	PREDICTED WORTH	PERCENT DIFFERENCE	ACCEPTANCE CRITERIA
	PCM	PCM	%	%
D	768	760	-1.0	Predicted ±15
C	1610	1561	-3.0	Predicted ±15
D+C	2378	2321	-2.4	
B	1075	1148	6.8	Predicted ±15
D+C+B	3452	3469	0.5	
A	1551	1429	-7.9	Predicted ±15
D+C+B+A	5003	4898	-2.1	Predicted ±10

$$\text{Percent Difference} = \frac{\text{Predicted} - \text{Measured}}{\text{Predicted}} \times 100$$

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H.B. ROBINSON UNIT 2 -- CYCLE 6
FLUX MAP SUMMARY

TABLE 6.1

MAP NO	MWD/MT	DATE	PWR %	D BANK	CORE AVG AO	CORE AVG FZ	N F ΔH	LOC F ΔH	KW/FT	LIM F Q	MAXIMUM F Q	LOC FQ	F R	F XY	LOC FXY	NODE FXY	F Z	LOC FZ
269	0	42378	0	214	21.56	1.421	1.508	F12	0.26	2.306	2.244	F12	1.304	1.510	F13	31	1.690	J8
*269	0	42378	0	214	21.40	1.420	1.483	K4	0.25	2.262	2.189	K4	1.279	1.456	J5	10	1.530	H8
270	30	42678	30	75	-10.81	1.232	1.579	L13	3.47	2.031	2.014	K12	1.342	1.556	K12	39	1.650	H8
*270	30	42678	30	75	-10.74	1.232	1.556	L3	3.31	1.934	1.922	N5	1.304	1.498	L3	39	1.650	H8
271	117	50278	70	151	-9.28	1.248	1.494	L13	7.69	2.040	1.915	L13	1.298	1.497	L11	21	1.470	H8
272	116	50278	70	124	-20.06	1.325	1.526	L11	8.22	2.054	2.047	L13	1.322	1.497	L13	28	1.670	H8
273	120	50378	70	161	0.49	1.259	1.492	L11	7.99	2.107	1.951	K12	1.297	1.522	K12	20	1.500	H8
274	194	50578	90	177	-2.14	1.217	1.481	L7	9.70	1.885	1.876	L7	1.284	1.485	K12	18	1.370	H8
275	235	50678	100	211	1.30	1.166	1.469	E9	10.26	1.837	1.788	E9	1.297	1.459	F9	10	1.200	L14
276	264	50778	100	189	-14.09	1.244	1.467	F9	11.39	1.926	1.928	L13	1.296	1.458	E7	20	1.240	J15
277	271	50778	100	200	-5.08	1.178	1.466	L7	10.47	1.824	1.823	L13	1.296	1.461	L13	44	1.220	J15
278	273	50778	100	208	6.67	1.234	1.497	E9	11.00	1.970	1.915	E9	1.304	1.479	F9	10	1.270	B5
279	305	50878	100	213	-1.02	1.146	1.499	G11	10.24	1.811	1.783	G11	1.304	1.469	E9	10	1.190	A9

F_Q INCLUDES 1.03 ENGINEERING FACTOR AND 1.05 MEASUREMENT UNCERTAINTY

$F^N_{\Delta H}$ INCLUDES 1.04 MEASUREMENT UNCERTAINTY

F_Z/FT INCLUDES 1.03 ENGINEERING FACTOR AND 1.05 MEASUREMENT UNCERTAINTY

* INDICATES MAP ANALYZED WITH QUARTER CORE SYMMETRY

MAP NO	MWD/MT	DATE	PWR %	D BANK	QUADRANT TILT NR	NF	SR	SE	POWER FRACTION 9A	7	8	9	STANDARD DEVIATION 9A	7	8	9
269	0	42378	0	214	1.007	0.992	0.992	1.010	0.812	0.960	1.188	0.855	5.15	2.80	2.85	2.31
*269	0	42378	0	214	1.000	1.000	1.000	1.000	0.811	0.962	1.187	0.854	5.28	2.20	2.17	1.42
270	30	42678	30	75	1.004	0.990	1.010	0.998	0.838	0.938	1.138	0.929	2.56	1.45	1.66	1.48
*270	30	42678	30	75	1.000	1.000	1.000	1.000	0.838	0.934	1.134	0.930	2.63	1.05	1.51	1.18
271	117	50278	70	151	0.997	0.988	1.015	1.000	0.737	0.960	1.172	0.874	4.04	1.63	1.64	1.41
272	118	50278	70	124	1.001	0.989	1.014	0.996	0.685	0.956	1.164	0.886	4.23	1.74	1.74	1.14
273	120	50378	70	161	1.001	0.991	1.010	0.998	0.737	0.961	1.172	0.872	4.37	1.53	1.63	1.07
274	194	50578	90	177	0.998	0.991	1.010	1.000	0.793	0.965	1.177	0.861	3.52	1.37	1.39	1.05
275	235	50678	100	211	0.997	0.994	1.004	1.005	0.919	0.971	1.185	0.846	0.44	1.39	1.43	1.62
276	264	50778	100	189	0.999	0.994	1.005	1.003	0.905	0.968	1.179	0.855	2.12	1.94	2.11	2.57
277	271	50778	100	200	0.998	0.992	1.006	1.004	0.909	0.970	1.184	0.848	1.76	1.67	1.71	2.09
278	273	50778	100	208	0.994	0.992	1.006	1.008	0.911	0.970	1.187	0.845	1.56	1.45	1.51	1.49
279	305	50878	100	213	0.997	0.995	1.004	1.004	0.916	0.971	1.186	0.845	1.18	1.43	1.40	2.08

HOT CONTROL ROD DROP

TABLE 7.1

RCCA BANK	RCCA GRID LOCATION	DROP TO DASH POT (t_1 sec)	DASH POT TO ROD BOT. (t_2 sec)	TOTAL DROP TIME ($t_1 + t_2$)	RCS Tavg (^oF)	RCS FLOW (%)	RCS PRESSURE (psig)
SA	J-3	1.32	0.55	1.87	541	100	2228
	G-3	1.25	0.53	1.78	542.5	100	2226
	C-7	1.25	0.59	1.84	541	100	2231
	C-9	1.25	0.54	1.79	542.9	100	2222
	G-13	1.23	0.53	1.76	541	100	2235
	J-13	1.24	0.58	1.82	541.1	100	2221
	N-9	1.27	0.56	1.83	540.9	100	2235
	N-7	1.23	0.55	1.78	542.9	100	2219
SB	L-5	1.25	0.52	1.77	541.5	100	2227
	E-5	1.27	0.53	1.80	540.9	100	2233
	E-11	1.32	0.55	1.87	541.0	100	2231
	L-11	1.27	0.56	1.83	541.1	100	2225
	H-6	1.25	0.58	1.83	542.0	100	2222
	F-8	1.27	0.59	1.86	541.9	100	2218
	H-10	1.27	0.58	1.85	541.8	100	2221
	K-8	1.29	0.61	1.90	541.8	100	2225
A	J-5	1.26	0.60	1.86	541.3	100	2233
	G-5	1.25	0.59	1.84	541.2	100	2225
	E-7	1.23	0.50	1.73	541.4	100	2231
	E-9	1.23	0.55	1.78	541.2	100	2227
	G-11	1.30	0.53	1.83	541.4	100	2228
	J-11	1.26	0.55	1.81	541.2	100	2230
	L-9	1.28	0.57	1.85	541.5	100	2225
	L-7	1.25	0.52	1.77	541.3	100	2231
B	K-2	1.25	0.57	1.82	541.9	100	2229
	F-2	1.24	0.55	1.79	540.4	100	2228
	B-6	1.30	0.55	1.85	542.7	100	2229
	B-10	1.27	0.52	1.79	540.8	100	2228
	F-14	1.25	0.53	1.78	542.5	100	2228
	K-14	1.30	0.55	1.85	541.3	100	2226
	P-10	1.32	0.52	1.84	542.5	100	2221
	P-6	1.23	0.60	1.83	541.6	100	2227
C	K-4	1.25	0.55	1.80	542	100	2222
	F-4	1.26	0.52	1.78	541.9	100	2234
	D-6	1.23	0.53	1.76	541.9	100	2217
	D-10	1.26	0.59	1.85	542	100	2230
	F-12	1.33	0.55	1.88	541	100	2221
	L-12	1.25	0.57	1.82	542.2	100	2228
	M-10	1.25	0.53	1.78	540.9	100	2223
	M-6	1.27	0.56	1.83	542.2	100	2225
D	H-4	1.28	0.57	1.85	542	100	2226
	D-8	1.30	0.55	1.85	542	100	2232
	H-12	1.25	0.55	1.80	542	100	2228
	M-8	1.30	0.60	1.90	542	100	2226
	H-8	1.28	0.59	1.87	542	100	2228

COLD CONTROL ROD DROP

TABLE 7.2

RCCA BANK	RCCA GRID LOCATION	DROP TO DASH POT (t_1 sec)	DASH POT TO ROD BOT. (t_2 sec)	TOTAL DROP TIME ($t_1 + t_2$)	RCS Tavg (^{o}F)	RCS FLOW (%)	RCS PRESSURE (psig)
SA	J-3	1.43	0.71	2.14	150	100	347
	G-3	1.39	0.70	2.09	150	100	348
	C-7	1.34	0.79	2.13	150	100	348
	C-9	1.22	0.68	1.90	150	100	346
	G-13	1.30	0.69	1.99	150	100	348
	J-13	1.39	0.77	2.16	150	100	347
	N-9	1.38	0.75	2.13	150	100	347
	N-7	1.33	0.73	2.06	150	100	347
SB	L-5	1.38	0.68	2.06	150	100	351
	E-5	1.38	0.70	2.03	150	100	351
	E-11	1.46	0.67	2.13	150	100	355
	L-11	1.40	0.72	2.12	150	100	350
	H-6	1.27	0.66	1.93	149.5	100	350
	F-8	1.26	0.71	1.97	149	100	338
	H-10	1.27	0.68	1.95	149	100	343
	K-8	1.35	0.73	2.08	149	100	345
A	J-5	1.21	0.73	1.94	149	100	341
	G-5	1.21	0.80	2.01	149	100	339
	E-7	1.22	0.63	1.85	149	100	341
	E-9	1.17	0.74	1.91	149	100	352
	G-11	1.22	0.72	1.94	149	100	352
	J-11	1.18	0.71	1.89	149	100	344
	L-9	1.27	0.65	1.92	149	100	352
	L-7	1.21	0.65	1.86	149	100	340
B	K-2	1.19	0.68	1.87	149	100	341
	F-2	1.38	0.71	2.09	149	100	342
	B-6	1.28	0.78	2.06	149	100	340
	B-10	1.37	0.68	2.05	149	100	340
	F-14	1.41	0.71	2.12	149	100	340
	K-14	1.29	0.70	1.99	149	100	338
	P-10	1.45	0.71	2.16	149	100	338
	P-6	1.18	0.73	1.91	149	100	338
C	K-4	1.30	0.70	2.00	149	100	340
	F-4	1.17	0.67	1.84	149	100	339
	D-6	1.26	0.68	1.94	149	100	342
	D-10	1.37	0.73	2.10	149	100	340
	F-12	1.45	0.68	2.13	149	100	342
	K-12	1.20	0.68	1.88	149	100	340
	M-10	1.41	0.68	2.09	149	100	341
	M-6	1.33	0.71	2.04	149	100	339
D	H-4	1.30	0.71	2.01	149	100	340
	D-8	1.33	0.70	2.03	149	100	339
	H-12	1.40	0.69	2.09	149	100	340
	M-8	1.44	0.74	2.18	149	100	340
	H-8	1.24	0.68	1.92	149	100	340

FIGURE 1.1

H. B. ROBINSON UNIT 2 -- CYCLE 6

FULL CORE LOADING PATTERN

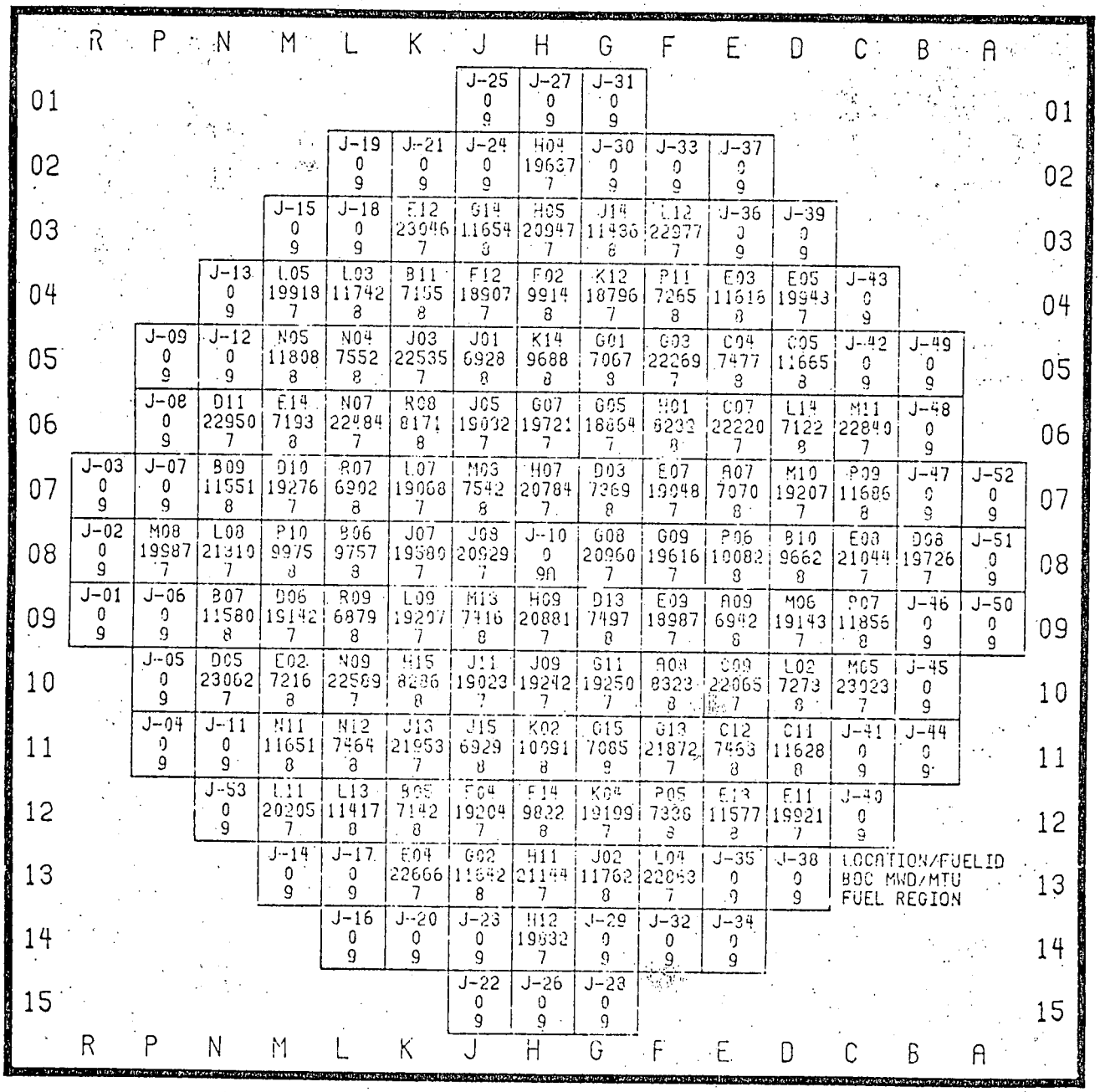

FIGURE 1.2

H. B. ROBINSON UNIT 2 -- CYCLE 6

CONTROL, SHUTDOWN, AND PART-LENGTH ROD LOCATIONS

FLUX THIMBLE LOCATIONS

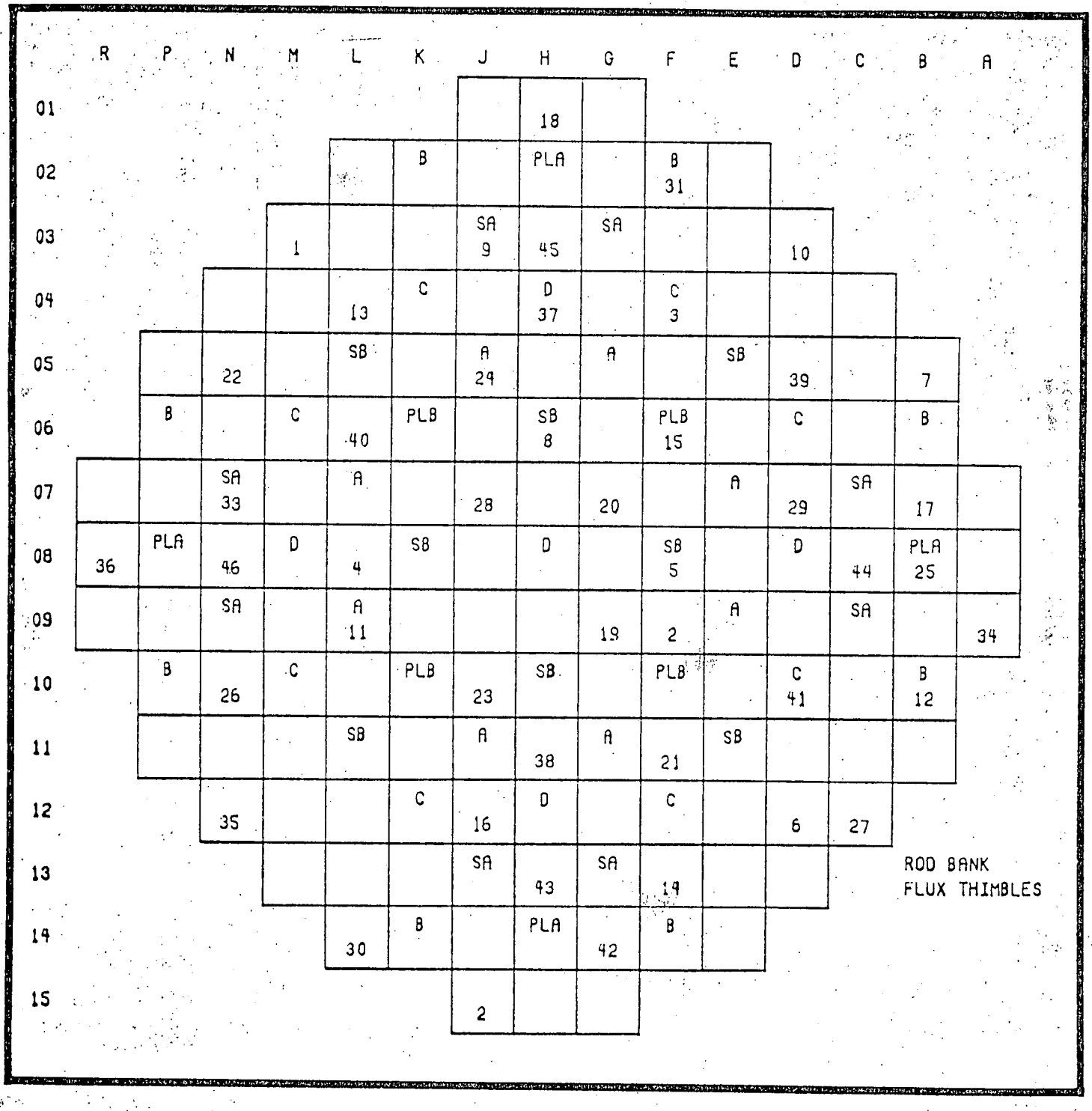

FIGURE 5.1

H. B. ROBINSON UNIT 2 -- CYCLE 6
CONTROL BANKS A, B, C, D IN OVERLAP
DIFFERENTIAL AND INTEGRAL ROD WORTH
-------ENC PREDICTED
———··MEASURED DATA

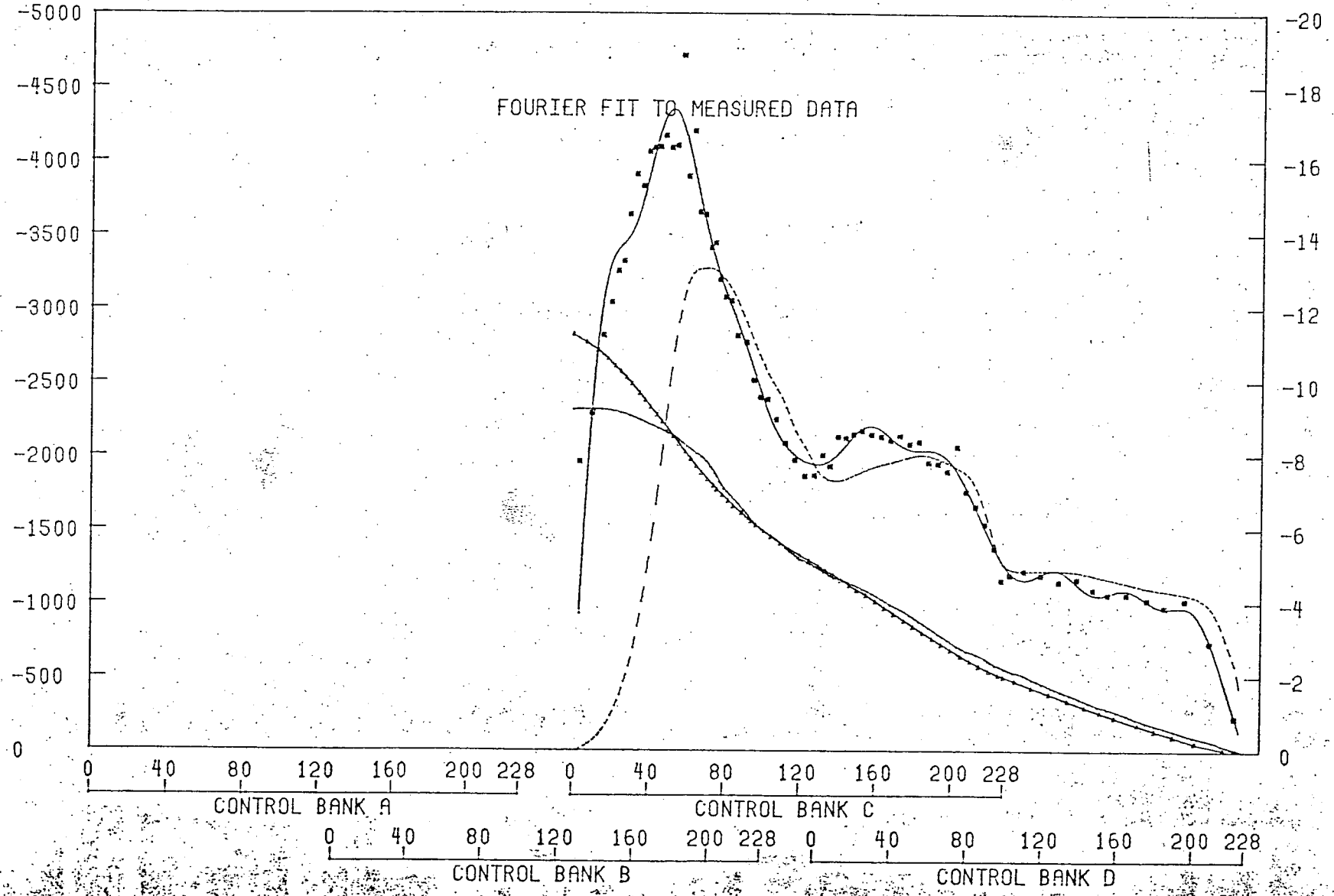

FIGURE 5.2

H. B. ROBINSON UNIT 2 -- CYCLE 6
CONTROL BANK D DIFFERENTIAL AND INTEGRAL ROD WORTH
--------- ENC PREDICTED
———△✳ MEASURED DATA

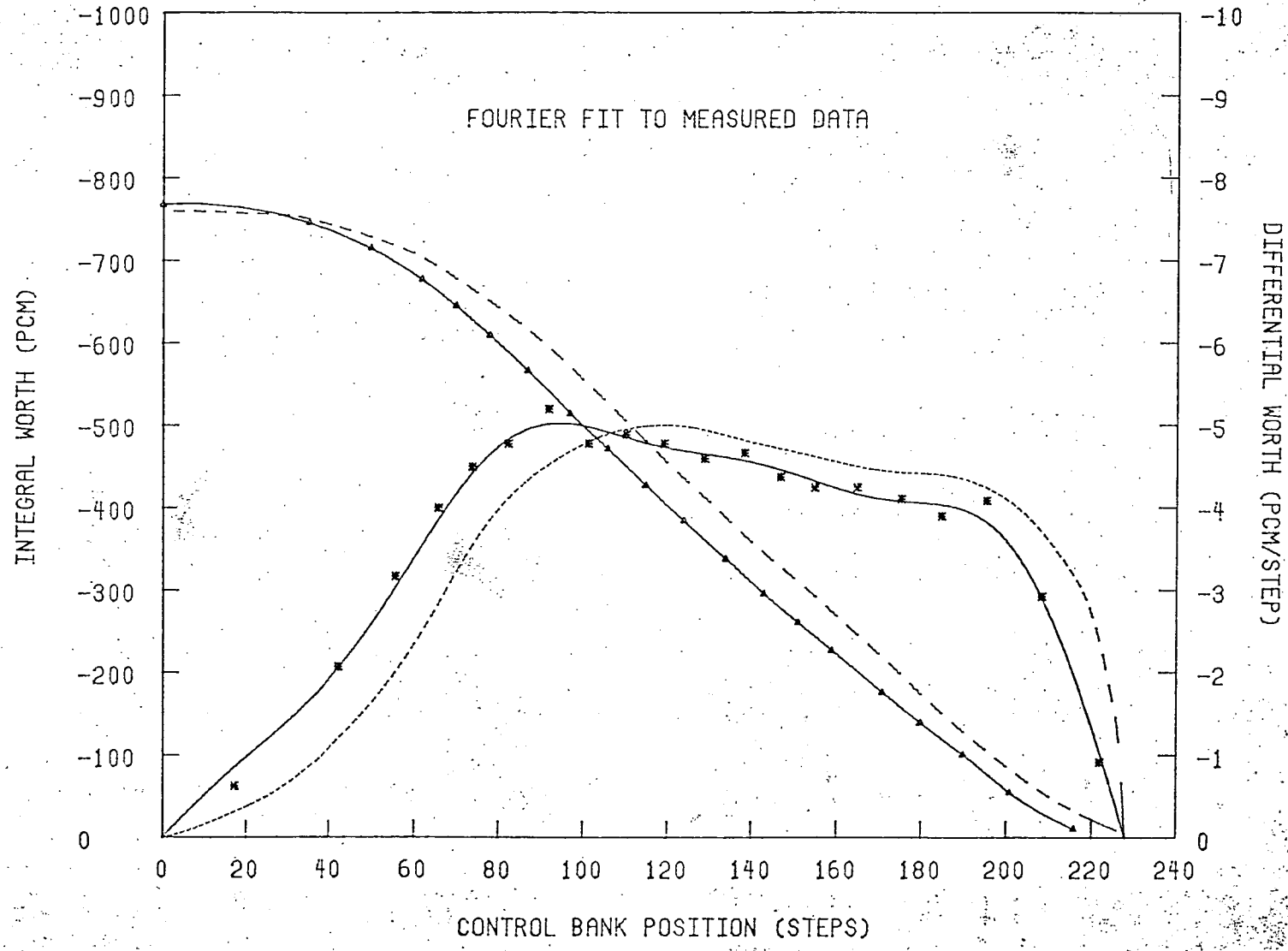

FIGURE 5.3

H. B. ROBINSON UNIT 2 -- CYCLE 6
CONTROL BANK C DIFFERENTIAL AND INTEGRAL ROD WORTH
--------- ENC PREDICTED
———△✱ MEASURED DATA

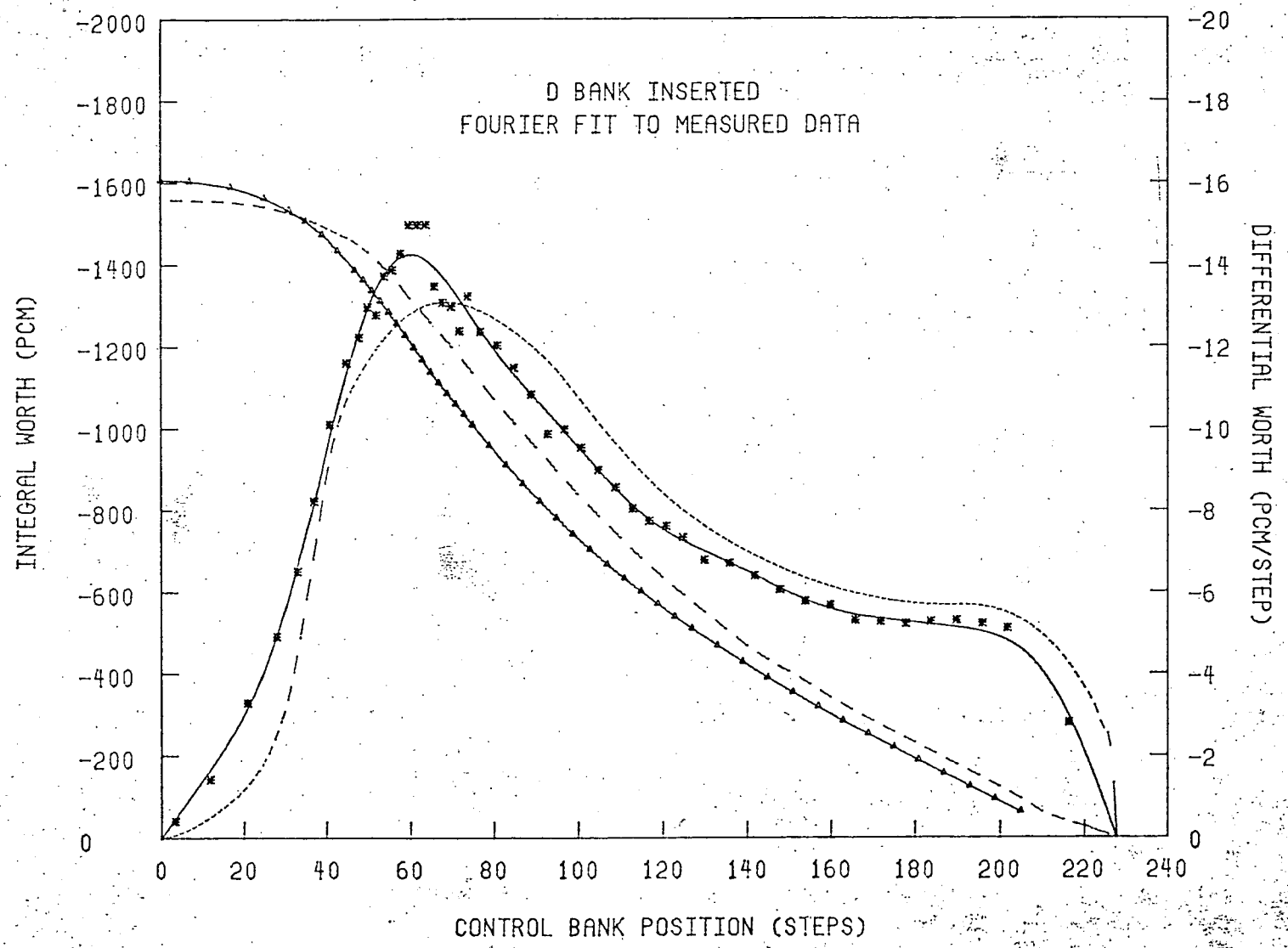

FIGURE 5.4

H. B. ROBINSON UNIT 2 -- CYCLE 6
CONTROL BANK B DIFFERENTIAL AND INTEGRAL ROD WORTH
---------- ENC PREDICTED
———△✳ MEASURED DATA

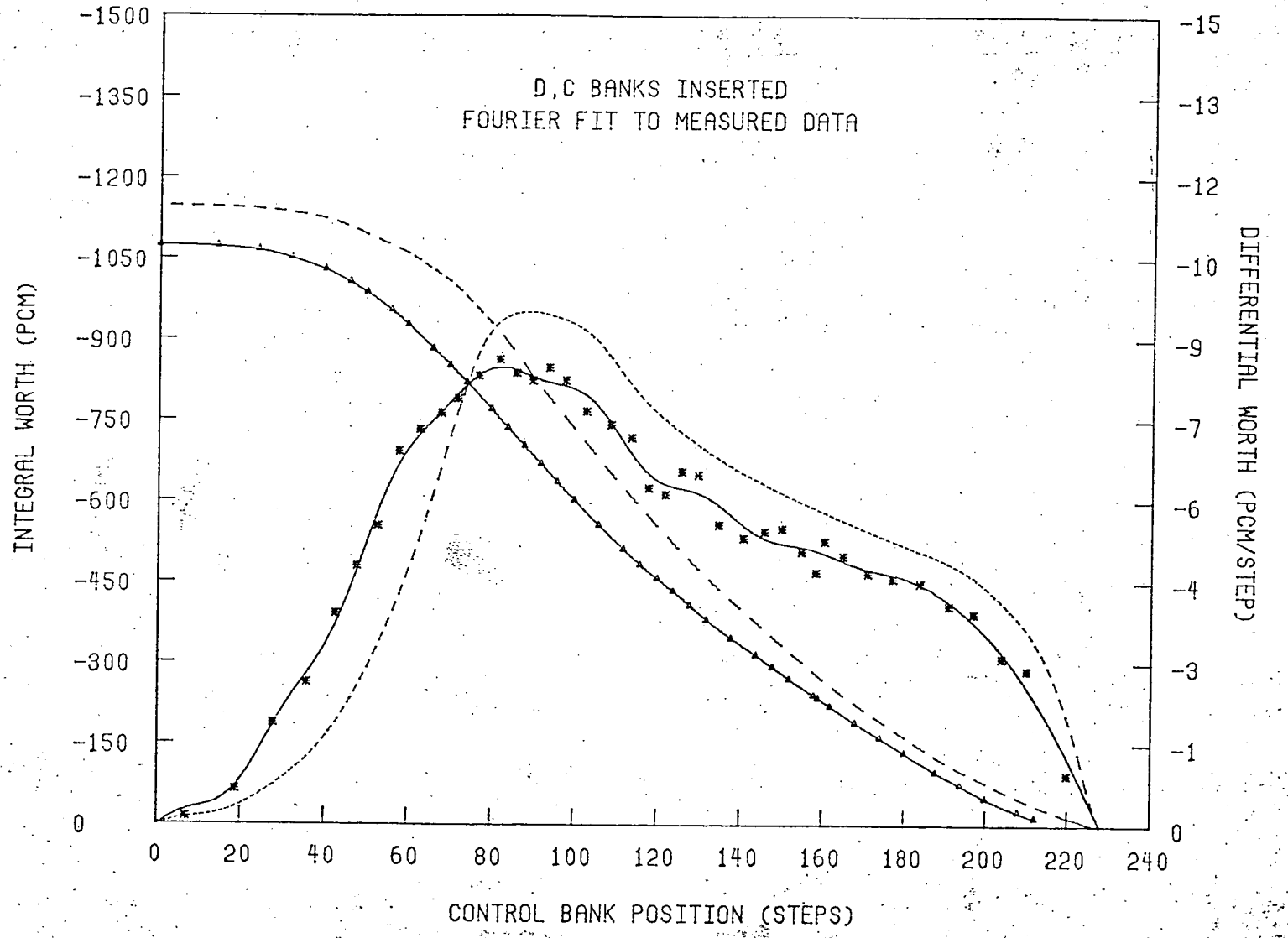

FIGURE 5.5

H. B. ROBINSON UNIT 2 -- CYCLE 6
CONTROL BANK A DIFFERENTIAL AND INTEGRAL ROD WORTH
---------- ENC PREDICTED
———△✱ MEASURED DATA