TENNESSEE VALLEY AUTHORITY

SEQUOYAH NUCLEAR PLANT

STARTUP REPORT

UNIT 1 CYCLE 1

REVIEW AND APPROVAL

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The following people have participated in the Sequoyah Nuclear Plant startup test program, provided offsite assistance and aided in preparation and review of this report:

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1.0 INTRODUCTION

Sequoyah Nuclear Plant, located in southeast Tennessee on the Tennessee River employs a Westinghouse four loop pressurized water reactor rated at 3411 MWt and a Westinghouse turbine generator rated at 1185 MWe. The reactor core consists of 193 fuel assemblies and 53 control rods. Part-length control rods have been eliminated from Sequoyah and replaced with fuel assembly plugging devices.

Sequoyah received a limited operating license (5% power) on February 29, 1980. Fuel loading commenced at 1456 CST on March 1, 1980, and criticality was achieved for the first time at 1052 CDT on July 5, 1980. A full power operating license was received on September 17, 1980. Further testing was performed at the following plateaus:

Power Level (%)	First Achieved
30	11/5/80
50	11/18/80
75	12/1/80
90	12/29/80
100	1/11/81

This report is prepared in accordance with the requirements of Technical Specification 6.9.1 and addresses the results of all startup testing, identified in the Final Safety Analysis Report, that has been completed as of February 28, 1981. The remainder of the startup program will be addressed in a supplementary report. Completed copies of the test procedures and their respective reports are considered the official records. Copies are available upon request through the Division of Nuclear Power, TVA.

2.0 TEST PROGRAM SUMMARY

This report covers the period from February 29, 1980, through February 28, 1981. Significant milestones, events and data for this period are illustrated graphically in Figure 2-1 and are summarized below.

Receipt of Low Power Testing License	February 29, 1980
Start of Core Loading	March 1, 1980
Completion of Core Loading	March 5, 1980
Initial Criticality	July 5, 1980
Start of Zero Power Physics Testing	July 5, 1980
Completion of Zero Power Physics	July 10, 1980
Start of Special Natural Circulation Tests	July 11, 1980
Escalate Power ≤5%	July 11, 1980
Completion of Special Tests	July 19, 1980
Initial Power Generation	July 22, 1980
Receipt of Full Power Operating License	September 17, 1980
Reactor Coolant System Heatup	September 26, 1980
Power Escalation to 10%	October 3, 1980
Power Escalation to 30%	November 5, 1980
Power Escalation to 50%	November 17, 1980
Power Escalation to 75%	December 1, 1980
Power Escalation to 90%	December 29, 1980
Power Escalation to 100%	January 11, 1981
Commercial Operation	N/A

Some of the major problems that were encountered during testing are listed below:

A. After completion of core loading and upper internals installation, a rod control cluster assembly (RCCA) experienced binding during drag testing. The RCCA was replaced by a spare RCCA.

B. During several zero power flux maps the quadrant power tilt ratio (QPTR) exceeded the 1.02 limit. However, additional flux maps taken at power have demonstrated the ability to operate with a QPTR of less than 1.02.

2.0 TEST PROGRAM SUMMARY (continued)

C. The measured reactivity worth of control bank A was determined to be 15% less than design predictions. However, since the measured worth of all control banks was within 1% of the design prediction, it was determined acceptable.

D. The initial measured reactivity worth of control bank D, though within acceptable limits, did not agree with supporting data. The bank worth was remeasured and good agreement with all supporting data was obtained.

E. The all rods out (ARO) moderator temperature coefficient (MTC) was determined to be greater than zero during low power physics testing. Rod withdrawal limits were established to ensure reactor operations with a negative MTC as required by the Technical Specification.

F. The steam flowrate transmitters were not scaled to the correct range of the measurement. These transmitters have been replaced with correctly scaled transmitters.

G. An unexpected difference in flowrate between the four feedwater lines was experienced. This problem is still under investigation.

H. During the performance of a 50% step load reduction test from 75% power, the main feedpump speed control had to be switched to manual control in order to stabalize the plant. The resolution of this problem and the acceptability of the test is still being evaluated.

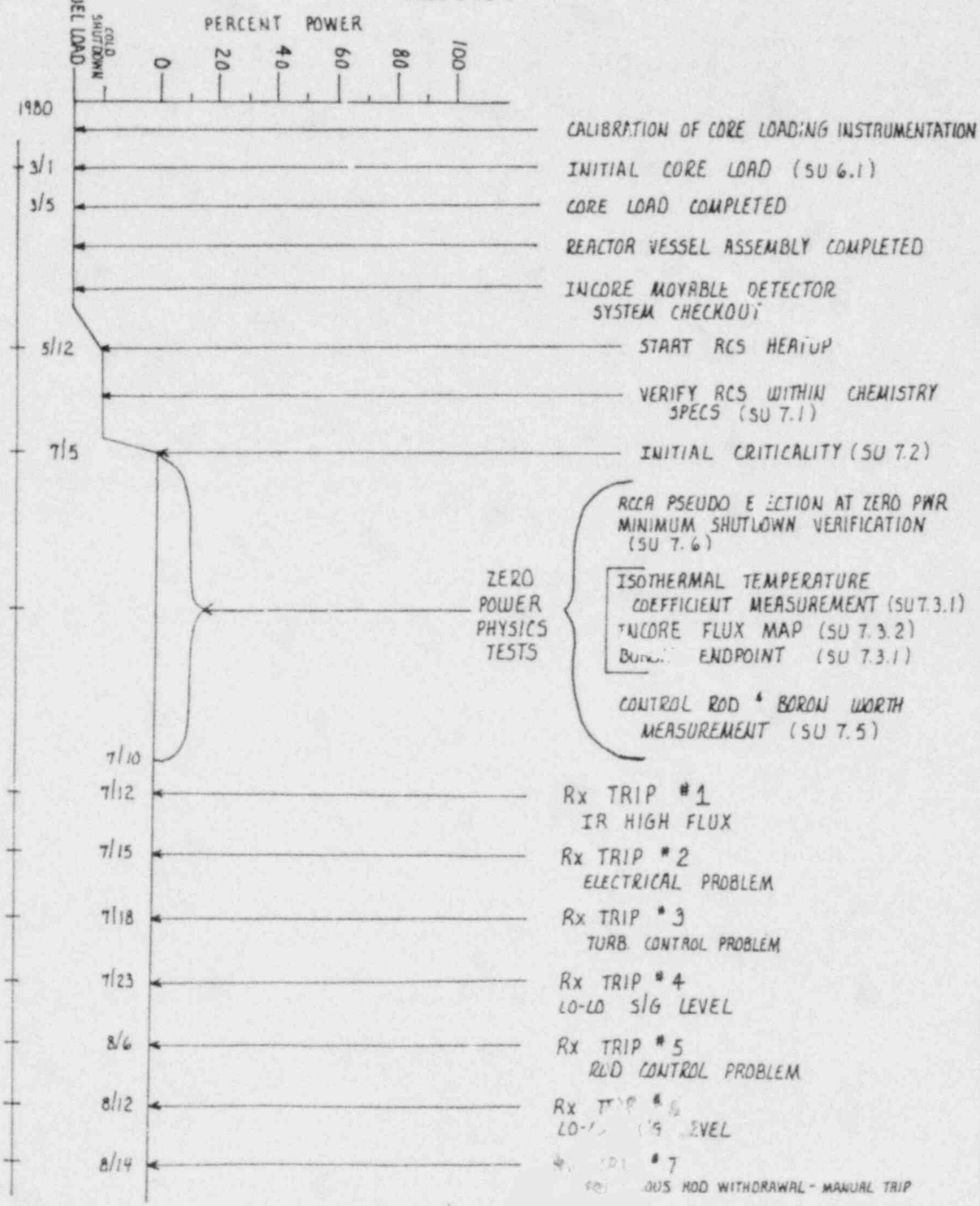
PERCENT POWER
FUEL LOAD
COLD SHUTDOWN
0
20
40
60
80
100
1980
3/1
3/5
5/12
7/5
7/10
7/12
7/15
7/18
7/23
8/6
8/12
8/14
CALIBRATION OF CORE LOADING INSTRUMENTATION
INITIAL CORE LOAD (SU 6.1)
CORE LOAD COMPLETED
REACTOR VESSEL ASSEMBLY COMPLETED
INCORE MOVABLE DETECTOR SYSTEM CHECKOUT
START RCS HEATUP
VERIFY RCS WITHIN CHEMISTRY SPECS (SU 7.1)
INITIAL CRITICALITY (SU 7.2)
ZERO POWER PHYSICS TESTS
RCCA PSEUDO E ECTION AT ZERO PWR MINIMUM SHUTDOWN VERIFICATION (SU 7.6)
ISOTHERMAL TEMPERATURE COEFFICIENT MEASUREMENT (SU 7.3.1)
INCORE FLUX MAP (SU 7.3.2)
ENDPOINT (SU 7.3.1)
CONTROL ROD & BORON WORTH MEASUREMENT (SU 7.5)
Rx TRIP #1
IR HIGH FLUX
Rx TRIP #2
ELECTRICAL PROBLEM
Rx TRIP #3
TURB. CONTROL PROBLEM
Rx TRIP #4
LO-LO S/G LEVEL
Rx TRIP #5
ROD CONTROL PROBLEM
Rx #6
LO- EVEL
#7
OUS ROD WITHDRAWAL - MANUAL TRIP

FIGURE 2-1
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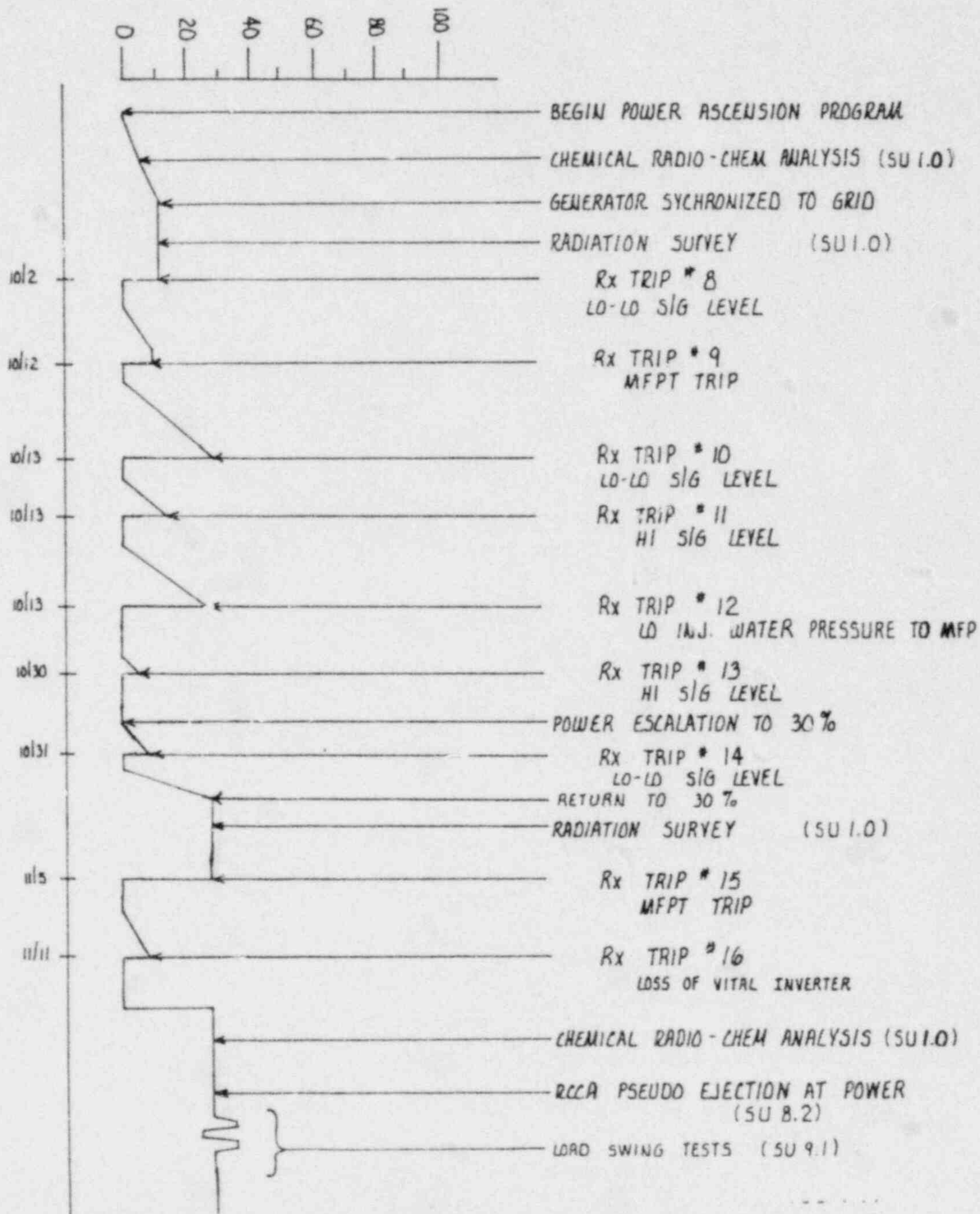

FIGURE 2-1
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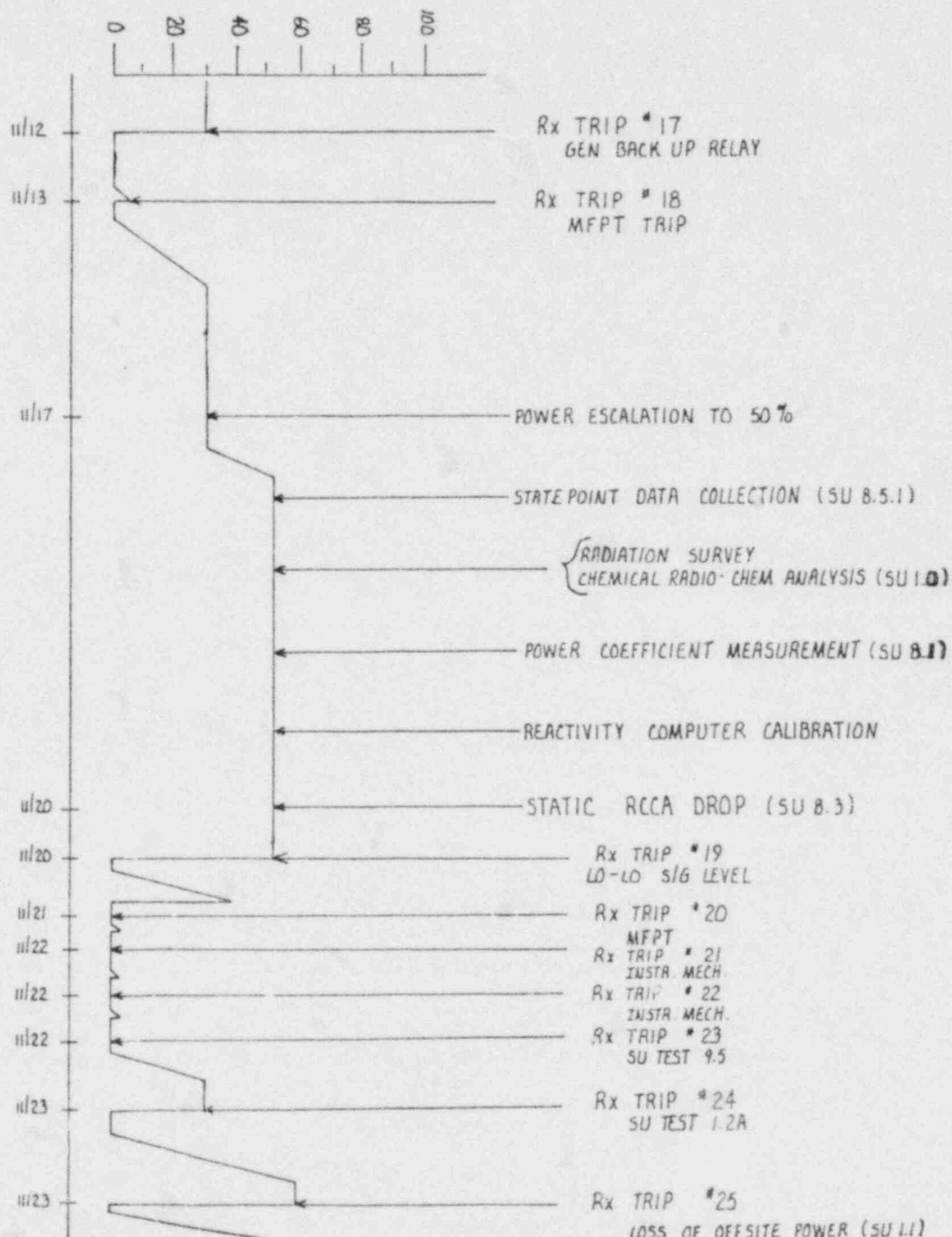

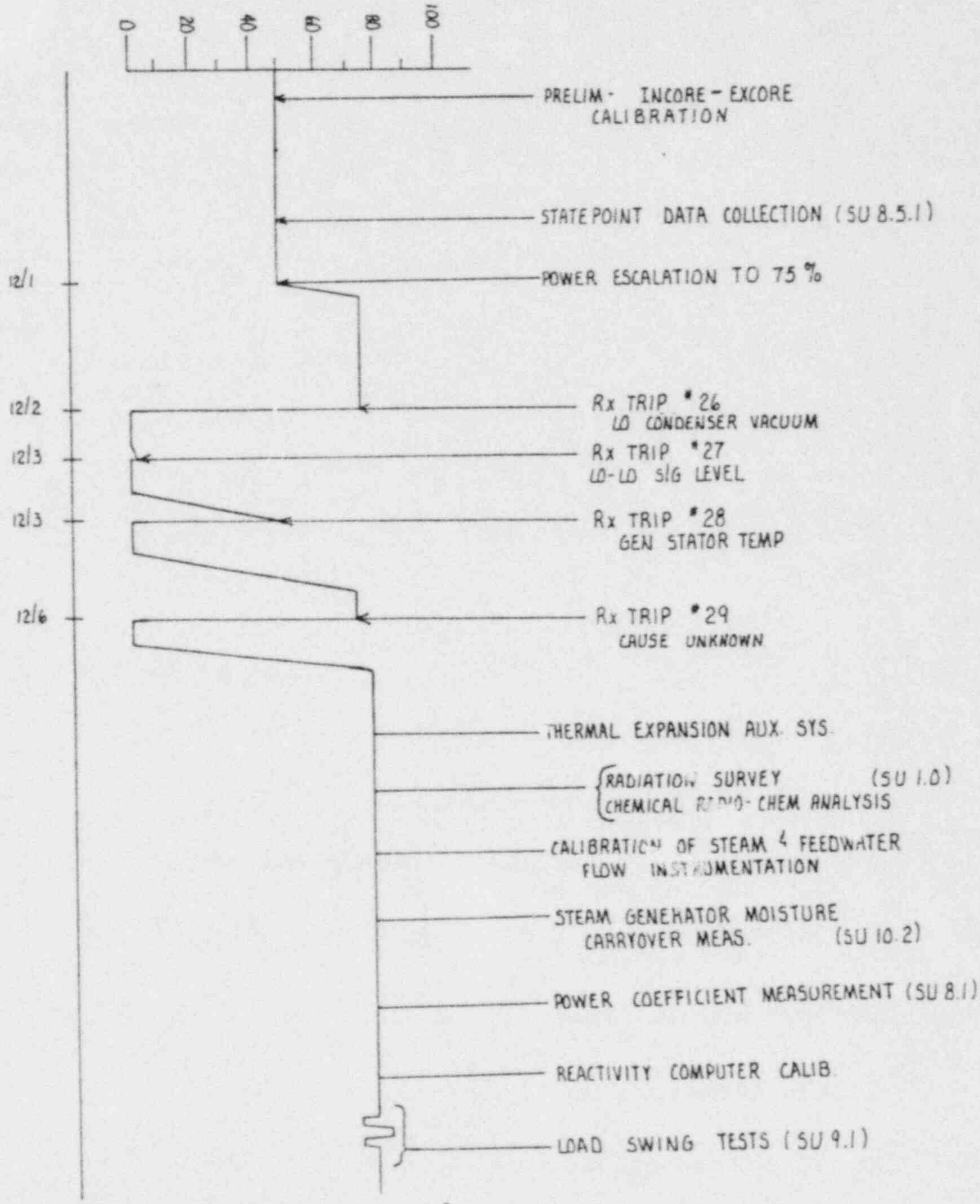
0
20
40
60
80
100
PRELIM- INCORE-EXCORE CALIBRATION
STATEPOINT DATA COLLECTION (SU 8.5.1)
12/1
POWER ESCALATION TO 75%
12/2
Rx TRIP #26
LO CONDENSER VACUUM
12/3
Rx TRIP #27
LO-LO S/G LEVEL
12/3
Rx TRIP #28
GEN STATOR TEMP
12/6
Rx TRIP #29
CAUSE UNKNOWN
THERMAL EXPANSION AUX SYS
RADIATION SURVEY (SU 1.0)
CHEMICAL RADIO-CHEM ANALYSIS
CALIBRATION OF STEAM & FEEDWATER FLOW INSTRUMENTATION
STEAM GENERATOR MOISTURE CARRYOVER MEAS. (SU 10.2)
POWER COEFFICIENT MEASUREMENT (SU 8.1)
REACTIVITY COMPUTER CALIB.
LOAD SWING TESTS (SU 9.1)

FIGURE 2-1
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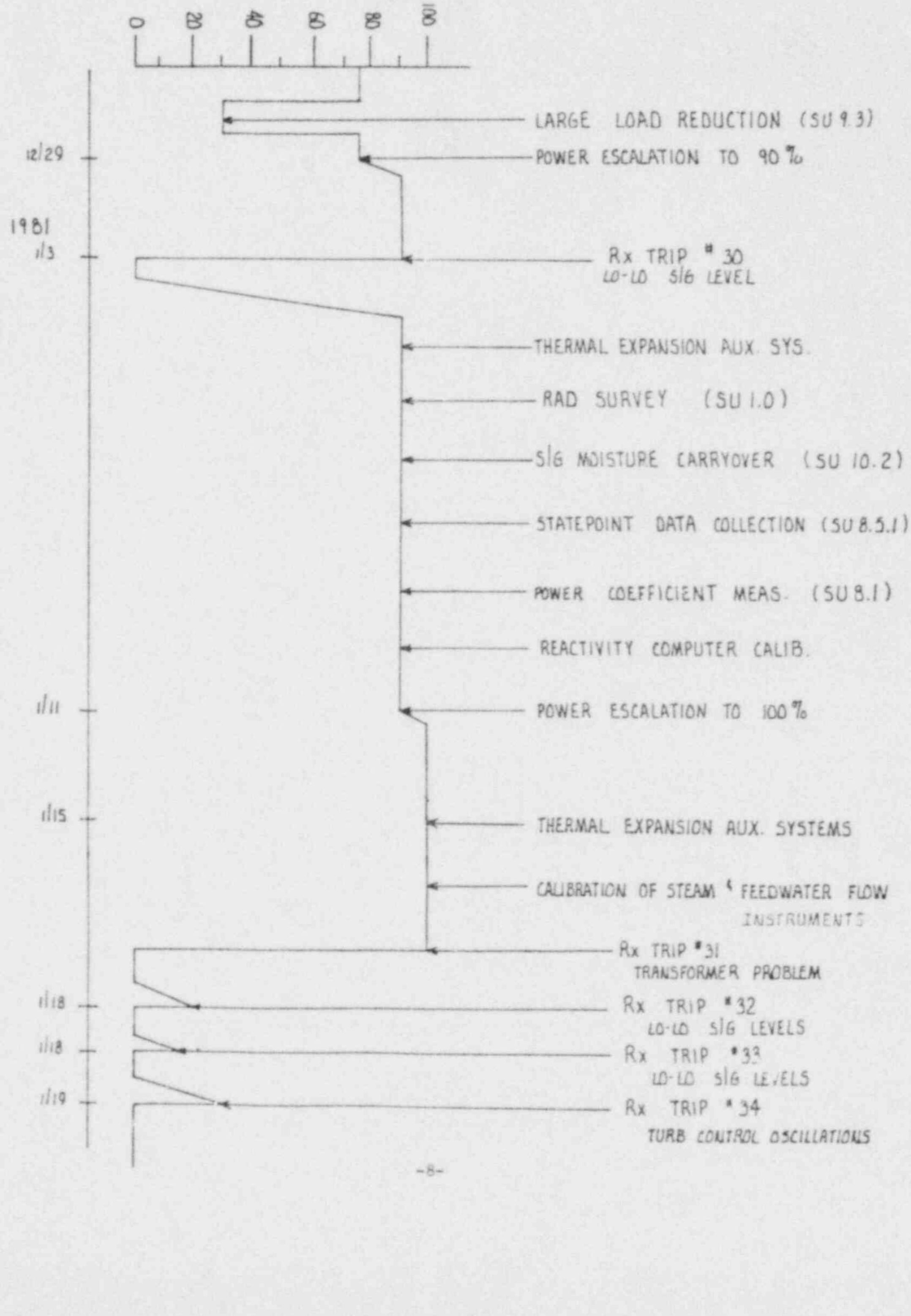
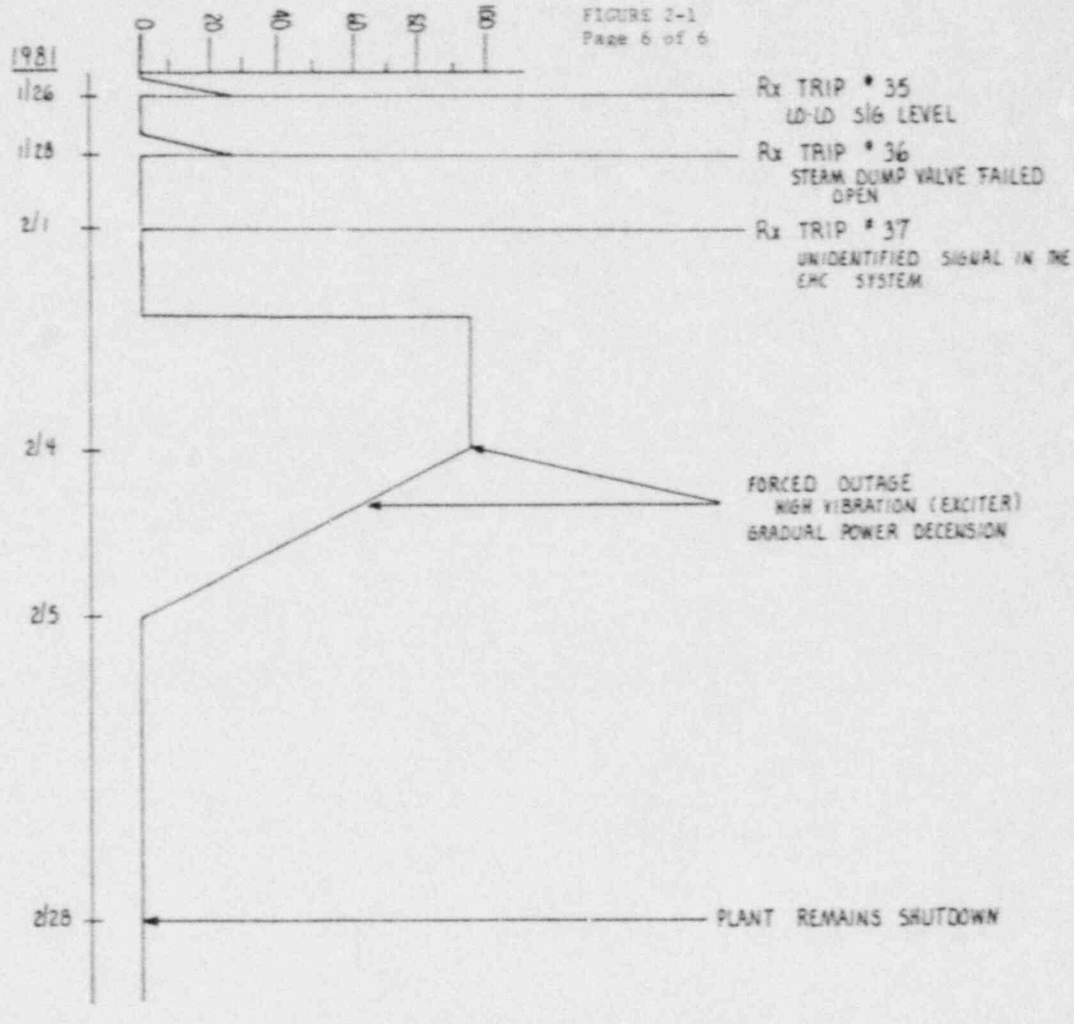


FIGURE 2-1
Page 6 of 6



3.0 INITIAL CORE LOADING (Test procedures SU-6.1, SU-6.2, and SU-6.3)

After completion of all prerequisites, initial core loading commenced at 1456 CST on March 1, 1980, with the insertion of assembly C-27. Fuel loading was completed four days later, March 5, 1980, at 1028 CST with the insertion of fuel assembly C-09. The final core configuration is shown in Figure 3-1. Figure 3-2 illustrates the configuration of the three fuel enrichment zones for the core load.

The neutron count rate was monitored throughout core load as a precaution to ensure that core loading proceeded as planned. This monitoring was accomplished by utilizing the permanent excore source range detectors and three temporary neutron detectors. Neutron count rate was monitored at 100-second intervals for each detector. After ten fuel assemblies had been loaded, a minimum count rate of one half count per second, attributable to core neutrons was verified to exist. This requirement assured proper placement and operational ability of the detectors.

Continuous plots of inverse count rate ratio were maintained to ensure an orderly and safe core loading. Plots of ICRR versus number of fuel assemblies loaded for detectors N-31 and N-32 are shown in Figures 3-3 and 3-4 respectively.

The initial soluble boron concentration for the fuel load program was 2072 ppm. This level rose to 2132 ppm due to a high concentration of boron in the volume control tank. The boron concentration stabilized at a value of approximately 2100 ppm after reactor coolant system mixing. Neutron count rate levels were analyzed for effects of the change in concentration and none were observed. Throughout fuel loading, the temperature of the Reactor Coolant System stayed between 50^{o}F and 60^{o}F.

Initial fuel loading was conducted with the reactor vessel filled with borated water to above the center of the vessel nozzles. The refueling cavity remained dry. However, to maintain containment integrity, water was maintained above the fuel transfer tube. A water level in the transfer canal was established and kept at 45 inches or greater for the duration of the loading operation. This level was only reduced when momentary pressure imbalances occurred between the containment and auxiliary buildings. In these instances dampers were opened to equalize pressure and the required water level was reestablished.

The test proceeded with only a few delays. Fuel handling had to be suspended when binding of the latching mechanism on the Spent Fuel Pit long handling tool was experienced. The tool was lubricated and loading continued. The majority of the delays were due to problems with the manipulator crane. The bridge would become slightly skewed and it was necessary to bump the stops periodically in order to realign it. Difficulties were encountered in releasing fuel assemblies at times. The latching cam in the gripper mechanism had some flat spots which required sanding down. The manipulator crane air supply was ultimately switched from service to control air in order to solve a problem caused by air pressure losses.

The final configuration after loading of the core was consistent with the predetermined core plan. The core loading procedure is shown in Figure 3-5.

FIGURE 3-1

SEQUOYAH UNIT 1

CYCLE 1

180°

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1					C33	C2	C47	C27	C1	C7	C12				
2			C30	C15	B8	A31	B67	A47	B20	A12	B29	C18	C4		
3		C40	C24	B41	A32	B14	A70	B37	A67	B5	A30	B66	C11	C45	
4		C8	B35	A55	B31	A45	B16	A15	B50	A71	B10	A72	B19	C38	
5	C42	B34	A69	B18	A56	B71	A11	B24	A41	B68	A68	B58	A57	B48	C37
6	C20	A42	B54	A17	B4	A13	B15	A59	B72	A66	B43	A7	B27	A29	C13
7	C6	B40	A21	B49	A38	B25	A44	A43	A73	B42	A52	B7	A39	B3	C28
8	C9	A49	B56	A6	B33	A69	A65	A62	A22	A26	B22	A27	B39	A61	C14
9	C29	B36	A14	B9	A36	B61	A58	A28	A46	B59	A53	B2	A51	B32	C34
10	C23	A34	B69	A59	B44	A19	B13	A33	B11	A10	B60	A23	B47	A40	C10
11	C46	B6	A8	B52	A9	B23	A50	B63	A60	B57	A2	B28	A16	B53	C44
12		C35	B70	A25	B46	A20	B38	A5	B65	A3	B64	A35	B12	C19	
13		C31	C43	B1	A18	B21	A4	B62	A37	B51	A1	B26	C26	C32	
14			C16	C36	B55	A63	B45	A24	B30	A48	B17	C25	C22		
15					C48	C41	C17	C39	C21	C5	C3				

90° (left) — 270° (right)

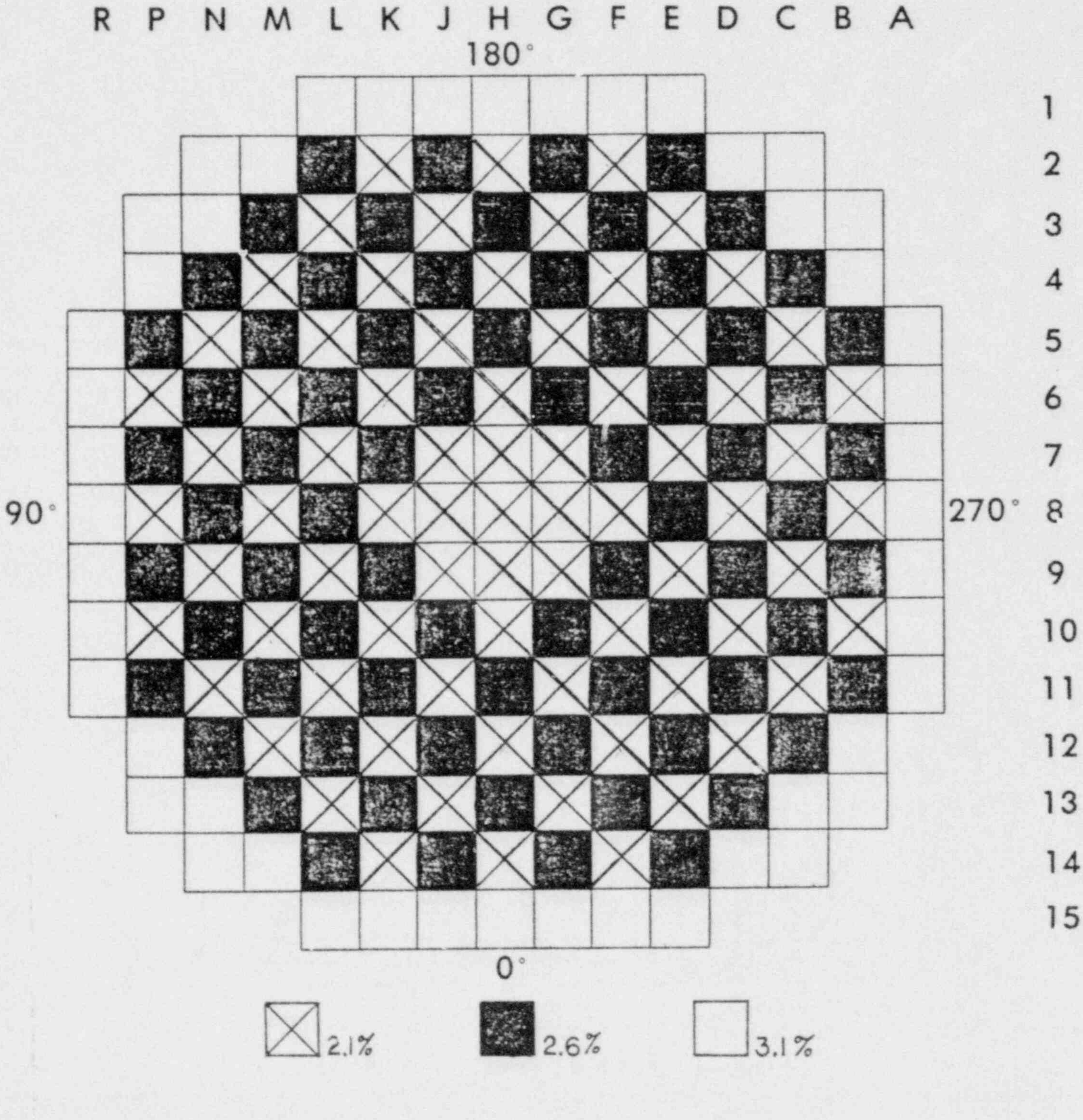
0°

FINAL CORE CONFIGURATION

FIGURE 3-2

SEQUOYAH UNIT 1

FUEL ENRICHMENT LOADING



TVA 7823A (PP-10-77) SEQUOYAH CORE MAP

FIG. 3-2

SOURCE CHANNEL N-31

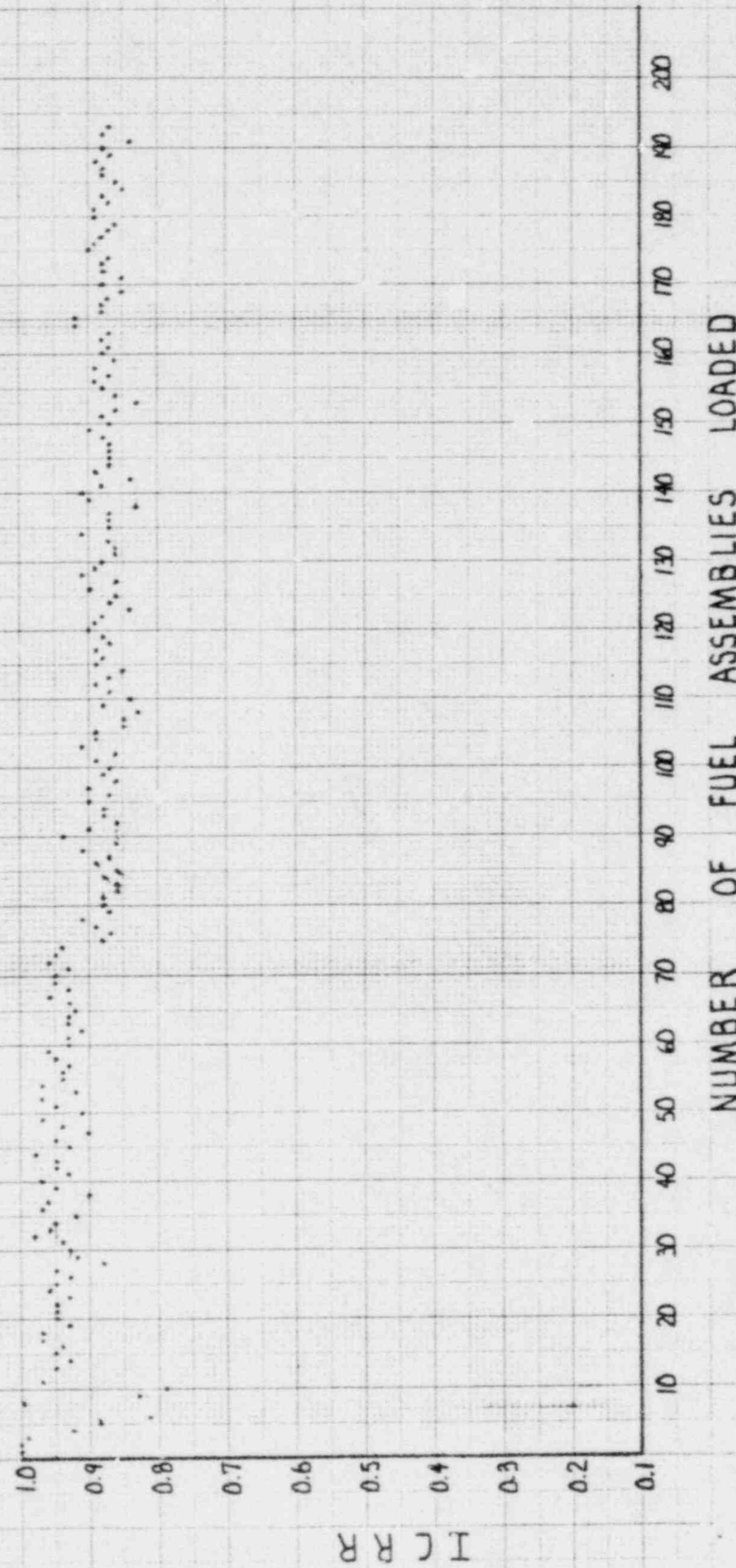
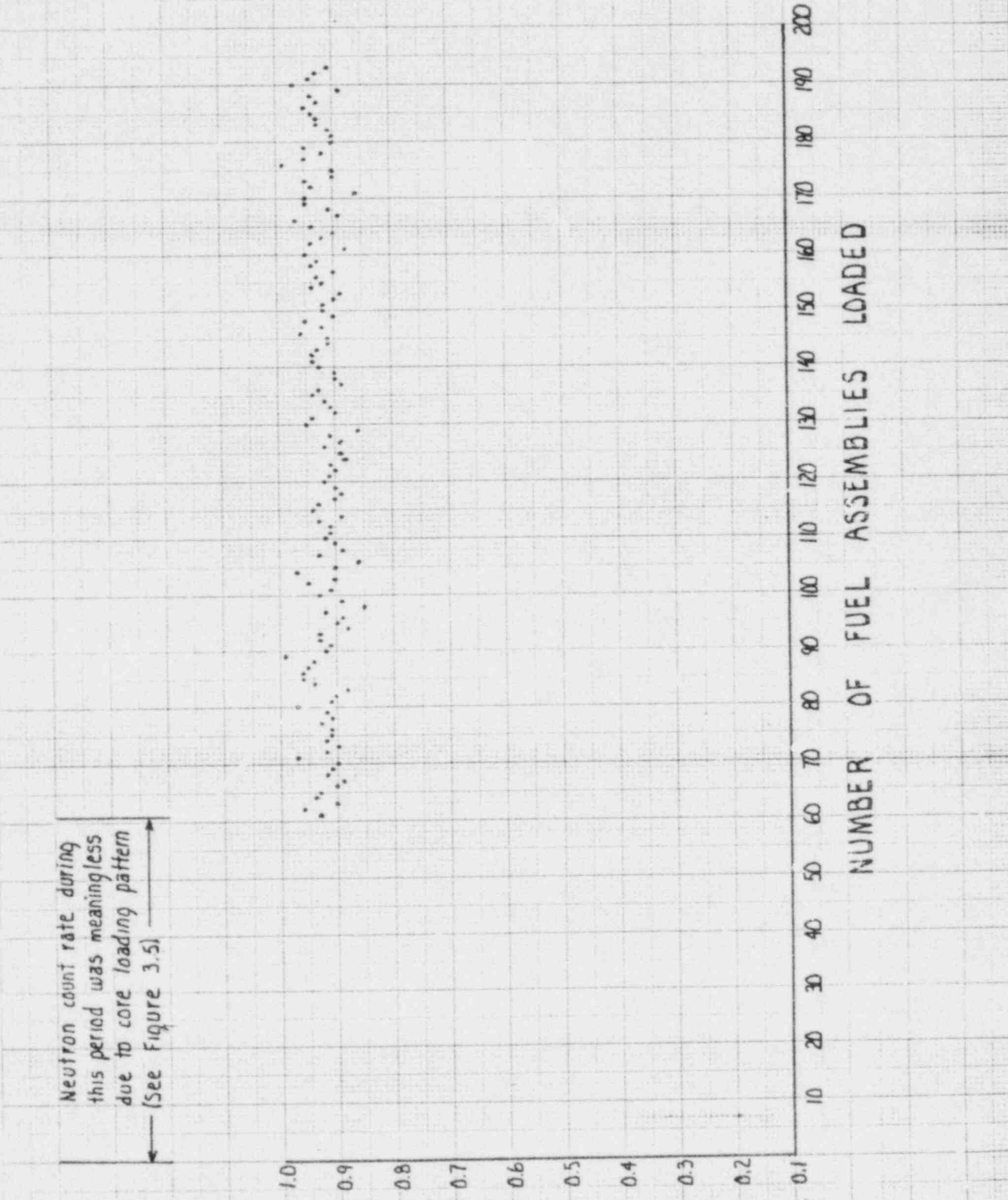
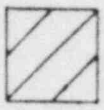


FIG. 3-4
SOURCE CHANNEL N-32

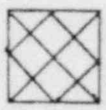


CORE LOADING SEQUENCE

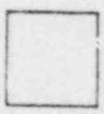
CORE LOADING LEGEND



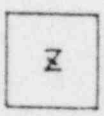
ASSEMBLY LOADED IN PERMANENT POSITION IN PREVIOUS STEP



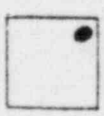
ASSEMBLY LOADED IN TEMPORARY POSITION IN PREVIOUS STEP



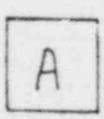
NOT AS YET LOADED



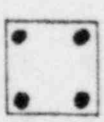
ASSEMBLY LOADED INTO POSITION DURING LOADING STEP NUMBER Z



ASSEMBLY WITH A PRIMARY SOURCE INSERT



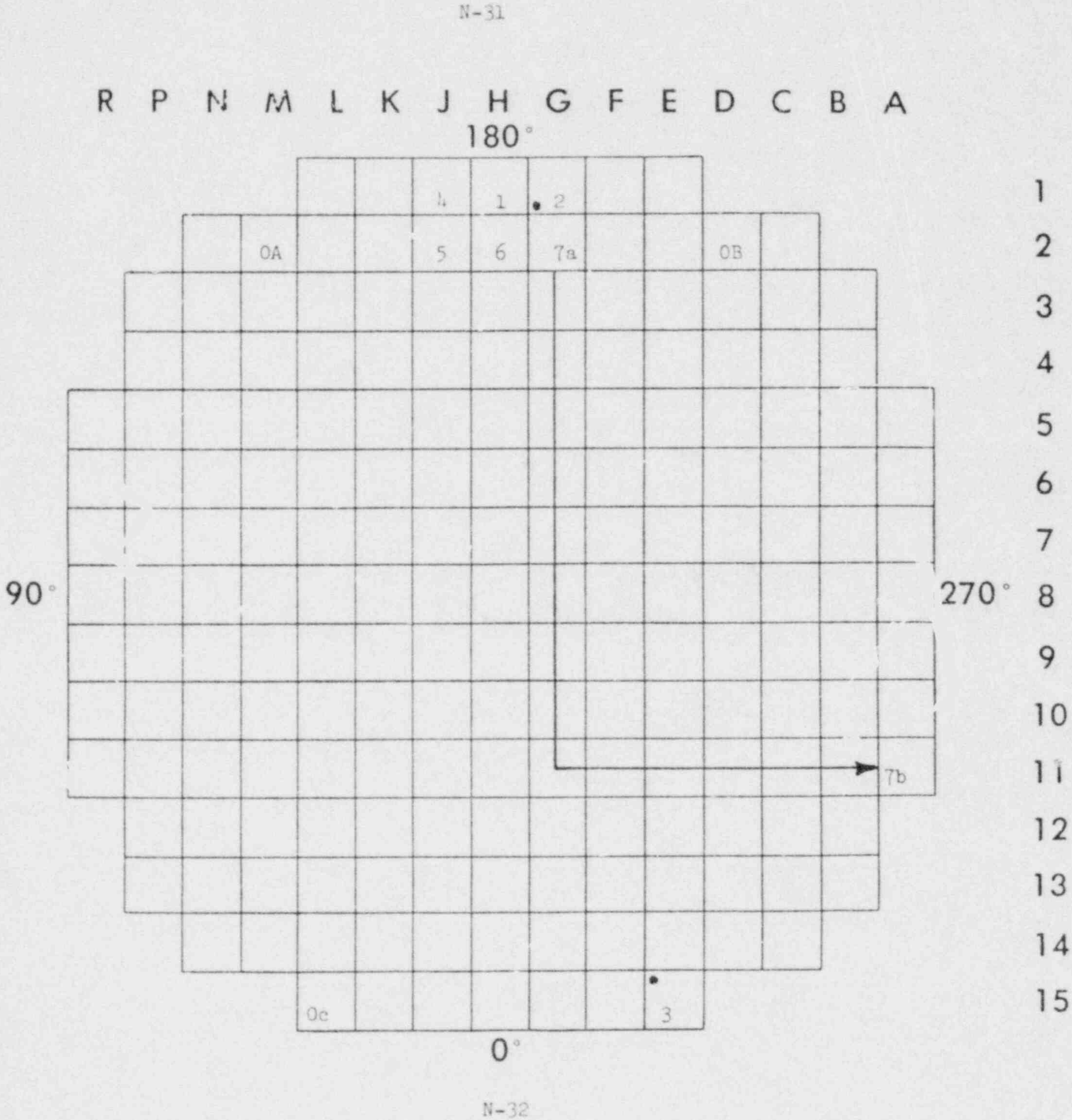
LOCATION OF TEMPORARY DETECTOR A (B AND C)



SECONDARY SOURCE

NOTE: ARROWS INDICATE DETECTOR OR FUEL MOVEMENT

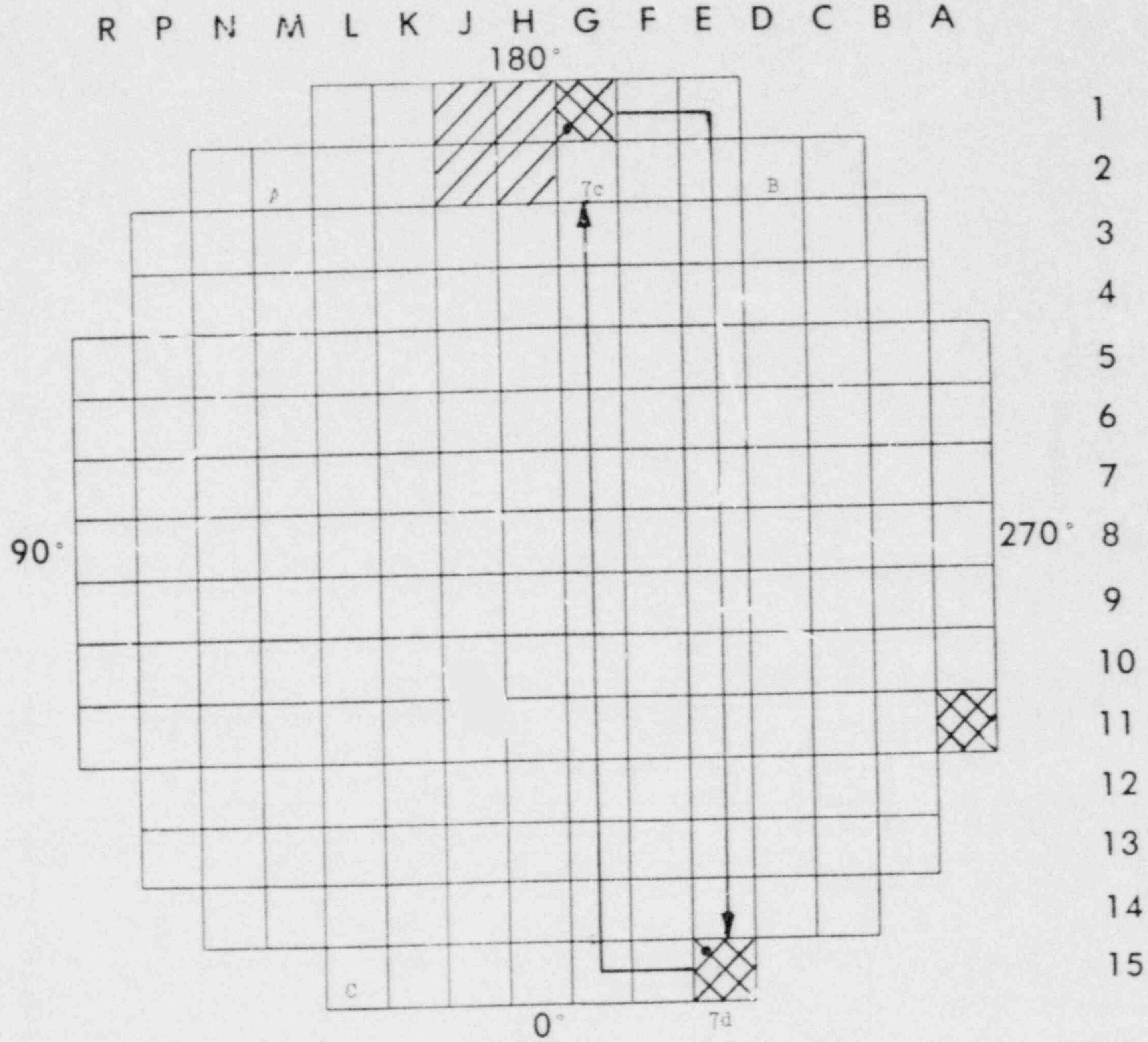
SEQUOYAH UNIT 1



Core Loading Sequence Step 0a to 7b.

SEQUOYAH UNIT 1

N-31

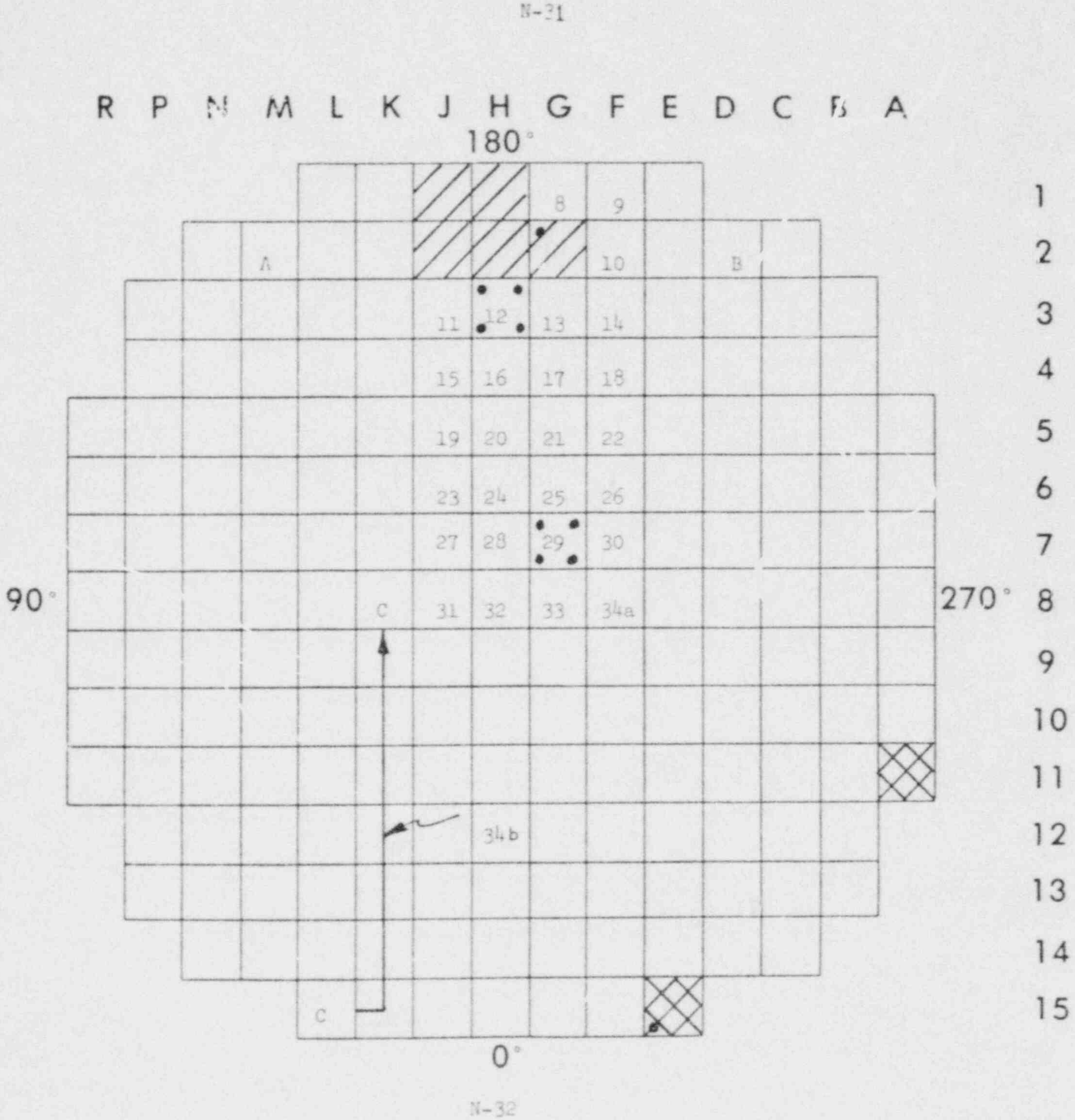


N-32

Core Loading Sequence Step 7c to 7d.

TVA 7823A (PP-10-77) SEQUOYAH CORE MAP

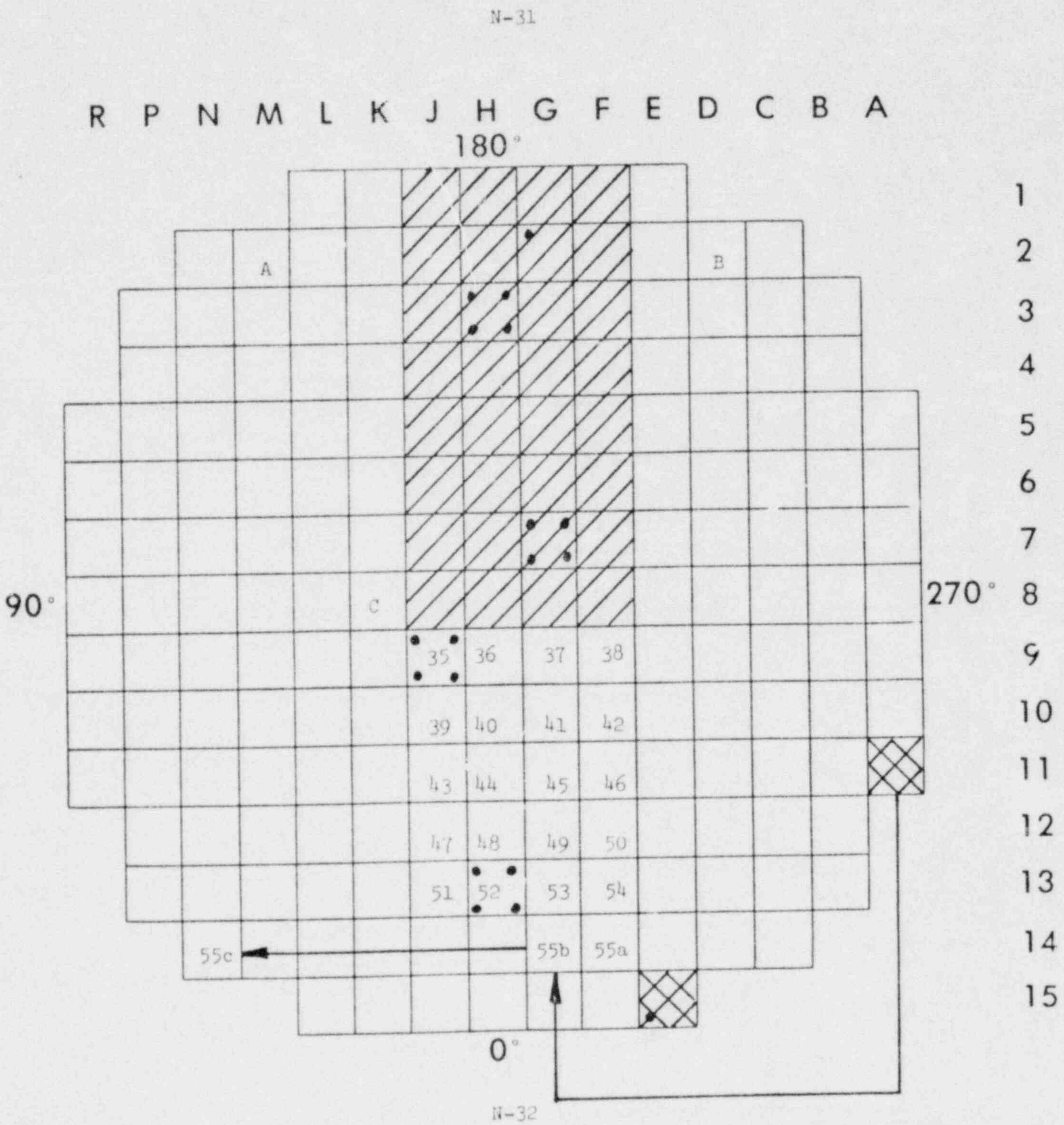
SEQUOYAH UNIT



Core Loading Sequence Step 8 to 34b

TVA 7823A (PP-10-77) SEQUO AH CORE MAP

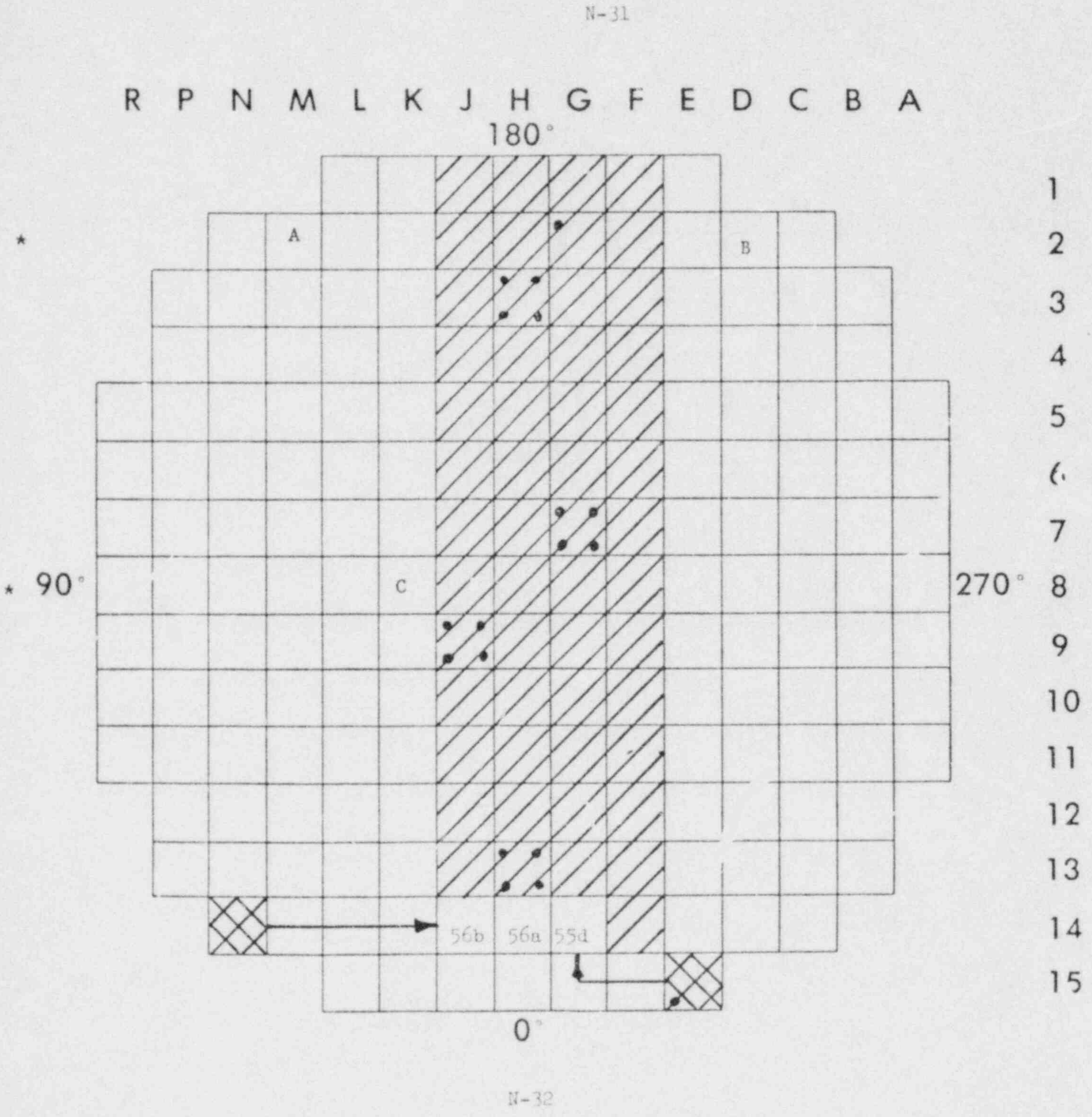
SEQUOYAH UNIT 1



Core Loading Sequence Step 35 to 55c

TVA 7823A (PP-10-77) SEQUOYAH CORE MAP

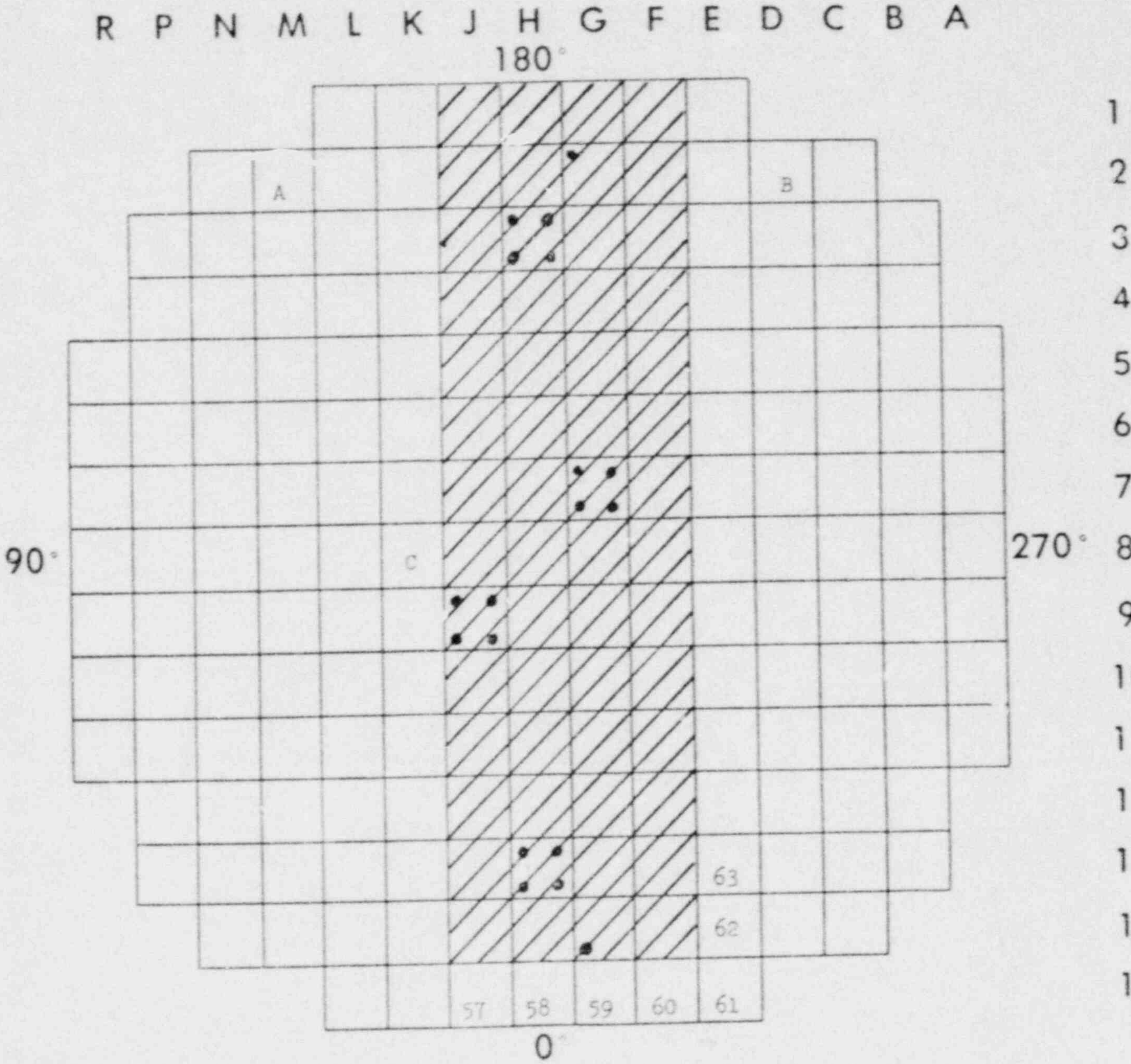
SEQUOYAH UNIT 1



Core Loading Sequence Step 55d to 56b.

SEQUOYAH UNIT 1

N-31

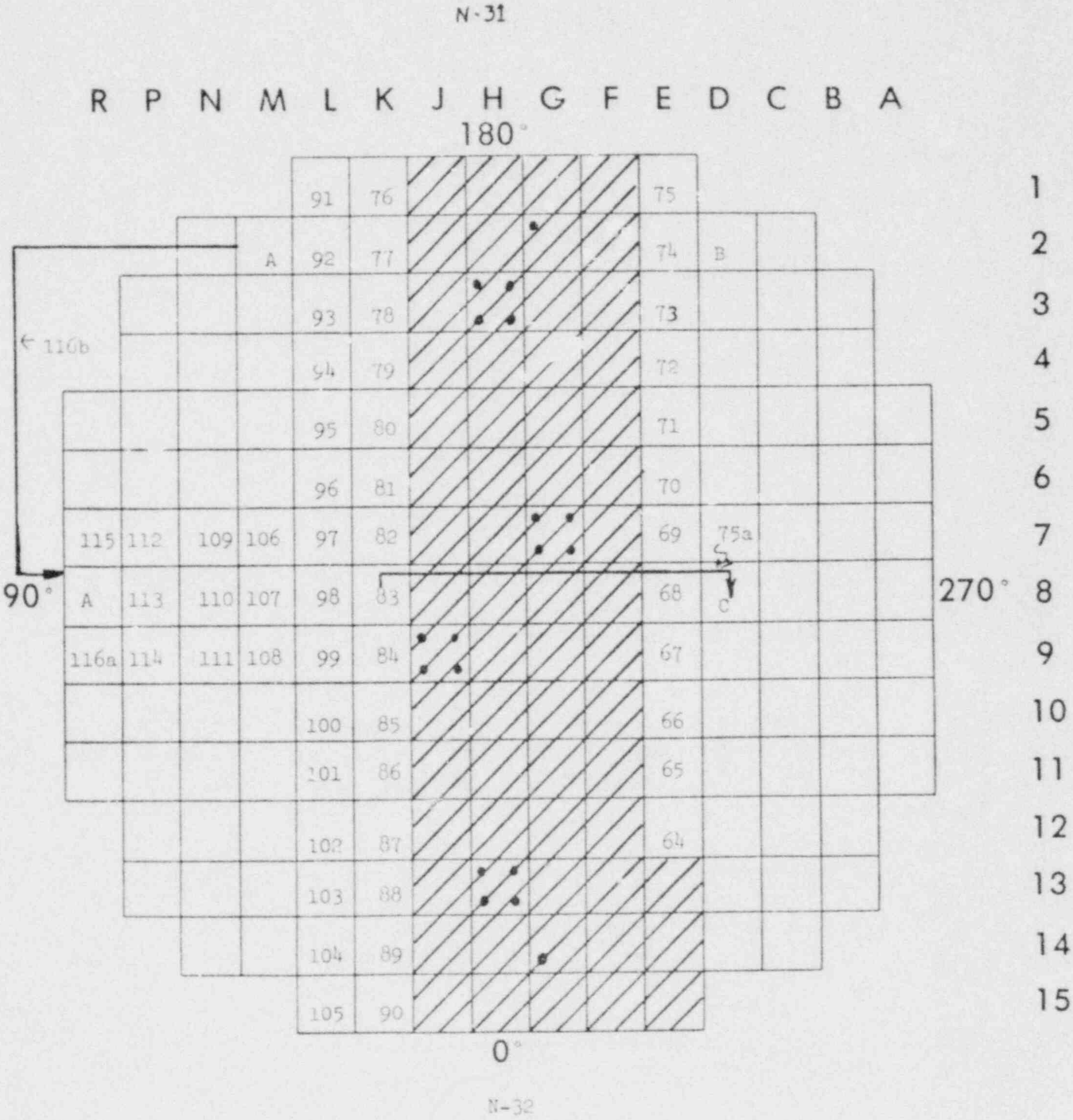


N-32

Core Loading Sequence Step 57 to 63.

TVA 7823A (PP-10-77) SEQUOYAH CORE MAP

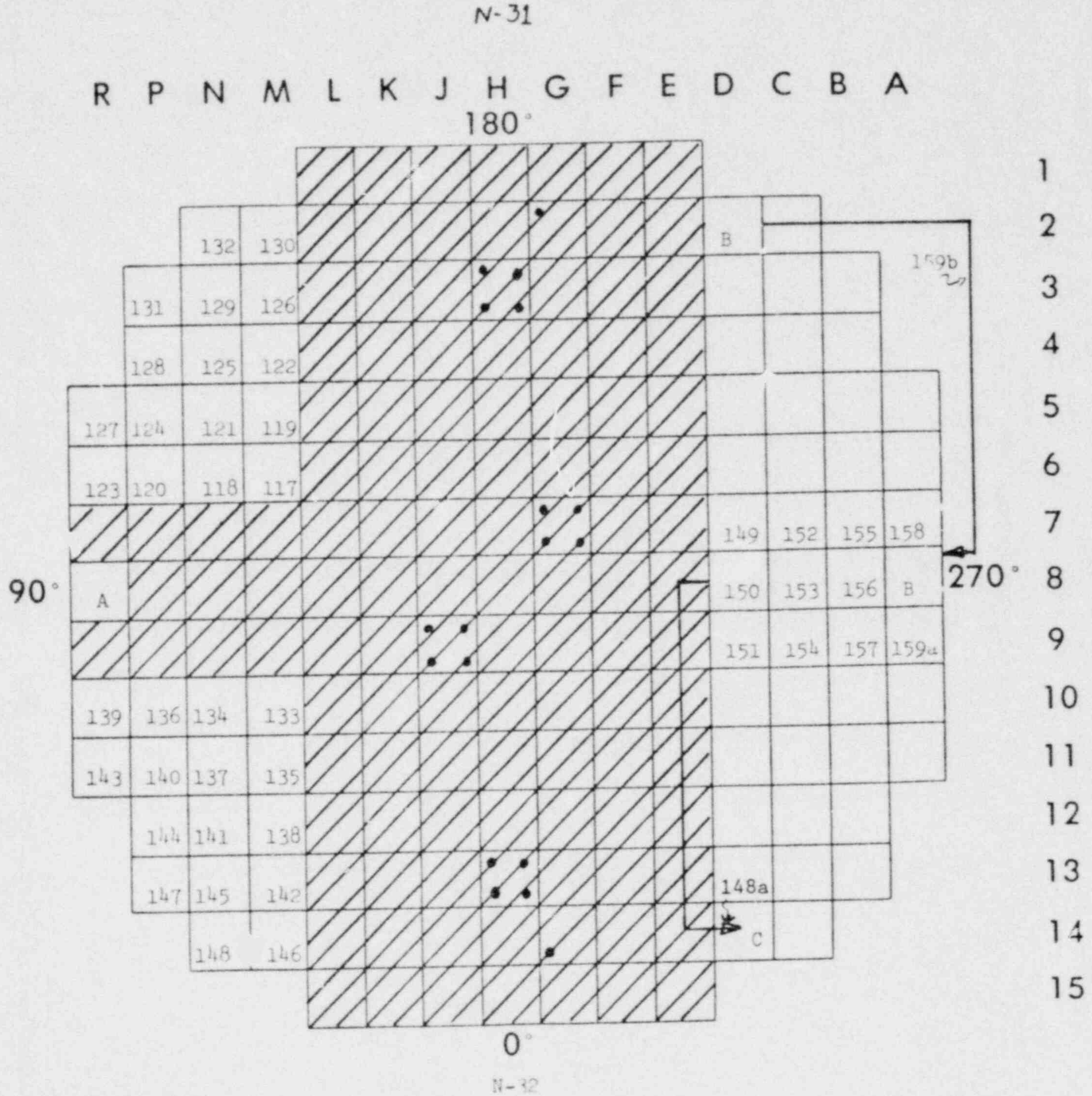
SEQUOYAH UNIT 1



Core Loading Sequence Step 64 to 116b

TVA 7823A (PP-10-77) SEQUOYAH CORE MAP

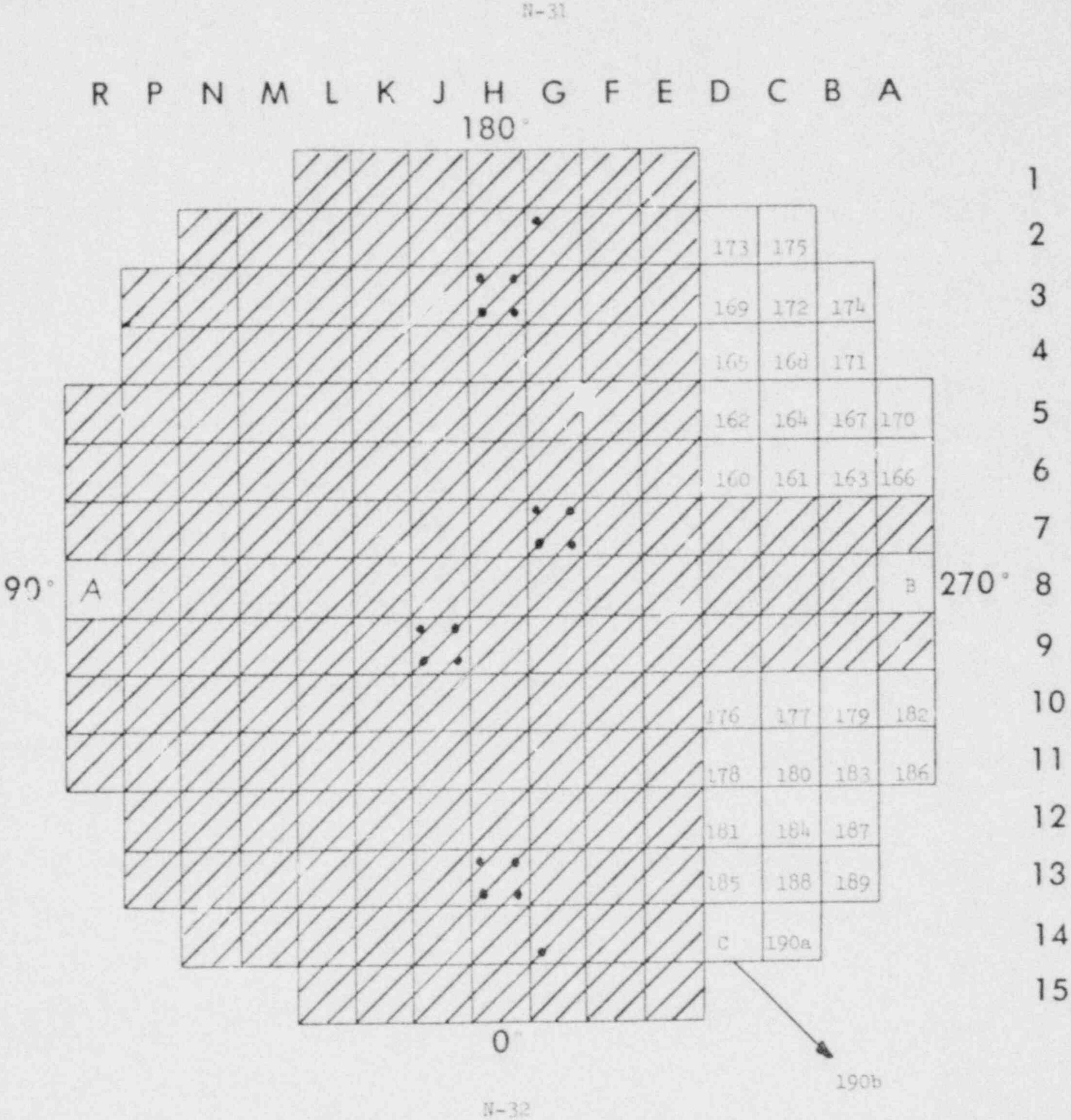
SEQUOYAH UNIT 1



Core Loading Sequence Step 117 to 159b.

TVA 7823A (PP-10-77) SEQUOYAH CORE MAP

SEQUOYAH UNIT 1

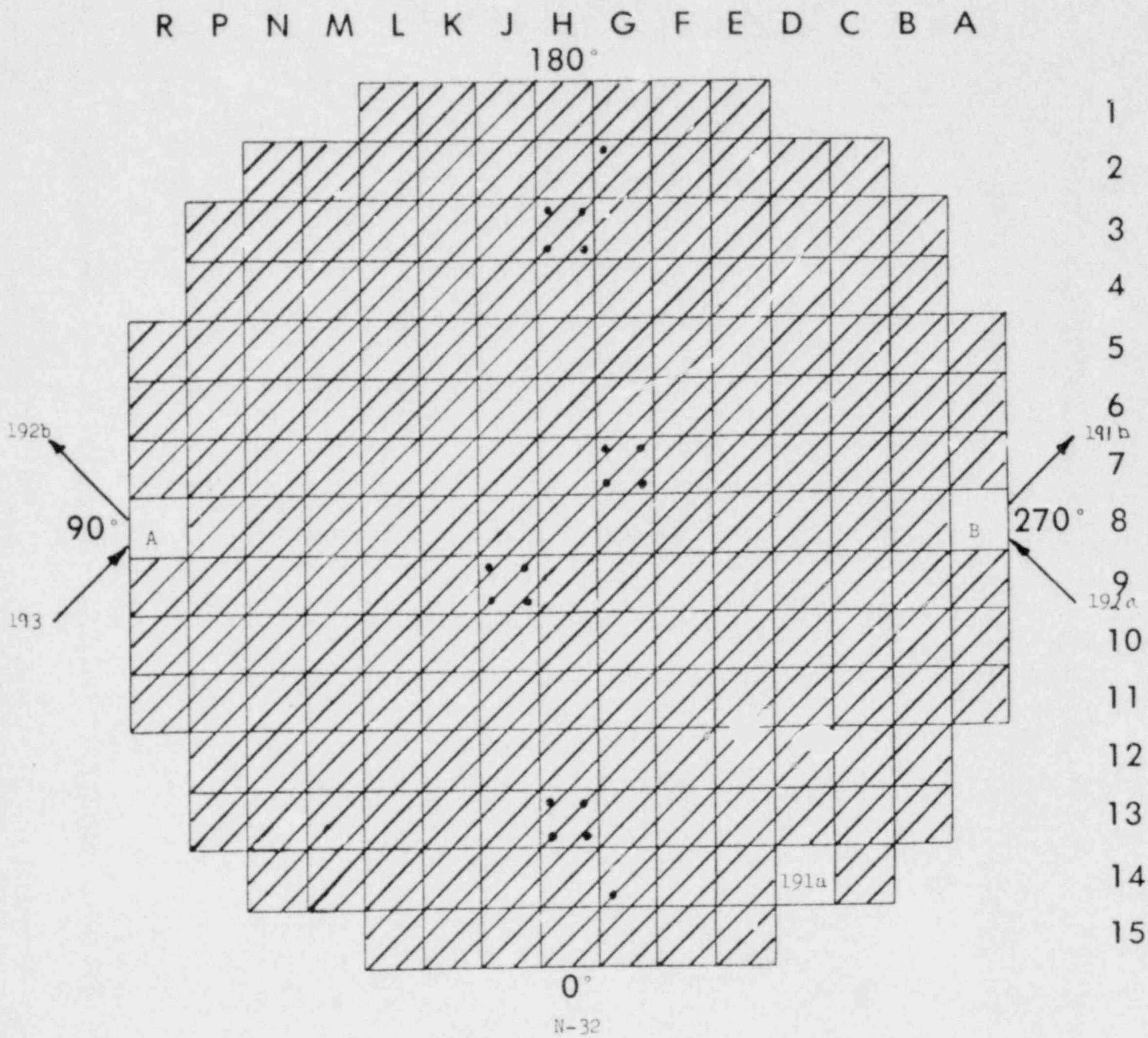


Core Loading Sequence Step 160 to 190b.

TVA 7823A (PP-10-77) SEQUOYAH CORE MAP

SEQUOYAH UNIT 1

N-31



N-32

Core Loading Sequence Step 191a to 193.

TVA 7823A (PP-10-77) SEQUOYAH CORE MAP

4.0 CORE PERFORMANCE

The operational power capabilities of Sequoyah Nuclear Plant are governed by limits imposed by the safety analysis as presented in the Sequoyah Final Safety Analysis Report (FSAR). Thus, various core parameters were measured during the startup program to ensure the conservatism of assumptions made in the FSAR and to verify the validity of the design of the core. The following paragraphs, which discuss the results of the core physics tests, will provide an insight to the performance of the core.

4.1 Initial Criticality (Test procedure SU-7.2)

Initial criticality was achieved on July 5, 1980, at 1052 CDT. The reactor coolant system temperature and pressure were 547°F and 2230 psig, respectively. All rod control banks were fully withdrawn with the exception of control bank D, which was at 150 steps. The soluble boron concentration was 1275 ppm.

The acceptance criterion for critical boron concentration with control bank D at 160 steps was 1248 ± 96 ppm. When the critical boron concentration was adjusted to bank D at 160 steps, it was 1281 ppm.

The approach to criticality as described below proceeded in a safe and judicious manner. With all rod banks fully inserted, the boron concentration at 2138 ppm, the reactor coolant system temperature and pressure at 547°F and 2235 psig, a boron dilution was initiated. The inverse count rate ratio plots versus boron concentration and dilution water, Figures 4.1-1 to 4.1-4, were maintained until the dilution was terminated at approximately 1500 ppm. All rod banks were then fully withdrawn, with the exception of control bank D which was withdrawn to 160 steps. Again, inverse count rate ratio plots versus rod bank position, Figures 4.1-5 and 4.1-6, were maintained. The dilution was then restarted and continued until criticality was achieved. This procedure differed from the description in the FSAR, but a review was performed in accordance with the requirements of 10 CFR 50.59 and no unreviewed safety question was determined to exist.

In addition to bringing the reactor critical for the first time, the initial criticality procedure accomplished several other objectives. The neutron flux level at which nuclear heating first occurred was determined, thus establishing a range below nuclear heating at which all zero power physics measurements were performed. The calibration of the reactivity computer was verified by comparing its output to several positive and negative reactor periods. Finally, at least one full decade of overlap was observed between the source and intermediate range nuclear instrumentation (see Table 4.1-1).

4.2 Core Depletion

The data used for this phase of the report was gathered from initial criticality to 100% full power operation. The accumulated core burnup through February 28, 1981, was 40 effective full power days. Figure 4.2-1 has not yet been normalized to actual data, but it can be seen that the data points taken thus far are very close to the predicted values. As evidenced by this figure, no appreciable reactivity anomaly has occurred.

TABLE 4.1-1

Source Range - Intermediate Range

Overlap Data

	RANGE	OVERLAP READINGS
SOURCE		
N-31	1 - 1×10^6 cps	1.8×10^4 cps
N-32	1 - 1×10^6 cps	1.8×10^4 cps
INTERMEDIATE		
N-35	10^{-11} - 10^{-3} amps	1×10^{-10} amps
N-36	10^{-11} - 10^{-3} amps	1×10^{-10} amps

FIGURE 4.1-1
ICRR VS. BORON
N-31

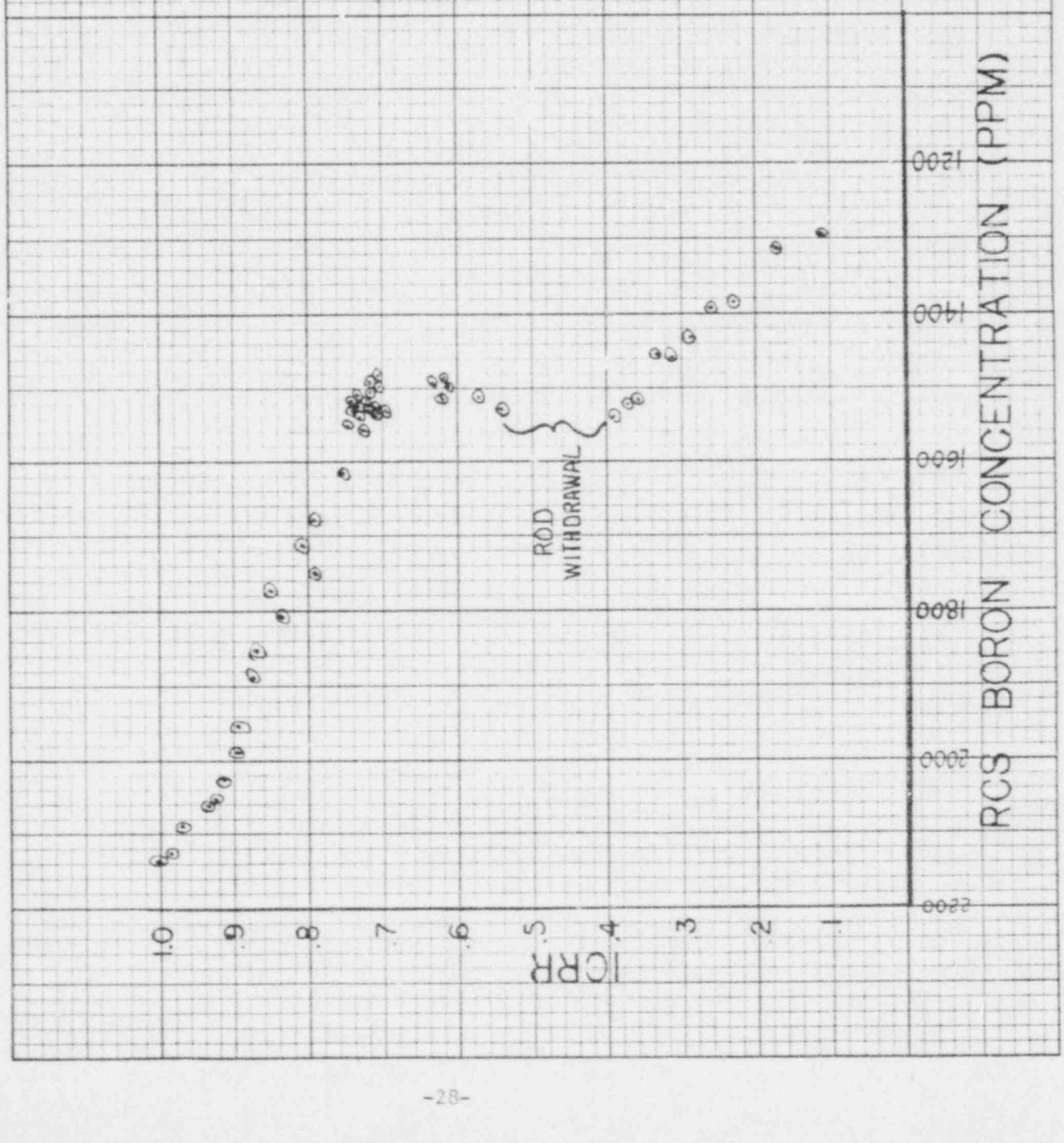


FIGURE 4.1-2

ICRR vs. BORON

N-32

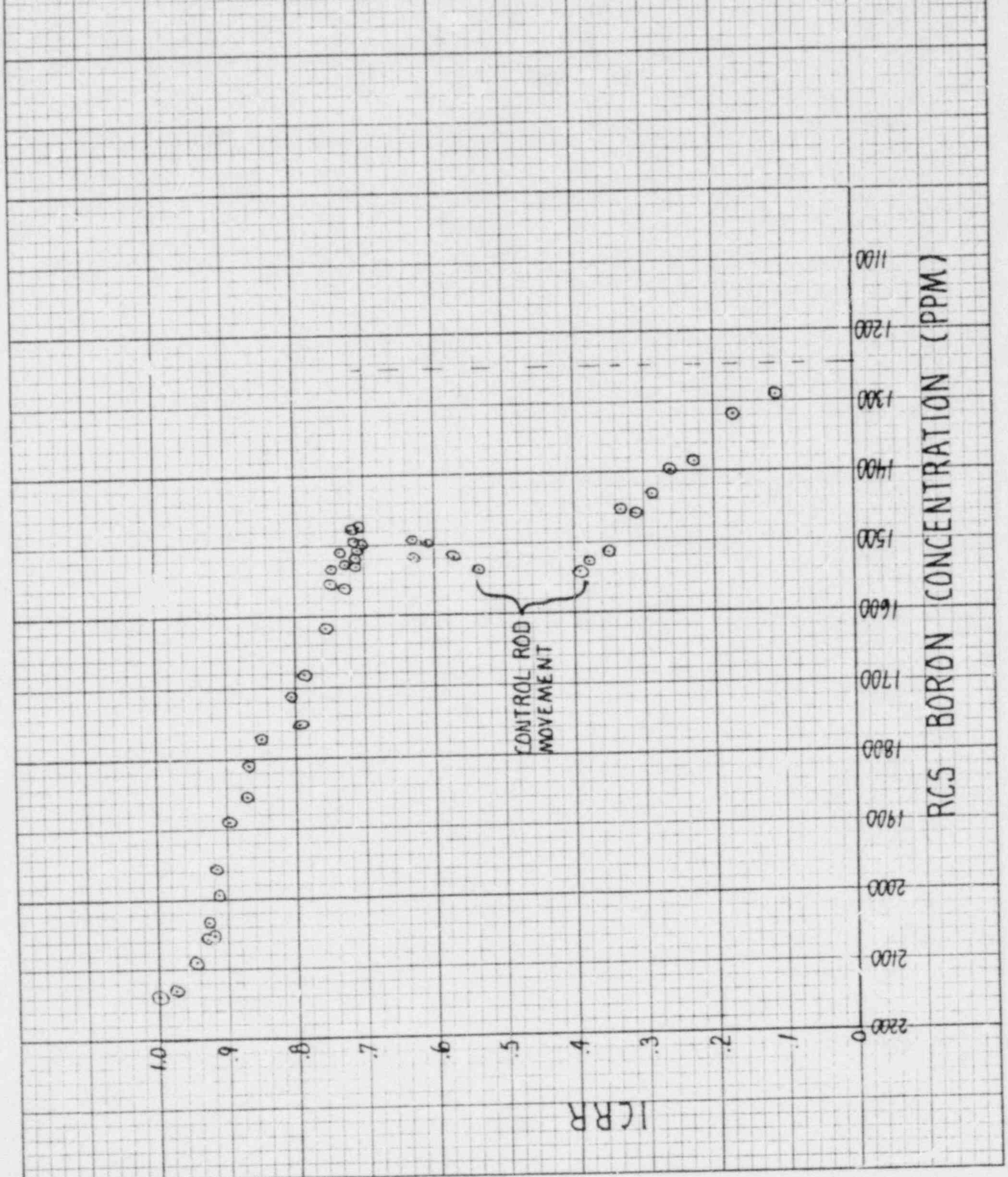


FIGURE 4.1-3

ICRR VS PRIMARY WATER

N-31

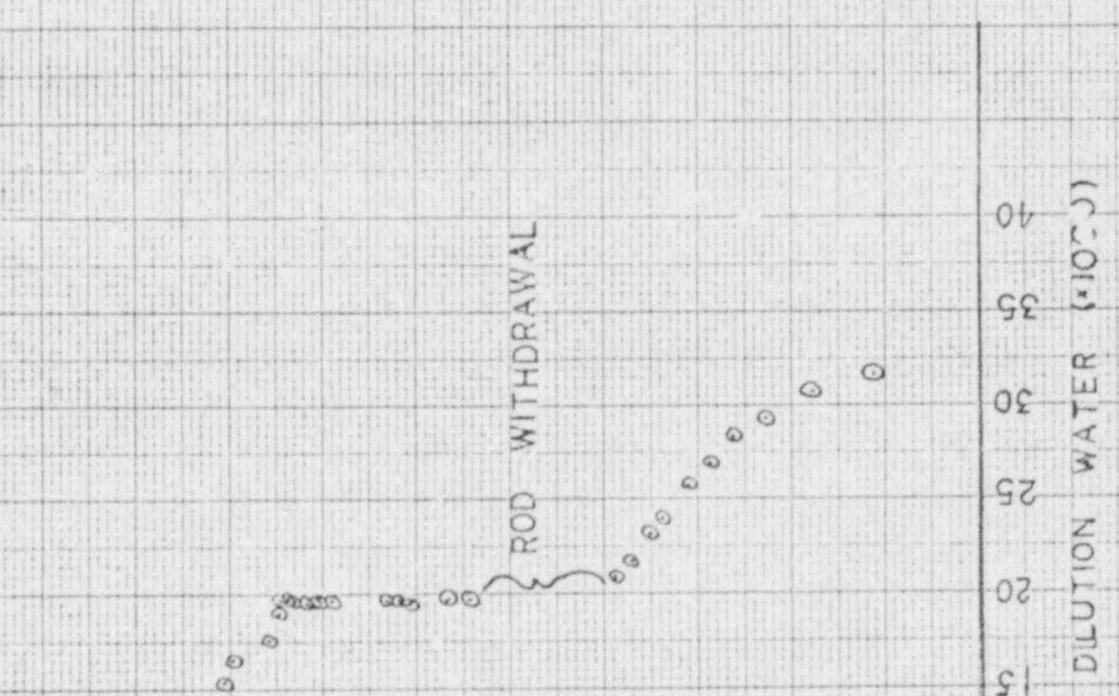


FIGURE 4.1-4

ICRR vs. PRIMARY WATER

N-32

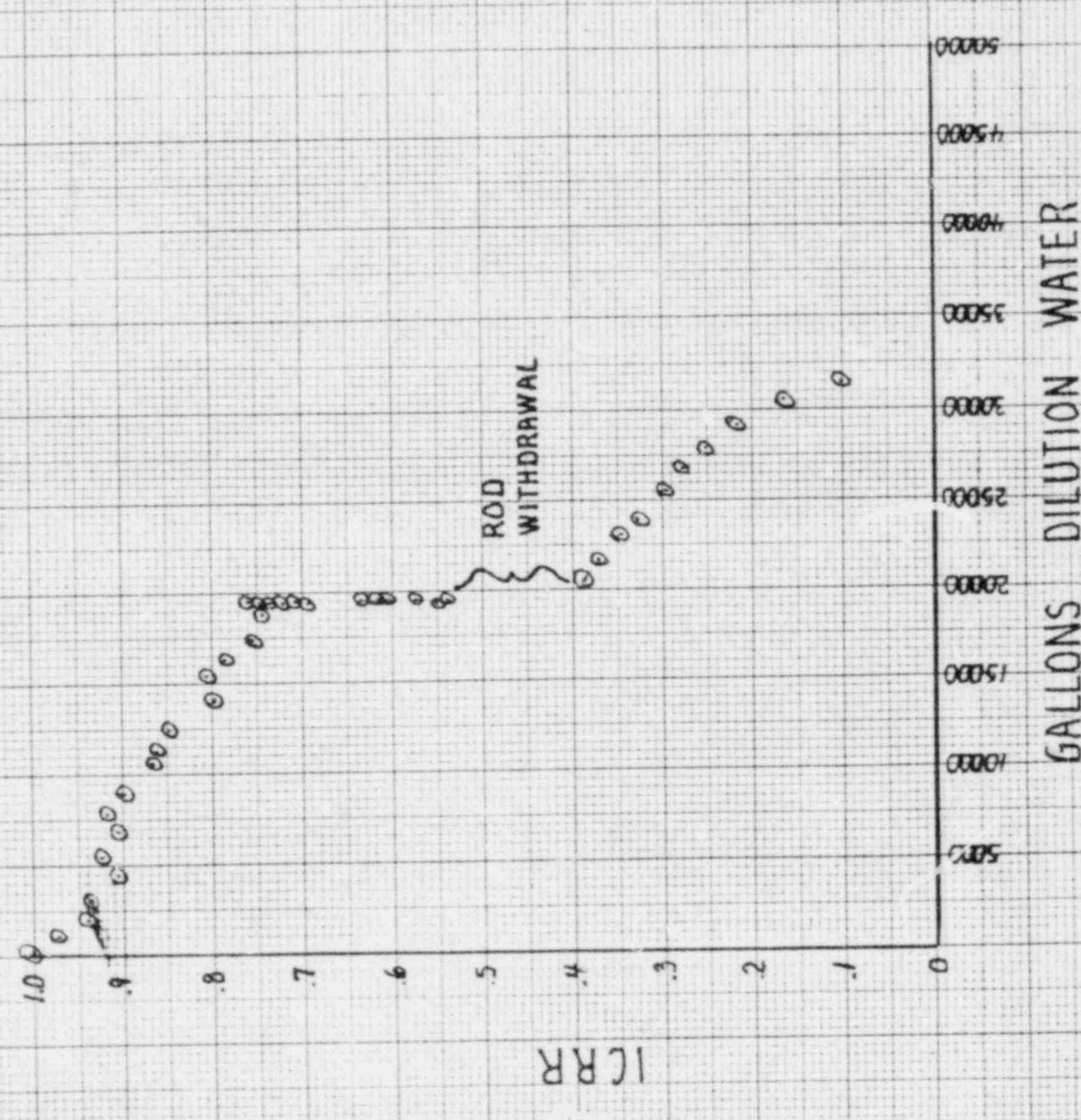


FIGURE 4.1-5

ICRR vs. ROD POSITION

N - 31

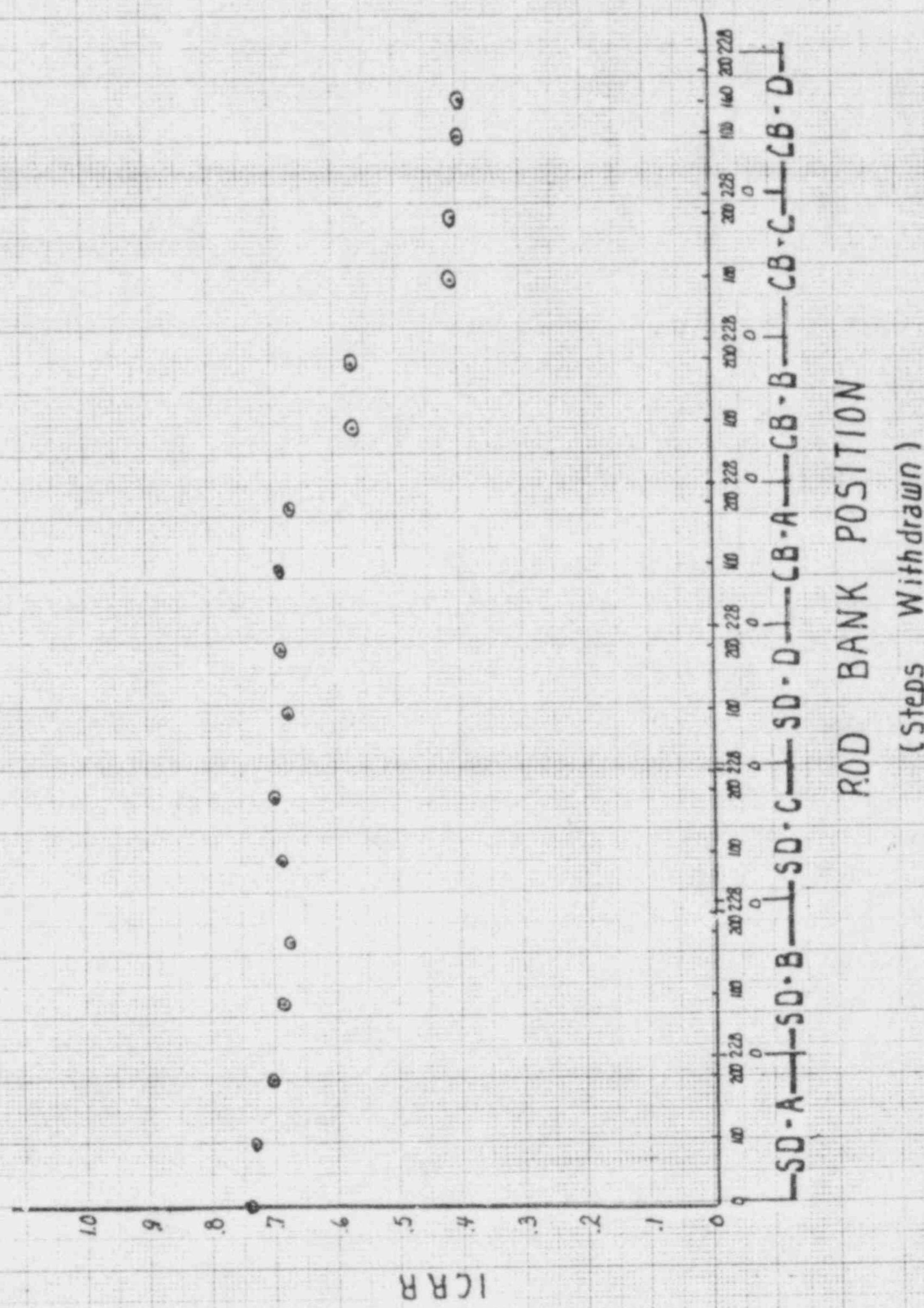


FIGURE 4.1-6

ICRR vs. ROD POSITION

N-32

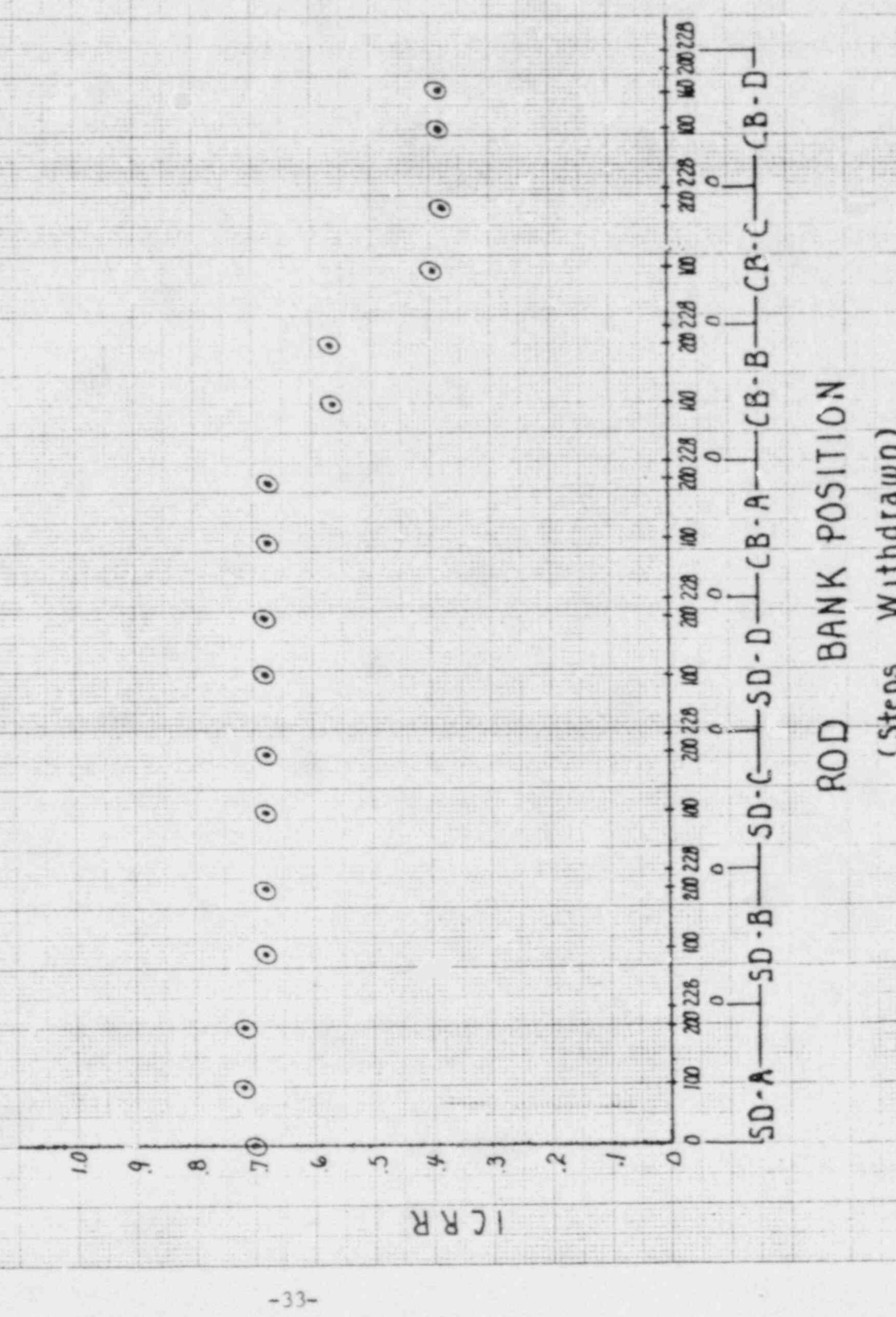
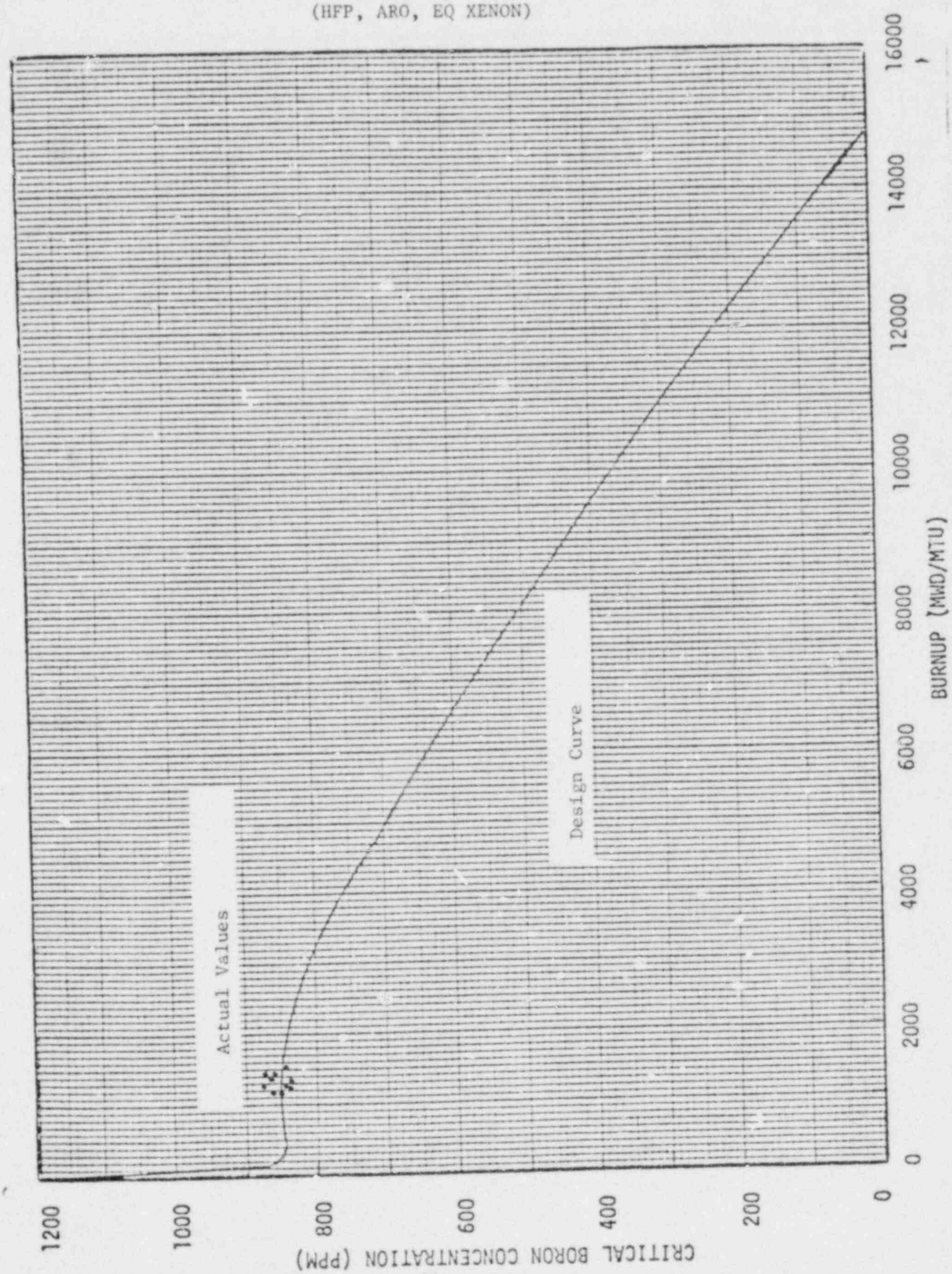


FIGURE 4.2-1
Critical Boron Concentration
Vs.
Burnup
(HFP, ARO, EQ XENON)



4.0 CORE PERFORMANCE (continued)

4.3 Reactivity Control

Excess reactivity is controlled by neutron absorbing control rods and boric acid dissolved in the reactor coolant. Both the control rod position and the boron concentration may be adjusted separately or in conjunction with one another to compensate for various reactivity changes and to maintain the required shutdown margin. Rod bank and boron reactivity worths are measured at hot zero power (HZP) to validate the design of the core. Additional measurements and analyses are performed to verify the conservatism of safety analysis assumptions for control rod worth requirements and for single ejected or dropped control rods.

4.3.1 RCCA Bank Worth Measurements (Test procedures SU-7.4, SU-7.5, and SU-7.7)

The differential and integral RCC bank worths were obtained by monitoring the change in reactivity around criticality at HZP with boron and shutdown or control bank exchanges. The boron concentration was changed at a constant rate and criticality was maintained by rod bank motion, while the reactivity changes were continuously monitored by a reactivity computer. The individual banks integral and differential worth were found for all rod banks, except shutdown banks A and B. The individual worths of these two banks were not determined because they were used in a reactivity exchange with the most reactive RCCA for the minimum shutdown verification.

Table 4.3-1 provides the results of these measurements for each individual control bank, shutdown banks C and D, and the total worth of all control banks measured with a 100 step overlap. Figures 4.3-1 to 4.3-14 provide plots of integral and differential worths of all measured banks.

It should be noted that the worth of control bank A did not meet the acceptance criteria. The acceptance criteria on individual control rod banks is intended to verify the accuracy of the design predictions. Failure to meet this criteria does not by itself constitute a safety problem or invalidate the design predictions. Even with the reduced bank A worth, the worth of all the control rods less the most reactive rod is within 1% of the design prediction. Thus, the reactor will meet all shutdown margin and control rod worth requirements. Westinghouse has analyzed the deficiency and found that control bank A does not present a problem in either safety or operation. Supporting data also indicated that the initial measurement of control bank D was low. Control bank D was remeasured and results were obtained that were consistent with all supporting data and design predictions.

TABLE 4.3-1

RCC Bank Measurement Results

RCC Bank	Measured (pcm)	Acceptance (pcm)
D	1361.6	1330±133
C	997.0	1090±109
B	1330.5	1233±123
A	348.1	410± 41
SDD	812.0	789± 79
SDC	1190.3	1088±109
Control banks in overlap	4075.9	4037.2±161

FIGURE 4.3-1

INTEGRAL ROD WORTH SHUTDN BANK C

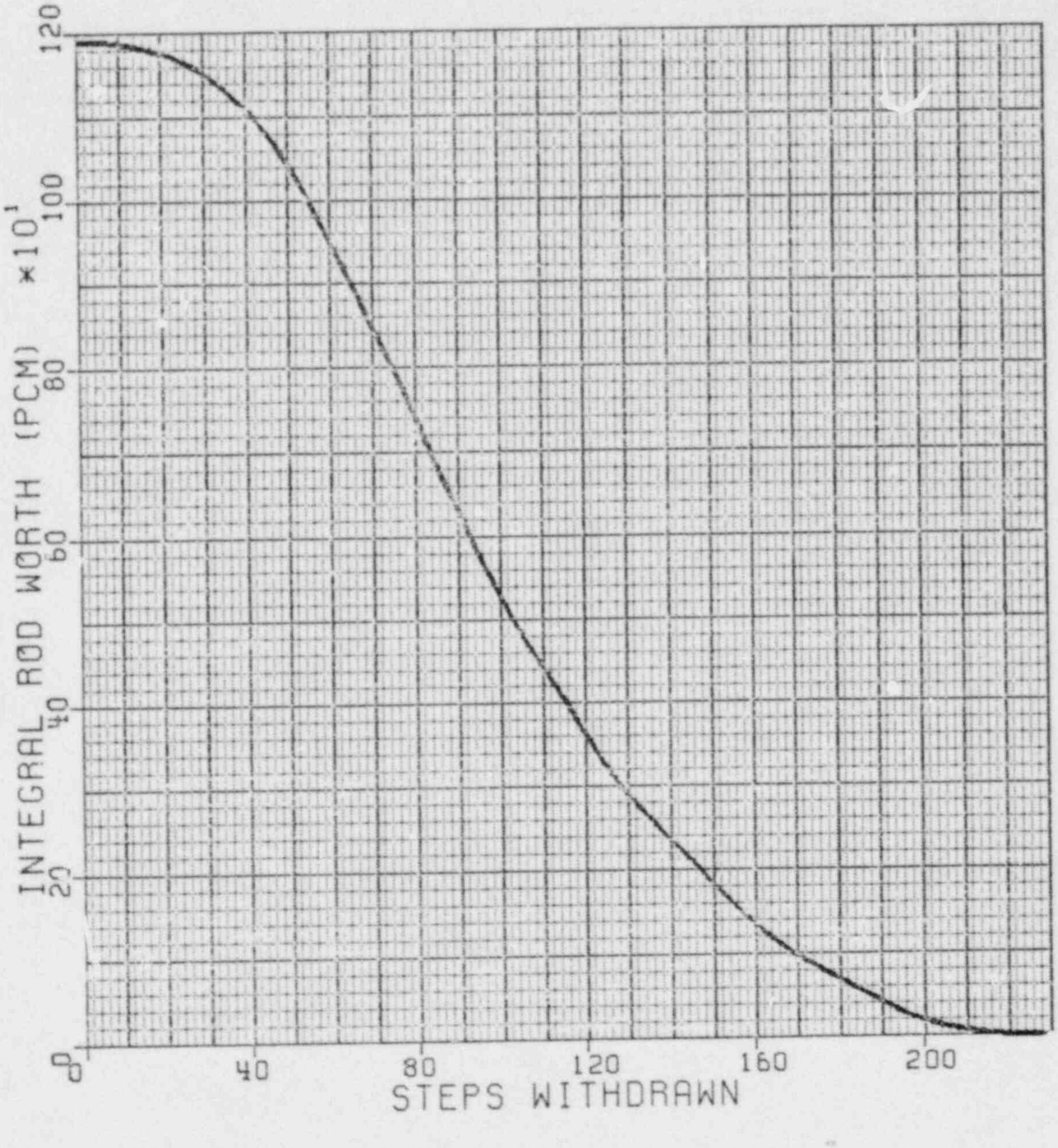


FIGURE 4.3-2

INTEGRAL ROD WORTH SHUTDN BANK D

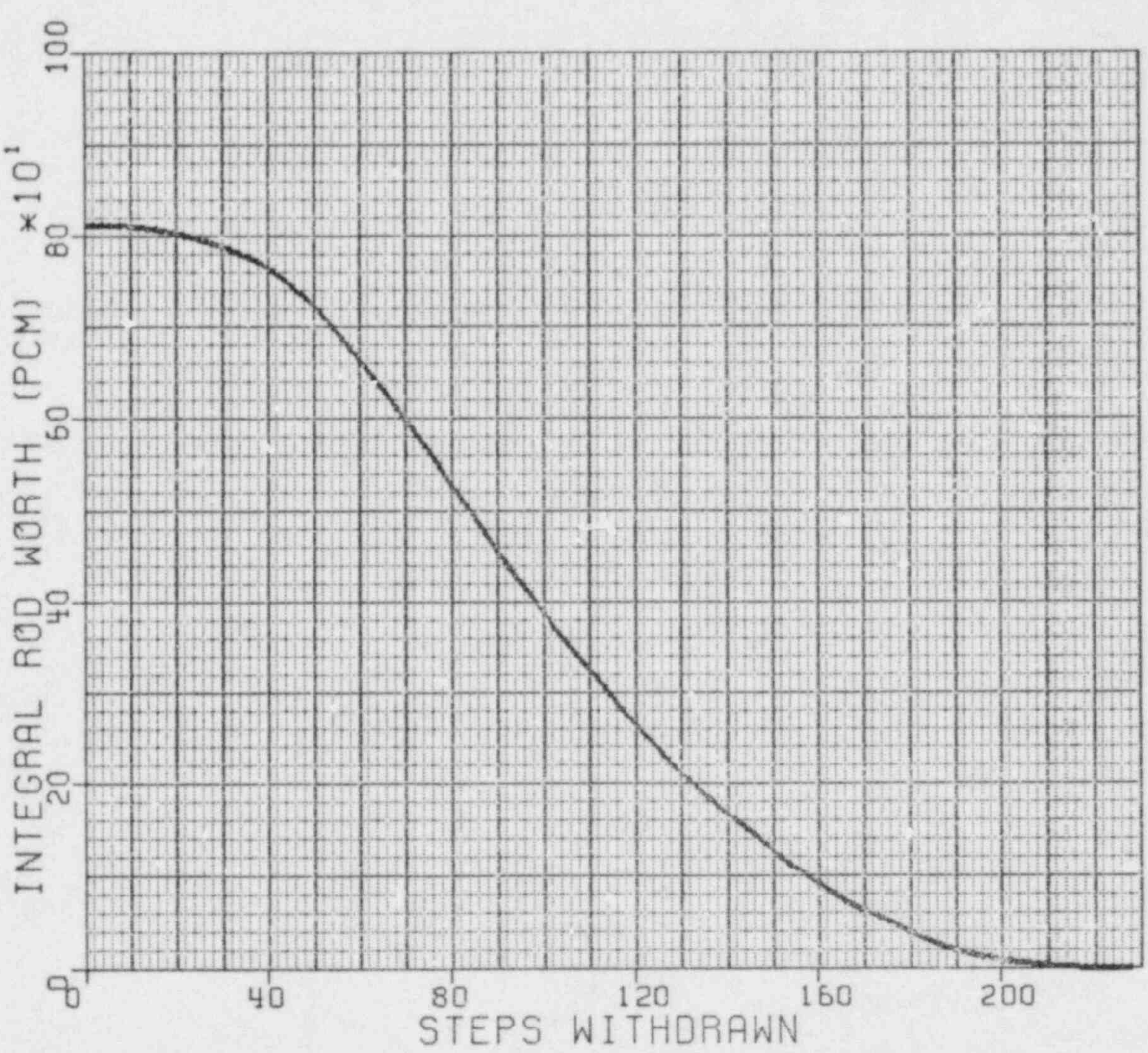


FIGURE 4.3-3
INTEGRAL ROD WORTH CONTROL BANK F

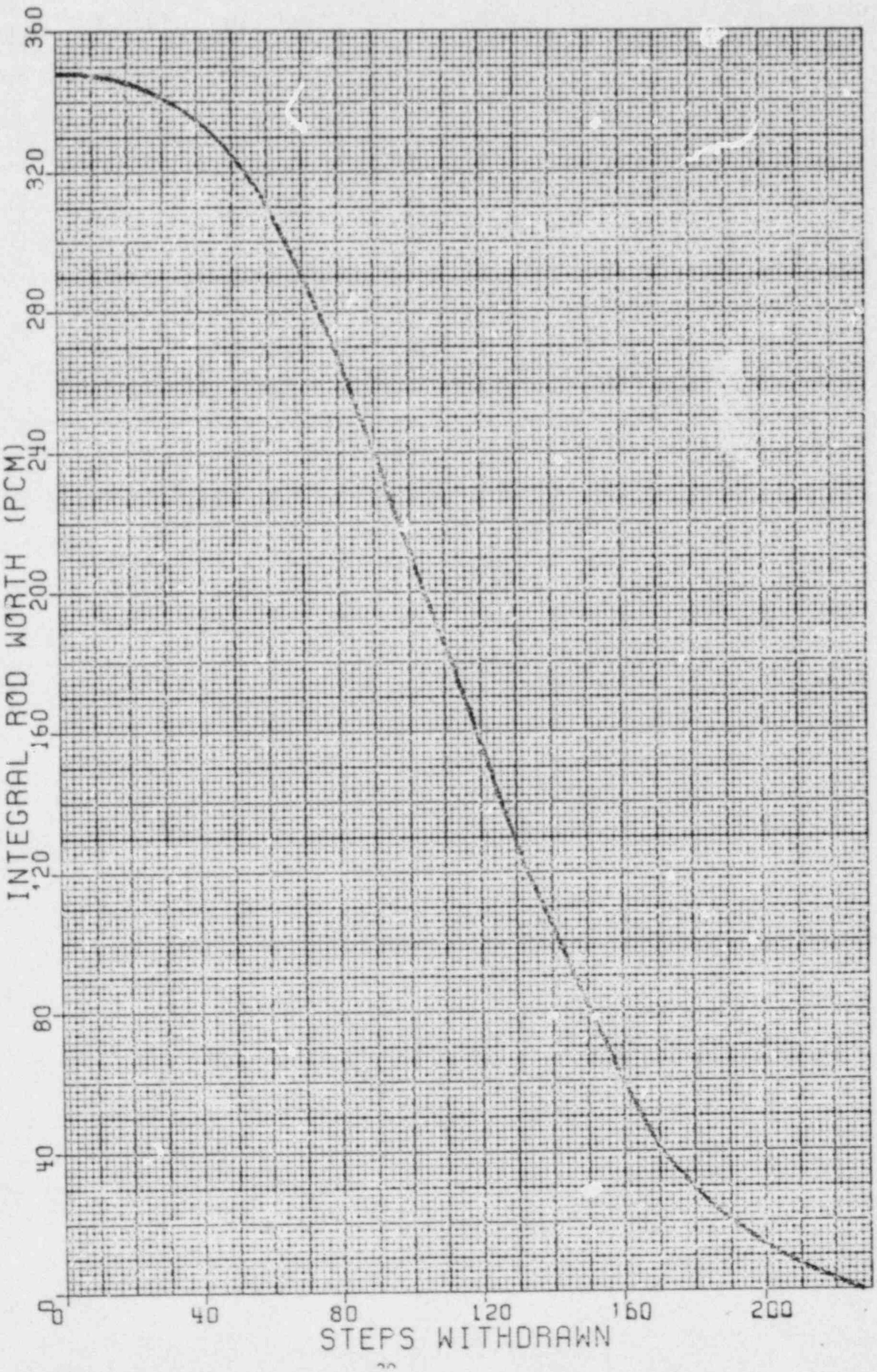


FIGURE 4.3-4

INTEGRAL ROD WORTH CONTROL BANK B

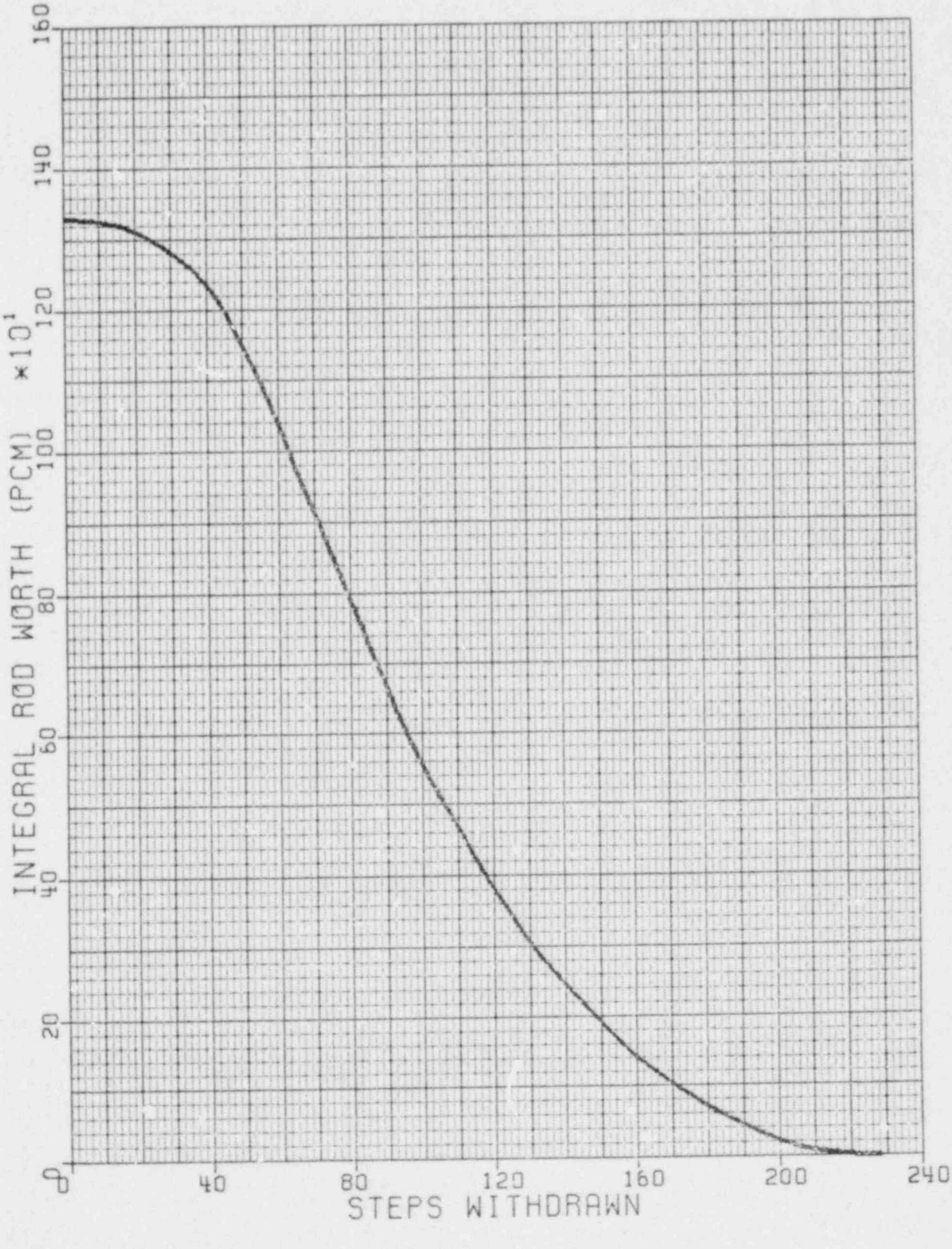


FIGURE 4.3-5

INTEGRAL ROD WORTH CONTROL BANK C

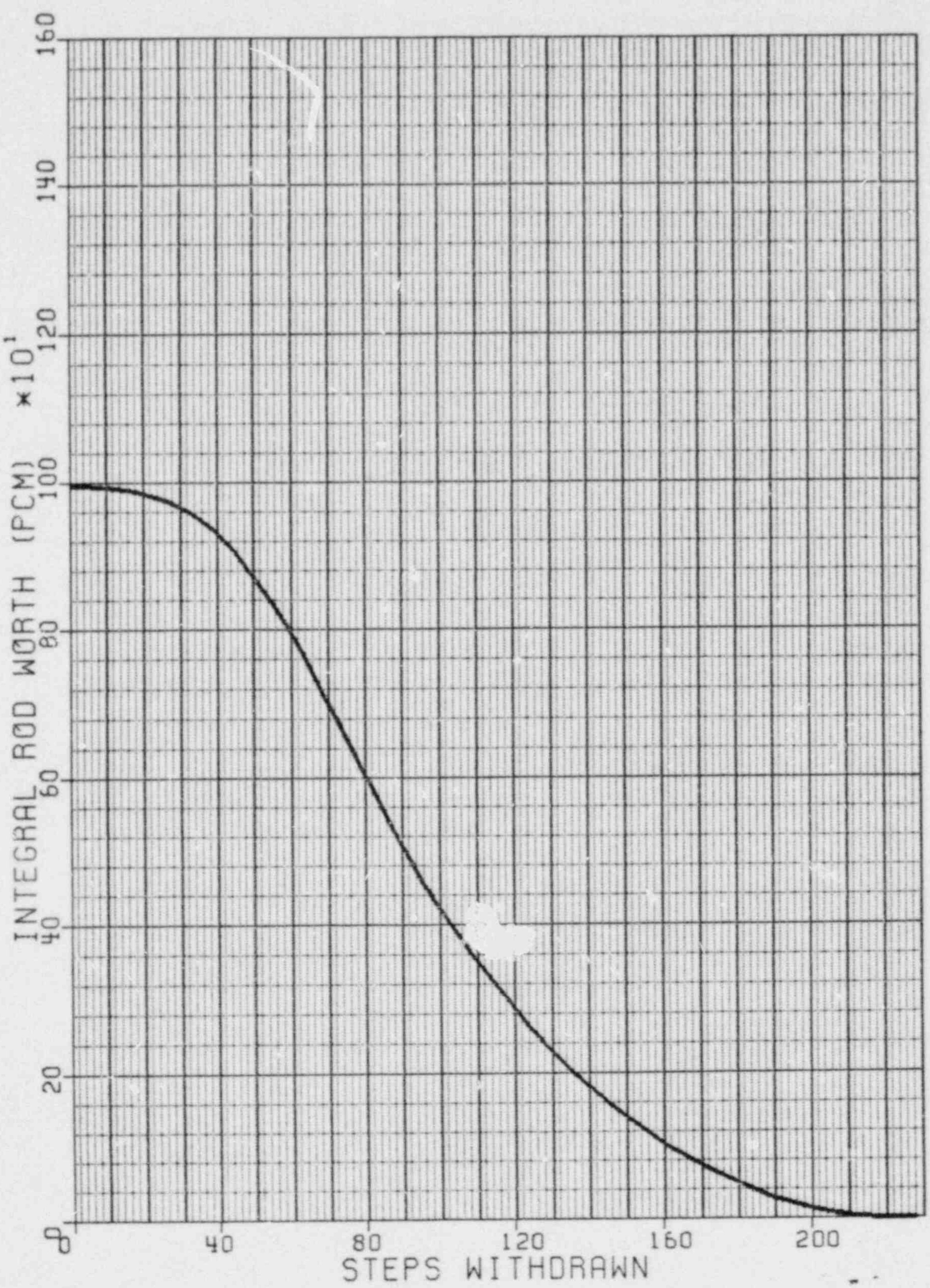


FIGURE 4.3-6

INTEGRAL ROD WORTH CONTROL BANK C

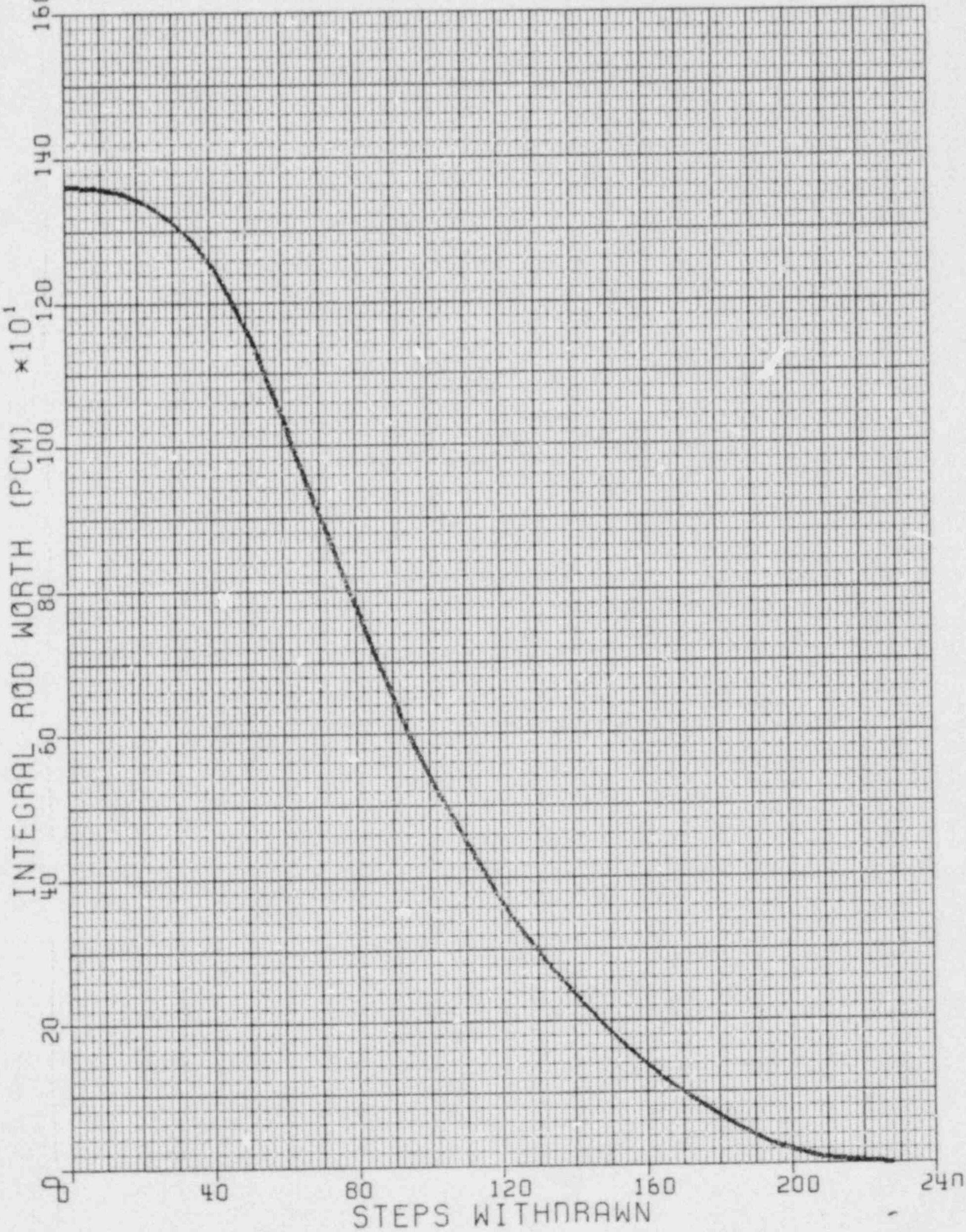


FIGURE 4.3-7
SHUTDOWN BANK C DIFFERENTIAL
ROD WORTH

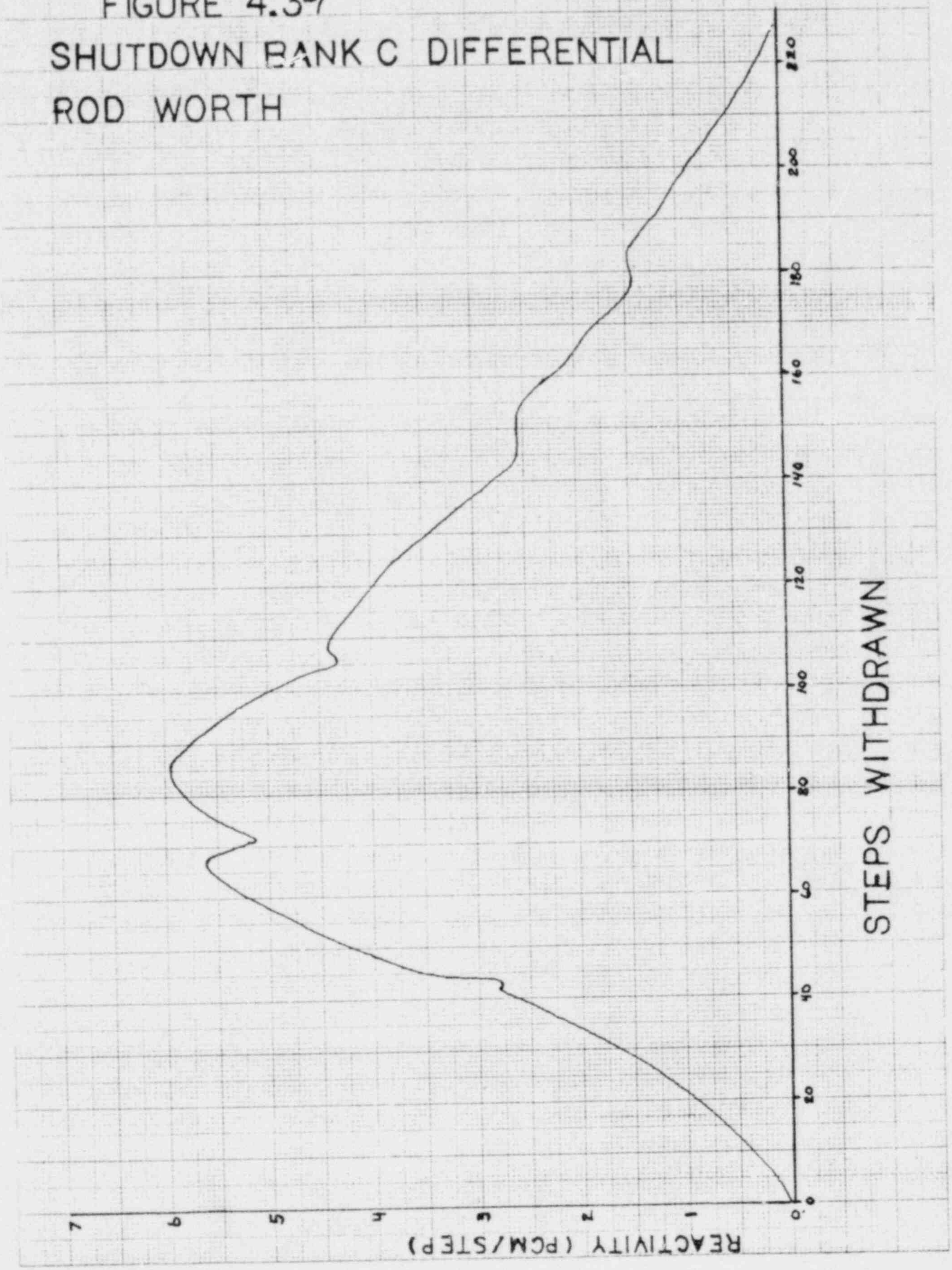


FIGURE 4.3-8
SHUTDOWN BANK D DIFFERENTIAL ROD WORTH

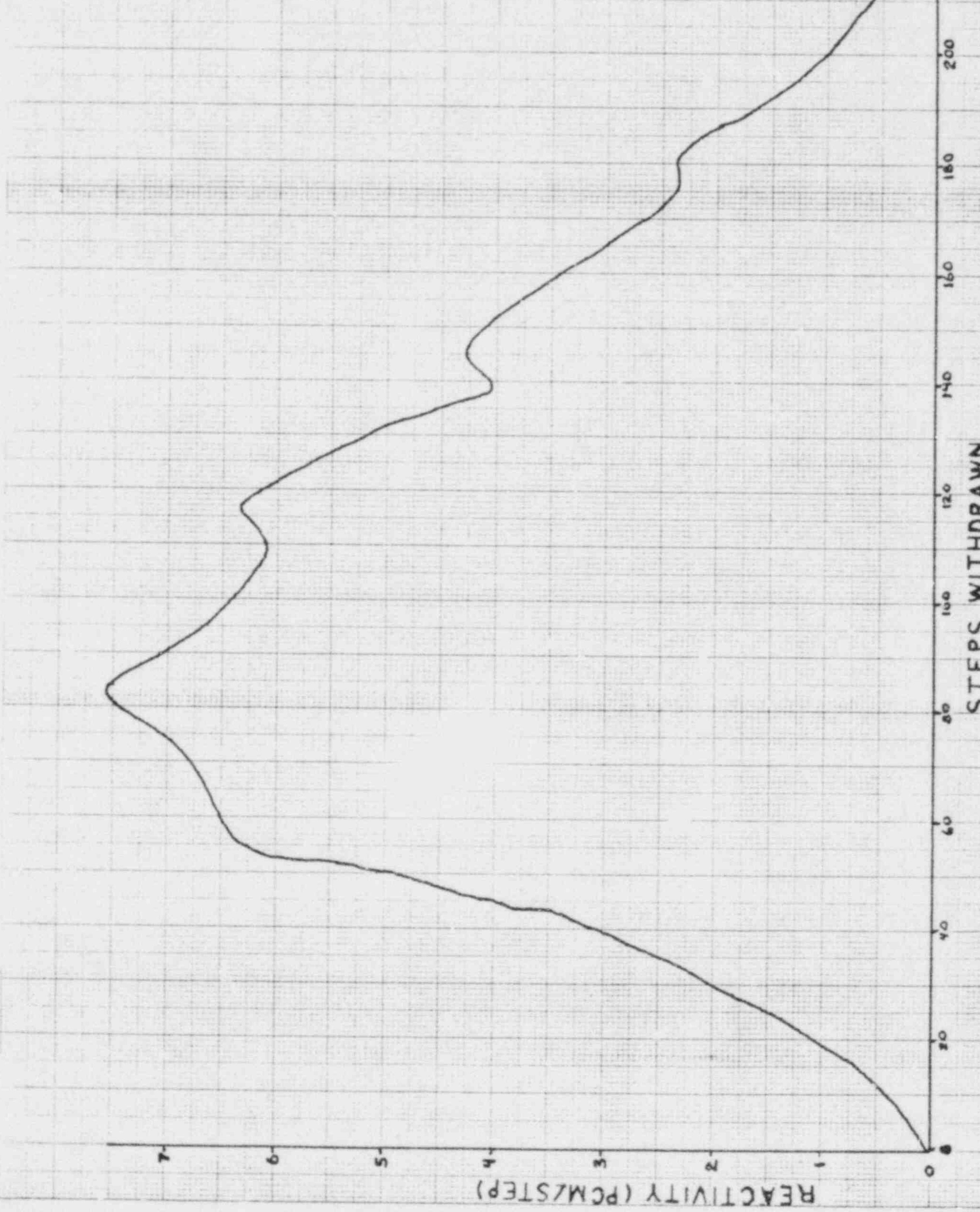
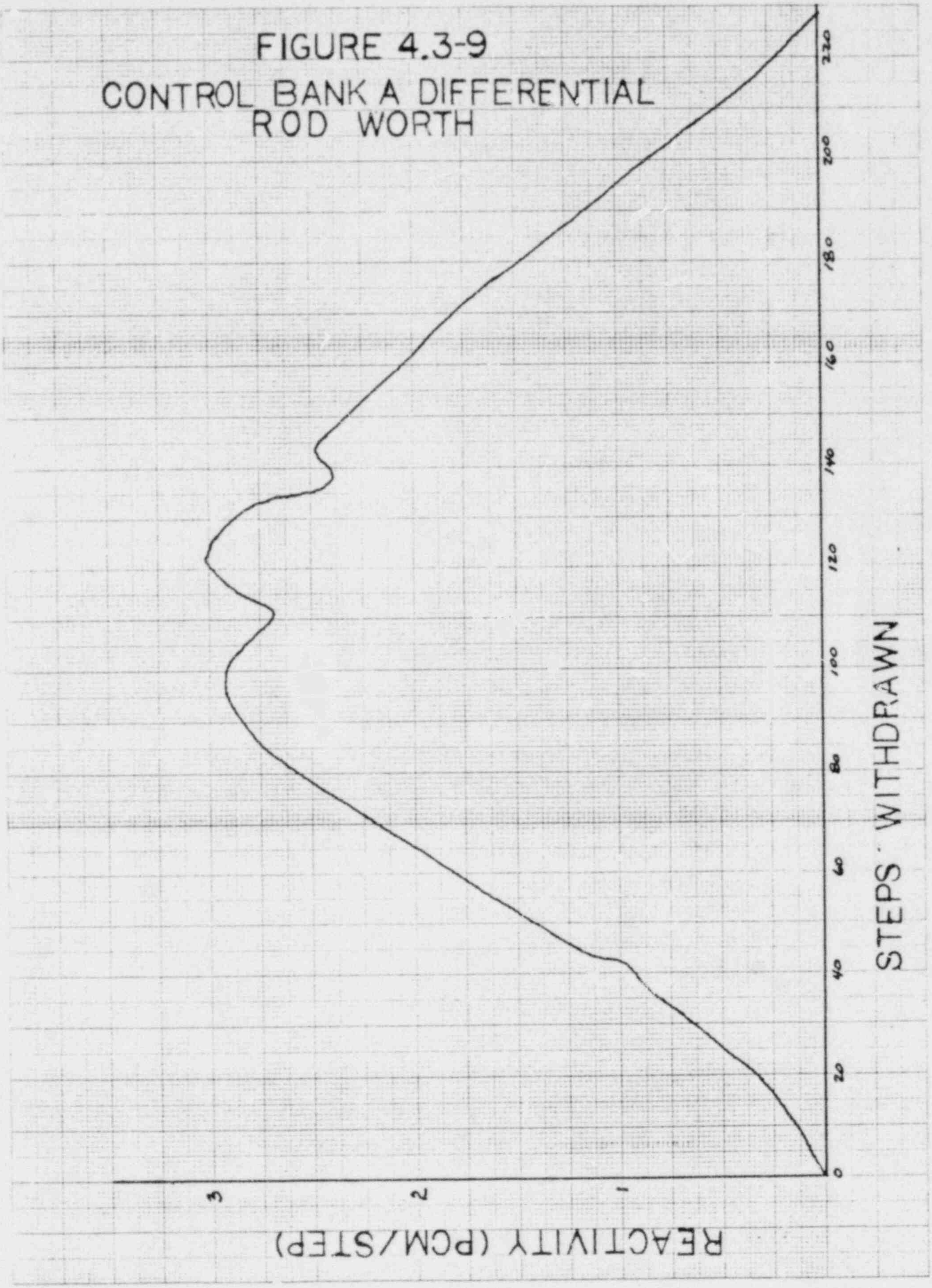


FIGURE 4.3-9

CONTROL BANK A DIFFERENTIAL ROD WORTH



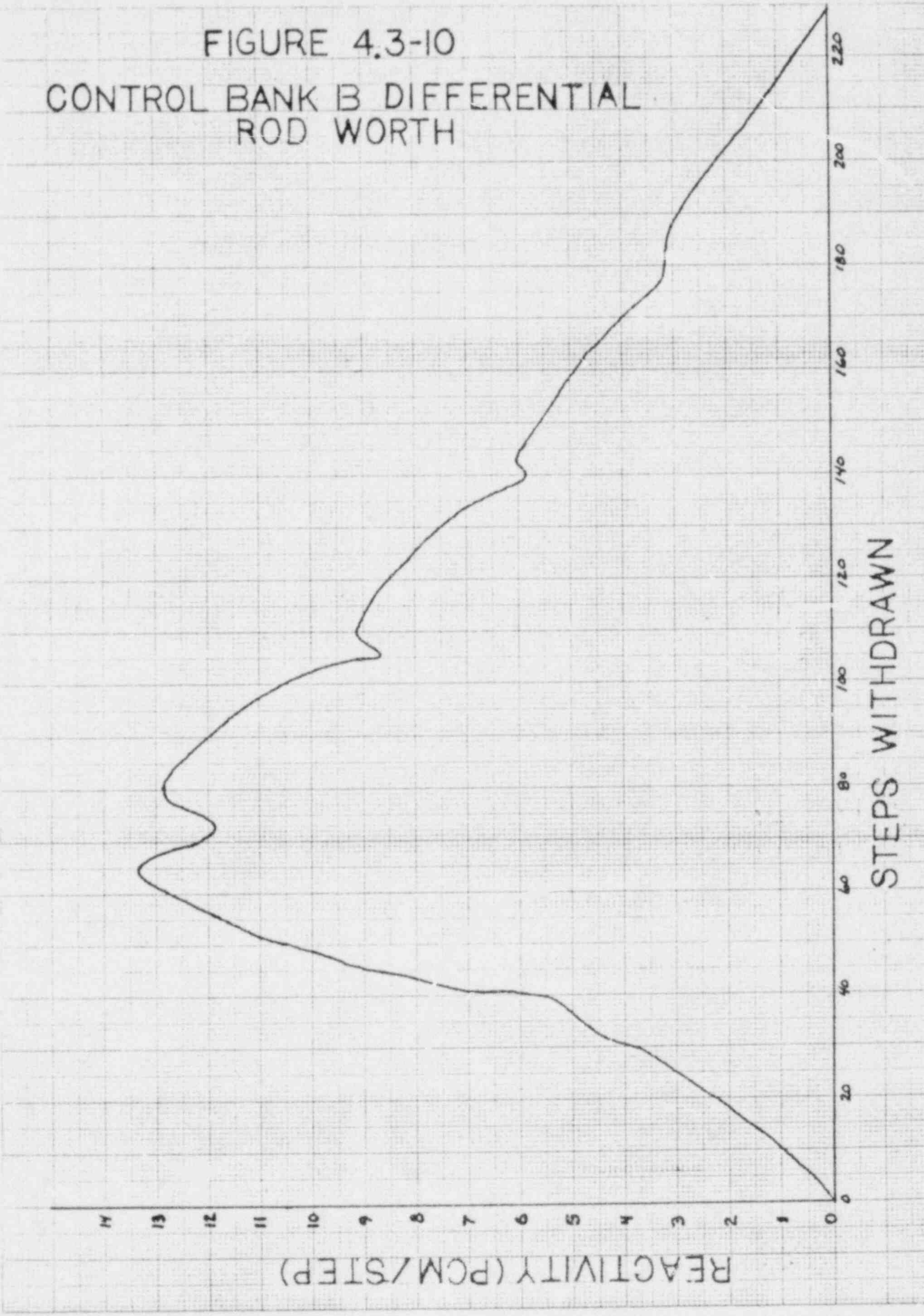


FIGURE 4.3-10

CONTROL BANK B DIFFERENTIAL ROD WORTH

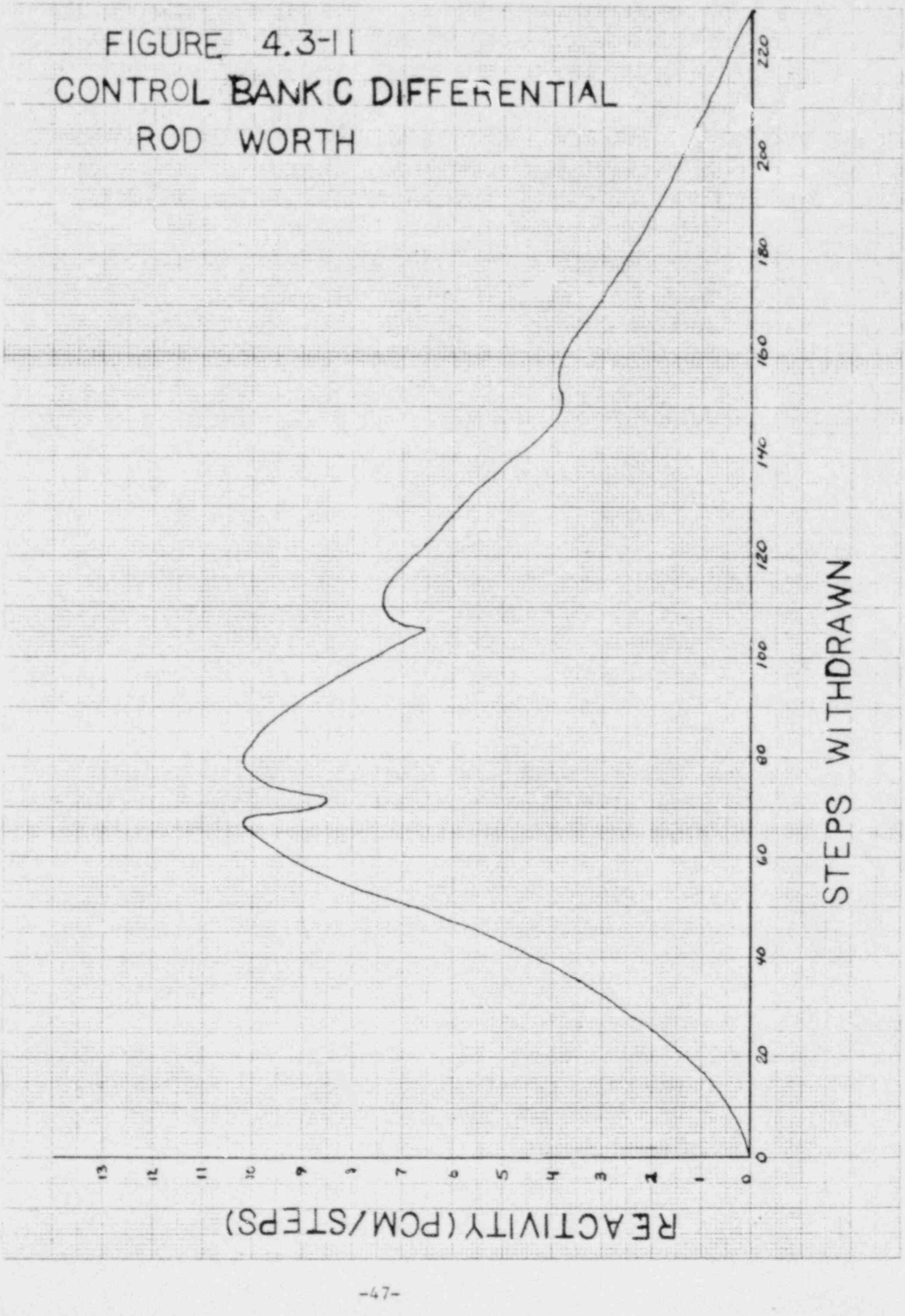


FIGURE 4.3-11
CONTROL BANK C DIFFERENTIAL ROD WORTH

FIGURE 4.3-12
CONTROL BANK D
DIFFERENTIAL ROD WORTH

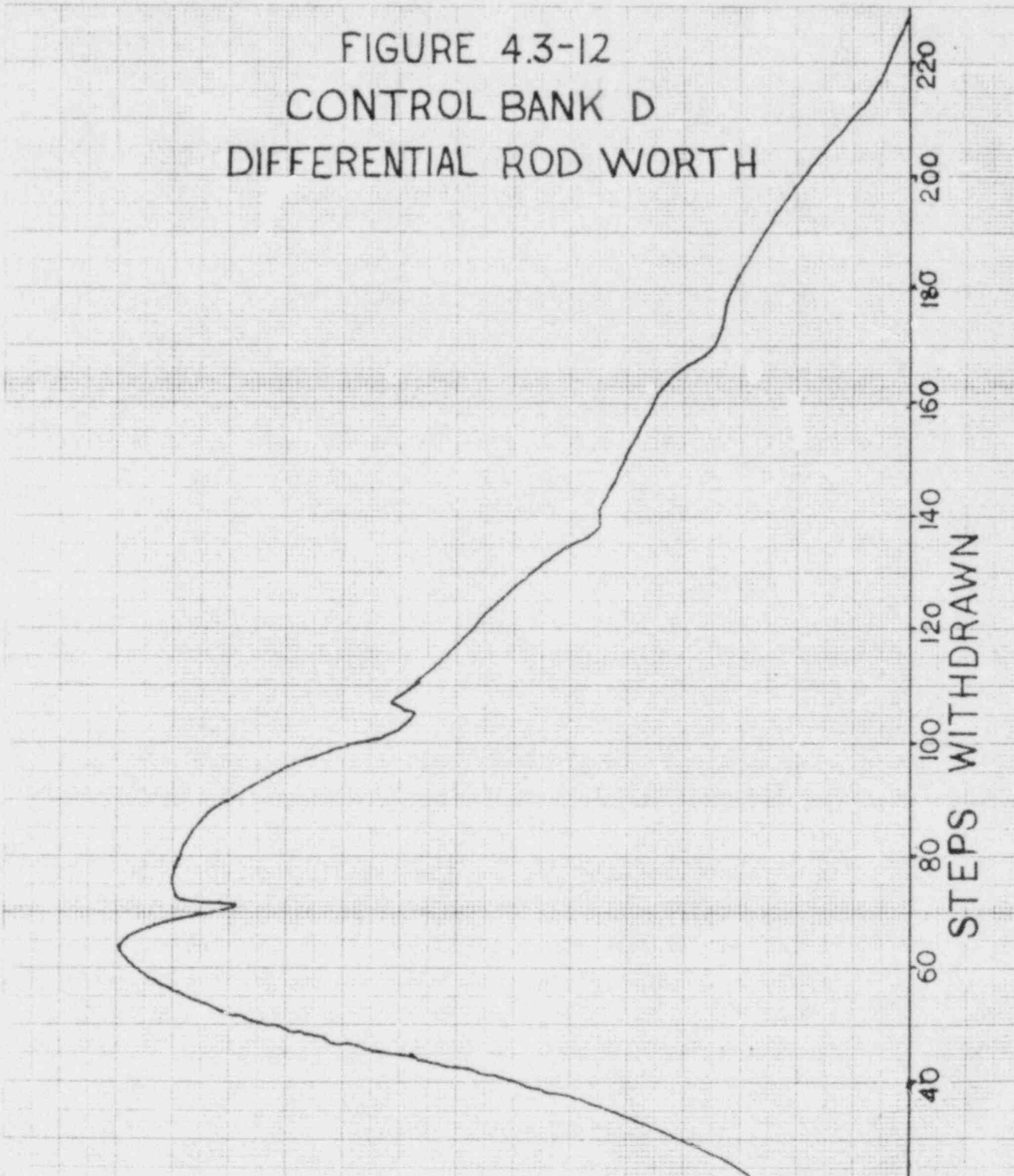
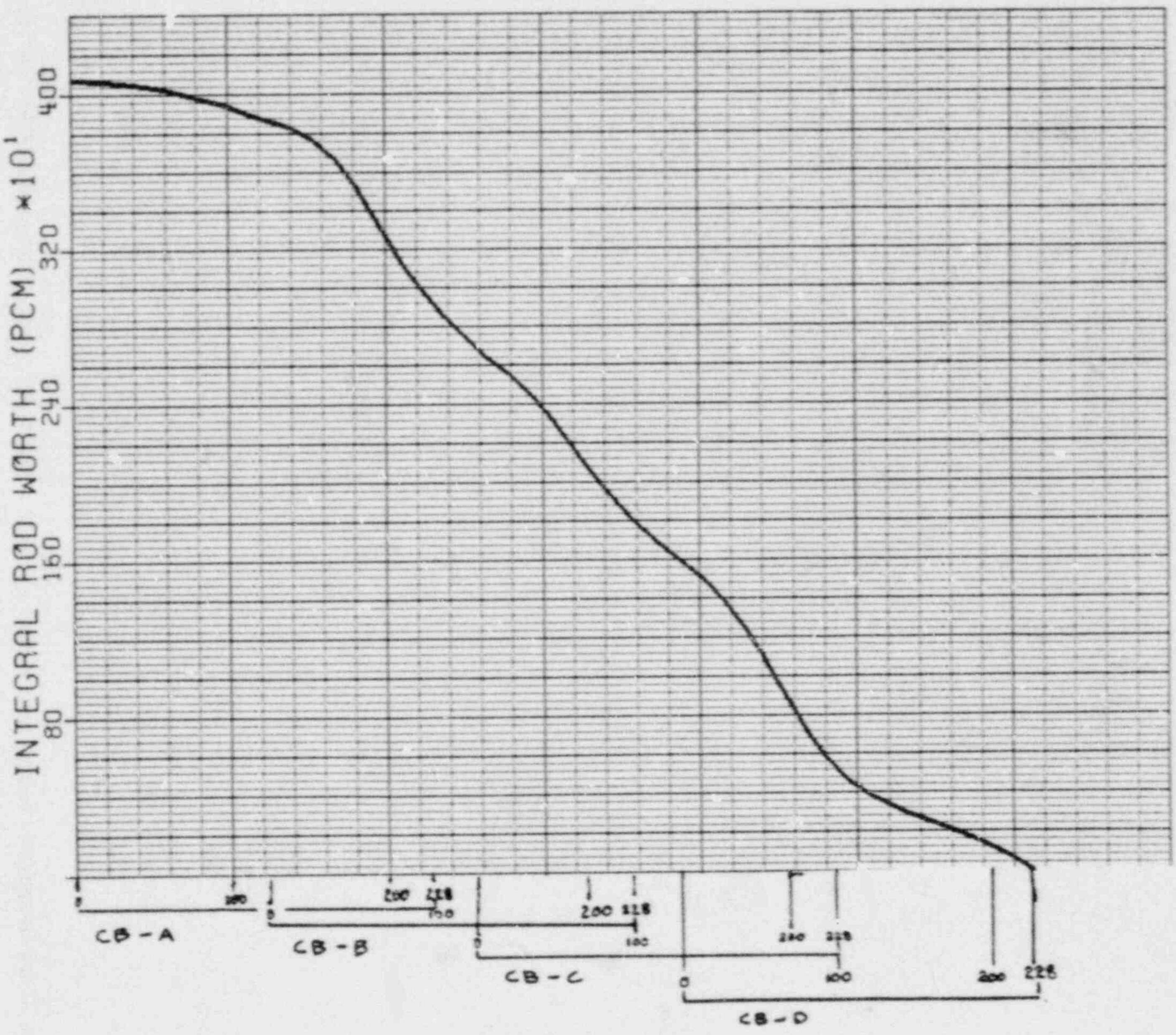


FIGURE 4.3-13

INTEGRAL ROD WORTH BANK OVERLAP



STEPS WITHDRAWN

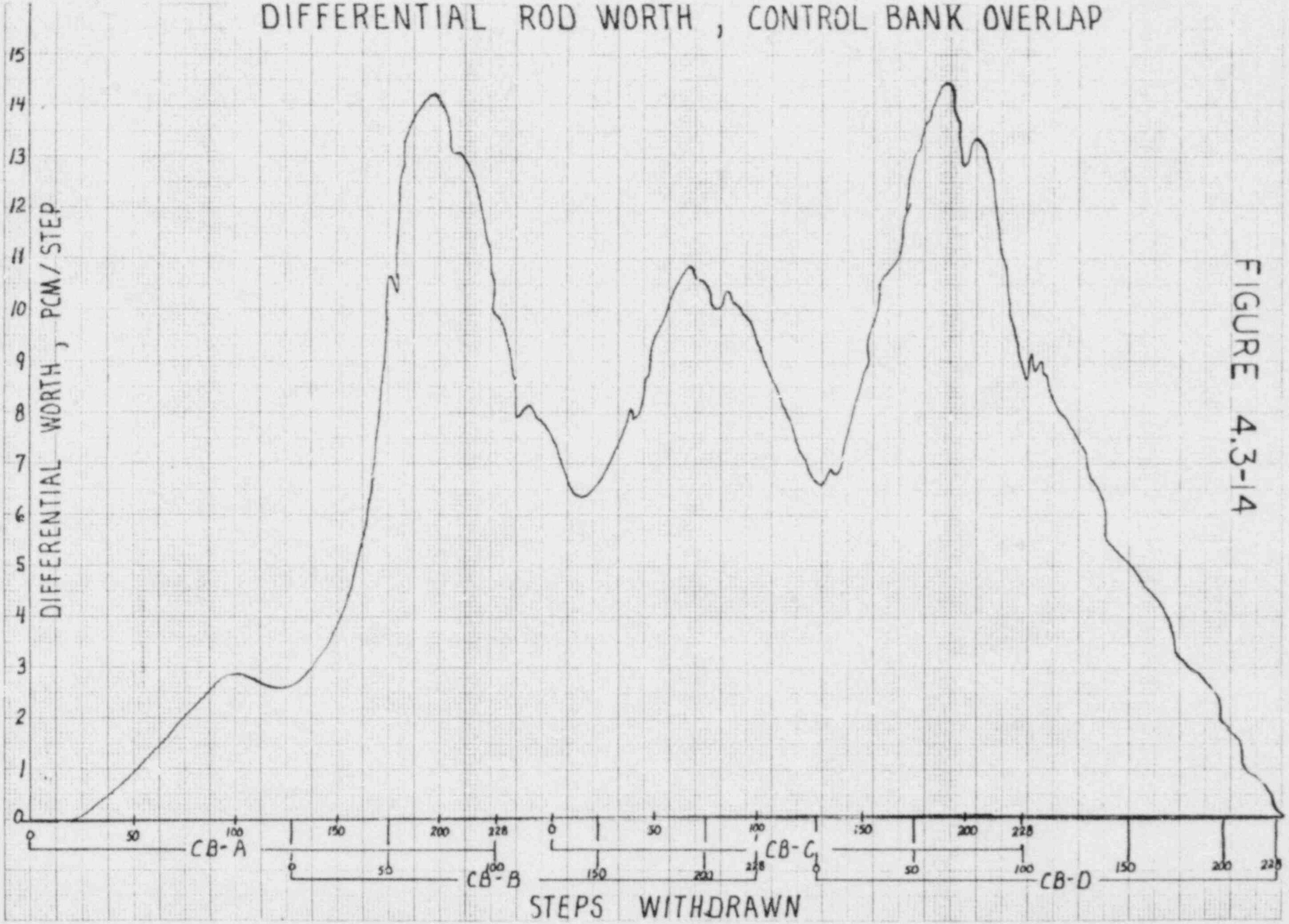

DIFFERENTIAL ROD WORTH , CONTROL BANK OVERLAP
DIFFERENTIAL WORTH , PCM/STEP
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
STEPS WITHDRAWN
CB-A
CB-B
CB-C
CB-D
0
50
100
150
200
228

FIGURE 4.3-14

4.0 CORE PERFORMANCE (continued)

4.3.2 Boron Worth (Test procedure SU-7.4 and SU-7.3.1)

The average differential boron worth measured over the range of the control banks at HZP is determined by plotting total reactivity change versus the boron concentration, Figure 4.3-15. The slope of a linear fit of this data provides a value of -10.68 pcm/ppm which compares favorably to an acceptable value of -10.52 $\pm$ 1.05 pcm/ppm.

Boron endpoint measurements were taken after each successive RCC bank was fully inserted. Table 4.3-2 shows a comparison of design predictions to measured boron endpoint values.

4.3.3 Dropped and Ejected RCCA's

To verify assumptions made in the safety analysis, a single rod is either statically dropped into the core or statically ejected from the core at various core conditions. This single rod is selected for its maximum adverse effect on power distribution. The reactivity worth of the rod will be discussed in the following paragraphs, while the power distribution effects will be discussed in section 4.5.

4.3.3.1 Ejected RCCA at HZP (Test procedure SU-7.6)

With the reactor at HZP and the rods at zero power insertion limits, a single rod was withdrawn from the core during a boration. RCCA D-12 was chosen because of its maximum effect on the power distribution. During the withdrawal of D-12, a recorder was discovered not properly calibrated. Thus, the worth of D-12 was remeasured by inserting the RCCA during a dilution. The integral worth determined during the insertion was 618 pcm. The acceptance criteria required that rod plus 10%, a value of 679.8 pcm, be less than 880 pcm.

4.3.3.2 Ejected RCCA at Power (Test procedure SU-8.2)

With the reactor at a nominal power of 30% and the control banks at the hot full power (HFP) insertion limits, a single RCCA was withdrawn from the core; RCCA D-12 was again chosen for withdrawal. Because of the extremely low worth of RCCA D-12 from this configuration, the worth could not be measured and the rod was withdrawn without changing the boron concentration. The turbine load was adjusted slightly to match T_{avg} and T_{ref}. Flux maps and nuclear instrumentation data was obtained to determine the effect of the ejected rod on the power distribution.

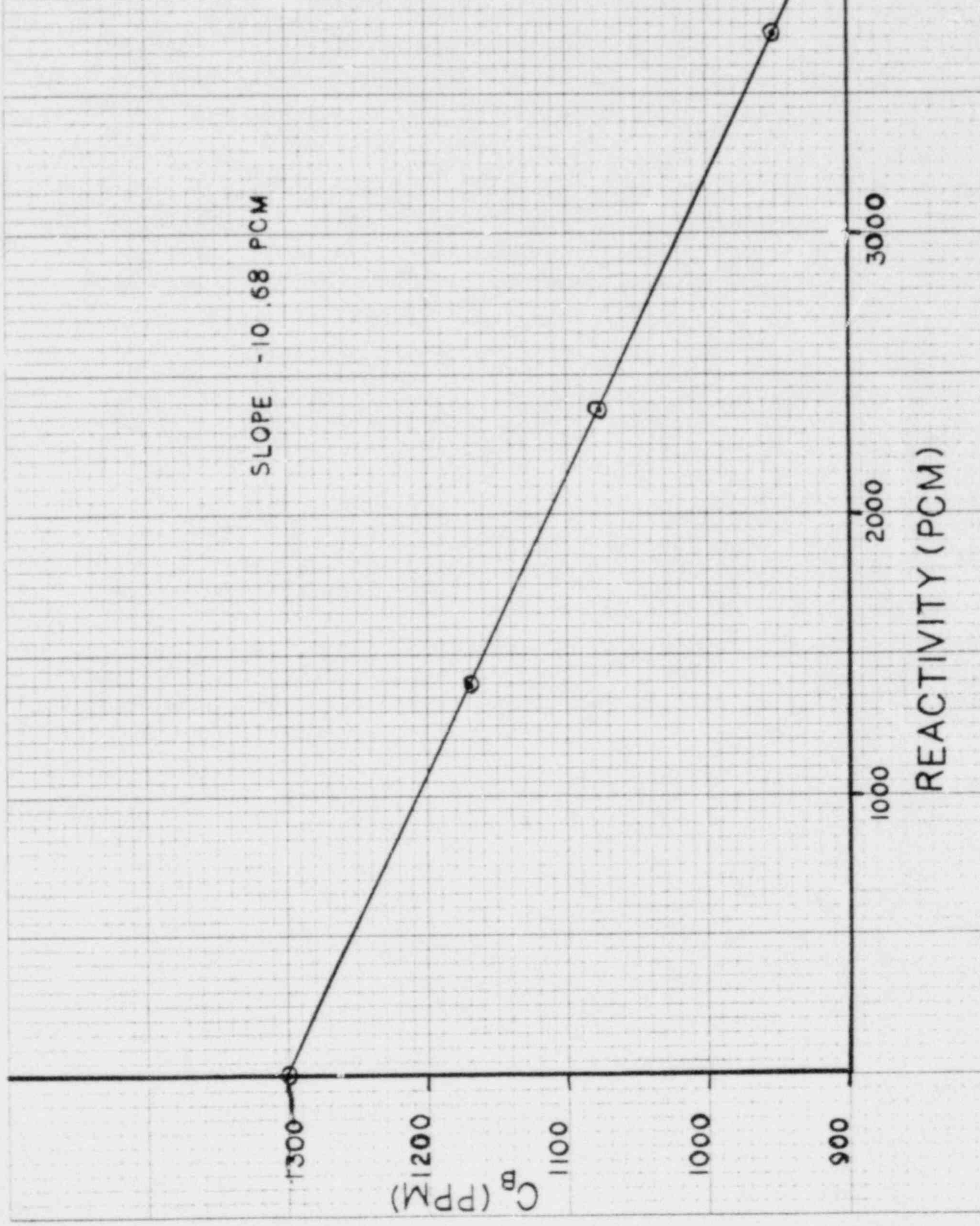
TABLE 4.3-2

Boron Endpoint Measurement

Rod Position	Test Results	Acc. Crit.
ARO	1300 ppm	1258 ± 50 ppm
D	1170 ppm	1171 ± 19 ppm
D + C	1076 ppm	1067 ± 15 ppm
D + C + B	953 ppm	960 ± 17 ppm
D+C+B+A	922 ppm	914 ± 8.6 ppm
D+C+B+A+SD	844 ppm	852 ± 11.2 ppm
D+C+B+A+SD+SC	733 ppm	741 ± 13.7 ppm

FIGURE 4.3-15

INTEGRAL BORON WORTH VS. BORON CONCENTRATION



4.3.3.3 Dropped Rod at Power (Test procedure SU-8.3)

At a nominal power of 50% and control bank D at 210 steps withdrawn, a single RCCA, D-12, was inserted into the core during a slow dilution. The measured worth of the rod was determined to be 133.7 pcm. Again, flux map and nuclear instrumentation data was taken to determine the effects of the dropped rod on power distribution.

4.3.4 Shutdown Margin (Test procedure SU-7.7)

The Technical Specifications require that the available shutdown margin be 1.6% $\Delta K/K$. The shutdown margin is defined as the instantaneous amount of reactivity by which the reactor is subcritical or would be subcritical from its present condition, assuming all full length rod cluster assemblies (shutdown and control) are fully inserted except for the single rod cluster assembly of highest reactivity worth which is assumed fully withdrawn. Control requirements have been quantified which would guarantee that the shutdown requirement can be met. Thus, the worth of all RCC banks inserted with the single most reactive rod withdrawn is measured to demonstrate that the shutdown margin requirement can be met. The measured worth of all RCC banks less the most reactive rod is 6682.4 pcm which is well within the acceptance criteria of 6708±671 pcm.

The boron endpoint, measured at the all rods in, most reactive rod out condition, was 684 ppm. This met the acceptance criteria of 637±50 ppm. To this measured boron concentration, an amount equivalent to 1.6% $\Delta K/K$ was added to obtain a minimum boron concentration of 816 pcm.

4.4 Reactivity Coefficients

The kinetic characteristics of the reactor determine the response of the core to changing plant conditions or to operator adjustments made during normal operation as well as the core response during abnormal or accidental transients. These kinetic characteristics are quantified in reactivity coefficients. The reactivity coefficients reflect the changes in neutron multiplication because of varying plant conditions such as power, moderator or fuel temperatures, or less significantly because of a change in pressure or void conditions. This section will address first the measurement of the Isothermal Temperature Coefficient and then the Power Coefficient.

4.4.1 Isothermal Temperature Coefficient (Test procedure SU-7.3.1)

The Isothermal Temperature Coefficient (ITC) is defined as the change in the core reactivity per unit change in moderator, clad and fuel temperatures. This can be broken down into the combination of the Moderator Temperature Coefficient (MTC) and the Doppler (or fuel) coefficient.

4.4.1 Isothermal Temperature Coefficient (continued)

This measurement is done with the reactor at hot zero power by causing the Reactor Coolant System (RCS) temperature to slowly change via steam dump either to the atmosphere or to the condenser. The test consists of a heatup and a cooldown while measuring the resultant change in reactivity.

For the cooldown portion, the RCS temperature started at approximately 547°F. A constant cooldown rate of approximately 10°F/hour via steam dumps was established. When the temperature reached approximately 542°F a heatup was begun at a constant rate of approximately 10°F/hour. During the heatup and cooldown, an X-Y recorder had been engaged to plot the change in reactivity with respect to the change in RCS temperature. The slope of this curve of T_{avg} versus reactivity is the Isothermal Temperature Coefficient.

Since there is a technical specification limitation on the value of the Moderator Temperature Coefficient (MTC), it was necessary to obtain a value for the MTC from the measured value of the Isothermal Temperature Coefficient (ITC). From the value of the relationship: ITC = MTC + Doppler Coefficient. The predicted hot zero power beginning of cycle Doppler Coefficient is -1.86 pcm/°F. Measurements of the ITC were taken for various control rod configurations and the resulting values of the ITC and calculated MTC are shown in Table 4.4-1.

Since the hot zero power all rods out moderator temperature coefficient was determined to be positive, subsequent hot zero power physics testing was performed under provision of Technical Specification 3.10.3, which allows for physics testing with a positive MTC below 5% power provided reactor trip setpoint on all operable intermediate and power range nuclear channels are $\leq$25% of rated thermal power. These requirements and Technical Specification 4.10.3 were complied with during zero power physics testing. Prior to power operation above 5% rated thermal power, rod withdrawal limits for maintaining a negative MTC were established in compliance with Technical Specification 3.1.1.3. A core average burnup at which the MTC would be restored to the hot zero power all rods out limit was conservatively calculated to be 1000 MWD/MTU. The rod withdrawal limits were complied with until the core average exposure reached 1000 MWD/MTU and a special report was prepared and transmitted as required by Technical Specification 3.1.1.3 and 6.9.1. Figure 4.4-1 shows the established rod withdrawal limits.

4.4.2 Power Coefficient and Power Defect (Test procedure SU-8.1)

The resulting reactivity change from a percent change in power as a result of the combined effects of moderator and fuel temperature changes is defined as the power coefficient. The power coefficient integrated over a power level change is defined

TABLE 4.4-1

Low Power Reactivity Coefficients

Rod Configuration	ITC (predicted) pcm/^{o}F	ITC (measured) pcm/^{o}F	MTC (measured) pcm/^{o}F
ARO	-1.53 $\pm$ 3.0	-1.01	0.85
D_{in}	-5.32 $\pm$ 3.0	-4.80	-2.94
$(D + C)_{in}$	-8.91 $\pm$ 3.0	-8.00	-6.14
$(D + C + B)_{in}$	-10.17 $\pm$ 3.0	-9.70	-7.84
$(D + C + B + A)_{in}$	-12.99 $\pm$ 3.0	-12.65	-10.79

OPERATING LIMITS TO MAINTAIN A NEGATIVE MTC

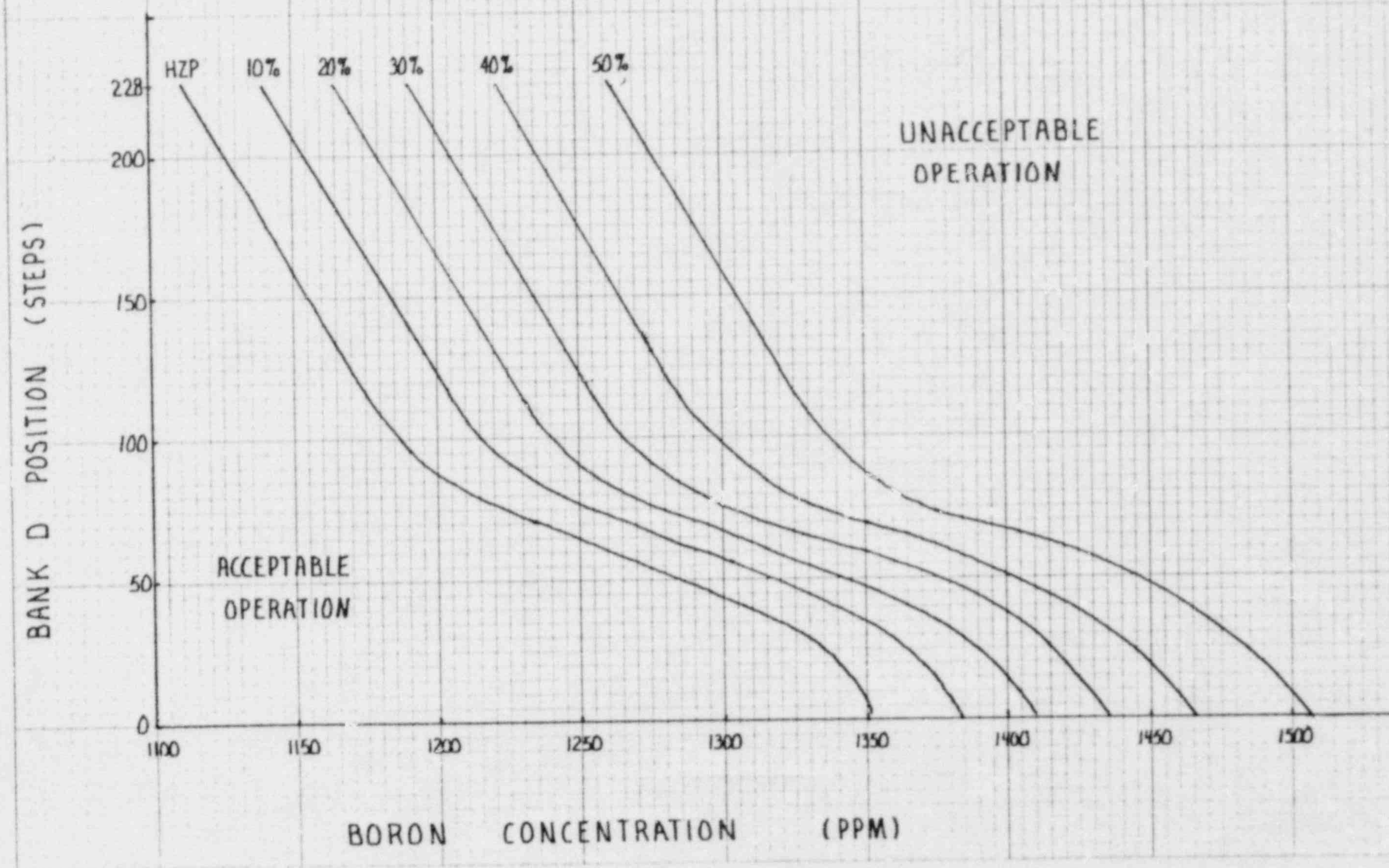


FIGURE 4.4-1

4.4.2 Power Coefficient and Power Defect (continued)

as the power defect. Measurements of the power coefficient were made at 30, 50, 75, and 90 percent power levels.

The test procedure utilized three sets of reactor transients to generate data for the determination of the moderator temperature coefficient, the isothermal temperature coefficient, and the total power coefficient. In addition, a fourth transient was included in order to develop a correction factor to apply to reactivity computer measurements taken at power. Each of these transients are described individually below.

Transient 1 involved changing the moderator temperature by adjusting control rod position while maintaining a constant load on the turbine. Since reactor power was essentially constant, power only doppler effects were essentially zero, enabling isolation of the effects contributed by the isothermal temperature coefficient. In practice, the calculations were performed using a reactivity balance which incorporated corrections for small power changes and changes in Xenon reactivity. Starting with T_{avg} equal to T_{ref}, the temperature was ramped up and down, pausing after each change to allow plant conditions to stabilize and to collect data. The results of this procedure was a cyclic series of temperature changes ending with a return to T_{avg} equal to T_{ref}.

Transient 2 consisted of cyclic changes in reactor power without any attempt to compensate with control rods. The reactivity balance for this series of transients was solved for the moderator temperature coefficient.

Transient 3 consisted of cyclic changes in turbine load while using rods to keep T_{avg} equivalent to T_{ref}. Under these circumstances, the control reactivity changes necessary to modify reactor power along the T_{avg} temperature program exactly compensates the reactivity change associated with the power change. Accordingly, the reactivity change because of rods, when boron is held constant and Xenon changes are taken into account, becomes a direct measure of the reactivity defect associated with a given power change.

Because of doppler feedback effect and short-lived reactivity fluctuations or noise, small instantaneous changes in reactivity, as measured by a reactivity computer at power, may not be displayed in full magnitude. Thus, a fourth transient was included in the test for the purpose of comparing the reactivity computer indicated reactivity change with the more accurately known reactivity value because of changes in boron concentrations. From this data, a calibration factor, consisting of the ratio of the actual reactivity change to the indicated reactivity change was formulated and used to correct the reactivity measurements in transients 1 and 3. The reactivity computer calibration factor found in this

4.4.2 Power Coefficient and Power Defect (continued)

test was 1.0720 at 30% power, 1.2186 at 50% power, 1.4704 at 75% power, and 1.4899 at 90% power.

The results of this test are shown in Table 4.4-2. A plot of the predicted power coefficient versus reactor power and a best fit measured curve is shown in Figure 4.4-2.

4.5 Power Distribution

At several stages during the startup test program the incore flux distribution was determined utilizing the incore movable detector system. Base case, steady state measurements were taken at several power statepoints: HZP, 30, 50, 75, 90, and 100 percent. Maps were also taken for abnormal conditions such as dropped and ejected rod cases. Measurements were also made during the special natural circulation testing. All of these measurements were done to provide data which verified design calculations, verified compliance with the Technical Specifications, and provided a relationship between incore power distribution and excore detector response.

4.5.1 Steady State Power Distribution (Test procedures SU-7.3.2, SU-8.6B, and SU-8.5.1)

Several power distribution parameters are of particular interest with respect to Technical Specifications. These parameters are heat flux hot channel factors, $F_Q(Z)$, nuclear enthalpy rise hot channel factors, $F^N_{\Delta H}$, radial hot channel factors, F_{xy}, incore axial offset, and Quadrant Power Tilt Ratios (QPTR). These values have been compiled and tabulated in Table 4.5-1 for each map taken during startup testing. An additional parameter, relative assembly power, was analyzed with respect to differences between design and measured values. The acceptance criteria applied to this parameter required the percent difference between design and measured values to be within $\pm$ 15% if the design value was less than 0.9 and within $\pm$ 10% if the design value was greater than or equal to 0.9. Several instances during the testing program showed failure to meet these assembly power criteria; however, Westinghouse design review of each instance showed that, with the conservatisms used in design values, these assemblies were well within safety margins and that failure to meet this criteria presented no safety or operational problems. Figures 4.5-1 through 4.5-16 provide an assembly-wise relative power distribution for all flux maps taken during the startup test program thus far.

The analysis of two flux maps at zero power, INC-1-F1-80-1G, Figure 4.5-1, and INC-1-F1-80-3F, Figure 4.5-3, revealed that the quadrant power tilt ratio exceeded the acceptance criteria of 1.02. A review of the deficiency determined that no safety or operational problem existed and that the tilt should fall within the acceptance criteria when the reactor was brought to power. This was in fact the case as can be observed from the 30% power flux map INC-1-F1-80-6A, Figure 4.5-6.

TABLE 4.4-2

At Power Reactivity Coefficients - Measured Values

Power Level (%)	ITC (pcm/^{o}F)	MTC (pcm/^{o}F)	Power Coefficient (pcm/%)	Power Coefficient Acceptance Criteria (pcm/%)
30	-5.70	-2.04	-15.17	-14.18 ± 4.25
50	-6.76	-3.65	-14.39	-13.89 ± 4.17
75	-9.18	-6.36	-12.33	-13.71 ± 4.11
90	-8.71	-8.34	-14.97	-13.74 ± 4.12

Integral Power Defect

Measured (pcm)	Acceptance Criteria (pcm)
-1445.45	-1395.41 ± 209.31

TABLE 4.5-1

Summary of Results of Incore Flux Maps

Date	Map # INC-1-F1-	Control Bank Pos. C	Control Bank Pos. D	Control Bank Pos. RCCA	Incore Hot Channel Factors $F_Q(Z)$	Incore Hot Channel Factors LIM $F_Q(Z)$	Incore Hot Channel Factors Axial Loc $F_Q(Z)$*	Incore Hot Channel Factors $F^N_{\Delta H}$	Incore Hot Channel Factors F_{xy}	Incore Hot Channel Factors Axial Loc F_{xy}*	QPTR** N41	QPTR** N42	QPTR** N43	QPTR** N44	Core Ave A.O.	Power Level
7/15/80	80-1G	-	204	-	2.6198	4.489	30	1.5543	1.7214	49	1.0259	.9837	1.0085	.9819	- 2.3[illegible]0	HZP
7/15/80	80-2F	-	29	-	2.3418	4.489	30	1.4686	1.6269	38	1.0199	.9853	1.0089	.9859	- 6.766	HZP
8/ 7/80	80-3F	64	0	-	2.9811	4.500	37	1.6580	2.0334	20	1.0299	.9789	1.0111	.9801	-37.865	HZP
7/ 7/80	80-4G	0	0	0	10.1280	4.500	39	6.0174	7.7327	11	.2542	2.4966	.6311	.6181	-32.243	0%
7/14/80	80-5D	-	167	-	2.4933	4.500	37	1.4203	1.5913	49	1.0000	1.0000	1.0000	1.0000	-16.456	5%
11/ 3/80	80-6A	-	176/177	-	2.2855	4.500	37	1.4333	1.7052	11	1.0107	.9949	1.0045	.9899	-11.361	30%
11/ 3/80	80-7A	-	176/177	D-12@228	2.2568	4.451	29	1.5288	2.0610	11	.9910	1.0376	.9910	.9804	-10.249	30%
11/18/80	80-8A	-	206	-	2.1103	4.440	28	1.4316	1.5635	26	1.0102	.9966	1.0003	.9928	.491	50%
11/20/80	80-9C	-	211	-	1.9808	4.451	29	1.3557	1.4965	49	1.0057	.9990	1.0037	.9917	-3.772	50%
11/20/80	80-10B	-	211	D-12@5	2.4157	4.451	29	1.6405	1.8472	49	1.1616	.7306	1.0626	1.0451	4.341	50%
11/30/80	80-11A	-	193	-	2.0234	3.356	37	1.3229	1.4732	49	1.0064	1.0023	1.0016	.9898	-8.753	75%
12/19/80	80-12D	-	191	-	2.0411	2.983	37	1.3004	1.4521	49	1.0068	1.0033	1.0031	.9868	-12.775	75%
12/20/80	80-13D	-	169	-	2.2460	2.983	38	1.3249	1.5054	11	1.0065	1.0052	1.0024	.9860	-24.555	75%
12/20/80	80-14D	-	195.5	-	2.0251	2.960	28	1.3053	1.4693	49	1.0056	1.0042	1.0023	.9878	7.191	75%
12/29/80	80-15A	-	205	-	1.9644	2.458	36	1.2937	1.4265	11	1.0084	1.0010	1.0019	.9888	- 8.495	90%
2/ 2/81	81-1A	-	190	-	2.0621	3.606	29	1.3151	1.4657	49	1.0153	.9962	1.0039	.9847	- 5.812	62%

*This number represents an axial plant. The INCORE computer code utilizes 61 axial core planes, plane number 1 being at the top of the core and plane 61 at the bottom.

**Relative location of excore detectors:

N41	N43
N44	N42

FIGURE 4.4-2

POWER COEFFICIENT VS. POWER

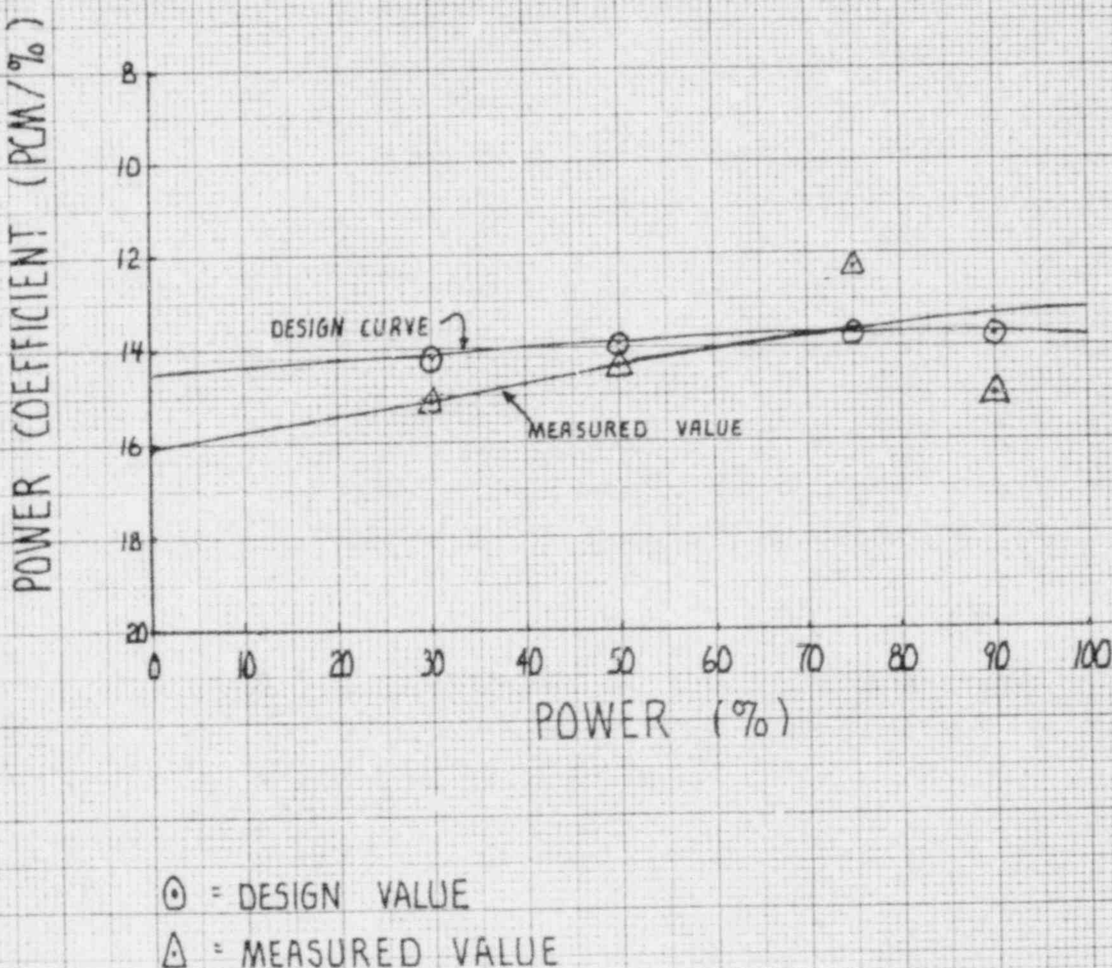


FIGURE 4.5-1

Relative Assembly Powers, HZP, ARO

MEASURED AND EXPECTED FDHN INC-1-F1-80-1G TI53 7/15/80 D0204

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
					0.637.	0.716.	0.858.	0.765.	0.856.	0.711.	0.620.				
1					0.588.	0.674.	0.810.	0.728.	0.810.	0.674.	0.588.				
			0.594.	1.038.	1.078.	1.080.	1.095.	1.070.	1.073.	1.036.	1.016.	1.009.	0.602.		
2			0.547.	0.956.	0.995.	1.014.	1.051.	1.041.	1.051.	1.014.	0.995.	0.956.	0.547.		
		0.596.	1.284.	1.187.	1.260.	1.214.	1.189.	1.058.	1.161.	1.106.	1.148.	1.080.	1.297.	0.602.	
3		0.547.	1.178.	1.093.	1.162.	1.120.	1.154.	1.046.	1.154.	1.120.	1.162.	1.093.	1.178.	0.547.	
		1.047.	1.196.	1.247.	1.198.	1.212.	1.113.	1.133.	1.112.	1.173.	1.159.	1.236.	1.167.	1.023.	
4		0.956.	1.093.	1.219.	1.170.	1.185.	1.124.	1.143.	1.124.	1.185.	1.170.	1.219.	1.093.	0.956.	
	0.626.	1.043.	1.223.	1.191.	1.194.	1.059.	1.097.	1.003.	1.096.	1.040.	1.171.	1.187.	1.204.	1.031.	0.610.
5	0.588.	0.995.	1.162.	1.170.	1.179.	1.048.	1.101.	1.008.	1.101.	1.048.	1.179.	1.170.	1.162.	0.995.	0.588.
	0.698.	1.038.	1.114.	1.188.	1.046.	1.059.	0.940.	0.993.	0.918.	1.021.	1.003.	1.198.	1.149.	1.041.	0.699.
6	0.674.	1.014.	1.120.	1.185.	1.048.	1.069.	0.961.	1.022.	0.961.	1.069.	1.048.	1.185.	1.120.	1.014.	0.674.
	0.845.	1.079.	1.151.	1.109.	1.074.	0.920.	0.960.	0.830.	0.950.	0.899.	1.053.	1.118.	1.165.	1.066.	0.837.
7	0.810.	1.051.	1.154.	1.124.	1.101.	0.961.	0.996.	0.869.	0.996.	0.961.	1.101.	1.124.	1.154.	1.051.	0.810.
	0.746.	1.058.	1.037.	1.119.	0.972.	0.965.	0.814.	0.908.	0.815.	0.968.	0.971.	1.132.	1.049.	1.050.	0.745.
8	0.728.	1.041.	1.046.	1.143.	1.008.	1.022.	0.869.	0.970.	0.869.	1.022.	1.008.	1.143.	1.046.	1.041.	0.728.
	0.828.	1.067.	1.154.	1.099.	1.061.	0.905.	0.917.	0.805.	0.941.	0.919.	1.076.	1.106.	1.150.	1.062.	0.828.
9	0.810.	1.051.	1.154.	1.124.	1.101.	0.961.	0.996.	0.869.	0.996.	0.961.	1.101.	1.124.	1.154.	1.051.	0.810.
	0.683.	1.026.	1.113.	1.149.	1.016.	[illegible]	0.864.	0.947.	0.896.	1.029.	1.023.	1.157.	1.095.	1.047.	0.696.
10	0.674.	1.014.	1.120.	1.185.	1.048.	1.069.	0.961.	1.022.	0.961.	1.069.	1.048.	1.185.	1.120.	1.014.	0.674.
	0.606.	1.025.	1.198.	1.135.	1.147.	0.999.	1.033.	0.930.	1.019.	0.995.	1.158.	1.150.	1.147.	1.043.	0.617.
11	0.588.	0.995.	1.162.	1.170.	1.179.	1.048.	1.101.	1.008.	1.101.	1.048.	1.179.	1.170.	1.162.	0.995.	0.588.
		0.970.	1.092.	1.220.	1.158.	1.170.	1.063.	1.060.	1.043.	1.123.	1.153.	1.202.	1.115.	1.002.	
12		0.956.	1.093.	1.219.	1.170.	1.185.	1.124.	1.143.	1.124.	1.185.	1.170.	1.219.	1.093.	0.956.	
		0.555.	1.195.	1.105.	1.152.	1.092.	1.098.	0.977.	1.099.	1.081.	1.163.	1.089.	1.204.	0.572.	
13		0.547.	1.178.	1.093.	1.162.	1.120.	1.154.	1.046.	1.154.	1.120.	1.162.	1.093.	1.178.	0.547.	
			0.556.	0.977.	1.021.	1.012.	1.009.	1.000.	1.031.	1.019.	1.000.	0.953.	0.572.		
14			0.547.	0.956.	0.995.	1.014.	1.051.	1.041.	1.051.	1.014.	0.995.	0.956.	0.547.		
					0.617.	0.674.	0.789.	0.712.	0.813.	0.677.	0.591.				
15					0.588.	0.674.	0.810.	0.728.	0.810.	0.674.	0.588.				

. MEAS .
. EXP .

-63-

FIGURE 4.5-2

Relative Assembly Powers, HZP, D_{in}

MEASURED AND EXPECTED FDHN INC-1-F1-80-2F SU 7.3.2 7/15/80 DA29 BOL

Row		R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1	MEAS					0.711	0.865	1.073	0.981	1.091	0.886	0.743				
	EXP					0.696	0.830	1.017	0.916	1.017	0.830	0.696				
2	MEAS			0.611	1.119	1.128	1.242	1.300	1.295	1.297	1.238	1.142	1.005	0.561		
	EXP			0.535	0.980	1.105	1.195	1.248	1.234	1.248	1.195	1.105	0.980	0.535		
3	MEAS		0.581	1.166	1.032	1.180	1.232	1.226	1.022	1.221	1.212	1.173	0.971	1.126	0.573	
	EXP		0.535	1.074	0.948	1.156	1.207	1.212	1.014	1.212	1.207	1.156	0.948	1.074	0.535	
4	MEAS		1.038	1.001	0.666	1.035	1.197	0.988	0.620	1.001	1.190	1.040	0.663	0.988	1.031	
	EXP		0.980	0.948	0.654	1.033	1.194	1.018	0.636	1.018	1.194	1.033	0.654	0.948	0.980	
5	MEAS	0.744	1.157	1.203	1.049	1.124	1.050	1.014	0.838	1.011	1.040	1.116	1.046	1.174	1.120	0.693
	EXP	0.696	1.105	1.156	1.033	1.122	1.049	1.047	0.870	1.047	1.049	1.122	1.033	1.156	1.105	0.696
6	MEAS	0.880	1.237	1.200	1.189	1.042	1.077	0.925	0.957	0.923	1.071	1.026	1.214	1.227	1.213	0.826
	EXP	0.830	1.195	1.207	1.194	1.049	1.091	0.950	0.987	0.950	1.091	1.049	1.194	1.207	1.195	0.830
7	MEAS	1.077	1.290	1.210	1.007	1.026	0.916	0.901	0.712	0.903	0.915	0.991	0.996	1.212	1.272	1.044
	EXP	1.017	1.248	1.212	1.018	1.047	0.950	0.937	0.749	0.937	0.950	1.047	1.018	1.212	1.248	1.017
8	MEAS	0.948	1.264	1.012	0.622	0.843	0.939	0.706	0.479	0.715	0.932	0.813	0.607	1.013	1.275	0.963
	EXP	0.916	1.234	1.014	0.636	0.870	0.987	0.749	0.513	0.749	0.987	0.870	0.636	1.014	1.234	0.916
9	MEAS	1.050	1.277	1.223	0.990	1.000	0.894	0.868	0.696	0.890	0.889	0.985	0.968	1.202	1.293	1.069
	EXP	1.017	1.248	1.212	1.018	1.047	0.950	0.937	0.749	0.937	0.950	1.047	1.018	1.212	1.248	1.017
10	MEAS	0.861	1.238	1.217	1.142	1.002	1.029	0.881	0.920	0.891	1.033	1.011	1.154	1.198	1.284	0.892
	EXP	0.830	1.195	1.207	1.194	1.049	1.091	0.950	0.987	0.950	1.091	1.049	1.194	1.207	1.195	0.830
11	MEAS	0.742	1.178	1.233	0.987	1.077	0.996	0.984	0.806	0.975	1.009	1.092	1.002	1.107	1.220	0.768
	EXP	0.696	1.105	1.156	1.033	1.122	1.049	1.047	0.870	1.047	1.049	1.122	1.033	1.156	1.105	0.696
12	MEAS		1.014	0.949	0.642	1.005	1.163	0.963	0.591	0.948	1.147	0.991	0.624	0.933	1.054	
	EXP		0.980	0.948	0.654	1.033	1.194	1.018	0.636	1.018	1.194	1.033	0.654	0.948	0.980	
13	MEAS		0.559	1.119	0.972	1.131	1.169	1.151	0.948	1.154	1.163	1.131	0.918	1.069	0.561	
	EXP		0.535	1.074	0.948	1.156	1.207	1.212	1.014	1.212	1.207	1.156	0.948	1.074	0.535	
14	MEAS			0.562	1.004	1.107	1.175	1.197	1.185	1.220	1.194	1.112	0.992	0.551		
	EXP			0.535	0.980	1.105	1.195	1.248	1.234	1.248	1.195	1.105	0.980	0.535		
15	MEAS					0.706	0.815	0.991	0.895	1.017	0.829	0.700				
	EXP					0.696	0.830	1.017	0.916	1.017	0.830	0.696				

MEAS

EXP

FIGURE 4.5-3

Relative Assembly Powers, HZP, C@,84

MEASURED AND EXPECTED FDHN INC-1-F1-80-3F 8/7/80 SU-7.6 C@84 D@0 BOL

		R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1	MEAS					0.851	0.939	1.029	0.841	1.014	0.914	0.817				
	EXP					0.780	0.872	0.963	0.796	0.963	0.872	0.780				
2	MEAS			0.691	1.241	1.360	1.363	1.228	0.951	1.199	1.297	1.279	1.176	0.672		
	EXP			0.640	1.148	1.247	1.264	1.167	0.919	1.167	1.264	1.247	1.148	0.640		
3	MEAS		0.684	1.357	1.155	1.401	1.387	1.208	0.911	1.183	1.275	1.303	1.113	1.335	0.689	
	EXP		0.640	1.271	1.086	1.284	1.271	1.179	0.909	1.179	1.271	1.284	1.086	1.271	0.640	
4	MEAS		1.222	1.153	0.695	1.116	1.257	0.966	0.551	0.980	1.226	1.096	0.679	1.129	1.204	
	EXP		1.148	1.086	0.670	1.087	1.224	0.990	0.561	0.990	1.224	1.087	0.670	1.086	1.148	
5	MEAS	0.837	1.312	1.344	1.119	1.108	0.963	0.936	0.787	0.954	0.970	1.110	1.096	1.320	1.283	0.810
	EXP	0.780	1.247	1.284	1.087	1.116	0.973	0.970	0.802	0.970	0.973	1.116	1.087	1.284	1.247	0.780
6	MEAS	0.928	1.312	1.267	1.231	0.958	0.780	0.792	0.880	0.793	0.768	0.931	1.241	1.308	1.301	0.908
	EXP	0.872	1.264	1.271	1.224	0.973	0.801	0.819	0.892	0.819	0.801	0.973	1.224	1.271	1.264	0.872
7	MEAS	1.024	1.209	1.178	0.978	0.932	0.781	0.789	0.642	0.785	0.770	0.908	0.969	1.185	1.196	1.004
	EXP	0.963	1.167	1.179	0.990	0.970	0.819	0.819	0.662	0.819	0.819	0.970	0.990	1.179	1.167	0.963
8	MEAS	0.818	0.930	0.903	0.549	0.774	0.855	0.634	0.399	0.622	0.846	0.758	0.546	0.902	0.934	0.825
	EXP	0.796	0.919	0.909	0.561	0.802	0.892	0.662	0.420	0.662	0.892	0.802	0.561	0.909	0.919	0.796
9	MEAS	0.990	1.188	1.181	0.957	0.917	0.767	0.763	0.616	0.776	0.782	0.929	0.953	1.156	1.195	1.000
	EXP	0.963	1.167	1.179	0.990	0.97[illegible]	0.819	0.819	0.662	0.819	0.819	0.770	0.990	1.179	1.167	0.963
10	MEAS	0.890	1.288	1.268	1.165	0.925	0.749	0.751	0.823	0.757	0.759	0.940	1.182	1.227	1.315	0.908
	EXP	0.872	1.264	1.271	1.224	0.973	0.801	0.819	0.892	0.819	0.801	0.973	1.224	1.271	1.264	0.872
11	MEAS	0.813	1.300	1.338	1.035	1.068	0.922	0.907	0.743	0.904	0.924	1.061	1.031	1.211	1.295	0.810
	EXP	0.780	1.247	1.284	1.087	1.116	0.973	0.970	0.802	0.970	0.973	1.116	1.087	1.284	1.247	0.780
12	MEAS		1.173	1.088	0.661	1.059	1.192	0.928	0.520	0.919	1.161	1.022	0.628	1.057	1.186	
	EXP		1.148	1.086	0.670	1.087	1.224	0.990	0.561	0.990	1.224	1.087	0.670	1.086	1.148	
13	MEAS		0.644	1.280	1.087	1.257	1.233	1.113	0.848	1.125	1.240	1.261	1.050	1.256	0.659	
	EXP		0.640	1.271	1.086	1.284	1.271	1.179	0.909	1.179	1.271	1.284	1.086	1.271	0.640	
14	MEAS			0.645	1.149	1.240	1.240	1.115	0.873	1.139	1.276	1.263	1.165	0.654		
	EXP			0.640	1.148	1.247	1.264	1.167	0.919	1.167	1.264	1.247	1.148	0.640		
15	MEAS					0.779	0.852	0.940	0.777	0.968	0.880	0.790				
	EXP					0.780	0.872	0.963	0.796	0.963	0.872	0.780				

FIGURE 4.5-4

Relative Assembly Powers, HZP, Ejected RCCA

MEASURED AND EXPECTED FDHN INC-1-F1-80-5D D@167 7/14/80 TI-5[illegible] BOL NATURAL CIRC

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1					0.610	0.697	0.838	0.742	0.838	0.697	0.610				
					0.603	0.695	0.838	0.754	0.838	0.695	0.603				
2			0.559	0.975	1.015	1.040	1.069	1.046	1.069	1.040	1.015	0.975	0.559		
			0.545	0.960	1.010	1.039	1.078	1.067	1.078	1.039	1.010	0.960	0.545		
3		0.562	1.181	1.082	1.159	1.122	1.152	1.023	1.152	1.122	1.159	1.082	1.181	0.562	
		0.545	1.164	1.073	1.161	1.132	1.162	1.042	1.162	1.132	1.161	1.073	1.164	0.545	
4		0.979	1.078	1.145	1.153	1.187	1.095	1.060	1.095	1.187	1.153	1.145	1.078	0.979	
		0.960	1.073	1.144	1.151	1.186	1.110	1.076	1.110	1.186	1.151	1.144	1.073	0.960	
5	0.618	1.026	1.161	1.151	1.172	1.041	1.087	0.979	1.087	1.041	1.172	1.151	1.161	1.026	0.618
	0.603	1.010	1.161	1.151	1.172	1.048	1.093	0.989	1.093	1.048	1.172	1.151	1.161	1.010	0.603
6	0.699	1.040	1.119	1.182	1.041	1.071	0.960	1.023	0.960	1.071	1.041	1.182	1.119	1.040	0.699
	0.695	1.039	1.132	1.186	1.048	1.072	0.959	1.017	0.959	1.072	1.048	1.186	1.132	1.039	0.695
7	0.837	1.070	1.154	1.099	1.084	0.954	0.993	0.864	0.993	0.954	1.084	1.099	1.154	1.070	0.837
	0.838	1.078	1.162	1.110	1.093	0.959	0.988	0.853	0.988	0.959	1.093	1.110	1.162	1.078	0.838
8	0.752	1.058	1.035	1.071	0.983	1.020	0.862	0.934	0.862	1.020	0.983	1.071	1.035	1.058	0.752
	0.754	1.067	1.042	1.076	0.989	1.017	0.853	0.909	0.853	1.017	0.989	1.076	1.042	1.067	0.754
9	0.837	1.070	1.154	1.099	1.084	0.954	0.993	0.864	0.993	0.954	1.084	1.099	1.154	1.070	0.837
	0.838	1.078	1.162	1.110	1.093	0.959	0.988	0.853	0.988	0.959	1.093	1.110	1.162	1.078	0.838
10	0.699	1.040	1.119	1.182	1.041	1.071	0.960	1.023	0.960	1.071	1.041	1.182	1.119	1.040	0.699
	0.695	1.039	1.132	1.186	1.048	1.072	0.959	1.017	0.959	1.072	1.048	1.186	1.132	1.039	0.695
11	0.618	1.026	1.161	1.151	1.172	1.041	1.087	0.979	1.087	1.041	1.172	1.151	1.161	1.026	0.618
	0.603	1.010	1.161	1.151	1.172	1.048	1.093	0.989	1.093	1.048	1.172	1.151	1.161	1.010	0.603
12		0.979	1.078	1.145	1.153	1.187	1.095	1.060	1.095	1.187	1.153	1.145	1.078	0.979	
		0.960	1.073	1.144	1.151	1.186	1.110	1.076	1.110	1.186	1.151	1.144	1.073	0.960	
13		0.562	1.181	1.082	1.159	1.122	1.152	1.023	1.152	1.122	1.159	1.082	1.181	0.562	
		0.545	1.164	1.073	1.161	1.132	1.162	1.042	1.162	1.132	1.161	1.073	1.164	0.545	
14			0.559	0.975	1.015	1.040	1.069	1.046	1.069	1.040	1.015	0.975	0.559		
			0.545	0.960	1.010	1.039	1.078	1.067	1.078	1.039	1.010	0.960	0.545		
15					0.610	0.697	0.838	0.742	0.838	0.697	0.610				
					0.603	0.695	0.838	0.754	0.838	0.695	0.603				

MEAS
EXP

FIGURE 4.5-5

Relative Assembly Power, 3%, Natural Circulation

MEASURED AND EXPECTED FDHN INC-1-F1-80-5D D@167 7/14/80 TI-53 BOL NATURAL CIRC

		R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1	MEAS					0.610	0.697	0.838	0.742	0.838	0.697	0.610				
	EXP					0.603	0.695	0.838	0.754	0.838	0.695	0.603				
2	MEAS			0.559	0.975	1.015	1.040	1.069	1.046	1.069	1.040	1.015	0.975	0.559		
	EXP			0.545	0.960	1.010	1.039	1.078	1.067	1.078	1.039	1.010	0.960	0.545		
3	MEAS		0.562	1.181	1.082	1.159	1.122	1.152	1.023	1.152	1.122	1.159	1.082	1.181	0.562	
	EXP		0.545	1.164	1.073	1.161	1.132	1.162	1.042	1.162	1.132	1.161	1.073	1.164	0.545	
4	MEAS		0.979	1.078	1.145	1.153	1.187	1.095	1.060	1.095	1.187	1.153	1.145	1.078	0.979	
	EXP		0.960	1.073	1.144	1.151	1.186	1.110	1.076	1.110	1.186	1.151	1.144	1.073	0.960	
5	MEAS	0.618	1.026	1.161	1.151	1.172	1.041	1.087	0.979	1.087	1.041	1.172	1.151	1.161	1.026	0.618
	EXP	0.603	1.010	1.161	1.151	1.172	1.048	1.093	0.989	1.093	1.048	1.172	1.151	1.161	1.010	0.603
6	MEAS	0.699	1.040	1.119	1.182	1.041	1.071	0.960	1.023	0.960	1.071	1.041	1.182	1.119	1.040	0.699
	EXP	0.695	1.039	1.132	1.186	1.048	1.072	0.959	1.017	0.959	1.072	1.048	1.186	1.132	1.039	0.695
7	MEAS	0.837	1.070	1.154	1.099	1.084	0.954	0.993	0.864	0.993	0.954	1.084	1.099	1.154	1.070	0.837
	EXP	0.838	1.078	1.162	1.110	1.093	0.959	0.988	0.853	0.988	0.959	1.093	1.110	1.162	1.078	0.838
8	MEAS	0.752	1.058	1.035	1.071	0.983	1.020	0.862	0.934	0.862	1.020	0.983	1.071	1.035	1.058	0.752
	EXP	0.754	1.067	1.042	1.076	0.989	1.017	0.853	0.909	0.853	1.017	0.989	1.076	1.042	1.067	0.754
9	MEAS	0.837	1.070	1.154	1.099	1.084	0.954	0.993	0.864	0.993	0.954	1.084	1.099	1.154	1.070	0.837
	EXP	0.838	1.078	1.162	1.110	1.093	0.959	0.988	0.853	0.988	0.959	1.093	1.110	1.162	1.078	0.838
10	MEAS	0.699	1.040	1.119	1.182	1.041	1.071	0.960	1.023	0.960	1.071	1.041	1.182	1.119	1.040	0.699
	EXP	0.695	1.039	1.132	1.186	1.048	1.072	0.959	1.017	0.959	1.072	1.048	1.186	1.132	1.039	0.695
11	MEAS	0.618	1.026	1.161	1.151	1.172	1.041	1.087	0.979	1.087	1.041	1.172	1.151	1.161	1.026	0.618
	EXP	0.603	1.010	1.161	1.151	1.172	1.048	1.093	0.989	1.093	1.048	1.172	1.151	1.161	1.010	0.603
12	MEAS		0.979	1.078	1.145	1.153	1.187	1.095	1.060	1.095	1.187	1.153	1.145	1.078	0.979	
	EXP		0.960	1.073	1.144	1.151	1.186	1.110	1.076	1.110	1.186	1.151	1.144	1.073	0.960	
13	MEAS		0.562	1.181	1.082	1.159	1.122	1.152	1.023	1.152	1.122	1.159	1.082	1.181	0.562	
	EXP		0.545	1.164	1.073	1.161	1.132	1.162	1.042	1.162	1.132	1.161	1.073	1.164	0.545	
14	MEAS			0.559	0.975	1.015	1.040	1.069	1.046	1.069	1.040	1.015	0.975	0.559		
	EXP			0.545	0.960	1.010	1.039	1.078	1.067	1.078	1.039	1.010	0.960	0.545		
15	MEAS					0.610	0.697	0.838	0.742	0.838	0.697	0.610				
	EXP					0.603	0.695	0.838	0.754	0.838	0.695	0.603				

. MEAS .
. EXP .

FIGURE 4.5-6

Relative Assembly Powers, 30%, D@ HFP Insertion Limit

MEASURED AND EXPECTED FDHN INC-1-F1-80-6A 30%POWER D @ 176/177 11/3/80 SU-8.2 BASE CASE

Row		R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1	MEAS					0.6[illegible]1	0.727	0.858	0.776	0.885	0.774	0.681				
	EXP					0.621	0.707	0.837	0.761	0.838	0.708	0.623				
2	MEAS			0.614	1.049	1.045	1.031	1.079	1.029	1.085	1.043	1.045	0.950	0.585		
	EXP			0.550	0.939	1.012	1.001	1.070	1.029	1.071	1.003	1.015	0.943	0.553		
3	MEAS		0.580	1.165	1.129	1.156	1.161	1.130	1.047	1.118	1.110	1.118	1.075	1.174	0.613	
	EXP		0.550	1.104	1.063	1.118	1.124	1.127	1.056	1.129	1.126	1.122	1.067	1.110	0.553	
4	MEAS		0.962	1.086	1.120	1.161	1.166	1.102	1.052	1.105	1.137	1.143	1.111	1.108	0.997	
	EXP		0.939	1.063	1.110	1.148	1.152	1.123	1.073	1.125	1.155	1.152	1.115	1.068	0.944	
5	MEAS	[illegible]	1.0[illegible]	1.132	1.153	1.141	1.071	1.075	1.018	1.076	1.059	1.129	1.143	1.137	1.030	0.641
	EXP	0.[illegible]21	1.012	1.118	1.143	1.142	1.073	1.089	1.032	1.091	1.076	1.146	1.153	1.124	1.017	0.624
6	MEAS	0.785	1.052	1.113	1.149	1.067	1.060	0.984	1.011	0.977	1.043	1.039	1.157	1.145	1.021	0.729
	EXP	0.707	1.001	1.124	1.152	1.073	1.072	1.008	1.036	1.010	1.074	1.077	1.157	1.129	1.006	0.711
7	MEAS	0.923	1.118	1.114	1.102	1.064	0.971	0.979	0.874	0.979	0.970	1.060	1.127	1.143	1.090	0.861
	EXP	0.837	1.070	1.127	1.123	1.089	1.008	1.014	0.911	1.015	1.011	1.093	1.128	1.133	1.075	0.842
8	MEAS	0.799	1.056	1.046	1.047	1.003	0.989	0.866	0.909	0.875	1.002	1.008	1.069	1.065	1.049	0.783
	EXP	0.761	1.029	1.056	1.073	1.032	1.036	0.911	0.955	0.912	1.038	1.035	1.077	1.061	1.034	0.765
9	MEAS	0.876	1.096	1.119	1.088	1.046	0.958	0.954	0.862	0.982	0.983	1.076	1.113	1.130	1.090	0.863
	EXP	0.838	1.071	1.129	1.125	1.091	1.010	1.015	0.912	1.016	1.012	1.094	1.129	1.133	1.076	0.842
10	MEAS	0.711	1.007	1.123	1.118	1.041	1.031	0.952	0.983	0.960	1.049	1.061	1.140	1.114	1.030	0.727
	EXP	0.708	1.003	1.126	1.155	1.076	1.074	1.011	1.038	1.012	1.077	1.079	1.159	1.131	1.008	0.712
11	MEAS	0.629	1.026	1.134	1.115	1.120	1.044	1.049	0.981	1.040	1.050	1.140	1.148	1.124	1.036	0.635
	EXP	0.623	1.015	1.122	1.152	1.146	1.077	1.093	1.035	1.094	1.079	1.149	1.156	1.126	1.020	0.626
12	MEAS		0.965	1.105	1.115	1.139	1.144	1.079	1.016	1.067	1.127	1.152	1.115	1.081	0.962	
	EXP		0.943	1.067	1.115	1.153	1.157	1.128	1.077	1.129	1.159	1.156	1.118	1.071	0.947	
13	MEAS		0.591	1.185	1.113	1.115	1.112	1.093	1.010	1.095	1.114	1.141	1.088	1.131	0.560	
	EXP		0.553	1.110	1.068	1.124	1.129	1.133	1.061	1.133	1.131	1.126	1.071	1.113	0.555	
14	MEAS			0.594	0.975	1.009	0.989	1.063	1.025	1.081	1.015	1.035	0.967	0.567		
	EXP			0.553	0.944	1.017	1.006	1.075	1.034	1.076	1.008	1.020	0.947	0.555		
15	MEAS					0.621	0.697	0.859	0.784	0.877	0.717	0.635				
	EXP					0.624	0.711	0.842	0.765	0.842	0.712	0.626				

Legend: MEAS (upper value) / EXP (lower value)

FIGURE 4.5-7

Relative Assembly Powers, 30%, Ejected RCCA

MEASURED AND EXPECTED FDHN INC-1-F1-80-7A 30%POWER D@ 176/177 11/3/80 SU-8.2 EJECTED ROD CASE

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
					0.631.	0.707.	0.838.	0.757.	0.882.	0.777.	0.685.				
1					0.598.	0.681.	0.806.	0.734.	0.810.	0.686.	0.604.				
			0.597.	1.020.	1.030.	1.005.	1.055.	1.006.	1.072.	1.037.	1.027.	0.911.	0.571.		
2			0.533.	0.909.	0.978.	0.966.	1.033.	0.996.	1.037.	0.974.	0.989.	0.922.	0.542.		
		0.568.	1.143.	1.100.	1.142.	1.146.	1.107.	1.026.	1.098.	1.094.	1.089.	1.035.	1.151.	0.610.	
3		0.533.	1.073.	1.035.	1.085.	1.088.	1.094.	1.030.	1.099.	1.098.	1.098.	1.050.	1.093.	0.545.	
		0.948.	1.070.	1.095.	1.128.	1.131.	1.072.	1.029.	1.081.	1.112.	1.120.	1.099.	1.097.	0.997.	
4		0.909.	1.035.	1.095.	1.117.	1.119.	1.096.	1.062.	1.103.	1.131.	1.134.	1.109.	1.057.	0.933.	
	0.654.	1.031.	1.120.	1.131.	1.118.	1.051.	1.055.	0.993.	1.051.	1.033.	1.113.	1.140.	1.127.	1.020.	0.626.
5	0.598.	0.978.	1.085.	1.119.	1.111.	1.043.	1.063.	1.013.	1.071.	1.057.	1.130.	1.143.	1.114.	1.008.	0.619.
	0.758.	1.032.	1.099.	1.129.	1.047.	1.041.	0.971.	0.991.	0.961.	1.027.	1.032.	1.146.	1.129.	1.008.	0.716.
6	0.681.	0.966.	1.088.	1.119.	1.043.	1.043.	0.985.	1.016.	0.994.	1.061.	1.067.	1.150.	1.124.	1.003.	0.709.
	0.903.	1.098.	1.096.	1.085.	1.048.	0.952.	0.965.	0.862.	0.969.	0.959.	1.049.	1.110.	1.130.	1.078.	0.857.
7	0.806.	1.033.	1.094.	1.096.	1.063.	0.985.	0.995.	0.899.	1.007.	1.006.	1.091.	1.130.	1.137.	1.080.	0.846.
	0.782.	1.032.	1.020.	1.033.	0.988.	0.968.	0.851.	0.906.	0.872.	1.003.	1.011.	1.074.	1.067.	1.049.	0.786.
8	0.734.	0.996.	1.030.	1.062.	1.013.	1.016.	0.899.	0.955.	0.913.	1.044.	1.046.	1.091.	1.078.	1.052.	0.778.
	0.858.	1.072.	1.089.	1.072.	1.035.	0.946.	0.941.	0.861.	0.984.	0.993.	1.094.	1.139.	1.155.	1.108.	0.876.
9	0.810.	1.037.	1.099.	1.103.	1.071.	0.994.	1.007.	0.913.	1.027.	1.031.	1.123.	1.164.	1.171.	1.111.	0.869.
	0.691.	0.980.	1.090.	1.104.	1.032.	1.026.	0.950.	0.991.	0.979.	1.080.	1.104.	1.194.	1.166.	1.066.	0.750.
10.	0.686.	0.974.	1.098.	1.131.	1.057.	1.061.	1.006.	1.044.	1.031.	1.112.	1.129.	1.223.	1.193.	1.060.	0.746.
	0.616.	1.008.	1.117.	1.106.	1.109.	1.039.	1.048.	0.990.	1.060.	1.086.	1.204.	1.230.	1.191.	1.100.	0.670.
11.	0.604.	0.989.	1.098.	1.134.	1.130.	1.067.	1.091.	1.046.	1.123.	1.129.	1.229.	1.259.	1.220.	1.093.	0.666.
		0.944.	1.079.	1.110.	1.134.	1.142.	1.082.	1.033.	1.096.	1.173.	1.232.	1.247.	1.225.	1.082.	
12		0.922.	1.050.	1.109.	1.143.	1.150.	1.130.	1.091.	1.164.	1.223.	1.259.	1.278.	1.187.	1.032.	
		0.574.	1.155.	1.099.	1.114.	1.109.	1.094.	1.020.	1.122.	1.154.	1.203.	1.166.	1.255.	0.665.	
13		0.542.	1.093.	1.057.	1.114.	1.124.	1.137.	1.078.	1.171.	1.193.	1.220.	1.187.	1.231.	0.610.	
			0.579.	0.966.	1.017.	0.994.	1.068.	1.041.	1.112.	1.051.	1.081.	1.019.	0.632.		
14			0.545.	0.933.	1.008.	1.003.	1.080.	1.052.	1.111.	1.060.	1.093.	1.032.	0.610.		
					0.626.	0.698.	0.862.	0.796.	0.900.	0.739.	0.658.				
15					0.619.	0.709.	0.846.	0.778.	0.869.	0.746.	0.666.				

. MEAS .

. EXP .

FIGURE 4.5-8

Relative Assembly Powers, 50% D@ 206

MEASURED AND EXPECTED FDHN INC-1-F1-80-8A 50% D @ 206 11/18/80 SI-126

Row		R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1	MEAS					0.624	0.710	0.834	0.758	0.867	0.768	0.677				
	EXP					0.607	0.689	0.812	0.739	0.812	0.689	0.607				
2	MEAS			0.604	1.031	1.024	1.018	1.060	1.019	1.072	1.041	1.031	0.921	0.575		
	EXP			0.544	0.929	0.997	0.987	1.050	1.015	1.050	0.987	0.997	0.929	0.544		
3	MEAS		0.572	1.152	1.130	1.151	1.147	1.120	1.042	1.111	1.110	1.113	1.059	1.158	0.611	
	EXP		0.544	1.095	1.068	1.121	1.117	1.131	1.065	1.131	1.117	1.121	1.068	1.095	0.544	
4	MEAS		0.951	1.091	1.165	1.154	1.148	1.096	1.098	1.112	1.141	1.150	1.158	1.111	0.992	
	EXP		0.929	1.068	1.166	1.163	1.157	1.141	1.135	1.141	1.157	1.163	1.166	1.068	0.929	
5	MEAS	0.659	1.040	1.139	1.163	1.141	1.068	1.074	1.025	1.073	1.060	1.131	1.157	1.130	1.004	0.611
	EXP	0.607	0.997	1.121	1.163	1.152	1.079	1.105	1.057	1.105	1.079	1.152	1.163	1.121	0.997	0.607
6	MEAS	0.776	1.051	1.112	1.150	1.067	1.066	0.995	1.028	0.988	1.053	1.043	1.153	1.122	0.993	0.693
	EXP	0.689	0.987	1.117	1.157	1.079	1.084	1.023	1.058	1.023	1.084	1.079	1.157	1.117	0.987	0.689
7	MEAS	0.906	1.107	1.121	1.122	1.080	0.984	1.002	0.904	0.995	0.974	1.058	1.121	1.125	1.053	0.824
	EXP	0.812	1.050	1.131	1.141	1.105	1.023	1.040	0.945	1.040	1.023	1.105	1.141	1.131	1.050	0.812
8	MEAS	0.778	1.042	1.052	1.109	1.025	1.008	0.898	0.983	0.903	1.014	1.014	1.110	1.056	1.027	0.763
	EXP	0.739	1.01[illegible]	1.065	1.135	1.057	1.058	0.945	1.031	0.945	1.058	1.057	1.135	1.065	1.015	0.739
9	MEAS	0.851	1.075	1.117	1.107	1.063	0.974	0.981	0.897	0.997	0.983	1.072	1.113	1.118	1.066	0.840
	EXP	0.812	1.050	1.131	1.141	1.105	1.023	1.040	0.945	1.040	1.023	1.105	1.141	1.131	1.050	0.812
10	MEAS	0.693	0.992	1.105	1.126	1.050	1.047	0.973	1.009	0.977	1.050	1.056	1.133	1.106	1.027	0.716
	EXP	0.689	0.987	1.117	1.157	1.079	1.084	1.023	1.058	1.023	1.084	1.079	1.157	1.117	0.987	0.689
11	MEAS	0.620	1.018	1.145	1.132	1.125	1.048	1.063	1.012	1.063	1.053	1.135	1.146	1.109	1.035	0.630
	EXP	0.607	0.997	1.121	1.163	1.152	1.079	1.105	1.057	1.105	1.079	1.152	1.163	1.121	0.997	0.607
12	MEAS		0.954	1.104	1.167	1.145	1.139	1.095	1.085	1.092	1.128	1.143	1.147	1.122	1.002	
	EXP		0.929	1.068	1.166	1.163	1.157	1.141	1.135	1.141	1.157	1.163	1.166	1.068	0.929	
13	MEAS		0.581	1.167	1.112	1.107	1.099	1.094	1.025	1.099	1.103	1.130	1.080	1.147	0.608	
	EXP		0.544	1.095	1.068	1.121	1.117	1.131	1.065	1.131	1.117	1.121	1.068	1.095	0.544	
14	MEAS			0.583	0.964	1.003	0.984	1.050	1.017	1.060	0.990	1.015	0.960	0.584		
	EXP			0.544	0.929	0.997	0.987	1.050	1.015	1.050	0.987	0.997	0.929	0.544		
15	MEAS					0.620	0.689	0.837	0.765	0.848	0.690	0.618				
	EXP					0.607	0.689	0.812	0.739	0.812	0.689	0.607				

MEAS
EXP

FIGURE 4.5-9

Relative Assembly Powers, 50%, D@ 211

MEASURED AND EXPECTED FDHN INC-1-F1-80-9C 50% POWER 11/20/80 D @ 211 SU-8.3 BASE CASE

		R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1	MEAS					0.608	0.696	0.832	0.753	0.828	0.688	0.598				
	EXP					0.586	0.674	0.803	0.728	0.803	0.674	0.586				
2	MEAS			0.550	0.951	0.999	1.039	1.059	1.053	1.043	1.007	0.971	0.920	0.539		
	EXP			0.519	0.899	0.962	1.005	1.039	1.039	1.039	1.005	0.962	0.899	0.519		
3	MEAS		0.542	1.120	1.071	1.171	1.146	1.166	1.050	1.150	1.085	1.131	1.050	1.115	0.546	
	EXP		0.519	1.074	1.026	1.127	1.104	1.154	1.050	1.154	1.104	1.127	1.026	1.074	0.519	
4	MEAS		0.931	1.062	1.195	1.160	1.203	1.117	1.149	1.118	1.173	1.145	1.188	1.061	0.935	
	EXP		0.899	1.026	1.168	1.143	1.185	1.136	1.166	1.136	1.185	1.143	1.168	1.026	0.899	
5	MEAS	0.606	0.984	1.150	1.157	1.180	1.069	1.122	1.034	1.125	1.063	1.177	1.158	1.163	0.992	0.606
	EXP	0.586	0.962	1.127	1.143	1.180	1.070	1.145	1.053	1.145	1.070	1.180	1.143	1.127	0.962	0.586
6	MEAS	0.694	1.015	1.082	1.174	1.058	1.104	0.992	1.070	0.987	1.091	1.034	1.203	1.134	1.033	0.697
	EXP	0.674	1.005	1.104	1.185	1.070	1.122	1.028	1.107	1.028	1.122	1.070	1.185	1.104	1.005	0.674
7	MEAS	0.826	1.050	1.136	1.111	1.111	0.984	1.051	0.926	1.051	0.980	1.106	1.140	1.177	1.067	0.840
	EXP	0.803	1.039	1.154	1.136	1.145	1.028	1.099	0.977	1.099	1.028	1.145	1.136	1.154	1.039	0.803
8	MEAS	0.738	1.046	1.036	1.137	1.016	1.050	0.919	1.033	0.928	1.061	1.024	1.164	1.066	1.068	0.761
	EXP	0.728	1.039	1.050	1.166	1.053	1.107	0.977	1.098	0.977	1.107	1.053	1.166	1.050	1.039	0.728
9	MEAS	0.812	1.045	1.149	1.100	1.093	0.968	1.022	0.911	1.051	0.992	1.132	1.129	1.169	1.070	0.839
	EXP	0.803	1.039	1.154	1.136	1.145	1.028	1.099	0.977	1.099	1.028	1.145	1.136	1.154	1.039	0.803
10	MEAS	0.683	1.018	1.100	1.152	1.039	1.075	0.965	1.041	0.971	1.092	1.064	1.179	1.108	1.047	0.702
	EXP	0.674	1.005	1.104	1.185	1.070	1.122	1.028	1.107	1.028	1.122	1.070	1.185	1.104	1.005	0.674
11	MEAS	0.604	0.992	1.163	1.113	1.160	1.039	1.100	0.997	1.092	1.047	1.177	1.141	1.124	1.008	0.614
	EXP	0.586	0.962	1.127	1.143	1.180	1.070	1.145	1.053	1.145	1.070	1.180	1.143	1.127	0.962	0.586
12	MEAS		0.933	1.072	1.196	1.155	1.197	1.102	1.112	1.084	1.158	1.137	1.162	1.047	0.943	
	EXP		0.899	1.026	1.168	1.143	1.185	1.136	1.166	1.136	1.185	1.143	1.168	1.026	0.899	
13	MEAS		0.545	1.127	1.069	1.147	1.108	1.128	1.010	1.128	1.094	1.152	1.047	1.108	0.546	
	EXP		0.519	1.074	1.026	1.127	1.104	1.154	1.050	1.154	1.104	1.127	1.026	1.074	0.519	
14	MEAS			0.545	0.932	0.985	1.013	1.013	1.013	1.030	1.030	0.998	0.943	0.546		
	EXP			0.519	0.899	0.962	1.005	1.039	1.039	1.039	1.005	0.962	0.899	0.519		
15	MEAS					0.596	0.673	0.791	0.718	0.810	0.690	0.608				
	EXP					0.586	0.674	0.803	0.728	0.803	0.674	0.586				

FIGURE 4.5-10

Relative Assembly Powers, 50% Dropped RCCA

MEASURED AND EXPECTED FDHN INC-1-F1-80-108 SU-8.3 50% POWER DROPPED ROD CASE 11/20/80 D@211

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1					0.714	0.816	0.955	0.866	0.979	0.860	0.754				
					0.688	0.779	0.915	0.829	0.907	0.765	0.671				
2			0.719	1.224	1.170	1.166	1.219	1.171	1.220	1.170	1.150	1.022	0.625		
			0.618	1.051	1.127	1.114	1.180	1.137	1.168	1.092	1.095	1.013	0.591		
3		0.669	1.344	1.324	1.313	1.304	1.290	1.201	1.268	1.251	1.240	1.167	1.247	0.646	
		0.618	1.239	1.207	1.265	1.257	1.267	1.188	1.252	1.227	1.223	1.157	1.178	0.583	
4		1.098	1.259	1.368	1.376	1.364	1.274	1.259	1.261	1.269	1.268	1.254	1.181	1.038	
		1.051	1.207	1.315	1.309	1.297	1.273	1.258	1.254	1.260	1.256	1.249	1.137	0.982	
5	0.758	1.198	1.311	1.354	1.335	1.241	1.224	1.157	1.198	1.162	1.228	1.227	1.175	1.038	0.627
	0.688	1.127	1.265	1.309	1.293	1.205	1.225	1.161	1.201	1.160	1.226	1.225	1.173	1.036	0.627
6	0.890	1.206	1.278	1.333	1.234	1.236	1.123	1.142	1.073	1.123	1.095	1.184	1.134	0.997	0.695
	0.779	1.114	1.257	1.297	1.205	1.202	1.123	1.148	1.093	1.142	1.121	1.188	1.138	1.000	0.694
7	1.036	1.270	1.289	1.287	1.230	1.105	1.107	0.977	1.050	0.998	1.059	1.089	1.085	1.009	0.790
	0.915	1.180	1.267	1.273	1.225	1.123	1.127	1.007	1.086	1.045	1.110	1.130	1.110	1.024	0.790
8	0.891	1.195	1.206	1.268	1.162	1.114	0.956	1.024	0.915	0.991	0.961	1.020	0.961	0.919	0.674
	0.829	1.137	1.188	1.258	1.161	1.148	1.007	1.072	0.956	1.039	1.010	1.065	0.989	0.939	0.683
9	0.969	1.225	1.273	1.248	1.182	1.057	1.031	0.911	0.971	0.907	0.941	0.942	0.937	0.881	0.692
	0.907	1.168	1.252	1.254	1.201	1.093	1.086	0.956	1.011	0.950	0.985	0.988	0.969	0.903	0.702
10	0.778	1.111	1.247	1.237	1.139	1.109	0.981	0.981	0.896	0.878	0.813	0.830	0.823	0.750	0.533
	0.765	1.092	1.227	1.260	1.160	1.142	1.045	1.039	0.950	0.941	0.869	0.884	0.851	0.769	0.546
11	0.683	1.114	1.245	1.233	1.206	1.094	1.058	0.939	0.906	0.787	0.729	0.634	0.653	0.663	0.427
	0.671	1.095	1.223	1.256	1.226	1.121	1.110	1.010	0.985	0.869	0.798	0.694	0.708	0.680	0.439
12		1.036	1.188	1.247	1.207	1.171	1.058	0.971	0.901	0.802	0.616	0.344	0.508	0.548	
		1.013	1.157	1.249	1.225	1.188	1.130	1.065	0.988	0.884	0.694	0.388	0.543	0.556	
13		0.626	1.248	1.174	1.153	1.102	1.042	0.905	0.894	0.798	0.649	0.486	0.528	0.300	
		0.591	1.178	1.137	1.173	1.138	1.110	0.989	0.969	0.851	0.708	0.543	0.568	0.300	
14			0.621	1.006	1.019	0.968	0.978	0.898	0.869	0.737	0.636	0.507	0.287		
			0.583	0.982	1.036	1.000	1.024	0.939	0.903	0.769	0.680	0.556	0.300		
15					0.619	0.669	0.780	0.677	0.700	0.524	0.410				
					0.627	0.694	0.790	0.683	0.702	0.546	0.439				

MEAS

EXP

FIGURE 4.5-11

Relative Assembly Powers, 75%, D@ 193

MEASURED AND EXPECTED FDHN INC-1-F1-80-11A 75% POWER 11/30/80 D @ 193 SI-126

		R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1	MEAS					0.616	0.696	0.835	0.754	0.833	0.685	0.595				
	EXP					0.591	0.680	0.812	0.736	0.812	0.680	0.591				
2	MEAS			0.532	0.922	1.008	1.038	1.062	1.054	1.045	1.003	0.960	0.898	0.530		
	EXP			0.519	0.900	0.967	1.013	1.047	1.047	1.047	1.013	0.967	0.900	0.519		
3	MEAS		0.532	1.095	1.034	1.176	1.155	1.174	1.052	1.153	1.078	1.111	1.016	1.093	0.543	
	EXP		0.519	1.070	1.019	1.128	1.108	1.156	1.047	1.156	1.108	1.128	1.019	1.070	0.519	
4	MEAS		0.923	1.042	1.147	1.150	1.200	1.116	1.127	1.114	1.172	1.126	1.150	1.046	0.936	
	EXP		0.900	1.019	1.139	1.137	1.186	1.131	1.139	1.131	1.186	1.137	1.139	1.019	0.900	
5	MEAS	0.603	0.979	1.145	1.144	1.188	1.081	1.147	1.046	1.142	1.067	1.177	1.156	1.157	0.992	0.600
	EXP	0.591	0.967	1.128	1.137	1.178	1.072	1.143	1.047	1.143	1.072	1.178	1.137	1.128	0.967	0.591
6	MEAS	0.682	1.014	1.099	1.184	1.072	1.134	1.028	1.100	1.004	1.098	1.039	1.206	1.132	1.034	0.691
	EXP	0.680	1.013	1.108	1.186	1.072	1.125	1.029	1.107	1.029	1.125	1.072	1.186	1.108	1.013	0.680
7	MEAS	0.821	1.050	1.145	1.113	1.126	1.005	1.080	0.946	1.069	0.991	1.123	1.139	1.176	1.066	0.839
	EXP	0.812	1.047	1.156	1.131	1.143	1.029	1.097	0.971	1.097	1.029	1.143	1.131	1.156	1.047	0.812
8	MEAS	0.737	1.043	1.030	1.11[illegible]	1.020	1.064	0.926	1.032	0.941	1.077	1.030	1.140	1.065	1.068	0.763
	EXP	0.736	1.047	1.047	1.139	1.047	1.107	0.971	1.071	0.971	1.107	1.047	1.139	1.047	1.047	0.736
9	MEAS	0.812	1.042	1.137	1.102	1.107	0.986	1.042	0.931	1.079	1.012	1.145	1.132	1.177	1.069	0.841
	EXP	0.812	1.047	1.156	1.131	1.143	1.029	1.097	0.971	1.097	1.029	1.143	1.131	1.156	1.047	0.812
10	MEAS	0.683	1.016	1.085	1.168	1.054	1.092	0.980	1.064	0.998	1.109	1.069	1.185	1.124	1.046	0.702
	EXP	0.680	1.013	1.108	1.186	1.072	1.125	1.029	1.107	1.029	1.125	1.072	1.186	1.108	1.013	0.680
11	MEAS	0.608	0.995	1.161	1.120	1.166	1.050	1.109	1.001	1.099	1.048	1.186	1.146	1.143	1.008	0.615
	EXP	0.591	0.967	1.128	1.137	1.178	1.072	1.143	1.047	1.143	1.072	1.178	1.137	1.128	0.967	0.591
12	MEAS		0.917	1.028	1.153	1.149	1.198	1.097	1.085	1.080	1.158	1.141	1.145	1.052	0.943	
	EXP		0.900	1.019	1.139	1.137	1.186	1.131	1.139	1.131	1.186	1.137	1.139	1.019	0.900	
13	MEAS		0.527	1.085	1.037	1.145	1.104	1.119	0.997	1.125	1.097	1.149	1.039	1.103	0.546	
	EXP		0.519	1.070	1.019	1.128	1.108	1.156	1.047	1.156	1.108	1.128	1.019	1.070	0.519	
14	MEAS			0.527	0.919	0.993	1.016	1.013	1.014	1.036	1.033	0.989	0.923	0.539		
	EXP			0.519	0.900	0.967	1.013	1.047	1.047	1.047	1.013	0.967	0.900	0.519		
15	MEAS					0.607	0.676	0.797	0.724	0.821	0.694	0.604				
	EXP					0.591	0.680	0.812	0.736	0.812	0.680	0.591				

. MEAS .
. EXP .

FIGURE 4.5-12

Relative Assembly Powers, 75%, D@ 191

MEASURED AND EXPECTED FDHN INC-1-F1-80-12D SU-8.6B R1R2 CALCULATION 75% POWER 12-19-8C

Row		R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1	MEAS					0.600	0.686	0.819	0.743	0.811	0.667	0.577				
	EXP					0.582	0.673	0.801	0.728	0.801	0.673	0.582				
2	MEAS			0.532	0.923	0.989	1.026	1.054	1.046	1.037	0.991	0.948	0.883	0.518		
	EXP			0.512	0.886	0.959	1.006	1.043	1.041	1.043	1.006	0.959	0.886	0.512		
3	MEAS		0.523	1.077	1.033	1.157	1.144	1.171	1.058	1.156	1.087	1.108	1.009	1.067	0.527	
	EXP		0.512	1.053	1.013	1.121	1.109	1.155	1.052	1.155	1.109	1.121	1.013	1.053	0.512	
4	MEAS		0.899	1.025	1.142	1.165	1.214	1.135	1.137	1.130	1.182	1.135	1.142	1.031	0.912	
	EXP		0.886	1.013	1.131	1.140	1.189	1.139	1.141	1.139	1.189	1.140	1.131	1.013	0.886	
5	MEAS	0.592	0.970	1.136	1.153	1.198	1.097	1.160	1.066	1.157	1.087	1.193	1.161	1.149	0.982	0.595
	EXP	0.582	0.959	1.121	1.140	1.182	1.084	1.153	1.062	1.153	1.084	1.182	1.140	1.121	0.959	0.582
6	MEAS	0.678	1.014	1.088	1.190	1.087	1.139	1.038	1.110	1.021	1.115	1.057	1.214	1.138	1.031	0.688
	EXP	0.673	1.006	1.109	1.189	1.084	1.137	1.046	1.121	1.046	1.137	1.084	1.189	1.109	1.006	0.673
7	MEAS	0.808	1.049	1.144	1.124	1.139	1.027	1.095	0.969	1.087	1.013	1.140	1.162	1.183	1.068	0.826
	EXP	0.801	1.043	1.155	1.139	1.153	1.046	1.113	0.991	1.113	1.046	1.153	1.139	1.155	1.043	0.801
8	MEAS	0.725	1.038	1.040	1.125	1.041	1.092	0.961	1.053	0.964	1.098	1.053	1.157	1.077	1.066	0.750
	EXP	0.728	1.041	1.052	1.141	1.062	1.121	0.991	1.086	0.991	1.121	1.062	1.141	1.052	1.041	0.728
9	MEAS	0.797	1.039	1.145	1.116	1.118	1.005	1.059	0.950	1.099	1.038	1.165	1.152	1.180	1.066	0.825
	EXP	0.801	1.043	1.155	1.139	1.153	1.046	1.113	0.991	1.113	1.046	1.153	1.139	1.155	1.043	0.801
10	MEAS	0.670	1.001	1.090	1.164	1.061	1.099	0.994	1.075	1.013	1.129	1.092	1.198	1.128	1.034	0.692
	EXP	0.673	1.006	1.109	1.189	1.084	1.137	1.046	1.121	1.046	1.137	1.084	1.189	1.109	1.006	0.673
11	MEAS	0.587	0.967	1.131	1.118	1.172	1.062	1.120	1.013	1.107	1.067	1.201	1.159	1.145	0.992	0.602
	EXP	0.582	0.959	1.121	1.140	1.182	1.084	1.153	1.062	1.153	1.084	1.182	1.140	1.121	0.959	0.582
12	MEAS		0.893	1.019	1.138	1.149	1.199	1.111	1.091	1.090	1.168	1.158	1.150	1.042	0.916	
	EXP		0.886	1.013	1.131	1.140	1.189	1.139	1.141	1.139	1.189	1.140	1.131	1.013	0.886	
13	MEAS		0.519	1.068	1.026	1.134	1.104	1.125	1.006	1.124	1.095	1.143	1.037	1.081	0.528	
	EXP		0.512	1.053	1.013	1.121	1.109	1.155	1.052	1.155	1.109	1.121	1.013	1.053	0.512	
14	MEAS			0.517	0.896	0.966	0.997	1.007	1.006	1.026	1.017	0.975	0.906	0.525		
	EXP			0.512	0.886	0.959	1.006	1.043	1.041	1.043	1.006	0.959	0.886	0.512		
15	MEAS					0.586	0.662	0.780	0.710	0.800	0.680	0.592				
	EXP					0.582	0.673	0.801	0.728	0.801	0.673	0.582				

. MEAS .
. EXP .

FIGURE 4.5-13

<u>Relative Assembly Powers, 75%, D@ 169</u>

MEASURED AND EXPECTED FDHN INC-1-F1-80-13D SU-8.6B R1R2 CALCULATION 75% POWER 12-20-80

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
					0.605.	0.690.	0.828.	0.752.	0.810.	0.653.	0.564.				
1					0.586.	0.678.	0.808.	0.734.	0.808.	0.678.	0.586.				
			0.534.	0.926.	0.995.	1.032.	1.063.	1.054.	1.037.	0.980.	0.940.	0.880.	0.520.		
2			0.511.	0.888.	0.963.	1.012.	1.050.	1.047.	1.050.	1.012.	0.963.	0.888.	0.511.		
		0.513.	1.054.	1.014.	1.159.	1.150.	1.183.	1.067.	1.165.	1.085.	1.102.	0.999.	1.067.	0.533.	
3		0.511.	1.050.	1.008.	1.121.	1.113.	1.157.	1.049.	1.157.	1.113.	1.121.	1.008.	1.050.	0.511.	
		0.874.	0.991.	1.103.	1.158.	1.213.	1.144.	1.121.	1.129.	1.178.	1.125.	1.115.	1.027.	0.918.	
4		0.888.	1.008.	1.108.	1.136.	1.190.	1.135.	1.118.	1.135.	1.190.	1.136.	1.108.	1.008.	0.888.	
	0.588.	0.955.	1.103.	1.130.	1.195.	1.098.	1.163.	1.062.	1.157.	1.083.	1.188.	1.153.	1.150.	0.987.	0.600.
5	0.586.	0.963.	1.121.	1.136.	1.181.	1.086.	1.152.	1.057.	1.152.	1.086.	1.181.	1.136.	1.121.	0.963.	0.586.
	0.683.	1.020.	1.120.	1.205.	1.096.	1.139.	1.032.	1.100.	1.008.	1.105.	1.045.	1.222.	1.150.	1.045.	0.694.
6	0.678.	1.012.	1.113.	1.190.	1.086.	1.140.	1.047.	1.122.	1.047.	1.140.	1.086.	1.190.	1.113.	1.012.	0.678.
	0.814.	1.060.	1.168.	1.136.	1.148.	1.033.	1.095.	0.966.	1.081.	1.012.	1.140.	1.179.	1.199.	1.089.	0.834.
7	0.808.	1.050.	1.157.	1.135.	1.152.	1.047.	1.112.	0.987.	1.112.	1.047.	1.152.	1.135.	1.157.	1.050.	0.808.
	0.735.	1.052.	1.054.	1.117.	1.049.	1.100.	0.966.	1.035.	0.958.	1.099.	1.051.	1.151.	1.090.	1.088.	0.760.
8	0.734.	1.047.	1.049.	1.118.	1.057.	1.122.	0.987.	1.063.	0.987.	1.122.	1.057.	1.118.	1.049.	1.047.	0.734.
	0.808.	1.053.	1.160.	1.118.	1.118.	1.013.	1.071.	0.952.	1.105.	1.046.	1.171.	1.157.	1.190.	1.086.	0.836.
9	0.808.	1.050.	1.157.	1.135.	1.152.	1.047.	1.112.	0.987.	1.112.	1.047.	1.152.	1.135.	1.157.	1.050.	0.808.
	0.677.	1.011.	1.104.	1.163.	1.060.	1.100.	0.989.	1.068.	1.005.	1.131.	1.092.	1.197.	1.124.	1.044.	0.699.
10.	0.678.	1.012.	1.113.	1.190.	1.086.	1.140.	1.047.	1.122.	1.047.	1.140.	1.086.	1.190.	1.113.	1.012.	0.678.
	0.590.	0.969.	1.128.	1.111.	1.176.	1.068.	1.121.	1.006.	1.104.	1.071.	1.193.	1.148.	1.136.	0.994.	0.605.
11.	0.586.	0.963.	1.121.	1.136.	1.181.	1.086.	1.152.	1.057.	1.152.	1.086.	1.181.	1.136.	1.121.	0.963.	0.586.
		0.879.	0.984.	1.095.	1.141.	1.198.	1.110.	1.068.	1.085.	1.173.	1.148.	1.122.	1.025.	0.909.	
12		0.888.	1.008.	1.108.	1.136.	1.190.	1.135.	1.118.	1.135.	1.190.	1.136.	1.108.	1.008.	0.888.	
		0.510.	1.046.	1.001.	1.128.	1.105.	1.133.	1.005.	1.138.	1.118.	1.147.	1.023.	1.067.	0.520.	
13		0.511.	1.050.	1.008.	1.121.	1.113.	1.157.	1.049.	1.157.	1.113.	1.121.	1.008.	1.050.	0.511.	
			0.511.	0.887.	0.964.	0.998.	1.013.	1.011.	1.042.	1.051.	0.988.	0.899.	0.519.		
14			0.511.	0.888.	0.963.	1.012.	1.050.	1.047.	1.050.	1.012.	0.963.	0.888.	0.511.		
					0.597.	0.672.	0.787.	0.716.	0.818.	0.704.	0.601.				
15					0.586.	0.678.	0.808.	0.734.	0.808.	0.678.	0.586.				

. MEAS .
. EXP .

FIGURE 4.5-14

Relative Assembly Powers, 75%, D@ 195

MEASURED AND EXPECTED FDHN INC-1-F1-80-14D SU-8.6B R1R2 CALCULATION 75% POWER 12-20-80

Row		R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1	MEAS					0.599	0.684	0.819	0.743	0.813	0.669	0.579				
	EXP					0.583	0.674	0.803	0.730	0.803	0.674	0.583				
2	MEAS			0.531	0.921	0.986	1.023	1.053	1.045	1.037	0.991	0.949	0.886	0.519		
	EXP			0.512	0.887	0.960	1.007	1.045	1.043	1.045	1.007	0.960	0.887	0.512		
3	MEAS		0.524	1.079	1.035	1.152	1.140	1.168	1.056	1.152	1.082	1.107	1.010	1.067	0.527	
	EXP		0.512	1.052	1.012	1.121	1.110	1.156	1.051	1.156	1.110	1.121	1.012	1.052	0.512	
4	MEAS		0.903	1.029	1.139	1.159	1.210	1.130	1.130	1.126	1.181	1.133	1.136	1.030	0.912	
	EXP		0.887	1.012	1.125	1.139	1.189	1.138	1.135	1.138	1.189	1.139	1.125	1.012	0.887	
5	MEAS	0.592	0.973	1.141	1.154	1.194	1.094	1.158	1.064	1.156	1.088	1.192	1.159	1.147	0.981	0.593
	EXP	0.583	0.960	1.121	1.139	1.182	1.085	1.153	1.060	1.153	1.085	1.182	1.139	1.121	0.960	0.583
6	MEAS	0.678	1.013	1.085	1.185	1.083	1.139	1.039	1.113	1.024	1.117	1.059	1.212	1.135	1.029	0.685
	EXP	0.674	1.007	1.110	1.189	1.085	1.138	1.047	1.121	1.047	1.138	1.085	1.189	1.110	1.007	0.674
7	MEAS	0.810	1.050	1.140	1.120	1.136	1.029	1.096	0.971	1.088	1.014	1.141	1.159	1.181	1.066	0.826
	EXP	0.803	1.045	1.156	1.138	1.153	1.047	1.113	0.990	1.113	1.047	1.153	1.138	1.156	1.045	0.803
8	MEAS	0.726	1.037	1.035	1.116	1.038	1.095	0.963	1.050	0.964	1.098	1.052	1.149	1.075	1.064	0.749
	EXP	0.730	1.043	1.051	1.135	1.060	1.121	0.990	1.080	0.990	1.121	1.060	1.135	1.051	1.043	0.730
9	MEAS	0.798	1.038	1.140	1.113	1.117	1.006	1.062	0.952	1.100	1.038	1.165	1.151	1.181	1.064	0.824
	EXP	0.803	1.045	1.156	1.138	1.153	1.047	1.113	0.990	1.113	1.047	1.153	1.138	1.156	1.045	0.803
10	MEAS	0.671	1.002	1.085	1.164	1.060	1.100	0.998	1.079	1.018	1.131	1.092	1.198	1.131	1.028	0.688
	EXP	0.674	1.007	1.110	1.189	1.085	1.138	1.047	1.121	1.047	1.138	1.085	1.189	1.110	1.007	0.674
11	MEAS	0.592	0.974	1.138	1.117	1.171	1.063	1.122	1.015	1.111	1.069	1.204	1.161	1.150	0.986	0.599
	EXP	0.583	0.960	1.121	1.139	1.182	1.085	1.153	1.060	1.153	1.085	1.182	1.139	1.121	0.960	0.583
12	MEAS		0.898	1.023	1.138	1.151	1.202	1.111	1.087	1.091	1.170	1.161	1.146	1.047	0.916	
	EXP		0.887	1.012	1.125	1.139	1.189	1.138	1.135	1.138	1.189	1.139	1.125	1.012	0.887	
13	MEAS		0.520	1.070	1.028	1.138	1.108	1.125	1.006	1.125	1.097	1.148	1.041	1.087	0.531	
	EXP		0.512	1.052	1.012	1.121	1.110	[illegible]	1.051	1.156	1.110	1.121	1.012	1.052	0.512	
14	MEAS			0.520	0.898	0.968	1.000	1.009	1.007	1.027	1.019	0.978	0.909	0.528		
	EXP			0.512	0.887	0.960	1.007	1.045	1.043	1.045	1.007	0.960	0.887	0.512		
15	MEAS					0.584	0.662	0.782	0.712	0.802	0.682	0.594				
	EXP					0.583	0.674	0.803	0.730	0.803	0.674	0.583				

. MEAS .
. EXP .

FIGURE 4.5-15

Relative Assembly Powers, 90%, D@ 205

MEASURED AND EXPECTED FDHN   INC-1-F1-80-15A   SU-8.5.1   90% POWER   12/29/80

Row		R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1	MEAS					0.590.	0.673.	0.804.	0.730.	0.798.	0.657.	0.568.				
	EXP					0.570.	0.660.	0.785.	0.715.	0.785.	0.660.	0.570.				
2	MEAS			0.524.	0.906.	0.979.	1.012.	1.044.	1.034.	1.026.	0.977.	0.933.	0.862.	0.508.		
	EXP			0.506.	0.875.	0.947.	0.992.	1.032.	1.029.	1.032.	0.992.	0.947.	0.875.	0.506.		
3	MEAS		0.515.	1.064.	1.030.	1.155.	1.143.	1.163.	1.059.	1.146.	1.077.	1.094.	1.001.	1.050.	0.517.	
	EXP		0.506.	1.046.	1.016.	1.117.	1.106.	1.152.	1.058.	1.152.	1.106.	1.117.	1.016.	1.046.	0.506.	
4	MEAS		0.883.	1.023.	1.166.	1.174.	1.214.	1.135.	1.163.	1.134.	1.179.	1.137.	1.165.	1.026.	0.895.	
	EXP		0.875.	1.016.	1.159.	1.149.	1.189.	1.151.	1.175.	1.151.	1.189.	1.149.	1.159.	1.016.	0.875.	
5	MEAS	0.579.	0.955.	1.125.	1.157.	1.205.	1.108.	1.169.	1.081.	1.163.	1.093.	1.196.	1.167.	1.144.	0.970.	0.585.
	EXP	0.570.	0.947.	1.117.	1.149.	1.186.	1.091.	1.161.	1.078.	1.161.	1.091.	1.186.	1.149.	1.117.	0.947.	0.570.
6	MEAS	0.665.	1.000.	1.078.	1.186.	1.094.	1.162.	1.072.	1.141.	1.041.	1.124.	1.070.	1.209.	1.131.	1.014.	0.677.
	EXP	0.660.	0.992.	1.106.	1.189.	1.091.	1.142.	1.057.	1.131.	1.057.	1.142.	1.091.	1.189.	1.106.	0.992.	0.660.
7	MEAS	0.796.	1.041.	1.137.	1.135.	1.150.	1.055.	1.129.	1.012.	1.113.	1.034.	1.148.	1.163.	1.175.	1.056.	0.812.
	EXP	0.785.	1.032.	1.152.	1.151.	1.161.	1.057.	1.126.	1.011.	1.126.	1.057.	1.161.	1.151.	1.152.	1.032.	0.785.
8	MEAS	0.716.	1.029.	1.044.	1.160.	1.059.	1.123.	1.006.	1.118.	0.992.	1.117.	1.072.	1.185.	1.077.	1.051.	0.736.
	EXP	0.715.	1.029.	1.058.	1.175.	1.078.	1.131.	1.011.	1.128.	1.011.	1.131.	1.078.	1.175.	1.058.	1.029.	0.715.
9	MEAS	0.785.	1.031.	1.141.	1.133.	1.134.	1.024.	1.082.	0.979.	1.119.	1.055.	1.170.	1.158.	1.170.	1.054.	0.808.
	EXP	0.785.	1.032.	1.152.	1.151.	1.161.	1.057.	1.126.	1.011.	1.126.	1.057.	1.161.	1.151.	1.152.	1.032.	0.785.
10	MEAS	0.659.	0.990.	1.085.	1.167.	1.071.	1.110.	1.015.	1.095.	1.031.	1.139.	[illegible]	1.198.	1.119.	1.016.	0.676.
	EXP	0.660.	0.992.	1.106.	1.189.	1.091.	1.142.	1.057.	1.131.	1.057.	1.142.	1.091.	1.189.	1.106.	0.992.	0.660.
11	MEAS	0.580.	0.962.	1.135.	1.129.	1.176.	1.072.	1.134.	1.035.	1.117.	1.072.	1.195.	1.158.	1.126.	0.977.	0.589.
	EXP	0.570.	0.947.	1.117.	1.149.	1.186.	1.091.	1.161.	1.078.	1.161.	1.091.	1.186.	1.149.	1.117.	0.947.	0.570.
12	MEAS		0.881.	1.013.	1.160.	1.155.	1.195.	1.123.	1.126.	1.102.	1.166.	1.155.	1.165.	1.033.	0.903.	
	EXP		0.875.	1.016.	1.159.	1.149.	1.189.	1.151.	1.175.	1.151.	1.189.	1.149.	1.159.	1.016.	0.875.	
13	MEAS		0.509.	1.051.	1.022.	1.126.	1.098.	1.120.	1.010.	1.120.	1.091.	1.126.	1.021.	1.061.	0.522.	
	EXP		0.506.	1.046.	1.016.	1.117.	1.106.	1.152.	1.058.	1.152.	1.106.	1.117.	1.016.	1.046.	0.506.	
14	MEAS			0.510.	0.881.	0.954.	0.983.	1.000.	0.997.	1.019.	1.007.	0.957.	0.881.	0.516.		
	EXP			0.506.	0.875.	0.947.	0.992.	1.032.	1.029.	1.032.	0.992.	0.947.	0.875.	0.506.		
15	MEAS					0.574.	0.650.	0.769.	0.702.	0.790.	0.670.	0.577.				
	EXP					0.570.	0.660.	0.785.	0.715.	0.785.	0.660.	0.570.				

. MEAS .
. EXP .

-77-

FIGURE 4.5-16

Relative Assembly Powers, 62%, D@ 190

MEASURED AND EXPECTED FDHN INC-1-F1-81-1A 62% POWER 2/2/81 SI-79 SI-126

Row		R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1	MEAS					0.579	0.667	0.790	0.720	0.787	0.659	0.566				
	EXP					0.566	0.659	0.782	0.716	0.782	0.659	0.566				
2	MEAS			0.531	0.916	0.965	1.002	1.045	1.031	1.039	0.989	0.945	0.868	0.505		
	EXP			0.499	0.860	0.942	0.990	1.037	1.028	1.037	0.990	0.942	0.860	0.499		
3	MEAS		0.520	1.065	1.047	1.134	1.140	1.158	1.066	1.150	1.111	1.110	1.012	1.035	0.507	
	EXP		0.499	1.022	1.004	1.106	1.112	1.149	1.064	1.149	1.112	1.106	1.004	1.022	0.499	
4	MEAS		0.887	1.034	1.150	1.192	1.236	1.154	1.145	1.153	1.192	1.155	1.128	1.016	0.873	
	EXP		0.860	1.004	1.117	1.147	1.189	1.156	1.147	1.156	1.189	1.147	1.117	1.004	0.860	
5	MEAS	0.587	0.971	1.140	1.183	1.222	1.144	1.184	1.098	1.173	1.117	1.204	1.163	1.122	0.955	0.574
	EXP	0.566	0.942	1.106	1.147	1.186	1.111	1.169	1.093	1.169	1.111	1.186	1.147	1.106	0.942	0.566
6	MEAS	0.661	1.027	1.091	1.200	1.127	1.172	1.090	1.146	1.081	1.152	1.106	1.200	1.123	0.999	0.669
	EXP	0.659	0.990	1.112	1.189	1.111	1.158	1.084	1.147	1.084	1.158	1.111	1.189	1.112	0.990	0.659
7	MEAS	0.784	1.045	1.146	1.157	1.174	1.077	1.134	1.018	1.138	1.057	1.140	1.162	1.162	1.049	0.796
	EXP	0.782	1.037	1.149	1.156	1.169	1.084	1.141	1.031	1.141	1.084	1.169	1.156	1.149	1.037	0.782
8	MEAS	0.709	1.026	1.055	1.149	1.092	1.129	1.000	1.079	1.002	1.131	1.089	1.155	1.075	1.041	0.731
	EXP	0.716	1.028	1.064	1.147	1.093	1.147	1.031	1.113	1.031	1.147	1.093	1.147	1.064	1.028	0.716
9	MEAS	0.774	1.033	1.143	1.157	1.163	1.060	1.098	0.994	1.104	1.075	1.183	1.169	1.164	1.054	0.799
	EXP	0.782	1.037	1.149	1.156	1.169	1.084	1.141	1.031	1.141	1.084	1.169	1.156	1.149	1.037	0.782
10	MEAS	0.645	0.968	1.087	1.176	1.098	1.134	1.053	1.114	1.058	1.157	1.125	1.204	1.121	1.009	0.672
	EXP	0.659	0.990	1.112	1.189	1.111	1.158	1.084	1.147	1.084	1.158	1.111	1.189	1.112	0.990	0.659
11	MEAS	0.554	0.923	1.084	1.135	1.175	1.092	1.144	1.061	1.138	1.098	1.200	1.160	1.117	0.961	0.577
	EXP	0.566	0.942	1.106	1.147	1.186	1.111	1.169	1.093	1.169	1.111	1.186	1.147	1.106	0.942	0.566
12	MEAS		0.854	1.010	1.116	1.141	1.182	1.136	1.114	1.123	1.174	1.162	1.129	1.019	0.878	
	EXP		0.860	1.004	1.117	1.147	1.189	1.156	1.147	1.156	1.189	1.147	1.117	1.004	0.860	
13	MEAS		0.505	1.035	1.009	1.097	1.089	1.116	1.023	1.112	1.075	1.101	1.010	1.033	0.509	
	EXP		0.499	1.022	1.004	1.106	1.112	1.149	1.064	1.149	1.112	1.106	1.004	1.022	0.499	
14	MEAS			0.506	0.857	0.923	0.960	1.000	0.992	1.006	0.960	0.929	0.861	0.504		
	EXP			0.499	0.860	0.942	0.990	1.037	1.028	1.037	0.990	0.942	0.860	0.499		
15	MEAS					0.548	0.633	0.752	0.689	0.759	0.639	0.558				
	EXP					0.566	0.659	0.782	0.716	0.782	0.659	0.566				

MEAS
EXP

4.0 CORE PERFORMANCE (continued)

4.5.2 Transient Power Distribution

There were three tests in which the power distribution effects, as a result of transients, were measured during the startup test program. These tests were the ejected rod at HZP and the ejected and dropped rod tests at power. The following paragraphs discuss the results of these tests.

4.5.2.1 Ejected RCCA at HZP (Test procedure SU-7.3.2)

The purpose of this test was to verify the conservatism of the assumed value of the heat flux hot channel factor, $F_Q(Z)$, in the safety analysis. With the control banks at the HZP insertion limits, RCCA D-12 was chosen as the rod to withdraw because of its maximum adverse effect on the hot channel factor.

With control bank D fully inserted and control bank C at 81/82 steps, a full core (base case) flux map along with associated nuclear instrumentation (NIS) data was taken. RCCA D-12 was withdrawn during a boration to the top of the core. A second full core (ejected case) flux map was taken along with NIS data. RCCA D-12 was then reinserted into the core during a dilution.

The power distribution prior to RCCA withdrawal and after RCCA withdrawal was measured by flux mapping and analyzed by the INCORE 3 computer program. The results of the analysis, INC-1-F1-80-3F, (base case) and INC-1-F1-80-4G (ejected case), is shown in Table 4.5-1 and Figures 4.5-3 and 4.5-4, respectively. Of specific interest is the $F_Q(Z)$ with RCCA D-12 withdrawn which is 10.13. This value meets the FSAR criteria of less than or equal to 14.05. Also, seven assemblies failed to meet acceptance criteria for the ejected rod map, on relative assembly power. Westinghouse review showed that when design value conservatism was considered, no safety or operational problem existed.

4.5.2.2 Ejected RCCA at Power (Test procedure SU-8.2)

At the 30% power plateau with bank D positioned at the HFP insertion limit, RCCA D-12 was withdrawn from the core. Flux maps and NIS data were taken prior to RCCA ejection and after RCCA ejection. The results of the flux maps, obtained from INCORE runs INC-1-F1-80-6A and INC-1-F1-80-7A, are shown in Table 4.5-1 and Figures 4.5-6 and 4.5-7. All acceptance criteria were met.

The NIS demonstrated a positive response to the RCCA being above the control bank D position. Figure 4.5-17 shows the NIS detector response to the ejected rod.

FIGURE 4.5-17

Excore Detector Response

Ejected RCCA

Base Case #

29.480	29.667	29.675	29.383

Ejected Case #

29.708	32.583	30.225	29.892

Normalized Tilt Values

Base Case

0.9976	1.0042
0.9943	1.0039

N-41	N-43
N-44	N-42

Ejected Case

0.9708	0.9877
0.9768	1.0647

Average values of Q (% Power) over the time flux maps were taken

4.0 CORE PERFORMANCE (continued)

4.5.2.3 Dropped RCCA at Power (Test procedure SU-8.3)

This test verified for safety margin considerations the effects on power distribution caused by a dropped RCC assembly. Again D-12 was chosen because of design predictions that it would produce the largest changes in hot channel factors.

With control bank D at 210 step, and reactor power near 50%, RCCA D-12 was inserted into the core during a boron dilution. Full core flux maps and NIS data were taken before and after the RCCA was inserted. Selected incore flux traces and NIS data were periodically obtained during the insertion of D-12. A reactor trip occurred immediately after the completion of the second flux map, thus, the realignment portion of the test procedure was not performed.

The results of the full core flux maps, INC-1-F1-80-9C (base case) and INC-1-F1-80-10B, are presented in Table 4.5-1 and Figures 4.5-9 and 4.5-10. All acceptance criteria with respect to the hot channel factors compared well with measured values. However, assembly N-2 failed to meet the relative assembly power acceptance criteria of ± 15% for fuel assemblies with a predicted relative assembly power of less than 0.9. A Westinghouse review of this discrepancy showed that there was no operational or safety concern since the hot channel factors were well within acceptance criteria.

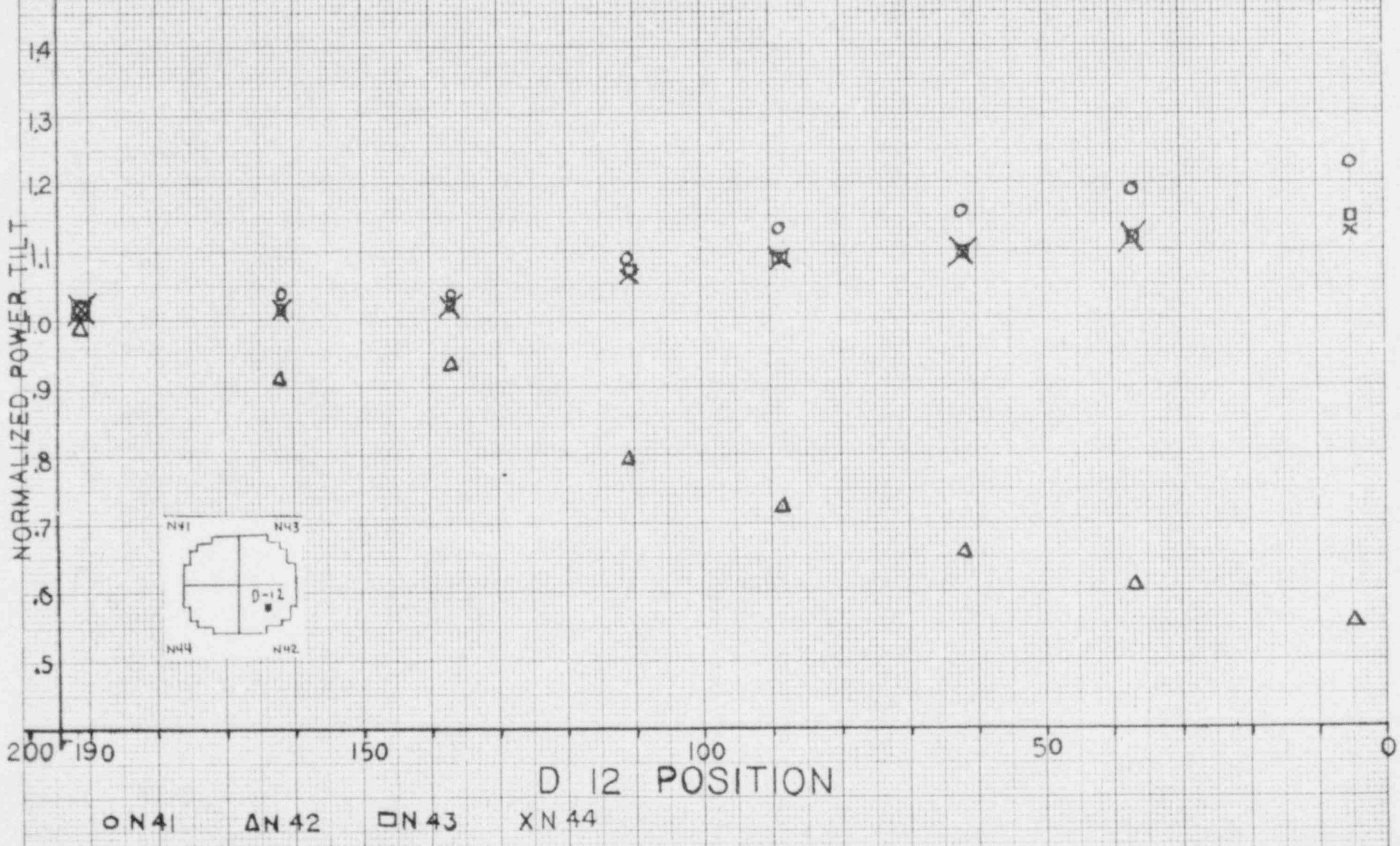
During D-12 insertion, incore movable detector and excore detector responses were monitored. Normalized power tilt ratios for the excore detectors are plotted as a function of D-12 position on Figure 4.5-18. Incore movable detector traces were obtained approximately every 25 steps during RCCA D-12 insertion. Some of these traces are reproduced in Figures 4.5-19 to 4.5-22. These figures illustrate the positive response of the excore and incore detectors to rod misalignment. This satisfied a prerequisite for ascension to 100% power which required that the incore and excore nuclear instrumentation systems be verified to be responsive to the power maldistribution caused by a rod misalignment.

Also as a prerequisite for proceeding to the 100% power testing plateau, this test verified that for each change 1% in Quadrant Power Tilt Ratio (QPTR), caused by the rod misalignment, there was a corresponding change in F_Q^N of 3% or less. It was found from this test that for each 1% increase in QPTR, the corresponding value of F_Q^N increased only 1.34%.

EXCORE DETECTOR RESPONSE

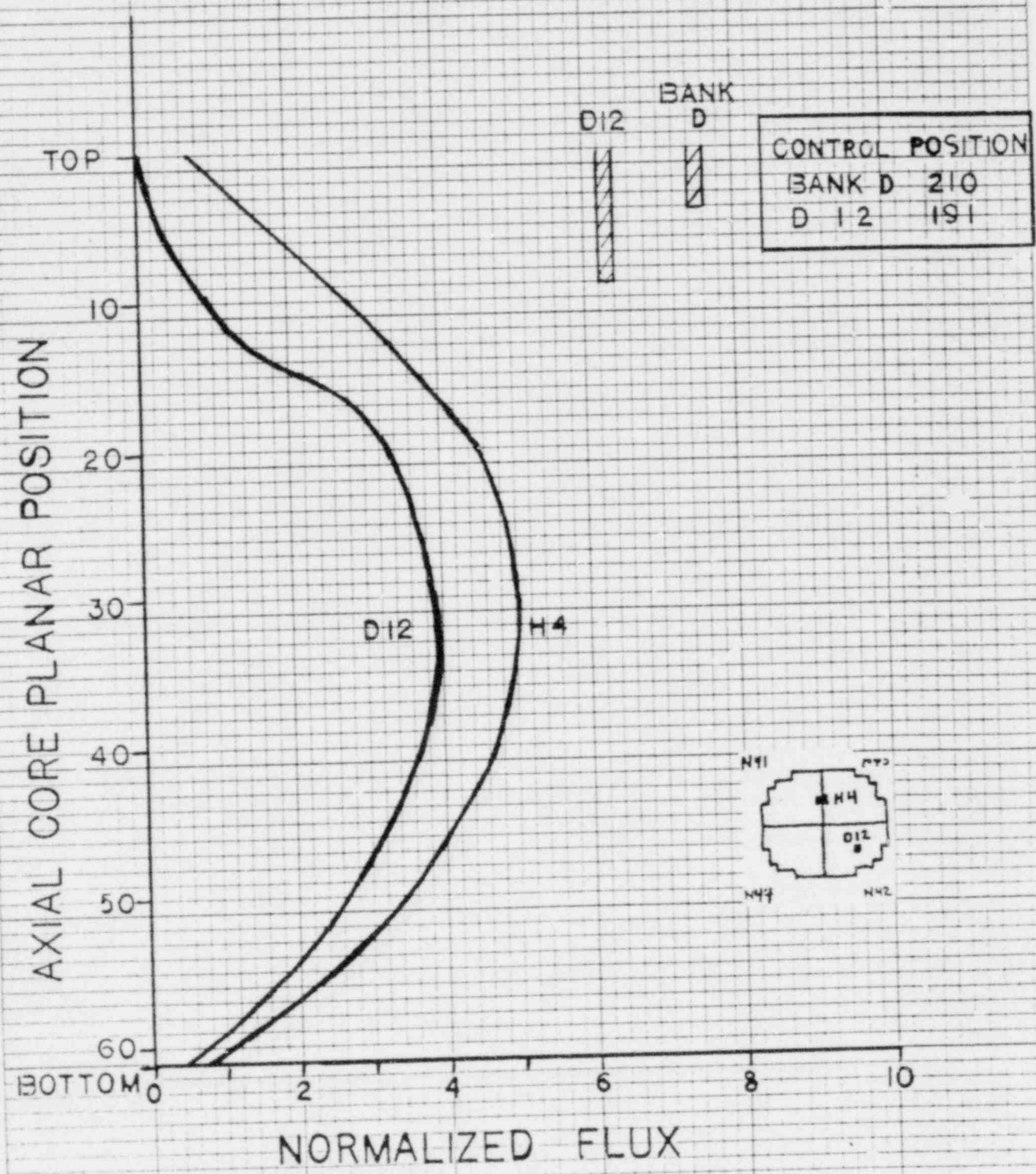
CONTROL BANK D AT 210 STEPS

FIGURE 4.5-18



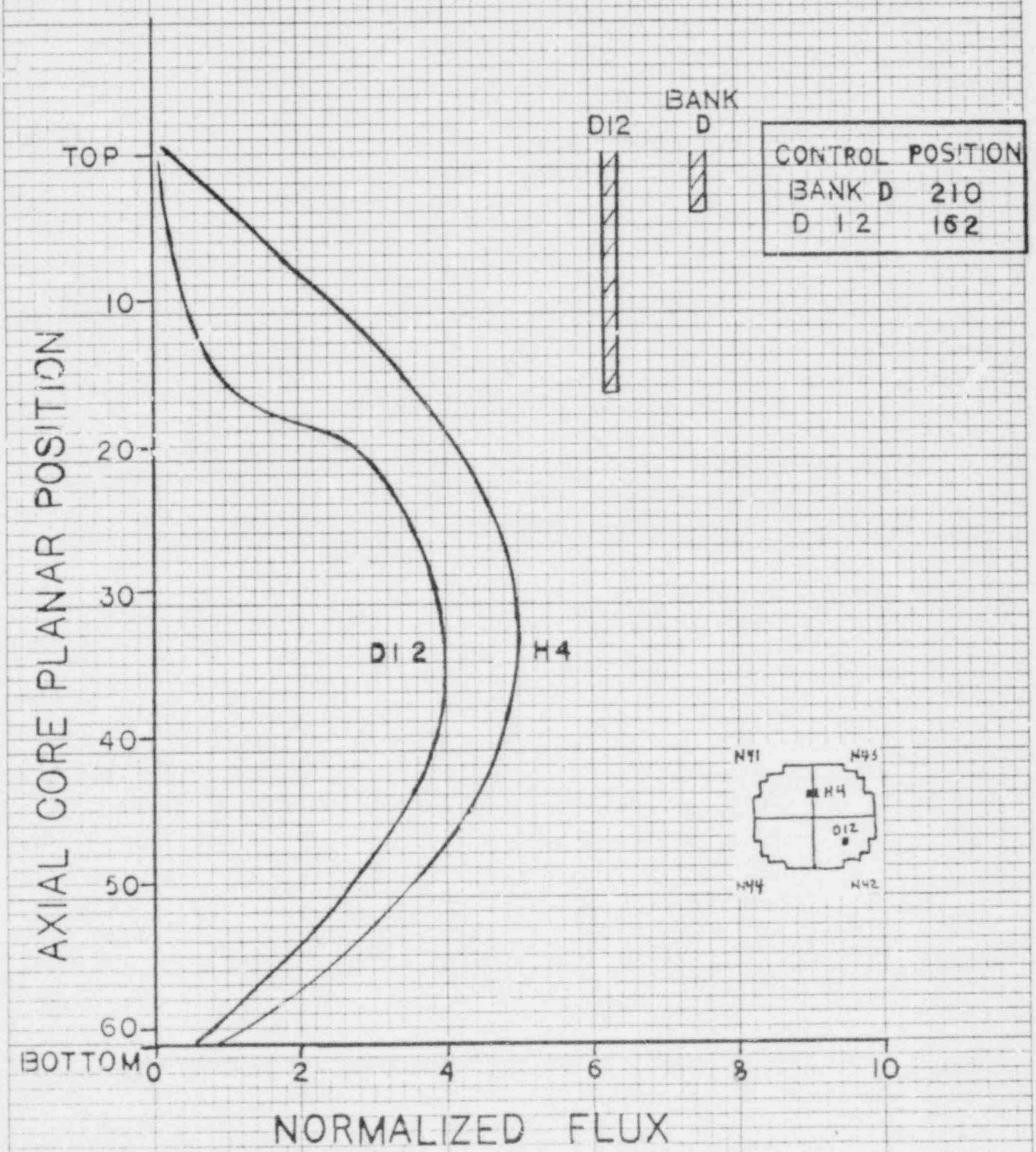
AXIAL FLUX DISTRIBUTION

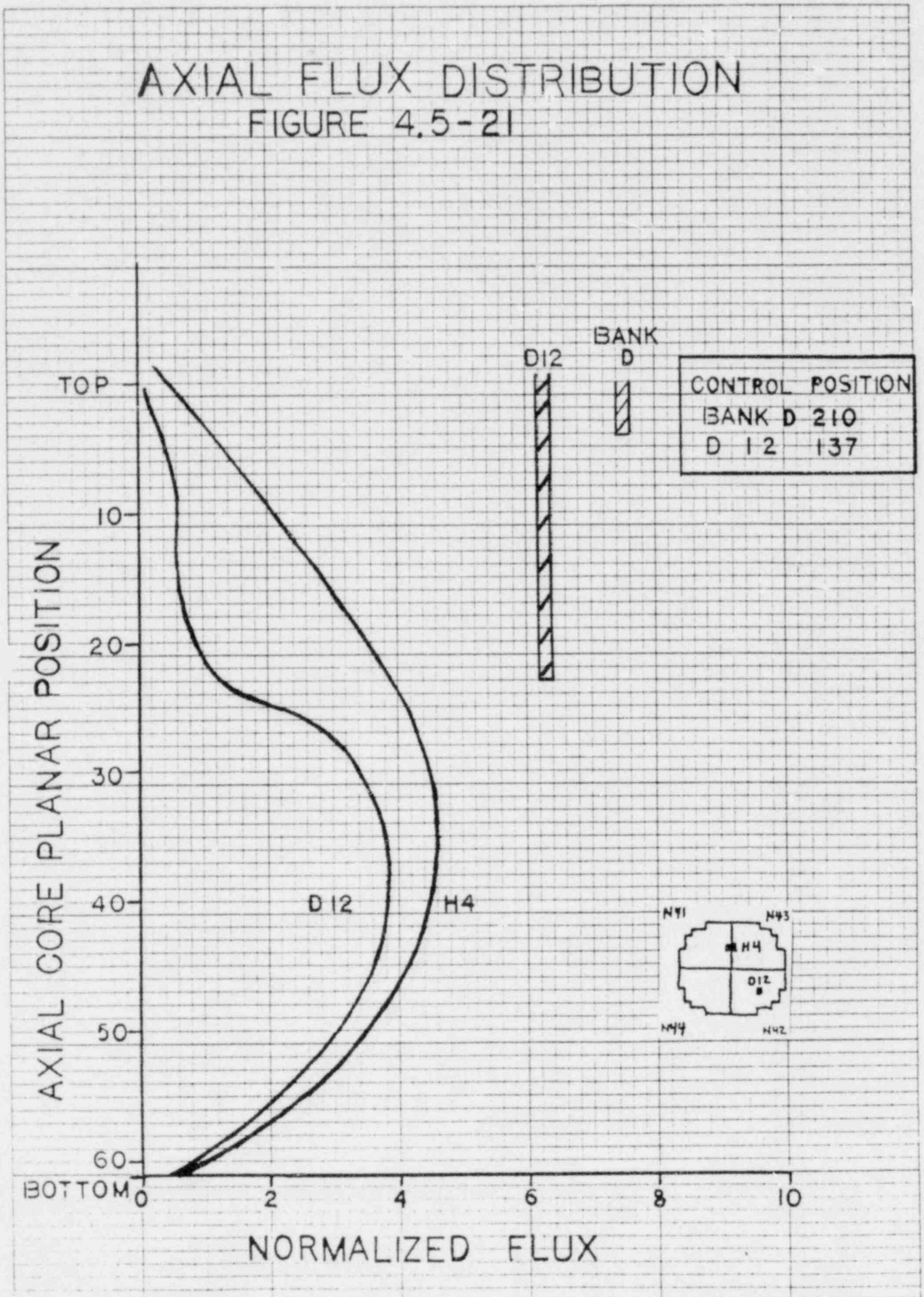
FIGURE 4.5-19



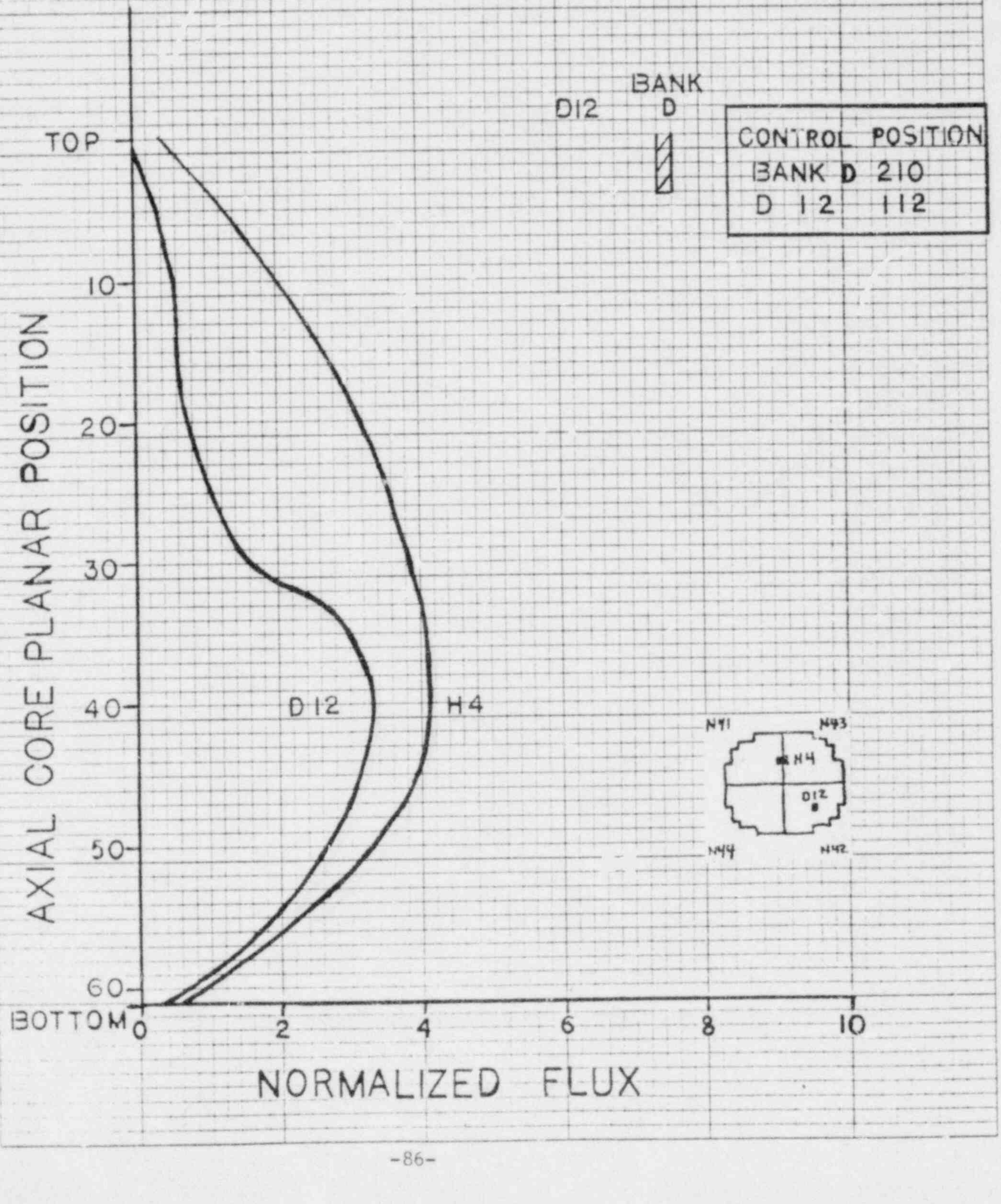
AXIAL FLUX DISTRIBUTION

FIGURE 4.5-20




AXIAL FLUX DISTRIBUTION
FIGURE 4.5-21
AXIAL CORE PLANAR POSITION
TOP
10
20
30
40
50
60
BOTTOM
0
2
4
6
8
10
NORMALIZED FLUX
D12
H4
BANK D
CONTROL POSITION
BANK D 210
D 12 137
N41
N43
N44
N42

AXIAL FLUX DISTRIBUTION
FIGURE 4.5-22



4.0 Core Performance (continued)

4.6 Xenon Oscillation and Suppression (Test procedure SU-8.6B)

An axial xenon oscillatron was introduced into the core at the 75% power plateau. The purpose of the oscillation was two-fold: to obtain data necessary for nuclear instrumentation calibration and to demonstrate the effectiveness of control bank D in suppressing an axial xenon oscillation.

The oscillation was produced by inserting control bank D (initially at 200 steps) to depress the flux to near the limit of acceptable operation as defined in Technical Specification Figure 3.2-1 (axial flux difference). After about five hours, control bank D was withdrawn to its starting position of approximately 200 steps, and the xenon oscillation was allowed to swing Δ flux without any adjustments in bank D position.

With Δflux near its positive peak, the oscillation was suppressed by inserting control bank D, forcing Δflux into the target bank, Control bank D was then adjusted as required to maintain flux in the target bank until the oscillation had been completely dampened.

The axial xenon oscillation provided the necessary variation in flux to obtain data to calibrate the nuclear instrumentation system (NIS). Three full core flux maps and eight quarter core flux maps were obtained during the oscillation along with associated calorimetric and NIS data. The analysis of this data is discussed in section 4.7 of this report.

Figure 4.6-1 provides a time history of Δflux during the test. The points at which the flux maps were taken are shown, and the limits of acceptable operation are included to demonstrate compliance with the technical specifications.

4.7 Excore Detector Sensitivity (Test procedure SU-8.4 and SU-8.5)

The nuclear instrumentation system (NIS) consists of incore and excore detectors. There are six incore moveable detectors and eight excore stationary detectors. The excore detectors, Figure 4.7-1, consist of two source range detectors (proportional counters), two intermediate range detectors (compensated ion chambers), and four power range detectors (uncompensated ion chambers).

The source range detectors, channels N-31 and N-32, were initially calibrated prior to fuel load using a temporary neutron source. After 1500 MWD/MTU core burnup, the source range detectors were recalibrated. The high voltage plateaus and discriminator settings were checked with only minor adjustments to the discriminator voltage required.

Prior to initial criticality, the power range channels were adjusted so that 200 μamps top and bottom detector current indicated 100% power. The low power trips were set at 25% while the high flux trip setpoints were set at 20% for hot zero power testing. The intermediate range high level trips were initially set at 10^{-4} amps and the high level rod stop bistable trips were set at 6.75×10^{-5} amps. The power range channels were adjusted

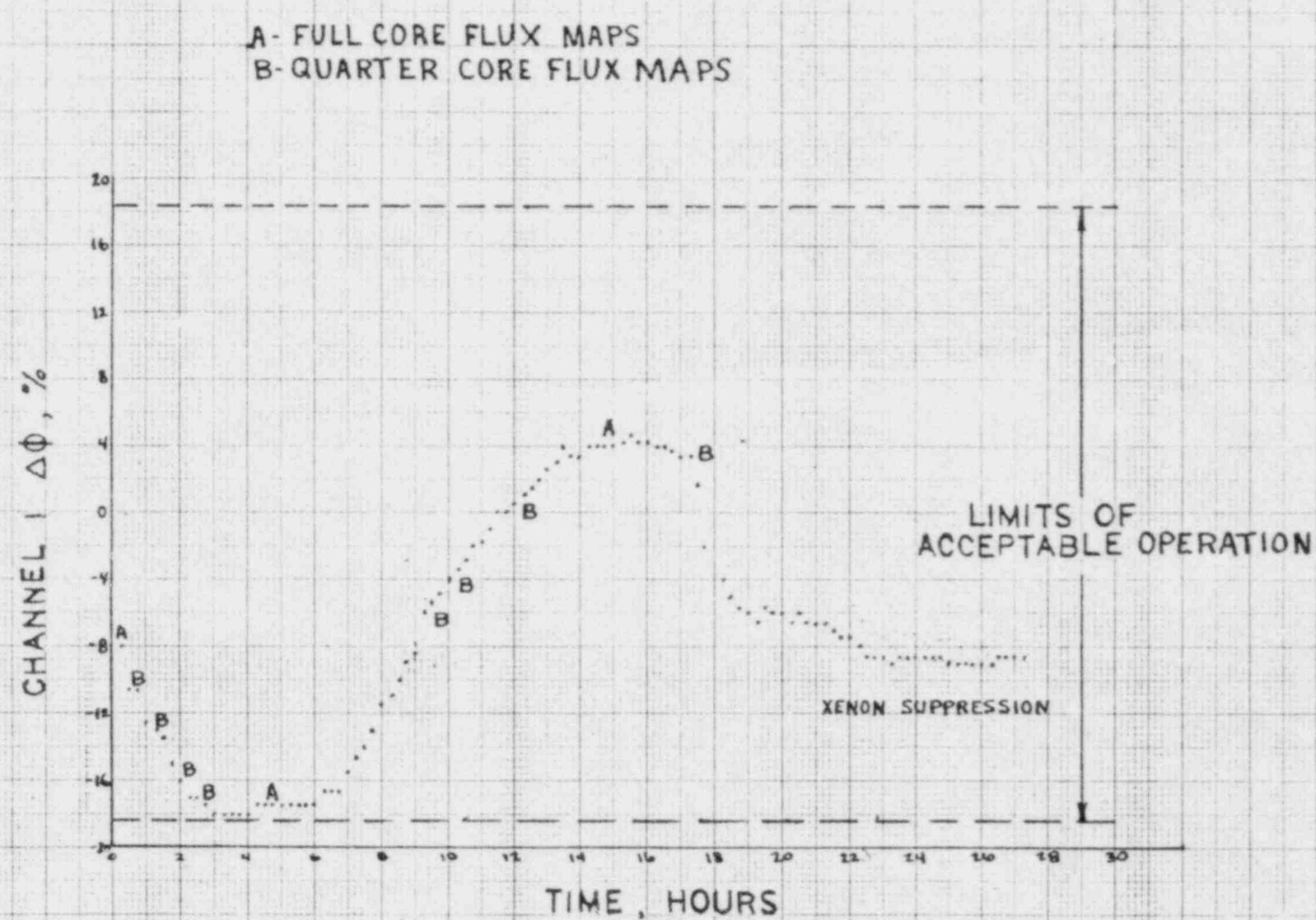
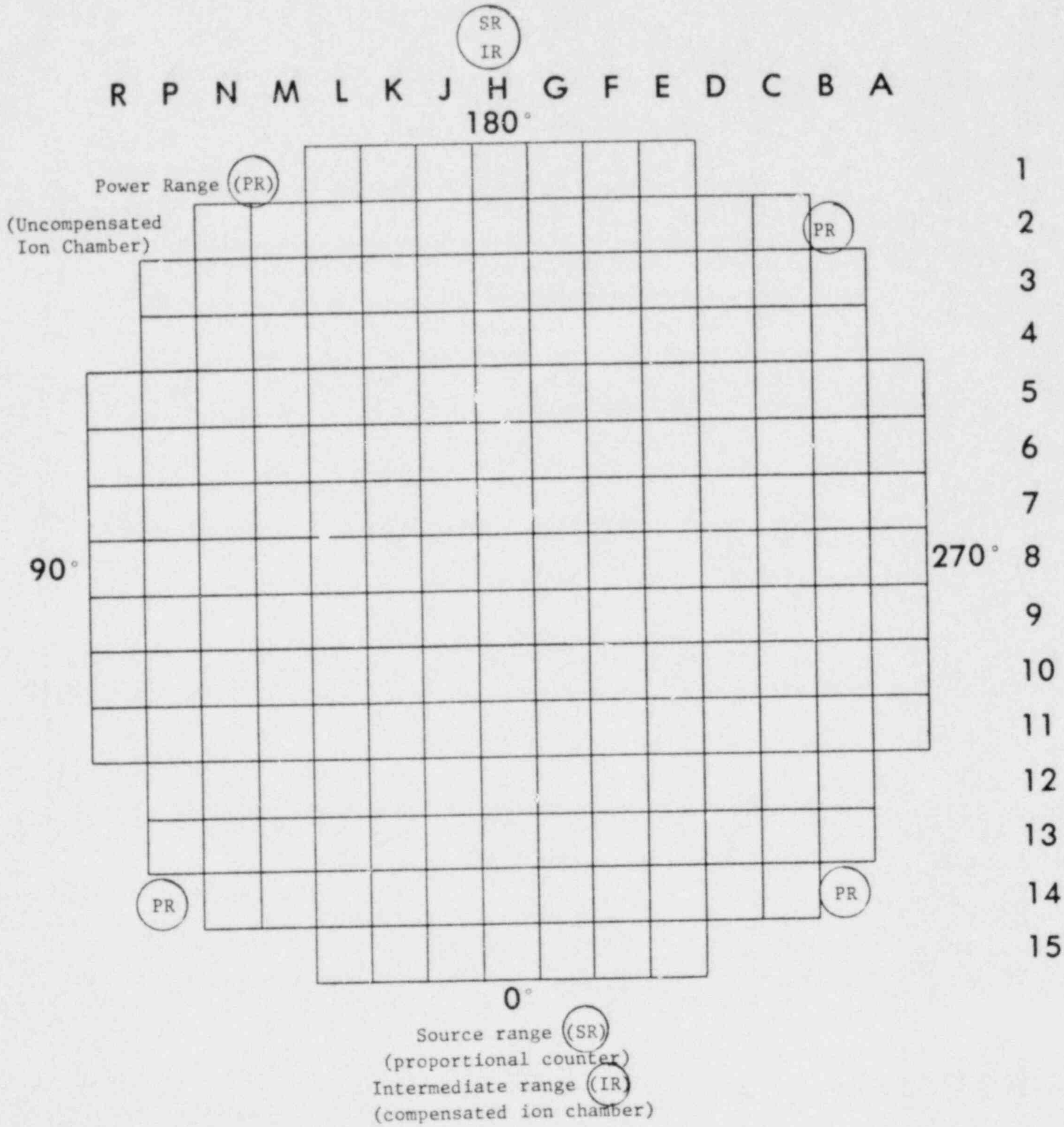


FIGURE 4.6-1
AXIAL XENON OSCILLATION
AND SUPPRESSION

FIGURE 4.7-1

SEQUOYAH UNIT 1



4.0 CORE PERFORMANCE (continued)

4.7 Excore Detector Sensitivity (continued)

during low power physics testing to reflect the calorimetric power. The NIS power range channels were compared with calorimetric measurements at each power testing plateau and readjusted as necessary to reflect the power level.

Prior to proceeding beyond the 50% power plateau, a preliminary calibration to delta flux was performed based on incore flux maps and associated data taken during 30% and 50% physics testing.

At the 75% power plateau, both the intermediate range channels and power range channels were recalibrated. The intermediate range channels, N-35 and N-36, were readjusted so that the 100% power currents would be 3.28×10^{-4} amps and 3.38×10^{-4} amps, respectively. These values were obtained by extrapolation, using data collected at 30, 50, and 75% power levels.

The power range channels, N-41 through N-44, were calibrated to full power using data collected by flux maps taken during the xenon oscillation test. Figures 4.7-2 through 4.7-5 show the normalized NIS detector currents versus incore axial offset. Figures 4.7-6 through 4.7-9 show incore axial offset for each power range channel. The power range detector currents for full power are presented in Figure 4.7-10.

The final full power settings for the NIS power range and intermediate range channels will be checked at 100% power. The results of the startup test will be submitted in a later report.

FIGURE 4.7-2

EXCORE DETECTOR CURRENT vs. INCORE ΔQ - N-41

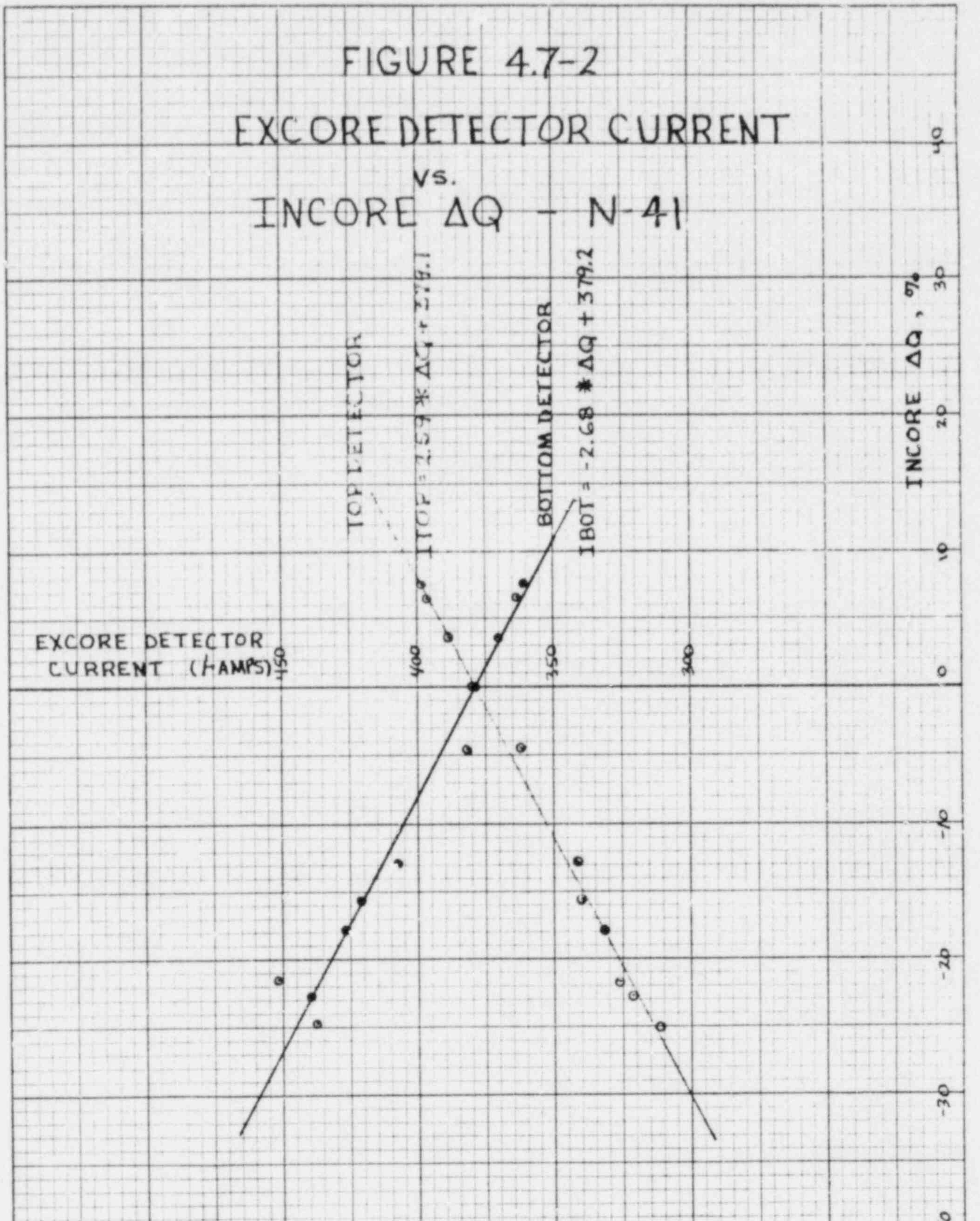
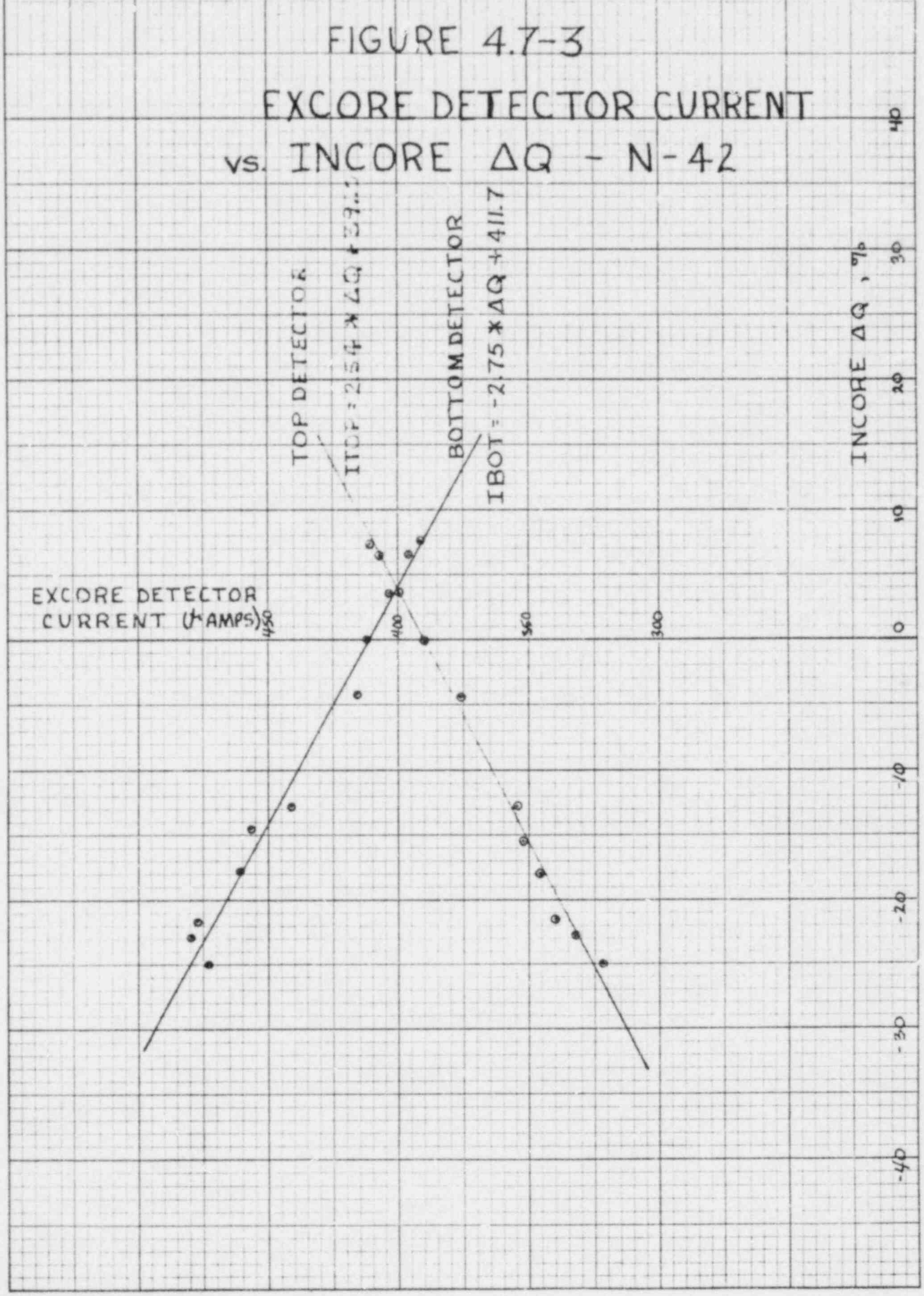


FIGURE 4.7-3

EXCORE DETECTOR CURRENT vs. INCORE ΔQ - N-42



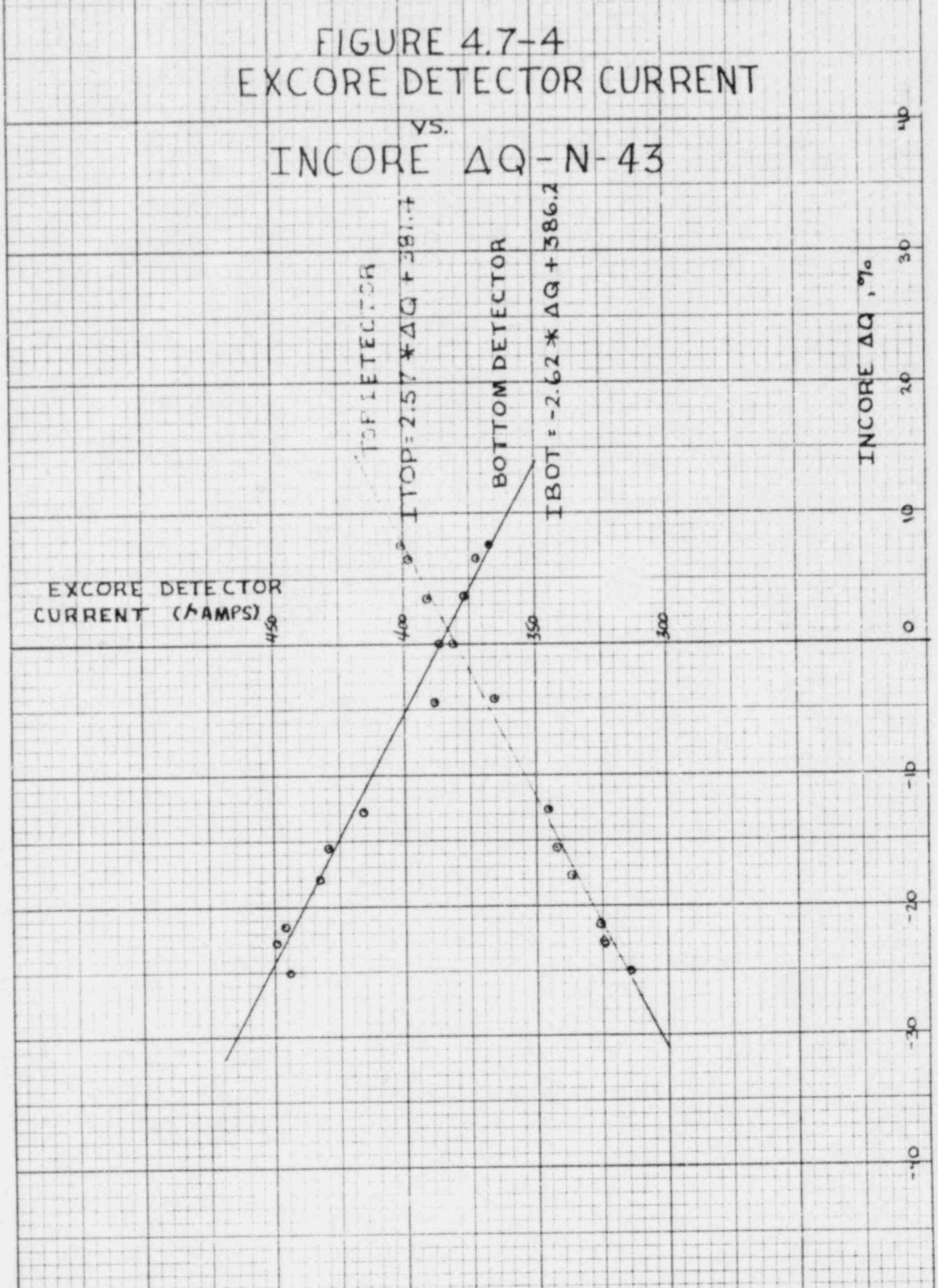


FIGURE 4.7-4
EXCORE DETECTOR CURRENT
VS.
INCORE ΔQ-N-43

FIGURE 4.7-5
EXCORE DETECTOR CURRENT
vs.
INCORE ΔQ - N-44

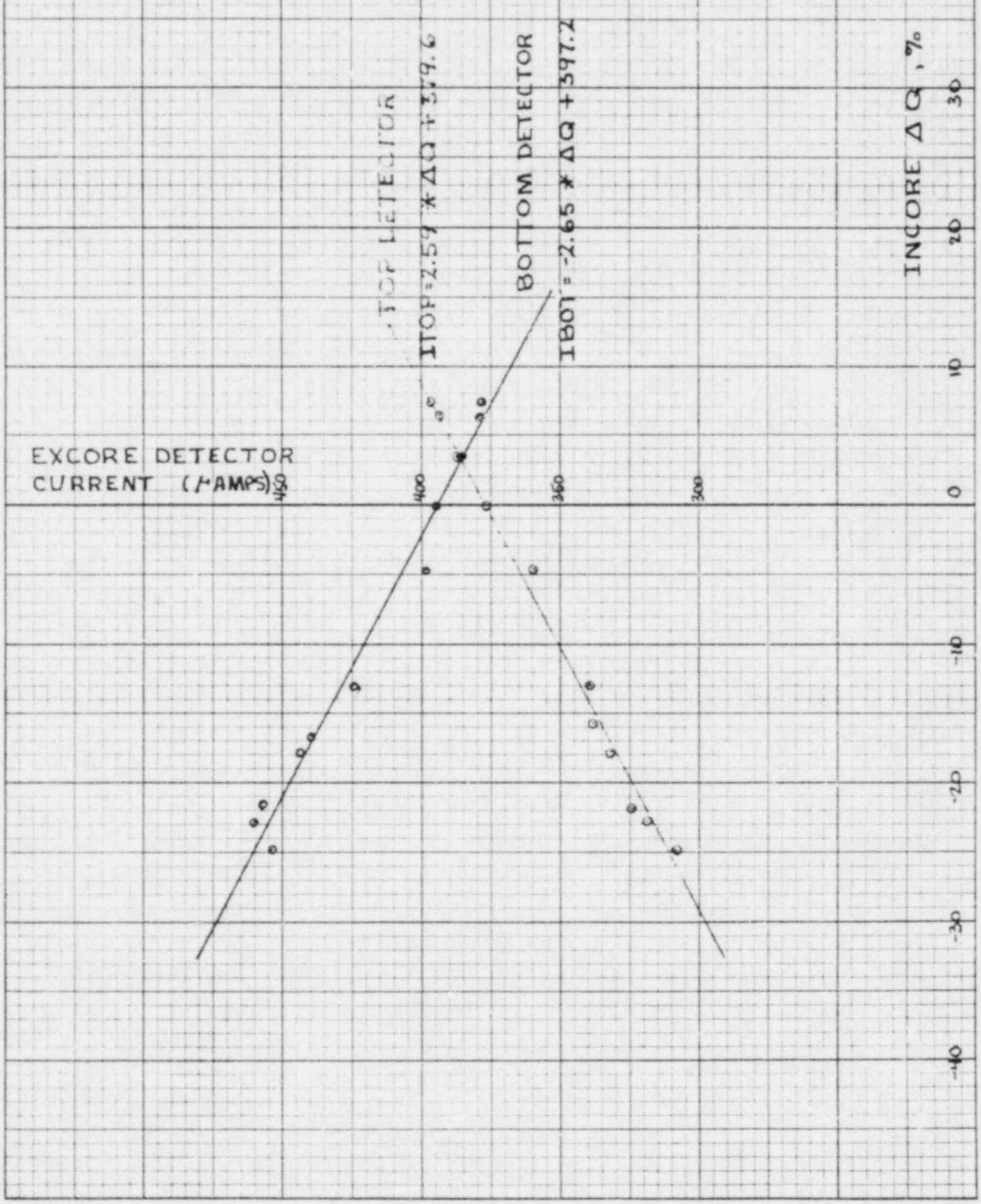


FIGURE 4.7-6

INCORE AXIAL OFFSET vs.
EXCORE AXIAL OFFSET - N-41

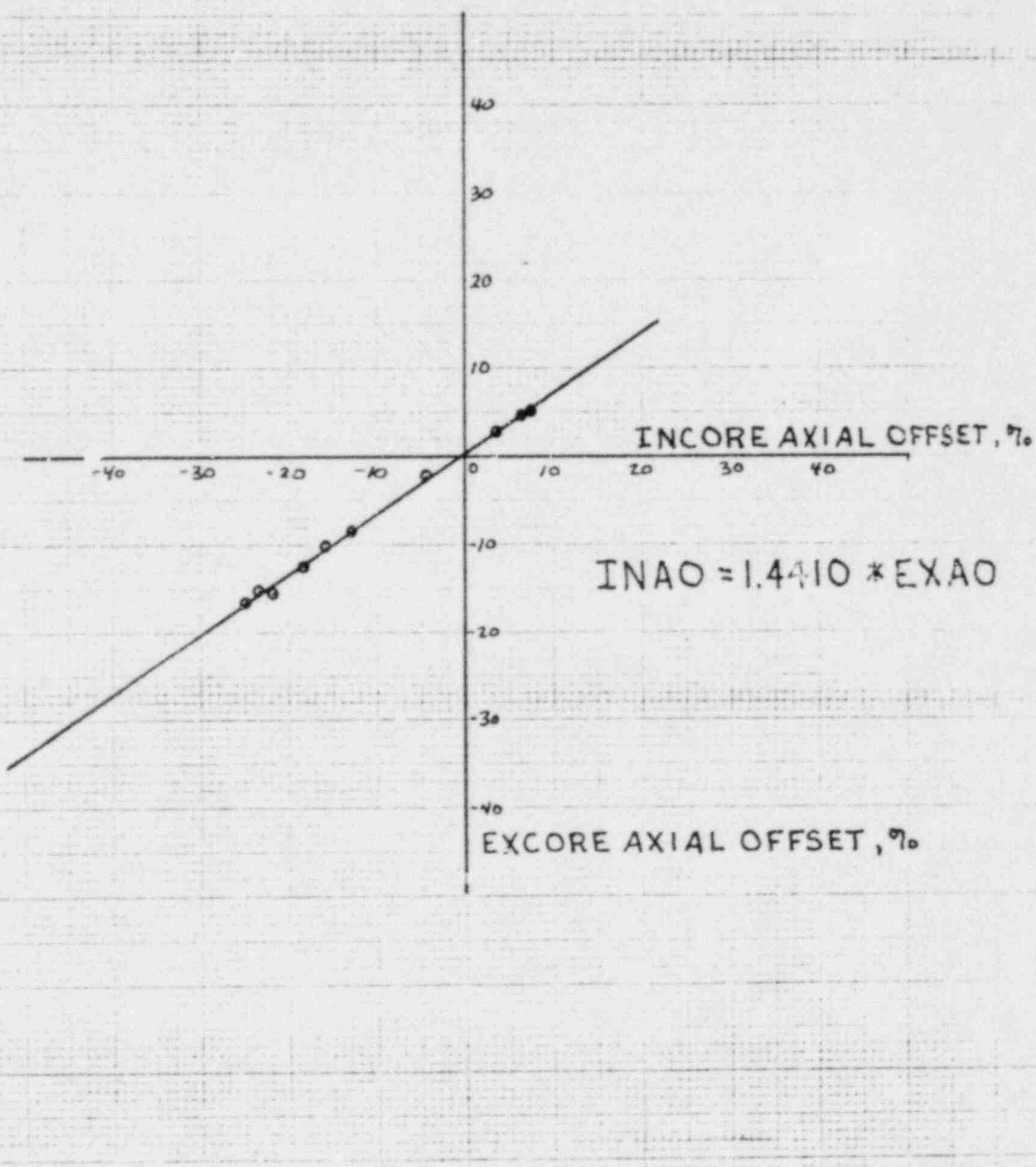


FIGURE 4.7-7

INCORE AXIAL OFFSET vs. EXCORE AXIAL OFFSET - N-42

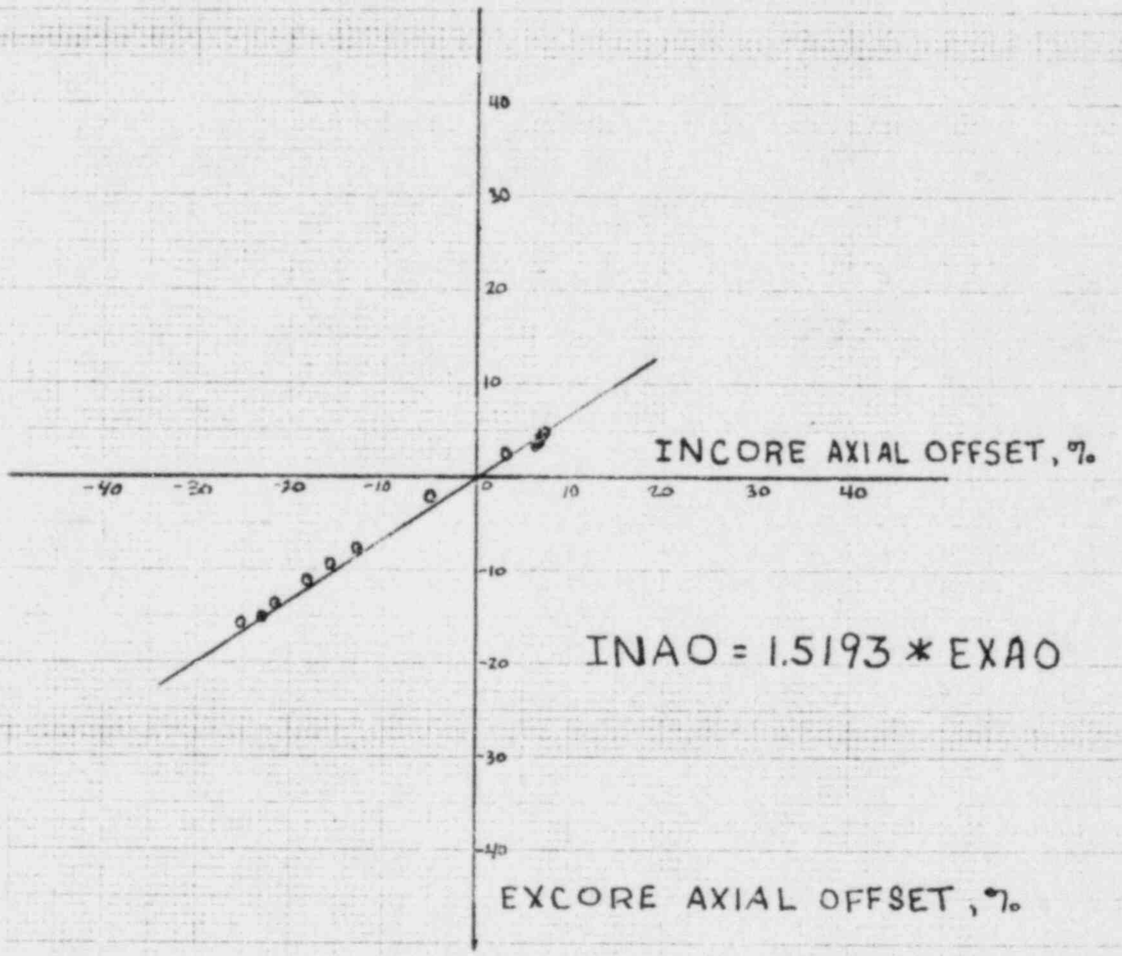


FIGURE 4.7-8

INCORE AXIAL OFFSET vs.
EXCORE AXIAL OFFSET - N-43

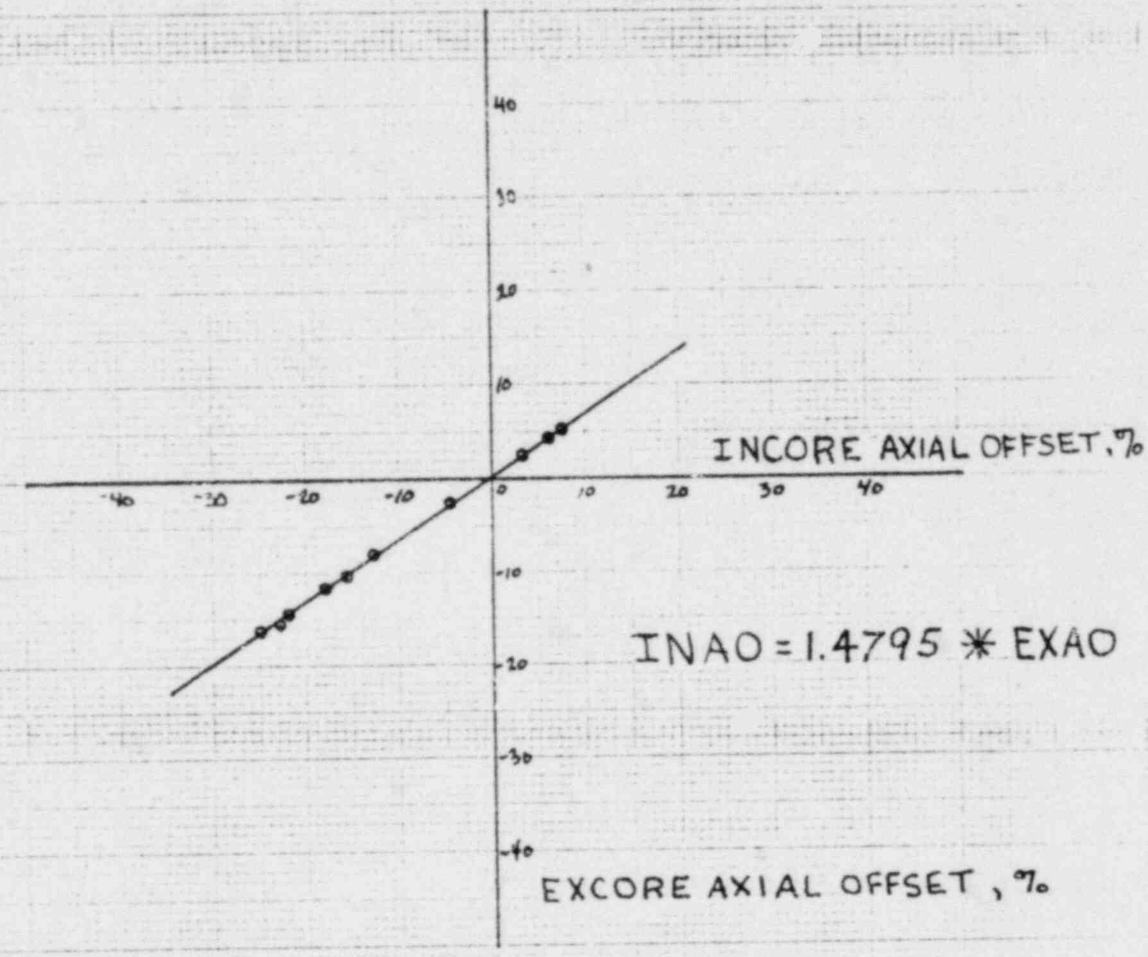


FIGURE 4.7-9

INCORE AXIAL OFFSET vs. EXCORE AXIAL OFFSET - N-44

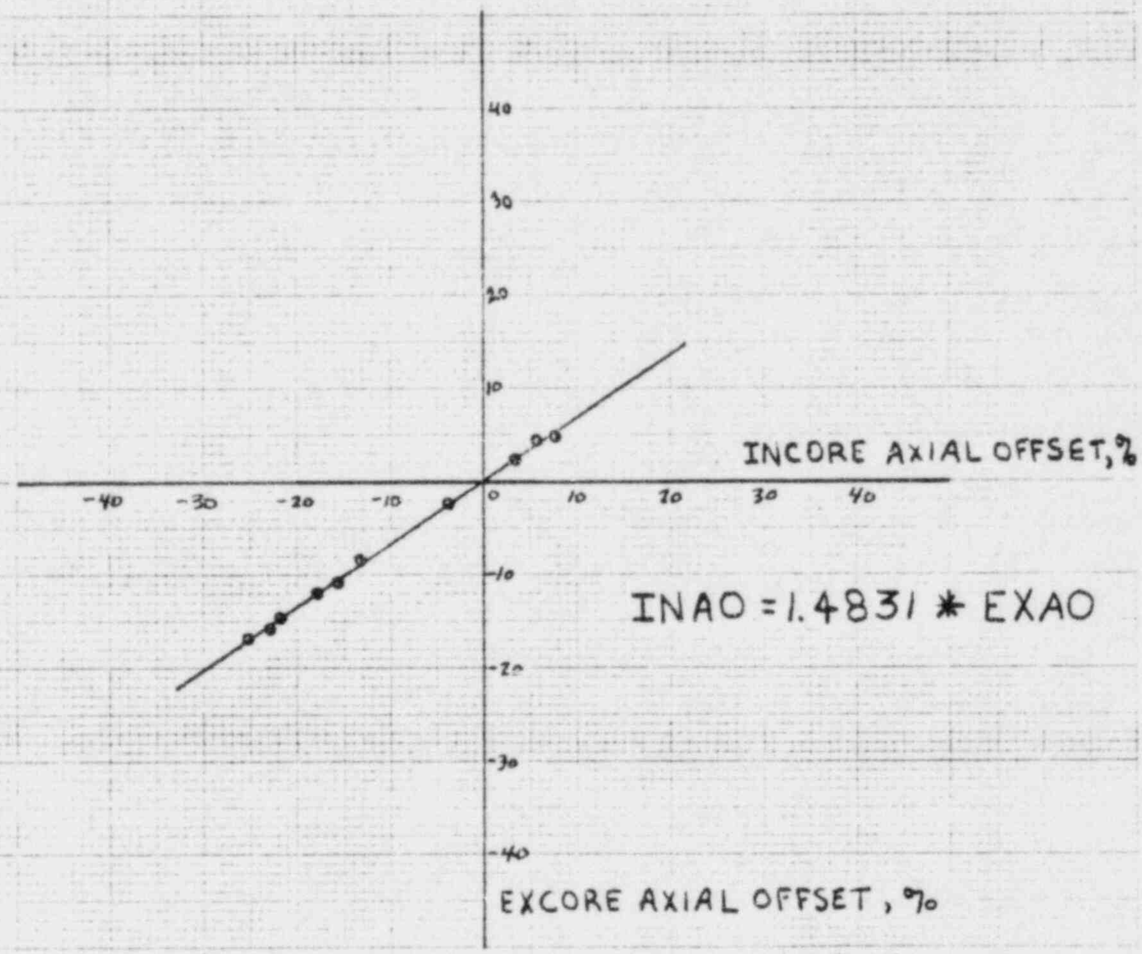
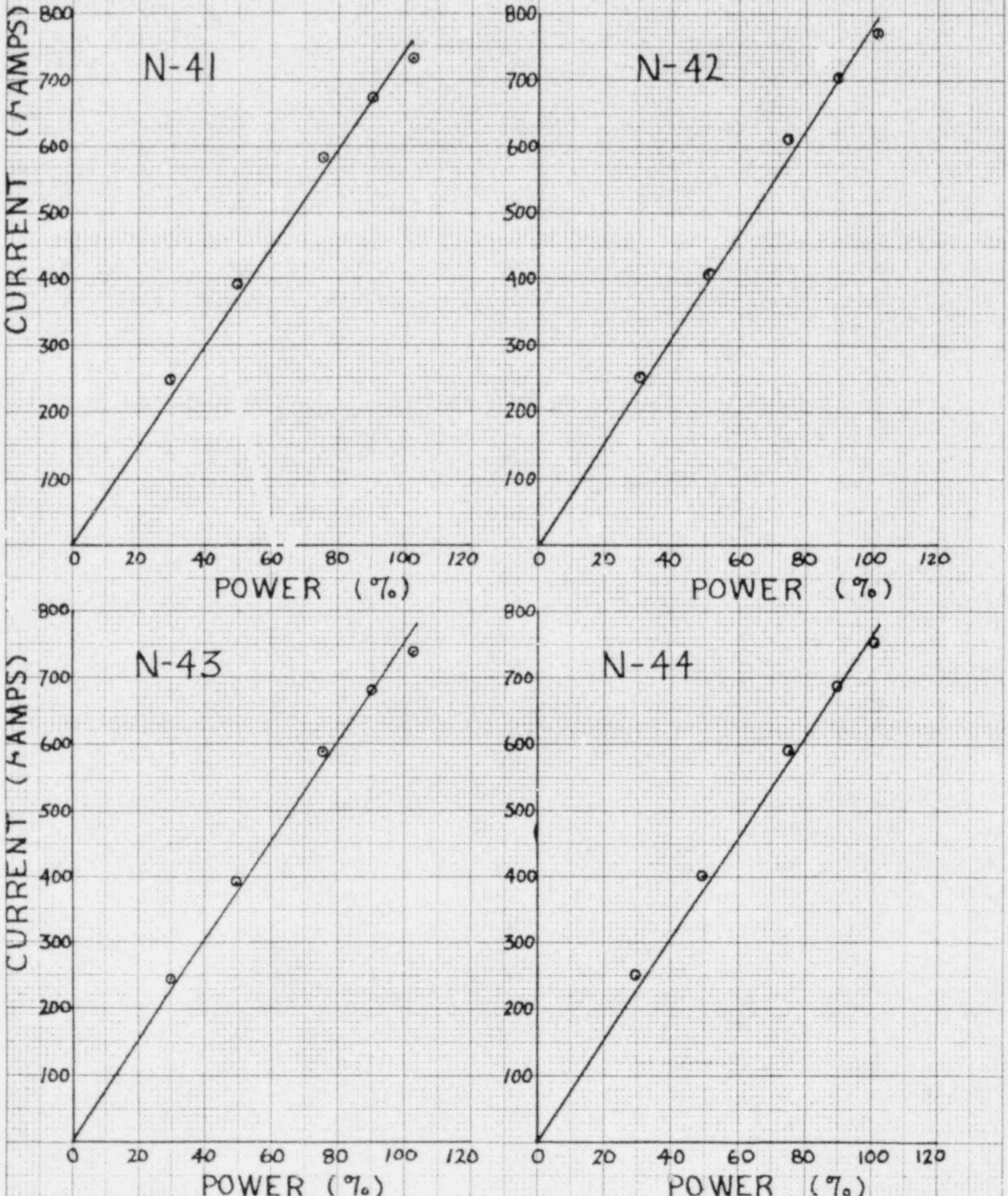


FIGURE 4.7-10
EXCORE DETECTOR CURRENT vs. POWER



5.0 OVERALL PLANT RESPONSE

Throughout the startup test program a series of tests were performed to determine overall plant response. Measurements were performed to determine base line data for water chemistry, radiochemistry, and radiation surveys. The plant was sub, ted to numerous power transients to ascertain plant response. The following sections provide the results of these tests.

5.1 Plant Measurements (Test Procedure SU-1.0)

This test implemented a program of gathering and analyzing baseline and operational data. Radiation surveys, chemical and radiochemical analyses were performed to determine baseline plant conditions at specified power levels. Additional data for use in evaluating plant and component performance were obtained from the secondary (turbine) side of the plant. Data was obtained at the following times: fuel loading, hot zero power, 30%, 50%, 75%, and 90% reactor power. An additional test at 100% reactor power will be performed at a later date.

Radiation survey results indicate dose levels in excess of the assumed FSAR exposure limits at two locations within primary containment for the 75% and 90% power level tests. These points will be surveyed again at 100% power and, if needed, steps will be taken to reduce the dose levels at these points below the limit specified in the FSAR.

Except for the excessive oxygen levels in the primary water storage tank, all the plant chemistry problems indicated in Table 5.1-1 were within acceptable limits when the unit reached 100% reactor power.

TABLE 5.1-1

PLANT CHEMISTRY PROBLEMS

POWER	CHEMISTRY PROBLEM
Pre Critical	Primary Water Storage Tank Oxygen Levels High Condensate Storage Tank Oxygen Levels High Condensate Storage Tank Free Hydroxide Levels Could Not Be Analyzed
Hot Zero Power	Primary Water Storage Tank Oxygen Levels High Condensate Storage Tank Free Hydroxide Levels Could Not Be Analyzed
30%	Primary Water Storage Tank Oxygen Levels High Steam Generator Blowdown Had Excessive Impurities And High Cation Conductivity Component Cooling System Heat Exchangers A&C Molybdenium Concentration Was Low
50%	Primary Water Storage Tank Oxygen Levels High Steam Generator Blowdown Cation Conductivity High Component Cooling System Heat Exchangers A&C Molybdenium Concentration Low
75%	Primary Water Storage Tank Oxygen Levels High Steam Generator Blowdown Cation Conductivity High Component Cooling System Heat Exchangers A&C Molybdenium Concentration Low

5.0 OVERALL PLANT RESPONSE (continued)

5.2 10% Load Swings (Test procedure SU-9.1)

This test was performed to verify the ability of the primary and secondary plant and the automatic reactor control systems to sustain a 10% step load swing. With the reactor power at approximately 35% of full power, a 10% step decrease in power was initiated. After stabilizing at the new power level, a 10% step increase in power was initiated to return reactor power to its initial value. This test was repeated at 75% reactor power. The 100% reactor power test will be completed at a later date.

The plant and control systems responded satisfactorily in achieving the new power levels, and all required acceptance criteria were met: neither the reactor nor the turbine tripped; safety injection did not occur; neither the steam generator nor the pressurizer relief and safety valves lifted; and nuclear power did not deviate from its final value by more than 3% during the transient. With one exception, no manual intervention was required to bring the plant conditions to steady state within the allotted 20 minutes. The exception was that MFPT automatic speed control for the 35% reactor power test was not operable at the time of the test. Since the MFPT speed was maintained at the automatic speed control setpoint during the 35% reactor power test via manual control, failure of the automatic control during this test had no affect. Furthermore, the acceptability of the automatic controls was reexamined and proven adequate by the 75% reactor power load swing test. The responses of key plant parameters during the transients were as indicated in Tables 5.2-1, 5.2-2, and 5.2-3, and as shown in Figures 5.2-1 through 5.2-8 for the 35% reactor power test and for the 75% reactor power test.

TABLE 5.2-1

PARAMETER RESPONSES TO 10% LOAD SWING

PARAMETER	35%								75%								100%	
	DECREASE 35-25%				INCREASE 25-35%				DECREASE 75-65%				INCREASE 65-75%				DECREASE 100-90%	INCREASE 90-100%
	I	MIN	MAX	F	I	MIN	MAX	F	I	MIN	MAX	F	I	MIN	MAX	F	I MIN MAX F	I MIN MAX F
Nuclear Power %	33.9	24	34	24	24	24	34	34	75	64	75	66	66	65	76	75	Test to be completed at a later date	
Auctioneered Tavg °F	558	553	558	553	553	551.5	556.5	556	569	565	569	566	566	565	570	569		
ΔT %	42	31	44	31	31	31	44	40	52	45	52	46	46	45	52	52		
Pressurizer Pressure Psig	2230	2205	2250	2220	2220	2220	2255	2230	2230	2225	2235	2230	2230	2215	2270	2230		
Pressurizer Level %	39	31	39	34	34	31	37	37	51	46	52	46	46	46	52	51		
Steam Header Pressure Psig	890	885	930	910	910	880	920	890	832	824	852	840	840	816	848	848		
S/G #1 Level %	45	39	52	43	43	39	50	41	45	40	49	43	43	38	50	44		
S/G #2 Level %	43	32	47	39	39	29	55	46	45	40	50	44	44	39	49	44		
SG #3 Level %	46	37	51	42	42	29	60	39	45	38	49	43	42	36	48	43		
SG #4 Level %	45	37	52	42	42	37	55	40	45	38	48	43	43	39	50	44		

TABLE 5.2-2

PARAMETER RESPONSES TO 10% LOAD SWINGS

PARAMETER	UNITS	35%			75%			100%		
		1	2	3	1	2	3	1	2	3
Gross Electrical Output	MWE	350	230	350	842	721	850			
Tref	oF	560	556	558	570	567	570	Test to be completed at a later date.		
ΔT Overtemperature Setpoint	%	131	133	131	120	122	119			
ΔT Overpower Setpoint	$x10^6$ lb/hr	105	105	105	105	104	104			
Steam Flow (Loop 1)	$x10^6$ lb/hr	*	*	*	2.55	2.3	2.7			
Steam Flow (Loop 2)	$x10^6$ lb/hr	*	*	*	2.55	2.2	2.45			
Steam Flow (Loop 3)	$x10^6$ lb/hr	*	*	*	2.5	2.2	2.45			
Steam Flow (Loop 4)	$x10^6$ lb/hr	*	*	*	2.45	2.15	2.45			
Feedwater Temperature (Loop 1)	^oF	345.7	321.4	344.8	408.4	398.4	409.0			
Feedwater Temperature (Loop 2)	^oF	346.1	321.3	344.5	407.9	398.2	408.8			
Feedwater Temperature (Loop 3)	^oF	345.3	322.4	345.4	408.7	398.9	409.5			
Feedwater TEmperature (Loop 4)	^oF	345.8	321.3	344.2	407.9	398.4	408.7			
Feedwater Flow (Loop 1)	$x10^6$ lb/hr	1.15	0.85	1.15	2.65	2.35	2.7			
Feedwater Flow (Loop 2)	$x10^6$ lb/hr	1.10	0.90	1.10	2.65	2.35	2.65			
Feedwater Flow (Loop 3)	$x10^6$ lb/hr	1.10	0.80	1.05	2.75	2.45	2.75			
Feedwater Flow (Loop 4)	$x10^6$ lb/hr	1.10	0.75	1.15	2.60	2.25	2.75			
MFPT A Speed	RPM	4200	3800	4200	4150	3900	4250			
MFPT B Speed	RPM	0	0	0	4550	4300	4550			
Control Bank C Position	Steps	228	228	228	228	228	228			
Control Bank D Position	Steps	181/182	155/156	181/182	193	178	208			
Boron Concentration	PPM	1031	1031	1031	1057.5	1057.5	1057.5			

1 - Initial Conditions
2 - Reduced Power Equilibrium Conditions
3 - Final Conditions at End of Test
* - Process Steam Flow Indication Was Not Scaled Correctly

TABLE 5.2-3

PARAMETER RESPONSES TO 10% LOAD SWINGS

PARAMETER	35%		75%		100%	
	DECREASE 35-25	INCREASE 25-35	DECREASE 75-65	INCREASE 65-75	DECREASE 100-90	INCREASE 90-100
Maximum Rod Speed During Transient (steps/min)	72	72	72	72	Test to be completed at a later date.	
Time From Test Initiation To Equilibrium* Conditions (seconds)	300	270	20	428		

*Equilibrium Conditions: $T_{avg} = T_{ref} \pm 1.5^{o}F$

Pressurizer Pressure = $P_{ref} \pm 25$ psig

Figure 5.2-1

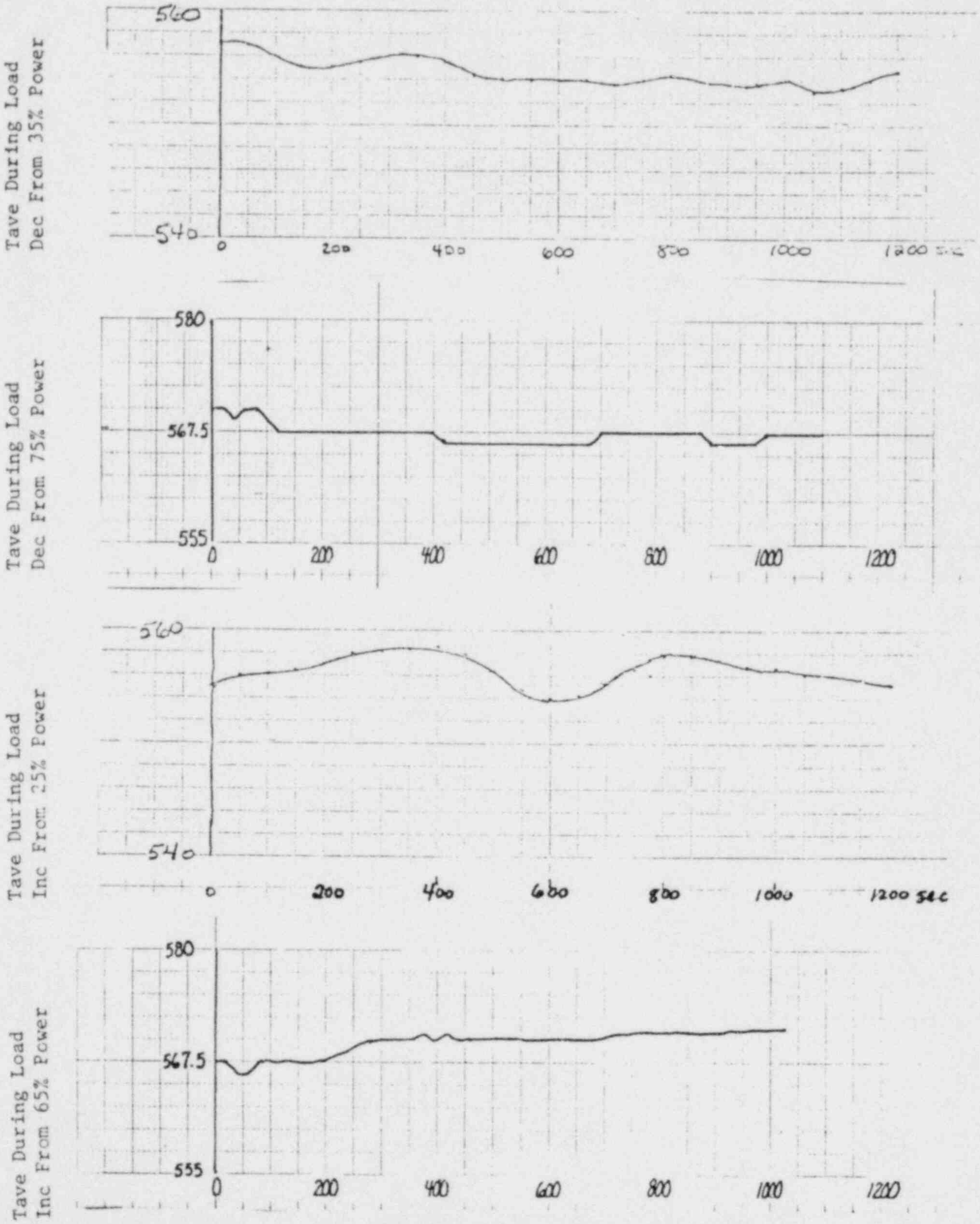

Tave During Load
Dec From 35% Power
560
540
0
200
400
600
800
1000
1200 sec
Tave During Load
Dec From 75% Power
580
567.5
555
0
200
400
600
800
1000
1200
Tave During Load
Inc From 25% Power
560
540
0
200
400
600
800
1000
1200 sec
Tave During Load
Inc From 65% Power
580
567.5
555
0
200
400
600
800
1000
1200

Figure 5.2-2

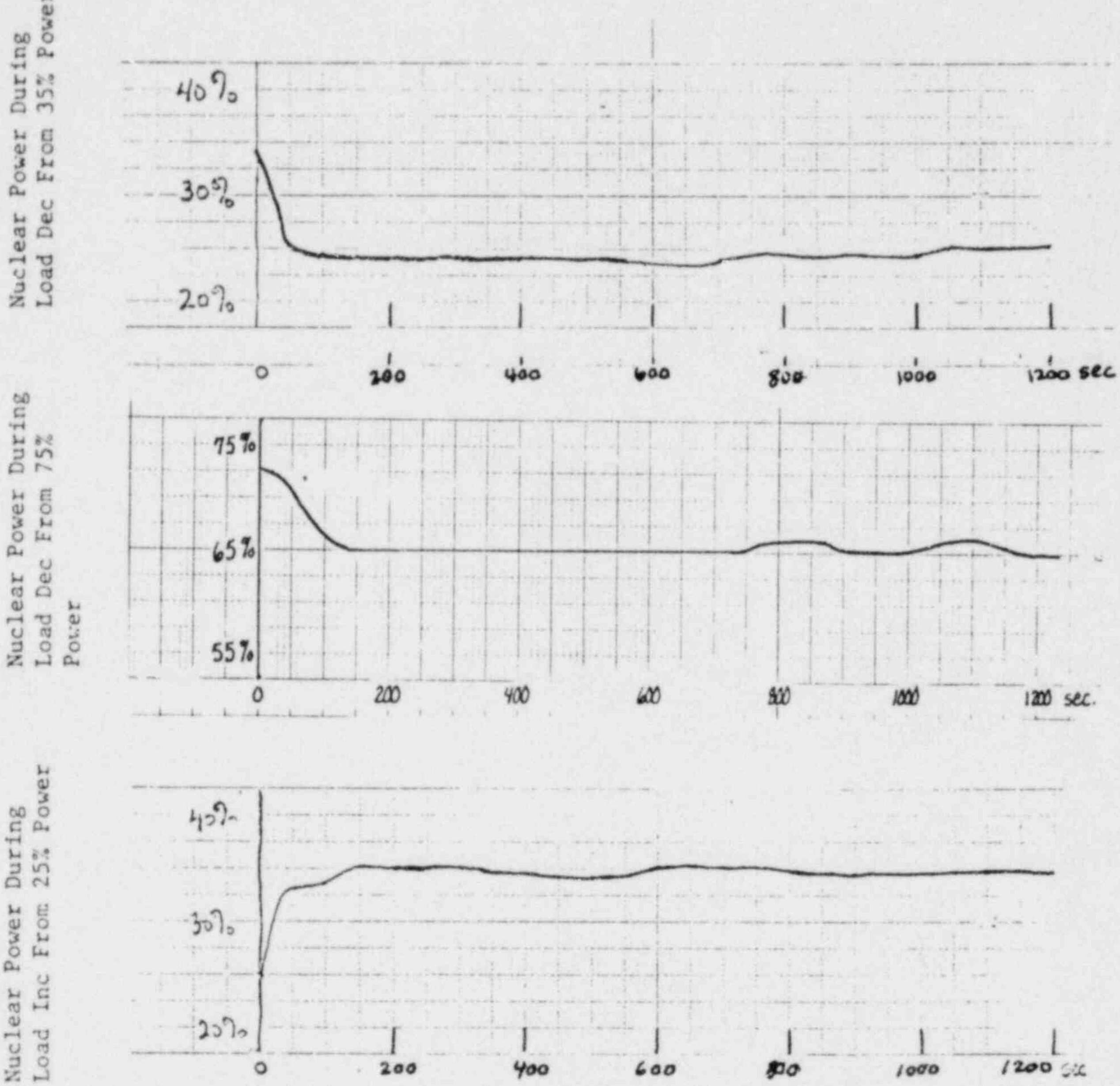
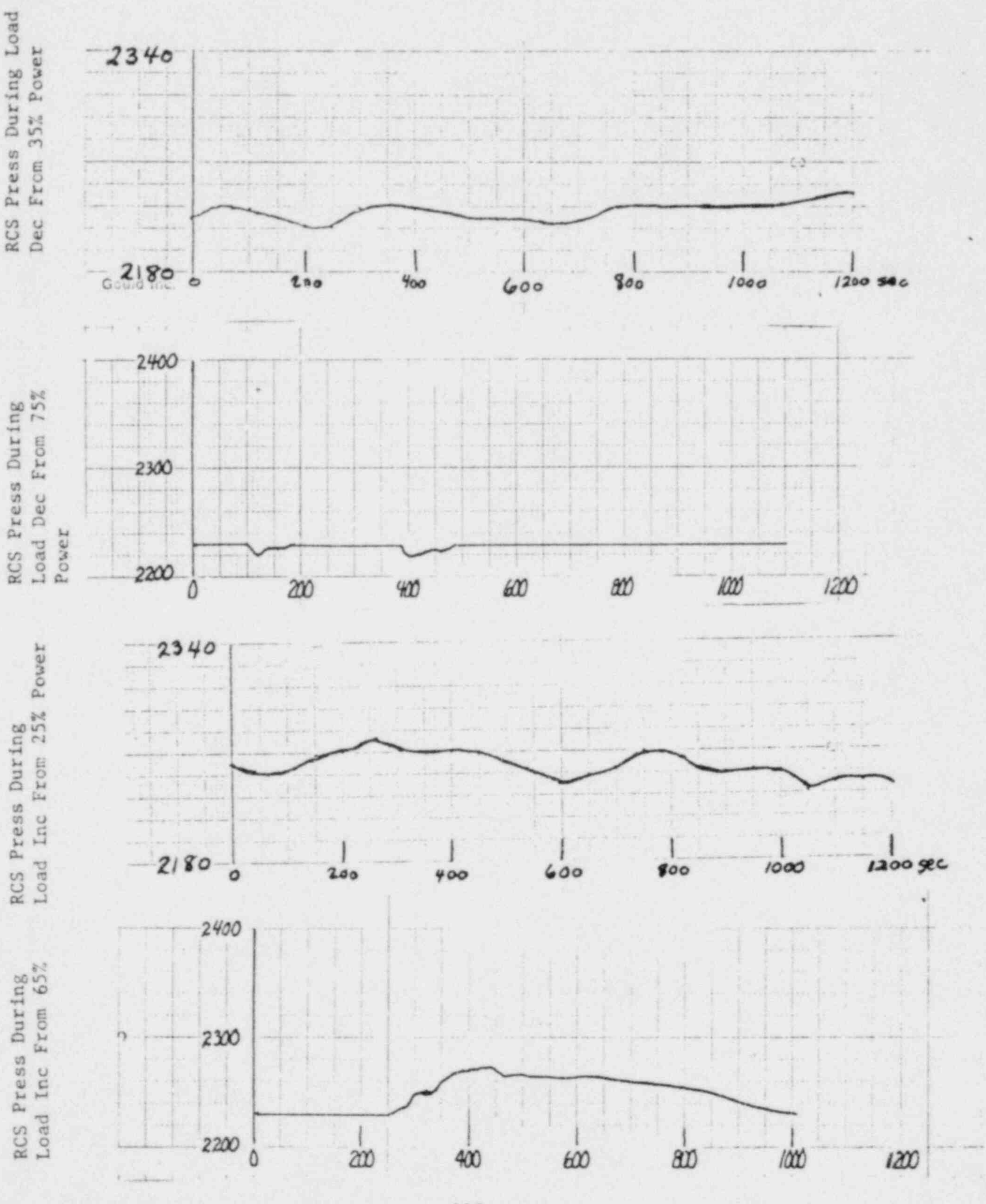

Nuclear Power During
Load Dec From 35% Power
40%
30%
20%
0
200
400
600
800
1000
1200 sec
Nuclear Power During
Load Dec From 75%
Power
75%
65%
55%
0
200
400
600
800
1000
1200 sec.
Nuclear Power During
Load Inc From 25% Power
40%
30%
20%
0
200
400
600
800
1000
1200 sec

Figure 5.2-3



RCS Press During Load Dec From 35% Power
2340
2180
0
200
400
600
800
1000
1200 sec
RCS Press During Load Dec From 75% Power
2400
2300
2200
0
200
400
600
800
1000
1200
RCS Press During Load Inc From 25% Power
2340
2180
0
200
400
600
800
1000
1200 sec
RCS Press During Load Inc From 65%
2400
2300
2200
0
200
400
600
800
1000
1200

Steam Hdr Press During Load Inc From 65% Power

Steam Hdr Press During Load Inc From 25% Power

Steam Hdr Press During Load Dec From 75% Power

Steam Hdr. Press During Load From 35% Power

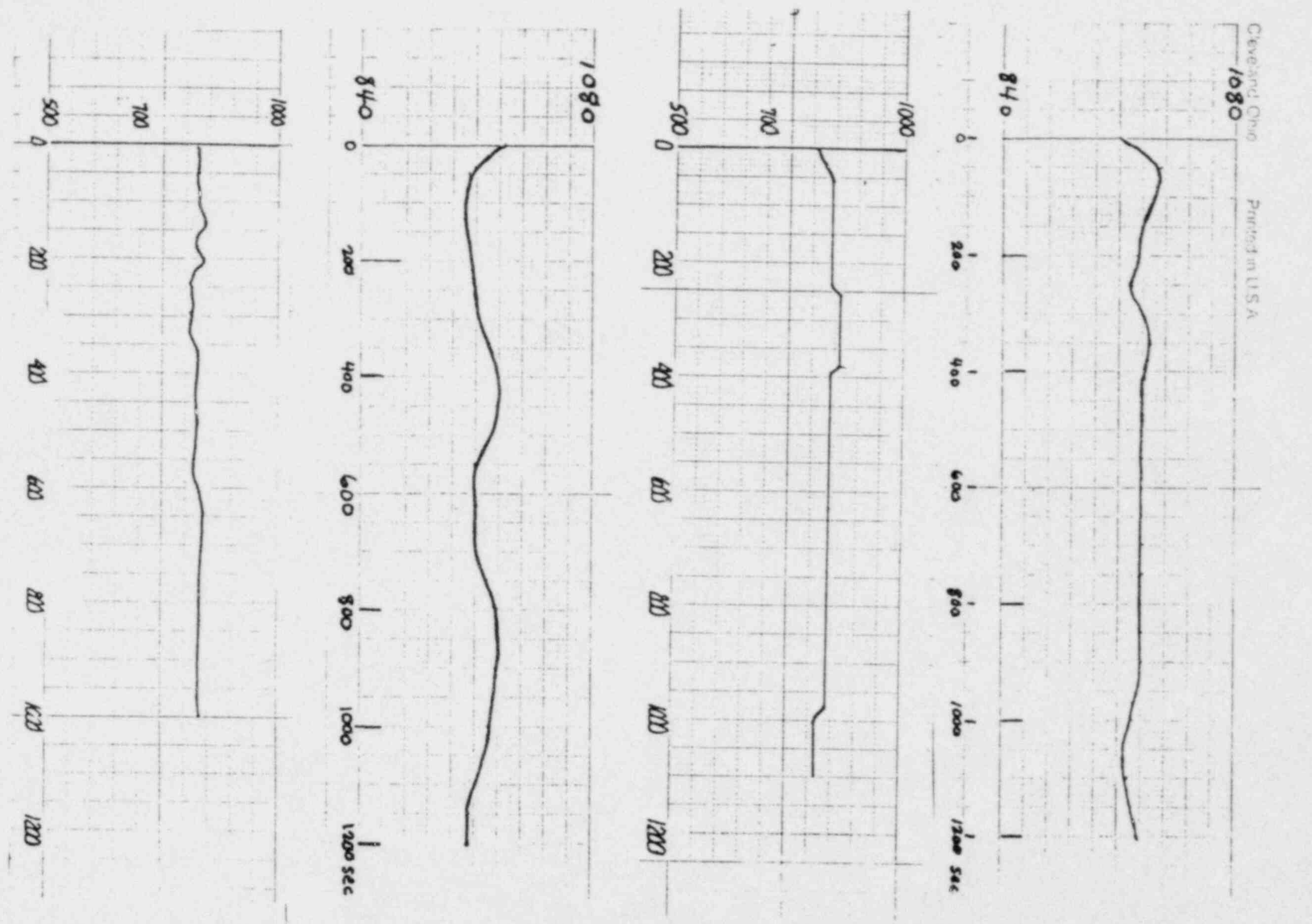


Figure 5.2-4

SG #1 Level During Load Inc From 65% Power

SG #1 Level During Load Inc From 25% Power

SG #1 Level During Load Dec From 75% Power

SG #1 Level During Load Dec From 35% Power

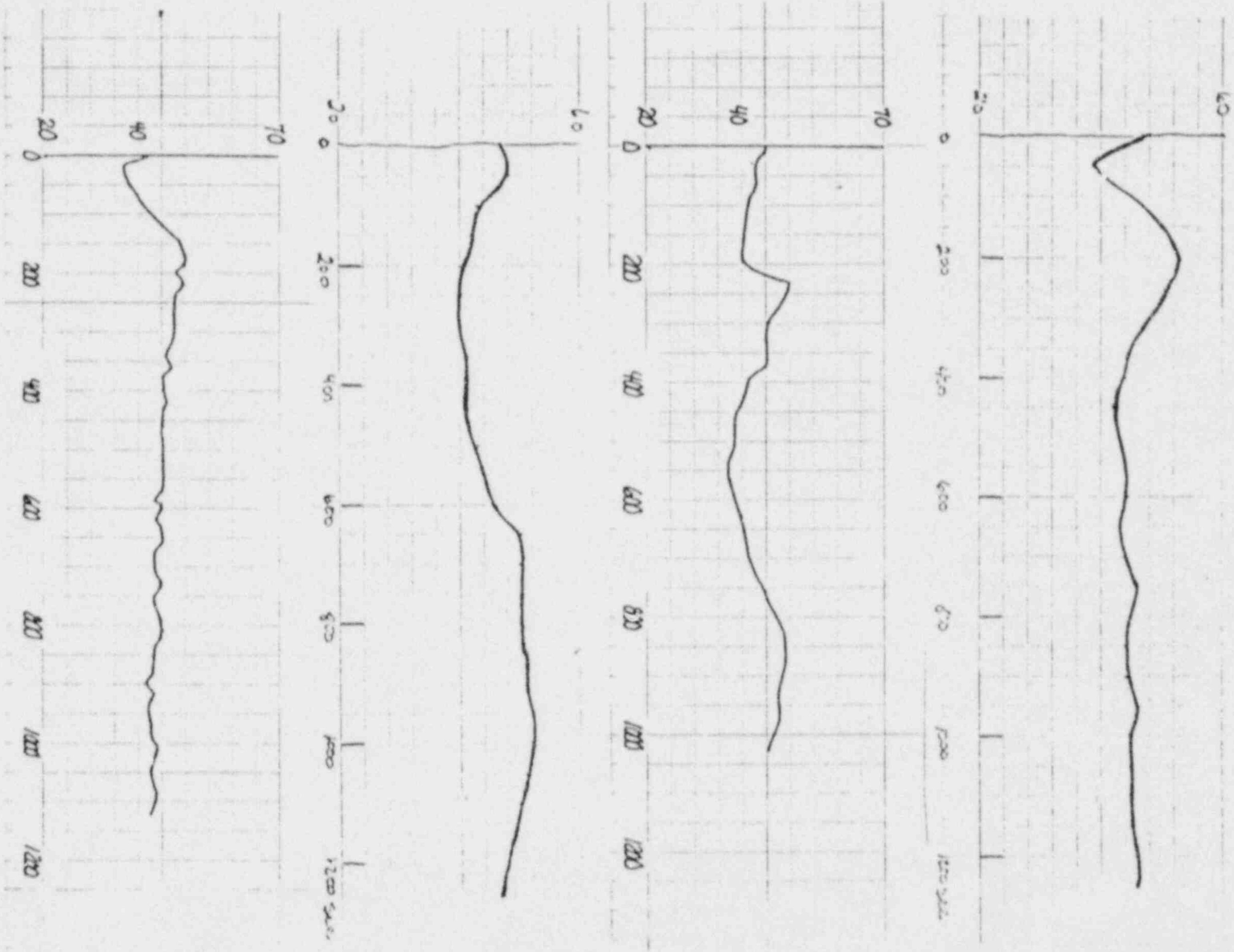


Figure 5.2-5

SG #2 Level During Load Inc From 65% Power

SG #2 Level During Load Inc From 25% Power

SG #2 Level During Load Dec From 75% Power

SG #2 Level During Load Dec From 35% Power

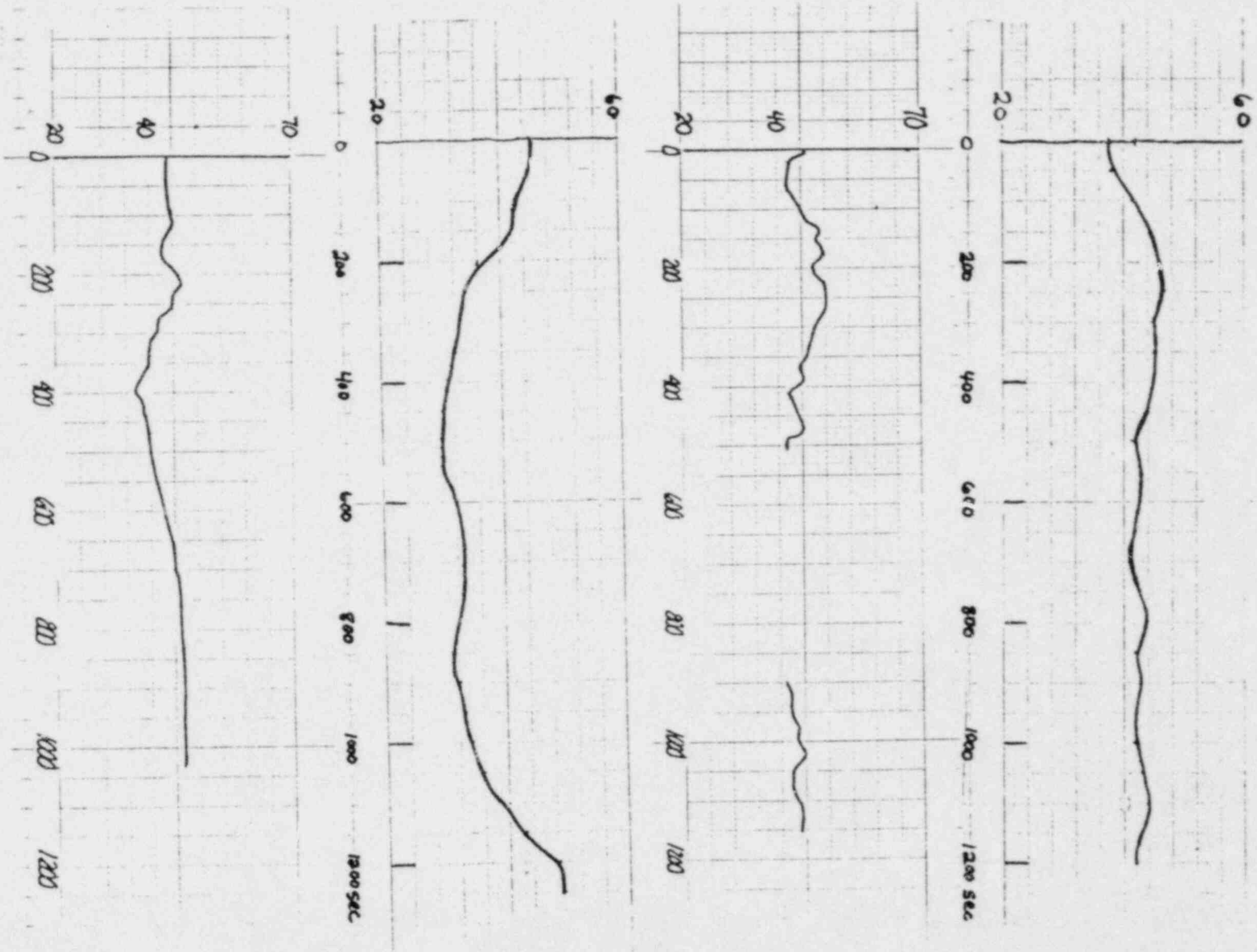


Figure 5.2-6

SG #3 Level During Load Inc From 25% Power

SG #3 Level During Load Dec From 75% Power

SG #3 Level During Load Dec From 35% Power

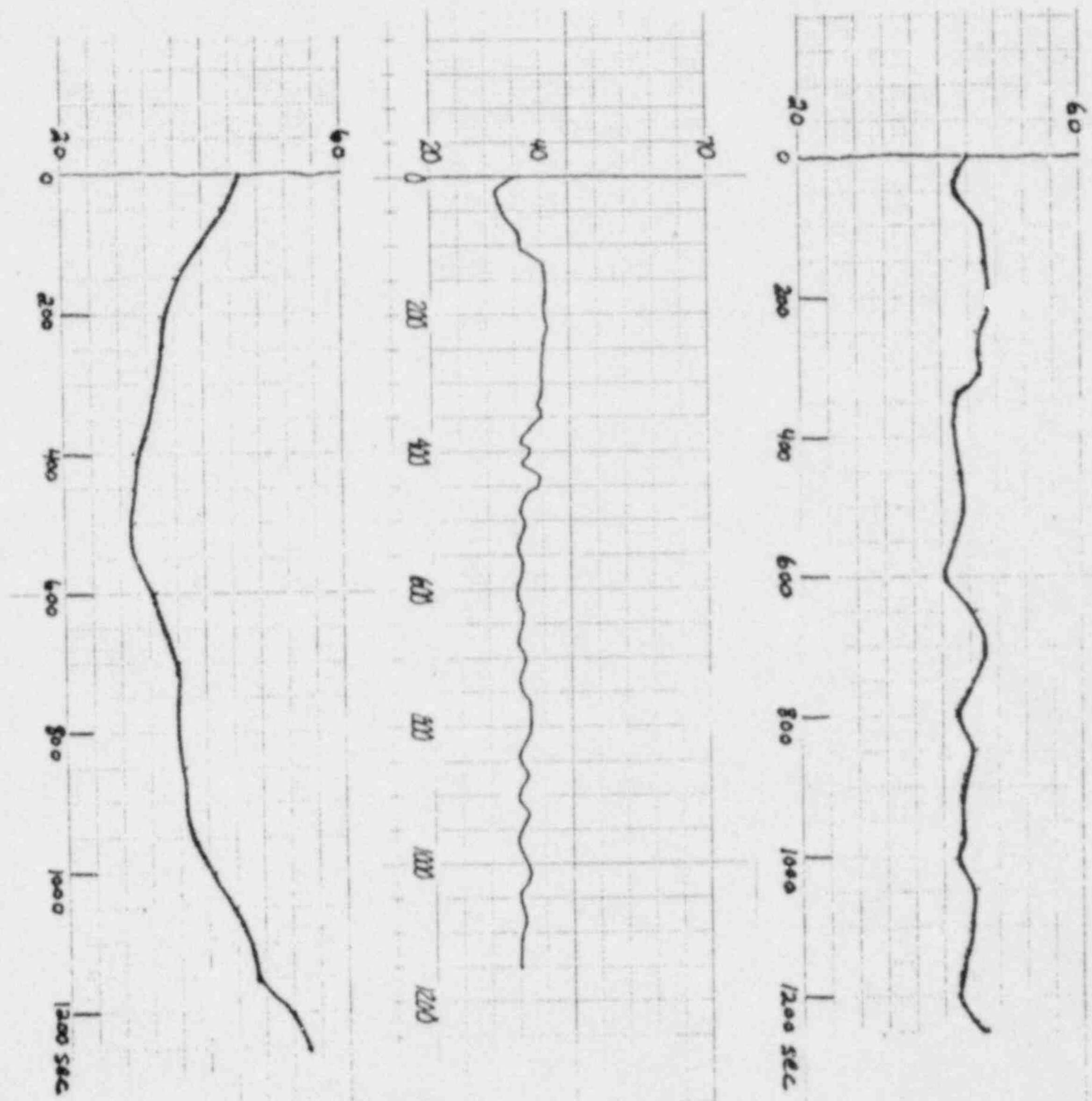


Figure 5.2-7

SG #4 Level During Load Inc From 25% Power

SG #4 Level During Load Dec From 75% Power

SG #4 Level During Load Dec From 35% Power

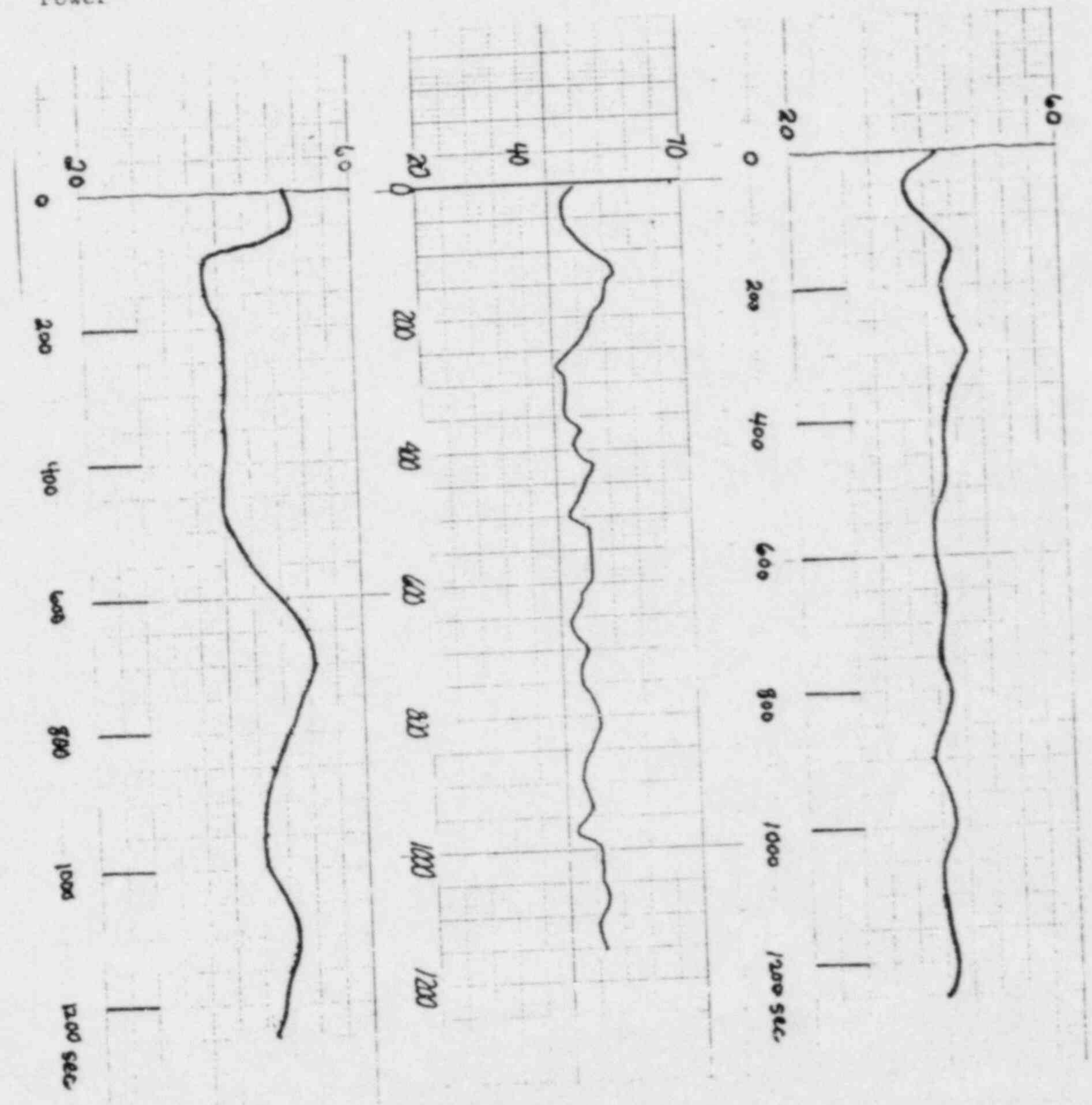


Figure 5.2-8

5.0 OVERALL PLANT RESPONSE (continued)

5.3 Large Load Reduction (Test procedure SU-9.3)

This test was performed to verify the ability of the plant to accept a step load reduction of 50% of rated power without incurring excessive or diverging oscillations in the automatic control systems. With the reactor power at approximately 75% of full power, a 50% decrease in power at a rate of 200% per minute was initiated. Approximately one minute into the test, both main feedwater pumps (A & B) were placed in manual control and pump A run to minimum speed. This action was required to stabilize erratic flow causing rapidly varying steam generator levels. From a review of the data it is believed that the reactor would have tripped had not the operator taken manual control of the main feed pumps. For this reason the validity of the test is still being considered, and the results will be presented in a supplementary report.

This test will also be performed at 100% power at a later date.

5.4 Plant Trip from 100% Power (Test procedure SU-9.4A)

This test is performed to verify the ability of the primary and secondary plant and automatic control systems to sustain a turbine trip from approximately 100% power and bring the plant to a stable condition. The test data will also be used to determine the overall response time of the reactor coolant resistive temperature detectors. This test will be run at a later date.

5.5 100% Net Load Trip (Test procedure SU-9.4B)

This test is performed to verify the ability of the automatic control and projection systems to sustain a net electrical load loss without exceeding turbine design overspeed. Data is taken to check for excessive or diverging oscillations in the plant automatic control systems. This test will be run at a later date.

5.6 Loss of Offsite Power (Test procedure SU-1.1)

The loss of offsite power startup test was performed to investigate reactor transient performance during a station blackout and to demonstrate the ability to place the reactor in a safe shutdown condition using emergency station power.

The shutdown power supply to the primary side of the plant (normally associated with the reactor coolant system and attendent systems) was interrupted by simultaneously opening the normal feeder breakers to the 6900-volt shutdown boards (this generated the blackout signal) and tripping all four reactor coolant pumps (the RCP's are powered from the station unit boards).

5.6 Loss of Offsite Power (continued)

Prior to test initiation, plant electrical systems were aligned to offsite power supplies, the 6.9-kV shutdown board alternate feeder breakers were placed in the tripped position, and the steam dump control switches were placed in the off position. The secondary side of the plant (normally associated with the turbine building) retained normal offsite power.

The reactor trip occurred as a result of undervoltage to the reactor coolant pumps, and immediately thereafter a turbine trip occurred. The turbine driven auxiliary feedwater pump and diesel generators started on the blackout signal. After the diesel generators deenergized the shutdown boards, essential loads began sequencing on. The motor driven auxiliary feedwater pumps were energized 25.2 seconds after the diesel generators were tied to the 6.9-kV shutdown boards. RCS temperature and pressure during natural circulation were controlled in a safe shutdown condition.

During the test, several plant parameters were monitored. Some of these parameters have been reproduced in Figures 5.6-1 to 5.6-5. All parameters behaved as expected.

5.7 Shutdown and Cooldown from Outside the Main Control Room (Test procedures SU-1.2A and SU-1.2B)

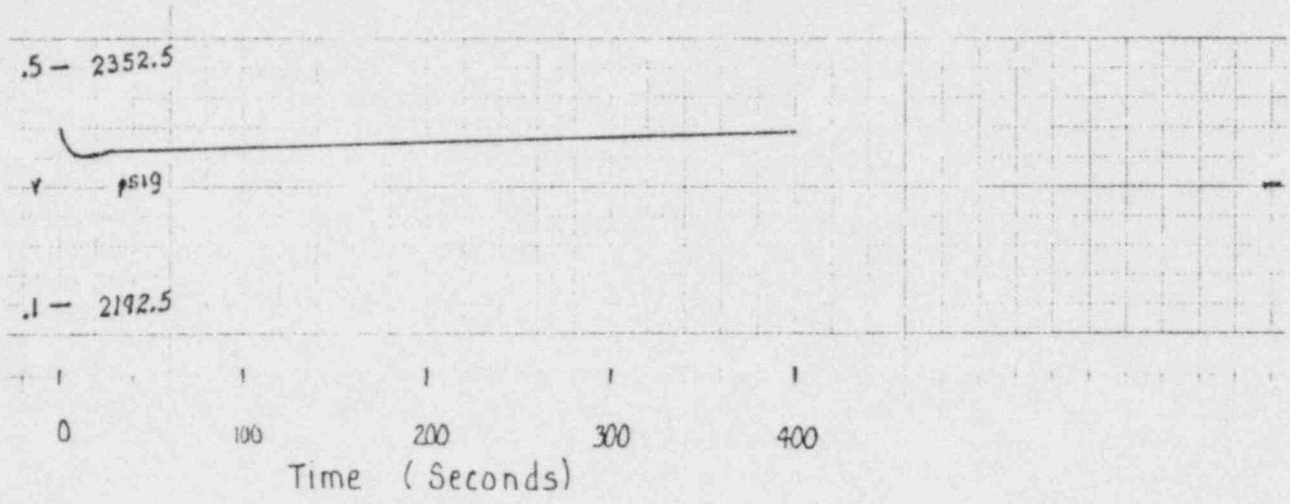
These tests were performed to demonstrate that the unit can be safely shutdown and maintained in hot standby from outside the main control room and to demonstrate that the plant can be safely cooled down from hot standby to cold shutdown.

The shutdown from outside the main control room was performed as follows: The unit was initially operating at ~30% power when the reactor was tripped from outside the main control room. Reactor trip was initiated by tripping the power supply to the control rod drive motor generator sets from the 1B 480V unit board. With one RO and SRO remaining in the main control room for observation, the unit control was transferred to the auxiliary control room. The auxiliary control room was manned with the minimum shift crew. With plant control from outside the main control room, the unit was maintained in hot standby for 30 minutes. All acceptance criteria were satisfied.

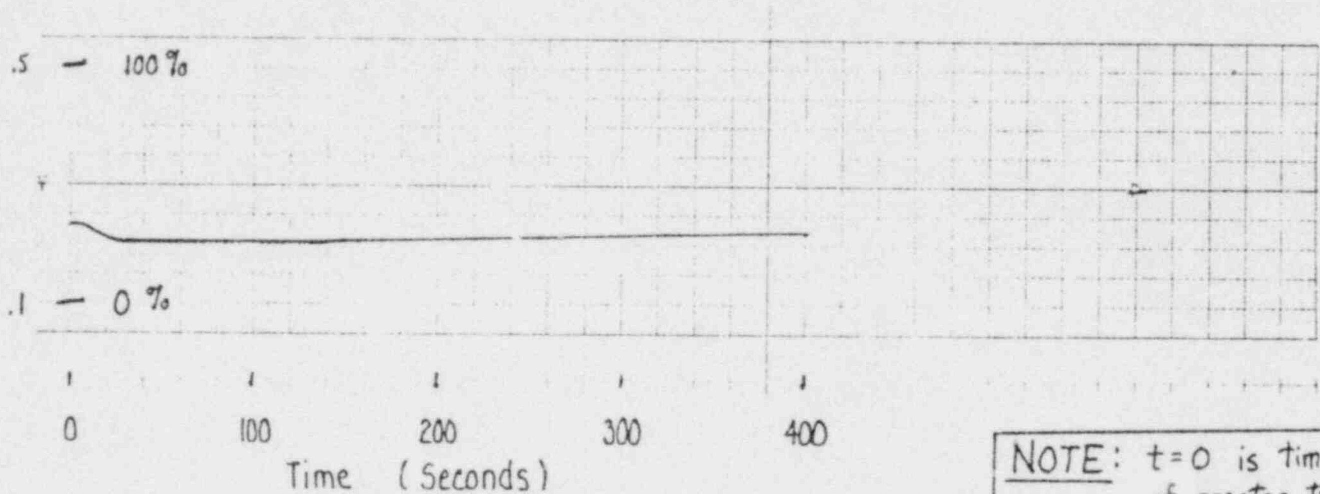
Cooldown from outside the main control room was initiated from hot zero power conditions and was performed as follows: With one SRO and one RO remaining in the main control room for observation, the plant control was transferred to the auxiliary control room. The auxiliary control room was manned with one SRO, one RO, and three AUO's (Assistant Unit Operators). From outside the main control room, the plant was cooled down from a T_{avg} of 551°F to 350°F using the steam generator atmospheric relief valves. After T_{avg} was less than 350°F, residual heat removal shutdown cooling was aligned and the RCS temperature was further reduced to 300°F. All acceptance criteria were met with exception that P-11 (low pressure pressurizer safety injection block) and P-12 (high steam flow safety injection

Figure 5.6-1

Pressurizer Pressure (PP/455B)



Pressurizer Level (LP/459B)



NOTE: t=0 is time of reactor trip.

Auctioneered Tavg (TP/412N)

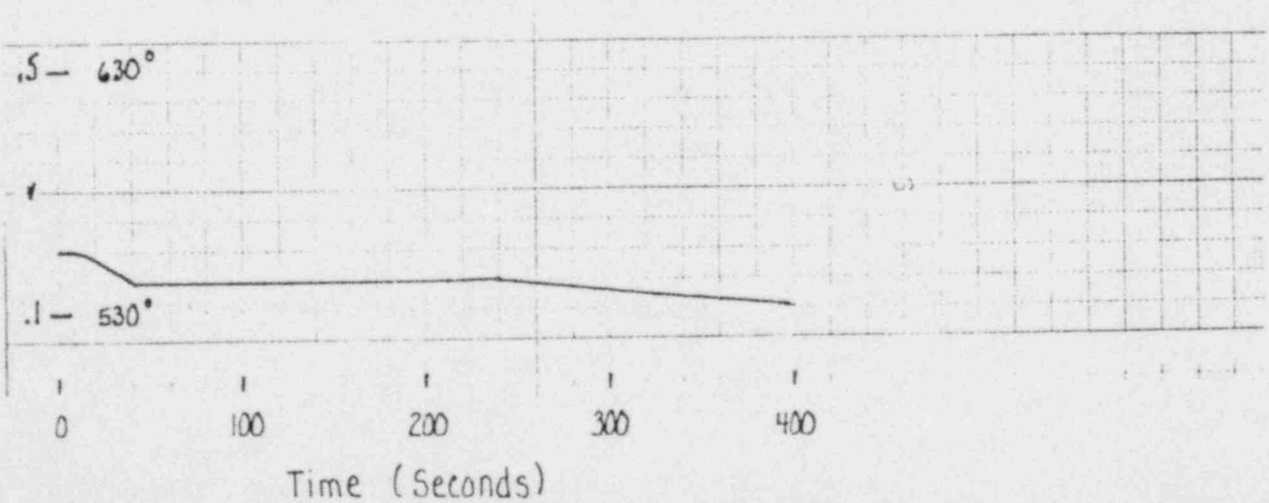
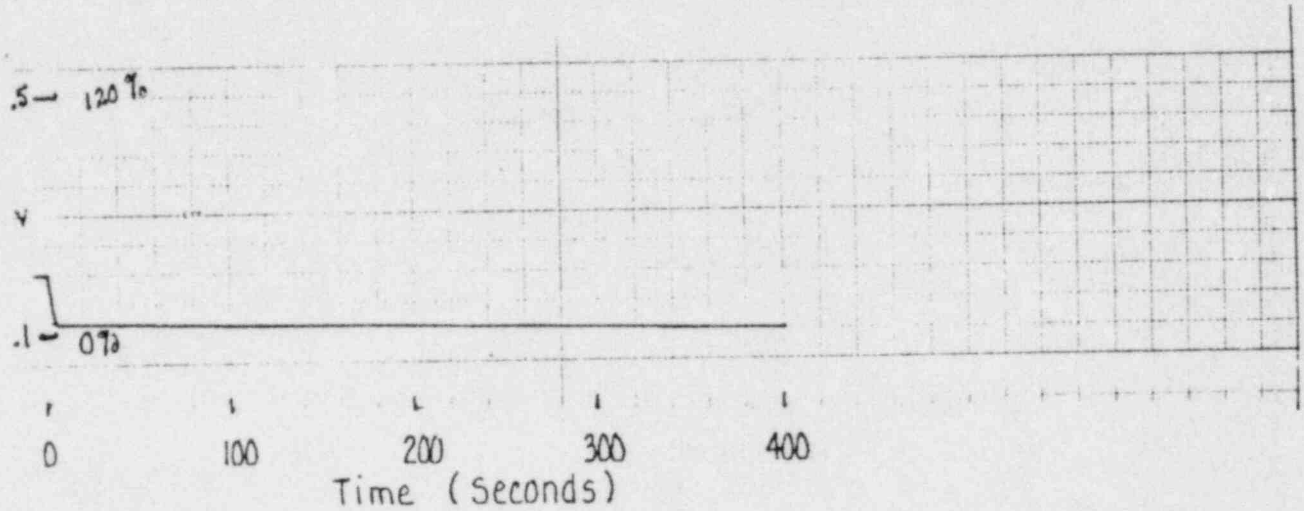
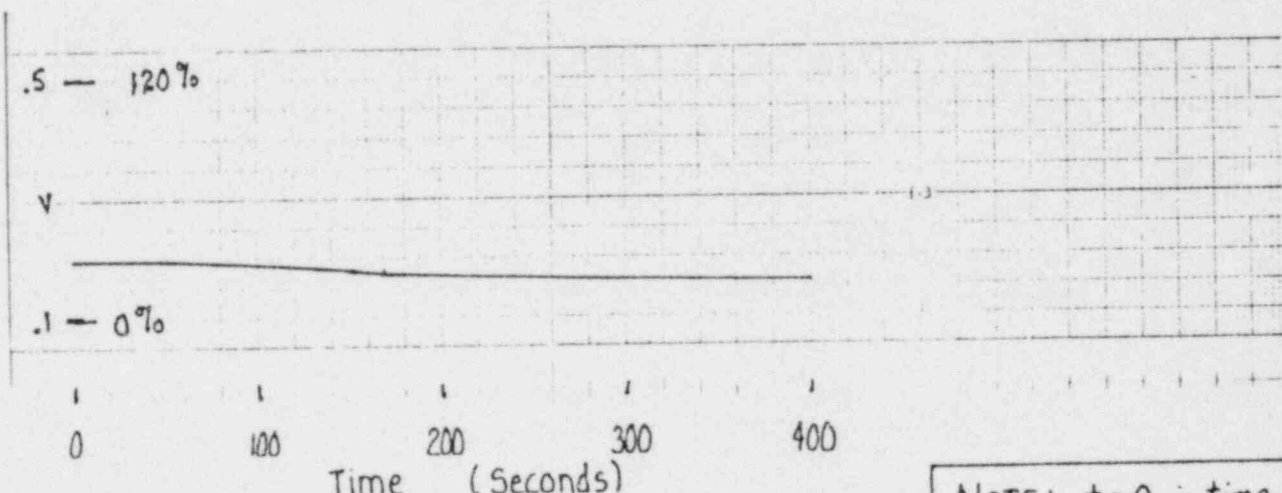


Figure 5.6-2

Auctioneered Nuclear Flux (JP/412)

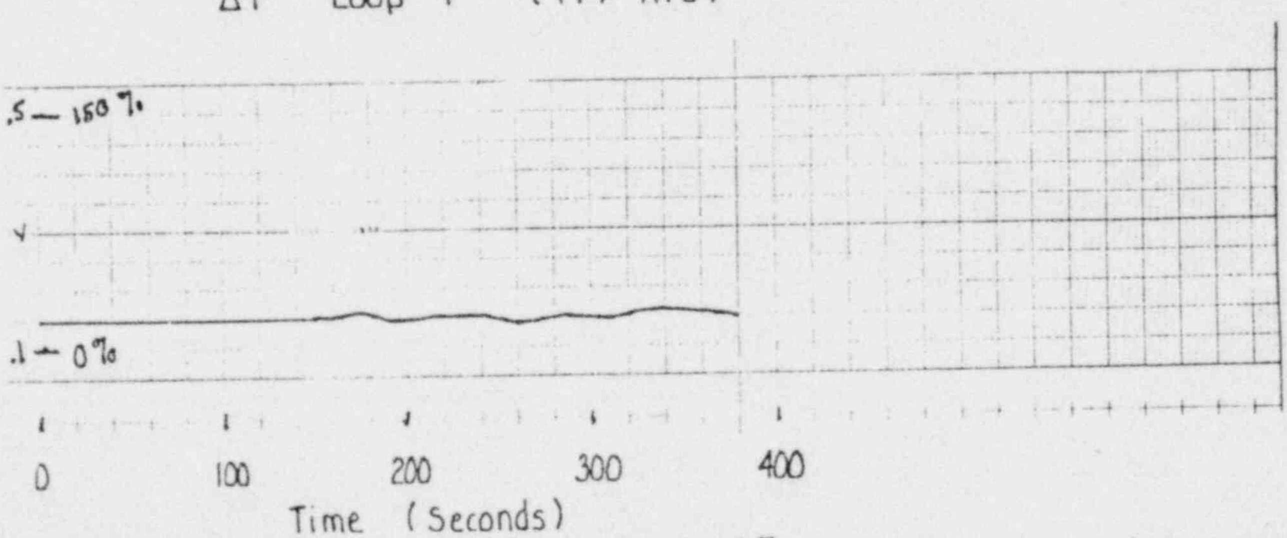


Tref (TP/505C)



NOTE: t = 0 is time of reactor trip.

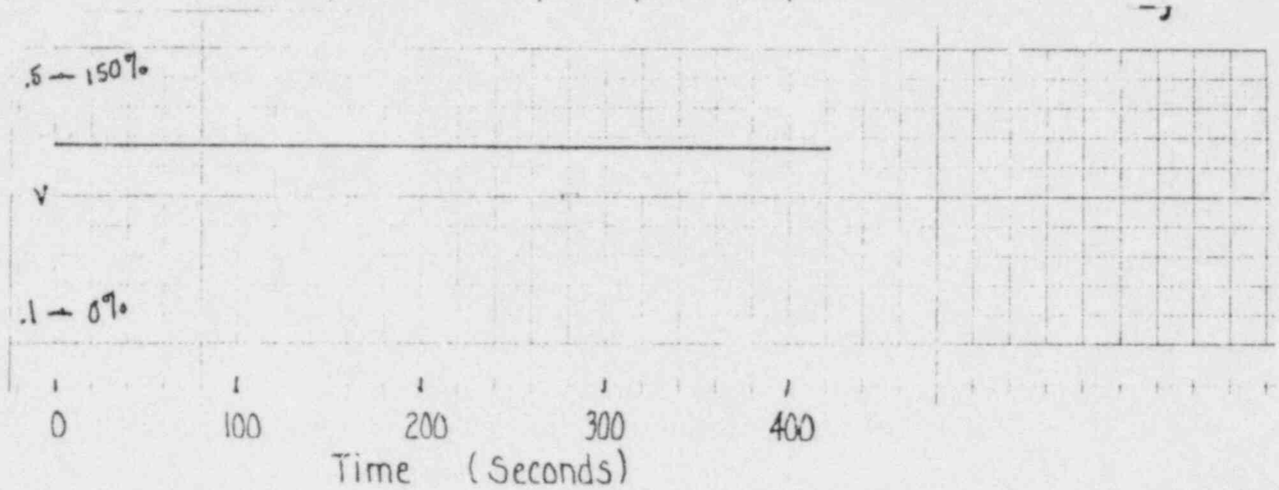
ΔT - Loop 1 (TP/411J)



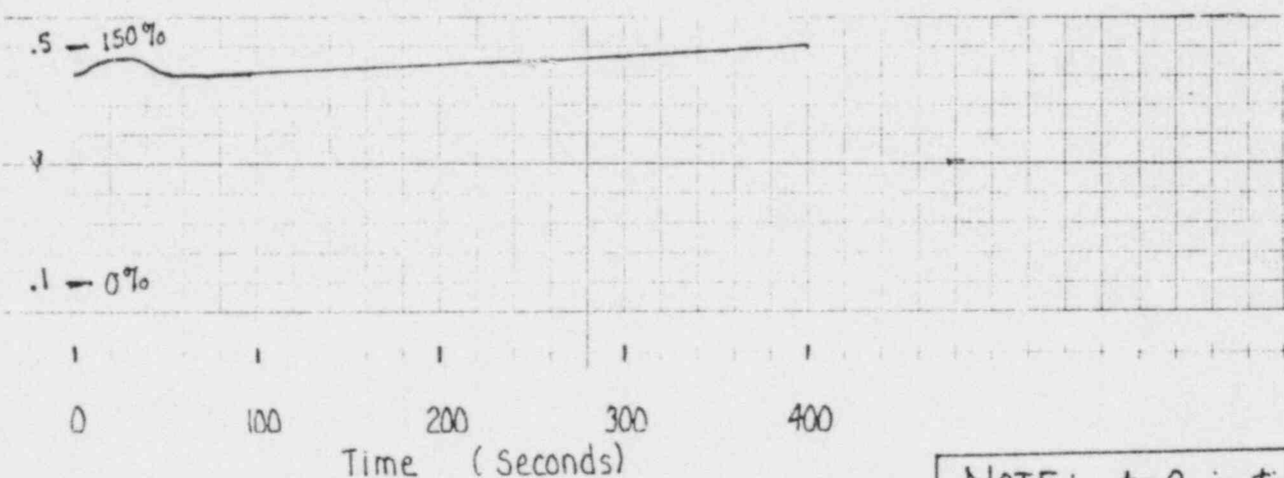
Loss of Offsite Power from 30%

Figure 5.6-3

Overpower ΔT Trip Setpoint - Loop 1 (TP/411 L)

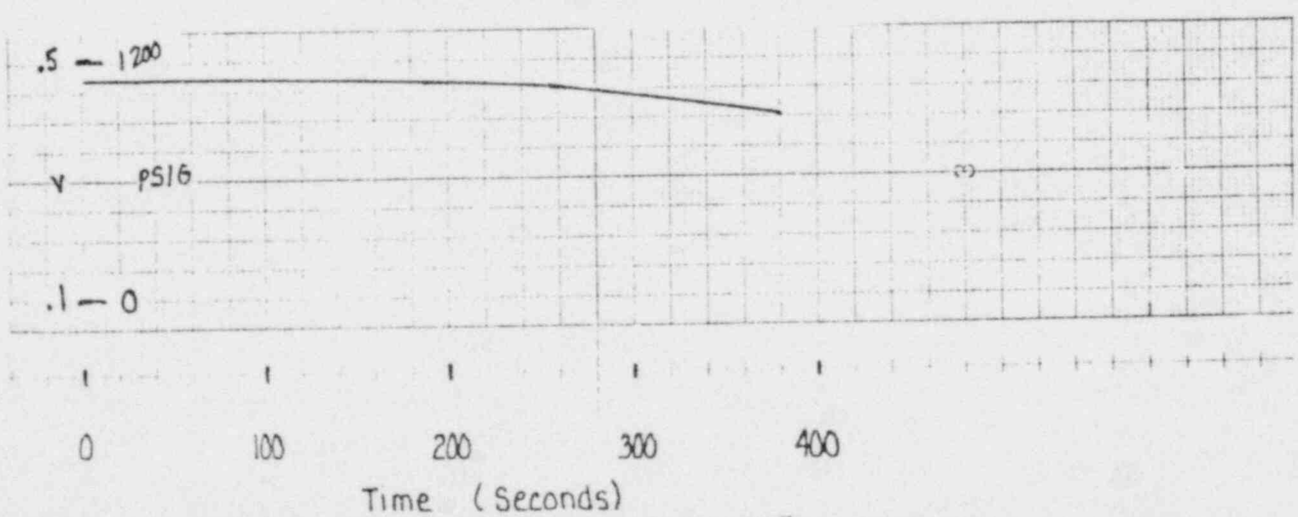


Overtemperature ΔT Trip Setpoint - Loop 1 (TP/411 K)



NOTE: t=0 is time of reactor trip.

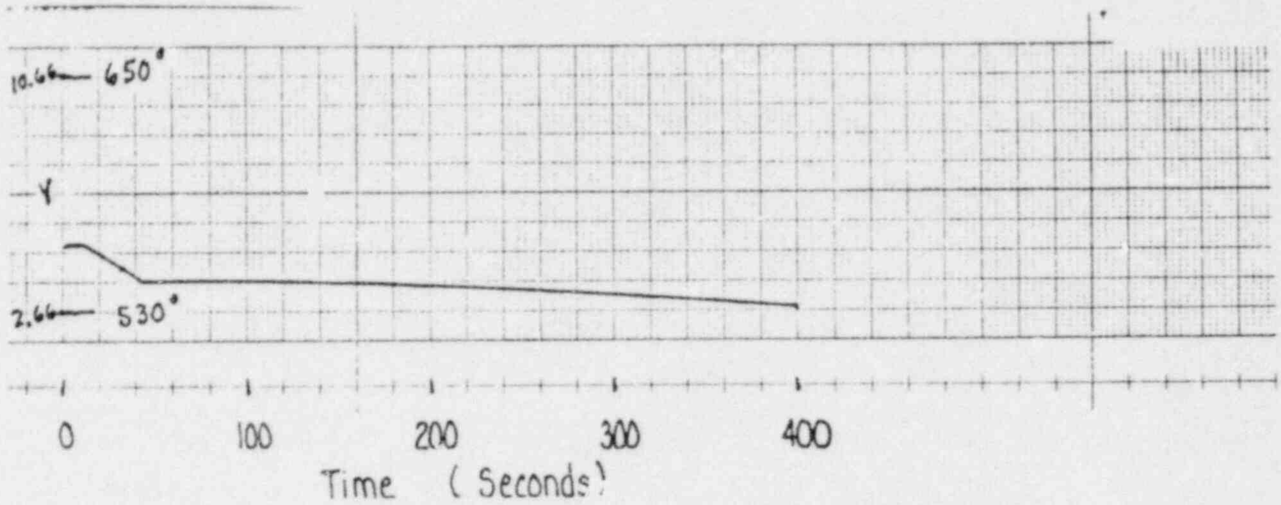
Steam Header Pressure (PP/507 A)



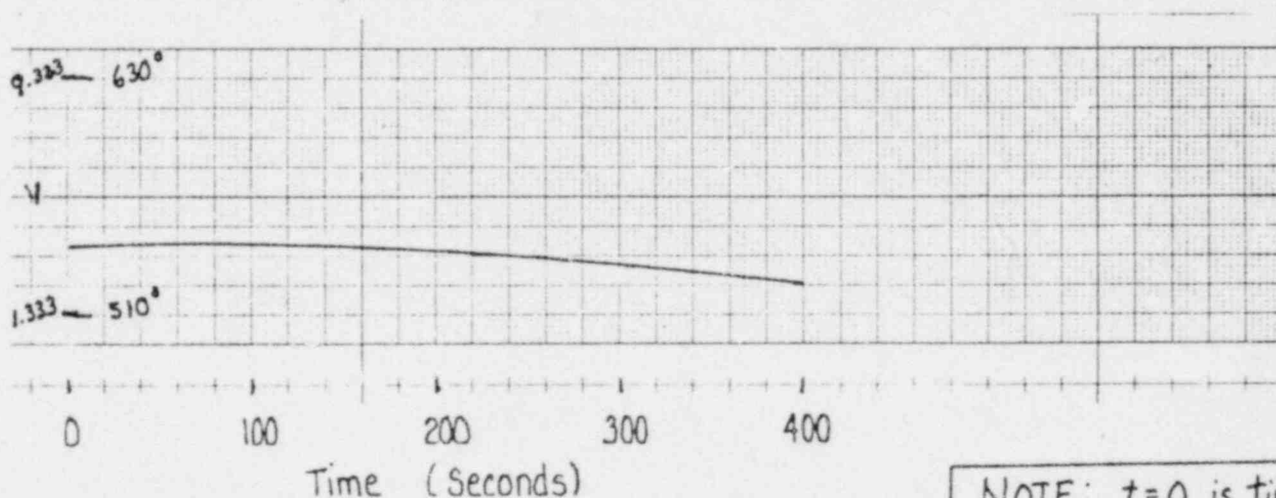
Loss of Offsite Power from 30%

Figure 5.6-4

Hot Leg Temperature (T_H) Loop 1 (TP/411 C)

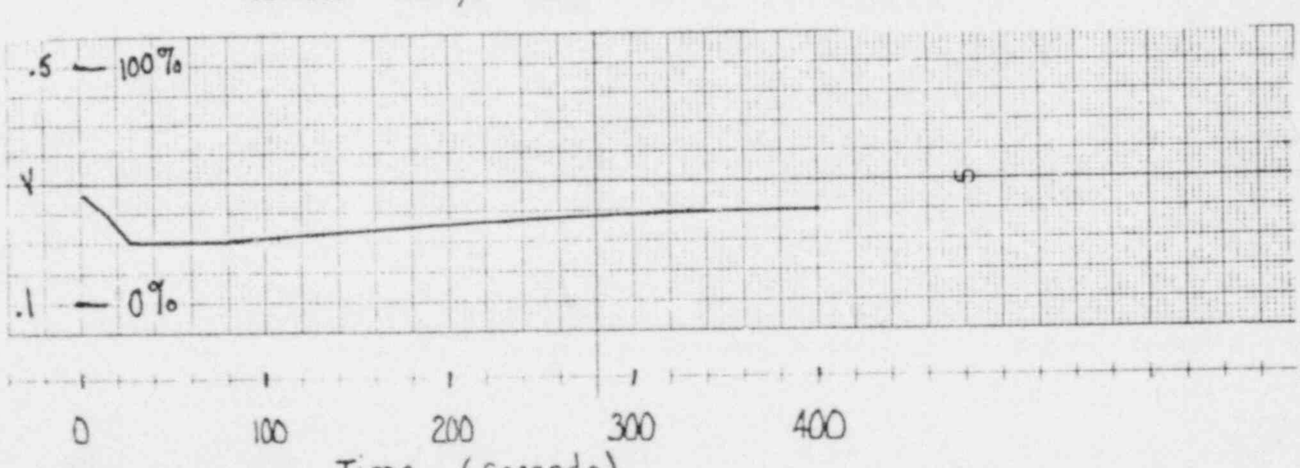


Cold Leg Temperature (T_C) - Loop 1 (TP/411 D)



NOTE: t=0 is time of reactor trip.

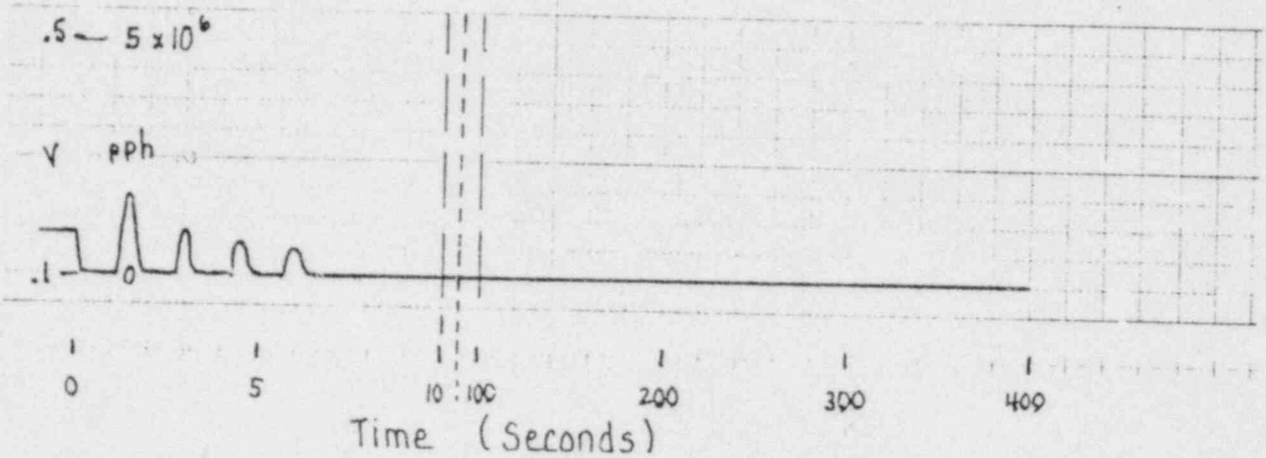
Narrow Range Level - SG 1 (LP/519 B)



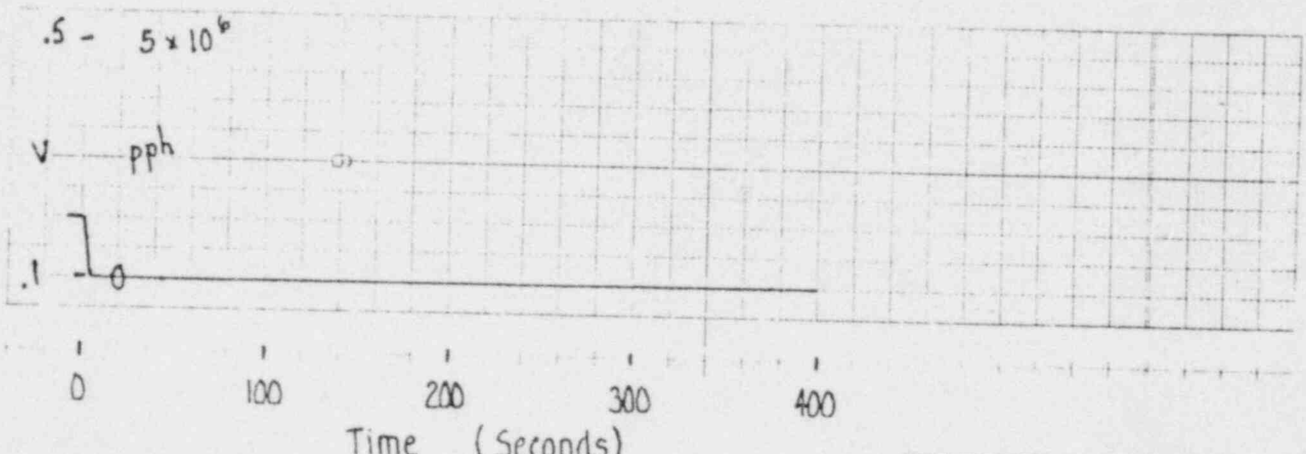
Loss of Offsite Power from 30%

Figure 5.6-5

Steam Flow - SG 1 (FP/512 F)

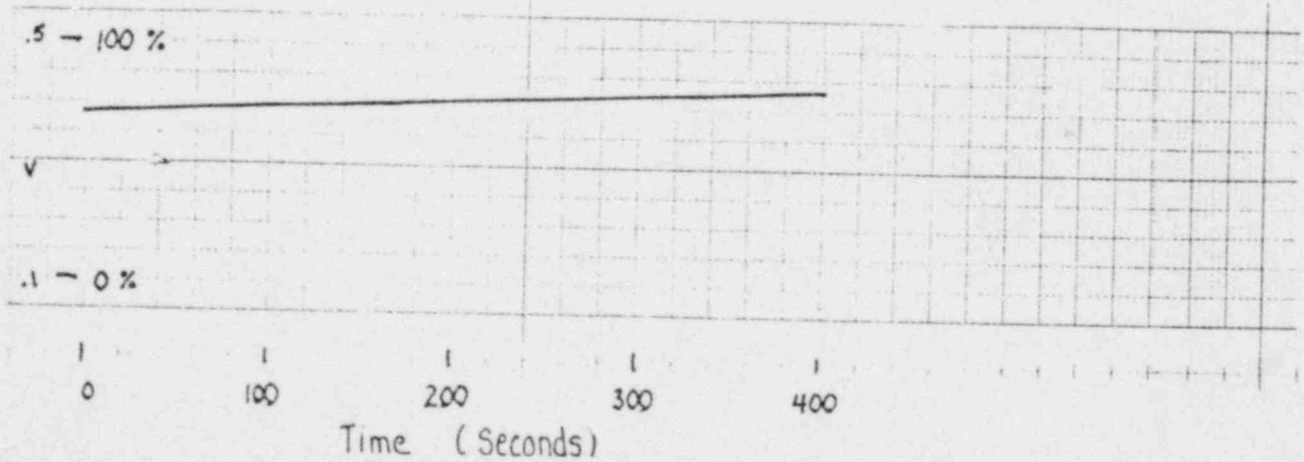


Feedwater Flow - SG 1 (FP/510 C)



NOTE: t=0 is time of reactor trip.

Wide Range Level - SG 1 (LP/501 B)



Loss of Offsite Power from 30 %

5.0 OVERALL PLANT RESPONSE (continued)

5.7 Shutdown and Cooldown from Outside the Main Control Room (continued)

block) were blocked from the main control room. The cause of these deficiencies (defective procedures) was corrected and P-11 and P-12 were successfully blocked from outside the main control room during a subsequent plant cooldown. Thus, the results of the test are acceptable.

5.8 Rod Group Drop and Plant Trip (Test procedure SU-9.5)

This test was performed to demonstrate the proper response of the power range nuclear instrumentation negative rate trip circuitry. Two rods, P-4 and D-2, in shutdown bank A (see Figure 5.8-1) were simultaneously dropped at a nominal 50% reactor power. These rods were chosen because their proximity to the excore detectors made the detector response most limiting for the 3 out of 4 trip criterion.

Reactor power was reduced at a rate sufficient to cause the negative rate trip circuitry of all four power range channels to function. The sequence of events occurring after the two rods were dropped is shown in Table 5.8-1. All acceptance criteria were satisfied.

TABLE 5.8-1

Sequence of Events

Negative Rate Reactor Trip

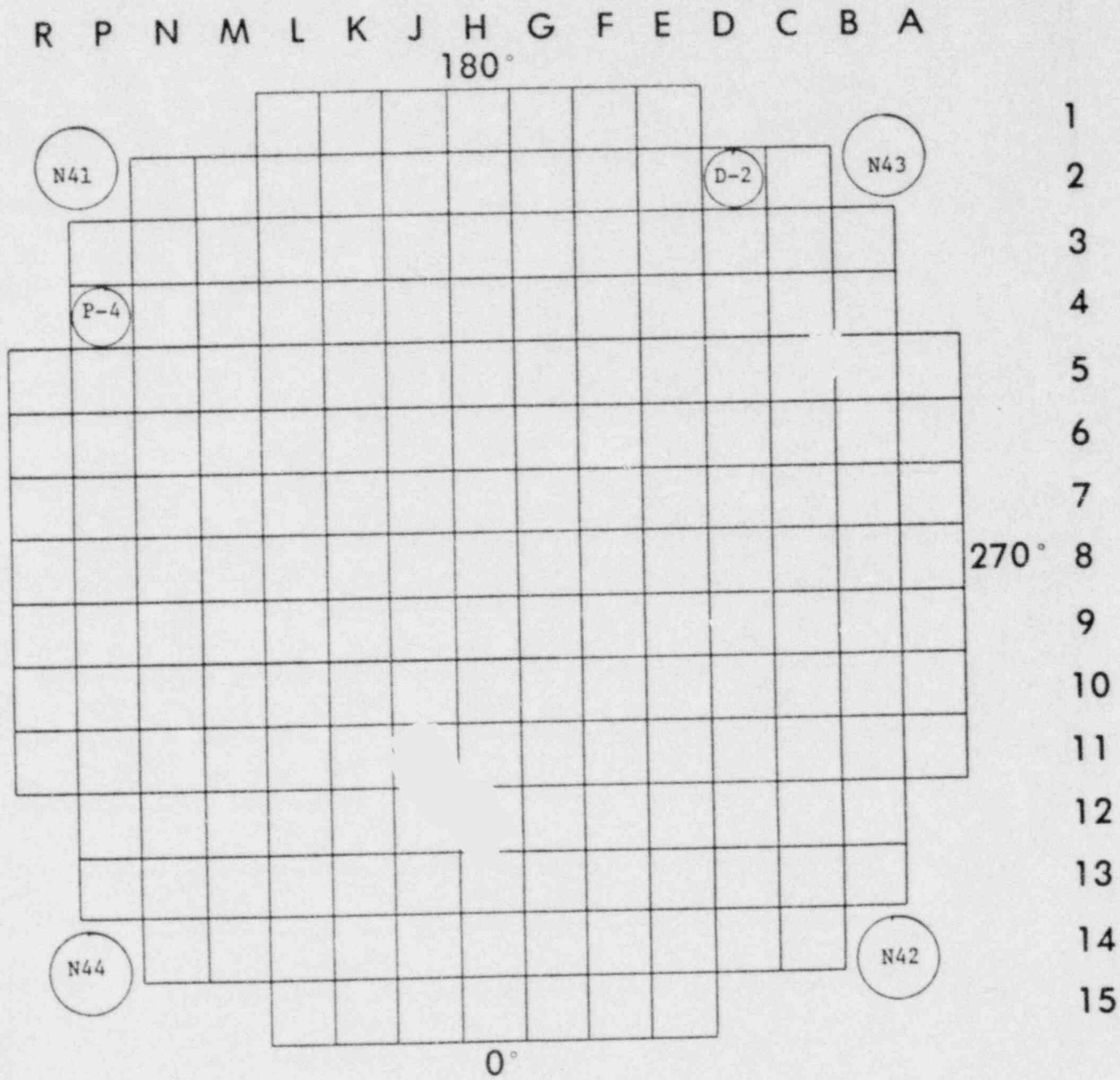
Time (Seconds)	EVENT			
0	RCCA's P-4 and D-2 dropped into core.			
	N-41	N-42	N-43	N-44
.5	Rate circuit responded		Rate circuit responded	
.8	Bistable tripped		Bistable tripped	
.9		Rate circuit responded		Rate circuit responded
1.0	Reactor trip - remaining RCCA's dropped into core.			
1.2		Bistable tripped		
1.3				Bistable tripped

FIGURE 5.8-1

SEQUOYAH UNIT 1

Figure 1

Proximity of Dropped Rods to Excore Detectors



TVA 7823A (PP-10-77) SEQUOYAH CORE MAP

5.0 OVERALL PLANT RESPONSE (continued)

5.9 Steam Generator Moisture Carryover (Test procedure SU-10.2)

This test was performed to ensure that the moisture content of the steam from the Nuclear Steam Supply System does not exceed .25%. This was accomplished by injecting sodium-24, a radioactive tracer, into the steam generators and measuring the corresponding activity carried over into the steam and feedwater flows. The amount of moisture carryover was determined to be 0.013% at 75% reactor power and 0.020% at 90% reactor power, satisfying the acceptance criteria of ≤.25% for both cases. A value for the moisture carryover at 100% reactor power will be determined at a later date.

5.10 Nuclear Steam Supply System Acceptance Test (Test procedure SU-10.1)

This test is performed to demonstrate the reliability and guaranteed output of the Nuclear Steam Supply System. Reliability is demonstrated by a 300-hour run at rated output power (+0%, -5%) completed without a load reduction or plant trip resulting from an NSSS malfunction. Guaranteed output is measured by a 4-hour performance measurement test conducted during the reliability run. This test will be completed at a later date.

6.0 PREOPERATIONAL TESTS PERFORMED AFTER FUEL LOADING

6.1 Preoperational Tests Conducted Prior to Initial Criticality

6.1.1 Incore Movable Detectors (Test procedure W-11.4)

The incore movable detector test measured all detector path lengths and verified the operation of the five and ten path transfer devices, drive mechanisms, limit switches, indicator lights, displays, and interlocks. The six detector cable leakage currents were measured. The operation of the CO_2 purge system and the leak and alarm systemwere also verified.

The following functions and settings were verified: (1) The core top and core bottom limits for each detector, (2) All limit switch settings for each detector using the encoder position readout indicator, (3) Proper switching and mode indication for the five and ten path transfer units, (4) Proper operation of each detector in the manual and automatic drive modes, (5) Contact closure inputs supplied to the plant computer from each detector, (6) Purge gas flow from the CO_2 gas system while withdrawing a detector, (7) Proper operation of the leak detection and alarm system, (8) All interlock functions of the multiple drive shutoff logic, (9) Multiple drive capability using six detector assemblies, (10) The leakage current values on each detector to be between 10^{-10} and 10^{-8} amperes, and (11) The detector speed during the record mode to be between 2.376 and 2.424 inches per second. This satisfied the acceptance criteria associated with the test.

6.1.2 Control Rod Drive Mechanism Timing (Test procedure W-9.1)

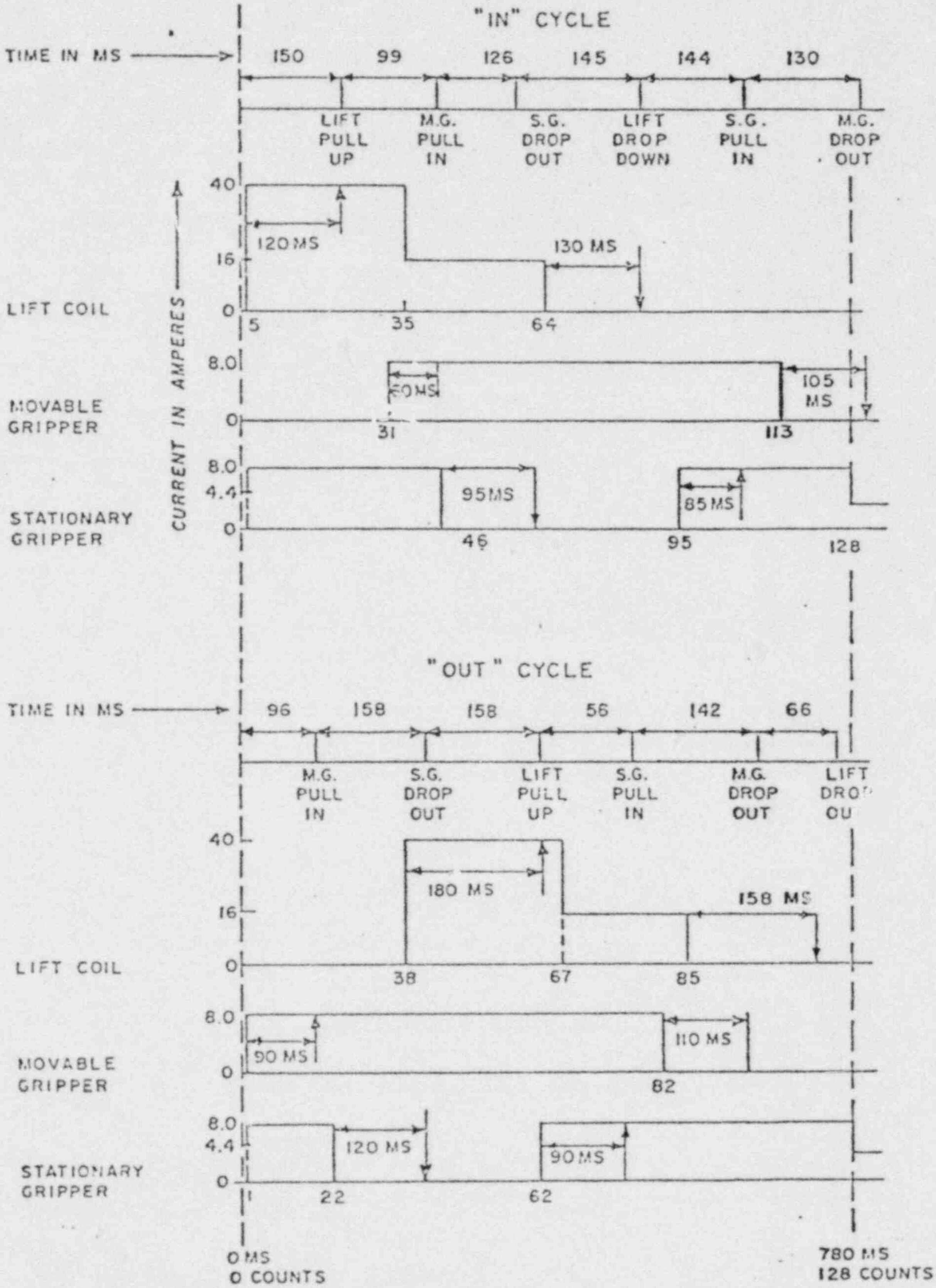
The control rod drive mechanism timing test verified the correct timing of each rod control system slave cycler. An oscillograph trace was taken for each control rod drive mechanism showing the mechanism noise, lift coil current, movable gripper coil current, and stationary gripper coil current during rod movement under both cold and hot plant conditions.

The test acceptance criteria are (1) The timing of each rod control system slave cycler is within the limits shown in Figure 6.1.2-1; (2) The lift coil, movable gripper coil, and stationary gripper coil currents are within the tolerances set by the vendor; and (3) The control rod drive mechanism with rod cluster control assembly is operational. These criteria were satisfied.

6.1.3 Rod Drop Time (Test procedure W-9.3)

The rod drop time of each control rod was measured with the plant in a cold, no-flow condition. The drop times were reviewed and the rods having the fastest drop time and the slowest drop time were selected. The two selected rods were then dropped an additional ten times and their drop times were measured each time. This entire procedure was repeated with the plant at cold full-flow conditions, at hot no-flow condition and at hot full-flow condition.

FIGURE 6.1.2-1
SLAVE CYCLER TIMING SEQUENCE



6.0 PREOPERATIONAL TESTS PERFORMED AFTER FUEL LOADING (continued)

6.1.3 Rod Drop Time (continued)

The test results for the rod drops are given in Tables 6.1.3-1 to 6.1.3-4.

The acceptance criteria are (1) The rod drop time of each control rod is $\leq$2.2 seconds from the beginning of decay of the stationary gripper coil voltage to dashpot entry at operating temperature and full-flow condition; and (2) The rod release time (the time it takes for the rod position detector to respond to rod motion, with time zero being when the stationary gripper fuses are pulled) is $\leq$150 milliseconds for each control rod. These criteria were satisfied.

Table 6.1.3-1 Rod Drop Times, Cold, No Flow

RCCA BANK	RCCA GRID LOCATION	TIME FROM START TO DASH POT t_1 (secs)	TIME FROM DASH POT TO BOTTOM t_2 (secs)	TOTAL DROP TIME $t_1 + t_2$ (secs)	ROD RELEASE TIME (secs)	RCS T_{avg} (°F)	RCS FLOW (%)	RCS PRESS (psig)
SHUTDOWN BANK A	D2	1.20	0.51	1.71	0.025	160	0	365
	B12	1.19	0.50	1.69	0.017	160	0	365
	M14	1.19	0.50	1.69	0.017	160	0	365
	P4	1.20	0.51	1.71	0.025	160	0	365
	B4	1.19	0.51	1.70	0.017	160	0	365
	D14	1.19	0.50	1.69	0.017	160	0	365
	P12	1.20	0.50	1.70	0.020	160	0	365
	M2	1.20	0.51	1.71	0.033	160	0	365
SHUTDOWN BANK B	G3	1.18	0.48	1.66	0.017	160	0	370
	C9	1.19	0.50	1.69	0.017	160	0	370
	J13	1.18	0.51	1.69	0.017	150	0	375
	N7	1.19	0.50	1.69	0.025	160	0	370
	C7	1.19	0.50	1.69	0.017	150	0	370
	G13	1.19	0.50	1.69	0.017	150	0	370
	N9	1.18	0.50	1.68	0.020	150	0	370
	J3	1.18	0.51	1.69	0.025	150	0	370
SHUTDOWN BANK C	E3	1.19	0.49	1.68	0.025	150	0	370
	C11	1.17	0.51	1.68	0.017	150	0	370
	L13	1.18	0.51	1.69	0.017	150	0	370
	N5	1.20	0.49	1.69	0.029	150	0	370
SHUTDOWN BANK D	C5	1.19	0.51	1.70	0.017	150	0	370
	E13	1.19	0.50	1.69	0.017	150	0	370
	M11	1.19	0.52	1.71	0.017	150	0	370
	L3	1.21	0.51	1.72	0.025	150	0	370

Table 6.1.3 - 1 Rod Drops for Cold, No - Flow

RCCA BANK	RCCA Grid Location	Time From Start to Dash Pot t_1 (secs)	Time From Dash Pot to Bottom t_2 (secs)	Total Drop Time t_1+t_2 (secs)	Rod Release Time (secs)	RCS T_{avg} (°F)	RCS Flow (%)	RCS Press (psig)
CONTROL BANK A	H6	1.18	0.51	1.69	0.017	150	0	360
	H10	1.18	0.49	1.67	0.033	150	0	360
	F8	1.19	0.50	1.69	0.025	150	0	360
	K8	1.19	0.50	1.69	0.033	150	0	360
CONTROL BANK B	F2	1.19	0.51	1.70	0.017	150	0	370
	B10	1.19	0.51	1.70	0.018	150	0	370
	K14	1.19	0.50	1.69	0.017	150	0	360
	P6	1.19	0.51	1.70	0.027	150	0	370
	B6	1.19	0.51	1.70	0.029	150	0	370
	F14	1.19	0.52	1.71	0.015	150	0	370
	P10	1.19	0.50	1.69	0.017	150	0	370
	K2	1.19	0.50	1.69	0.023	150	0	370
CONTROL BANK C	H2	1.18	0.50	1.68	0.017	150	0	360
	B8	1.20	0.51	1.71	0.027	150	0	360
	H14	1.19	0.52	1.71	0.017	150	0	360
	P8	1.19	0.50	1.69	0.025	150	0	360
	F6	1.17	0.49	1.66	0.017	150	0	360
	F10	1.19	0.49	1.68	0.025	150	0	360
	K10	1.19	0.50	1.69	0.017	150	0	360
	K6	1.19	0.52	1.71	0.033	150	0	360
CONTROL BANK D	D4	1.18	0.51	1.69	0.017	150	0	360
	D12	1.19	0.50	1.69	0.017	150	0	360
	M12	1.19	0.52	1.71	0.017	150	0	360
	M4	1.18	0.51	1.69	0.017	150	0	360
	H4	1.19	0.51	1.70	0.017	150	0	360
	D8	1.18	0.51	1.69	0.017	150	0	360
	H12	1.19	0.50	1.69	0.017	150	0	360
	M8	1.19	0.50	1.69	0.018	150	0	360
	H8	1.11	0.50	1.61	0.017	150	0	360

Table 6.1.3 - 1 Rod Drops For Cold ; No - Flow

ROD NO. H8

(Fastest Drop Time)

RCS Temp. 147 °F AVERAGE
RCS Press. 367 psig AVERAGE
RCS Flow 0 %
Date 5/2/80

Drop No.	Time from Start To Dash Pot t_1 (seconds)	Time From Dash Pot To Rod Bottom t_2 (seconds)	Total Drop Time $t_1 + t_2$ (seconds)
1	1.11	0.51	1.62
2	1.11	0.51	1.62
3	1.11	0.50	1.61
4	1.11	0.50	1.61
5	1.13	0.50	1.63
6	1.12	0.50	1.62
7	1.11	0.52	1.63
8	1.12	0.50	1.62
9	1.11	0.50	1.61
10	1.11	0.51	1.62

Avg. Drop Time (seconds)	1.62
Max. Drop Time (seconds)	1.63
Min. Drop Time (seconds)	1.61

ROD NO. L3

(Slowest Drop Time)

RCS Temp. 141 °F AVERAGE
RCS Press. 362 psig AVERAGE
RCS Flow 0 %
Date 5/2/80

Drop No.	Time from Start To Dash Pot t_1 (seconds)	Time From Dash Pot To Rod Bottom t_2 (seconds)	Total Drop Time $t_1 + t_2$ (seconds)
1	1.21	0.50	1.71
2	1.19	0.50	1.69
3	1.19	0.52	1.71
4	1.19	0.51	1.70
5	1.21	0.50	1.71
6	1.20	0.51	1.71
7	1.21	0.50	1.71
8	1.19	0.51	1.70
9	1.19	0.52	1.71
10	1.20	0.51	1.71

Avg. Drop Time (seconds)	1.71
Max. Drop Time (seconds)	1.71
Min Drop Time (seconds)	1.69

Table 6.1.3 - 2 Rod Drops for Cold, Full - Flow

RCCA BANK	RCCA GRID LOCATION	TIME FROM START TO DASH POT t_1 (secs)	TIME FROM DASH POT TO BOTTOM t_2 (secs)	TOTAL DROP TIME $t_1 + t_2$ (secs)	ROD RELEASE TIME (secs)	RCS T_{avg} (°F)	RCS FLOW (%)	RCS PRESS (psig)
SHUTDOWN BANK A	D2	1.61	0.70	2.31	0.025	140	100	375
	B12	1.41	0.60	2.01	0.017	140	100	375
	P4	1.41	0.61	2.02	0.025	140	100	375
	M14	1.59	0.66	2.25	0.025	140	100	375
	B4	1.42	0.61	2.03	0.017	140	100	375
	D14	1.51	0.67	2.18	0.017	140	100	375
	P12	1.41	0.60	2.01	0.017	140	100	375
	M2	1.50	0.66	2.16	0.025	140	100	375
SHUTDOWN BANK B	G3	1.44	0.59	2.03	0.017	140	100	370
	C9	1.40	0.60	2.00	0.017	140	100	370
	J13	1.44	0.64	2.08	0.017	140	100	370
	N7	1.36	0.60	1.96	0.017	140	100	370
	C7	1.39	0.58	1.97	0.017	140	100	370
	G13	1.39	0.62	2.01	0.017	140	100	370
	N9	1.38	0.59	1.97	0.017	140	100	370
	J3	1.41	0.64	2.05	0.017	140	100	370
SHUTDOWN BANK C	E3	1.46	0.60	2.06	0.025	140	100	380
	C11	1.38	0.61	1.99	0.017	140	100	380
	L13	1.44	0.63	2.07	0.020	140	100	380
	N5	1.39	0.59	1.98	0.025	140	100	380
SHUTDOWN BANK D	C5	1.37	0.60	1.97	0.017	140	100	360
	E13	1.44	0.62	2.06	0.017	140	100	360
	N11	1.39	0.60	1.99	0.017	140	100	360
	L3	1.44	0.62	2.06	0.025	140	100	360

Table 6.1.3-2 Rod Drops for Cold, Full-Flow

RCCA BANK	RCCA Grid Location	Time From Start to Dash Pot t_1 (secs)	Time From Dash Pot to Bottom t_2 (secs)	Total Drop Time t_1+t_2 (secs)	Rod Release Time (secs)	RCS T_{avg} (°F)	RCS Flow (%)	RCS Press (psig)
CONTROL BANK A	H6	1.36	0.61	1.97	0.020	140	100	360
	H10	1.35	0.60	1.95	0.033	140	100	360
	F8	1.37	0.61	1.98	0.025	140	100	360
	K8	1.36	0.60	1.96	0.033	140	100	360
CONTROL BANK B	F2	1.50	0.66	2.16	0.017	140	100	360
	B10	1.37	0.61	1.98	0.017	140	100	360
	K14	1.47	0.64	2.11	0.025	140	100	360
	P6	1.39	0.62	2.01	0.025	140	100	360
	B6	1.33	0.60	1.98	0.017	140	100	360
	F14	1.44	0.67	2.11	0.017	140	100	360
	P10	1.37	0.59	1.96	0.020	140	100	360
	K2	1.48	0.63	2.11	0.017	140	100	360
CONTROL BANK C	H2	1.48	0.62	2.10	0.025	140	100	360
	B8	1.38	0.60	1.98	0.017	140	100	360
	H14	1.43	0.63	2.06	0.025	140	100	360
	P8	1.39	0.60	1.99	0.029	140	100	360
	F6	1.3[illegible]	0.59	1.95	0.017	140	100	360
	F10	1.36	0.60	1.96	0.017	140	100	360
	K10	1.38	0.61	1.99	0.017	140	100	360
	K6	1.36	0.61	1.97	0.025	140	100	360
CONTROL BANK D	D4	1.38	0.62	2.00	0.017	140	100	360
	D12	1.41	0.60	2.01	0.017	140	100	360
	M12	1.40	0.62	2.02	0.017	140	100	360
	M4	1.40	0.63	2.03	0.017	140	100	360
	H4	1.41	0.62	2.03	0.017	140	100	360
	D8	1.37	0.60	1.97	0.017	140	100	360
	H12	1.39	0.60	1.99	0.017	140	100	360
	M8	1.36	0.60	1.96	0.020	140	100	360
	H8	1.32	0.59	1.91	0.017	140	100	360

Table 6.1.3-2 Rod Drops for Cold, Full Flow

ROD NO. H-8
(Fastest Drop Time)

RCS Temp. 139 °F
RCS Press. 364 psig
RCS Flow 100 %
Date 5-3-80

(Temp. and Press.: AVG.)

Drop No.	Time from Start To Dash Pot t_1 (seconds)	Time From Dash Pot To Rod Bottom t_2 (seconds)	Total Drop Time $t_1 + t_2$ (seconds)
1	1.32	.60	1.92
2	1.33	.60	1.93
3	1.33	.61	1.94
4	1.34	.61	1.95
5	1.35	.60	1.95
6	1.35	.60	1.95
7	1.35	.61	1.96
8	1.35	.62	1.97
9	1.36	.61	1.97
10	1.36	.61	1.97

Avg. Drop Time (seconds)	1.95
Max. Drop Time (seconds)	1.97
Min. Drop Time (seconds)	1.92

ROD NO. D-2
(Slowest Drop Time)

RCS Temp. 140 °F
RCS Press. 362 psig
RCS Flow 100 %
Date 5-3-80

(Temp. and Press.: AVG.)

Drop No.	Time from Start To Dash Pot t_1 (seconds)	Time From Dash Pot To Rod Bottom t_2 (seconds)	Total Drop Time $t_1 + t_2$ (seconds)
1	1.62	.71	2.33
2	1.63	.71	2.34
3	1.63	.70	2.33
4	1.63	.70	2.33
5	1.62	.70	2.32
6	1.63	.71	2.34
7	1.62	.71	2.33
8	1.65	.70	2.35
9	1.62	.72	2.34
10	1.64	.70	2.34

Avg. Drop Time (seconds)	2.34
Max. Drop Time (seconds)	2.35
Min Drop Time (seconds)	2.32

Table 6.1.3 - 3 Rod Drops for Hot, No - Flow

RCCA BANK	RCCA GRID LOCATION	TIME FROM START TO DASH POT t_1 (secs)	TIME FROM DASH POT TO BOTTOM t_2 (secs)	TOTAL DROP TIME $t_1 + t_2$ (secs)	ROD RELEASE TIME (secs)	RCS T_{avg} (°F)	RCS FLOW (%)	RCS PRESS (psig
SHUTDOWN BANK A	D2 2nd 1st	1.09 1.07	0.46 0.47	1.55 1.54	.02 .02	540 549	0 0	2230 2240
	B12 2nd 1st	1.10 1.12	0.45 0.42	1.55 1.54	.02 .02	541.5 549	0 0	2235 2280
	M14	1.10	0.44	1.54	.03	541.5	0	2245
	P4	1.12	0.44	1.56	.02	534.8	0	2250
	B4	1.11	0.44	1.55	.02	539.3	0	2250
	D14	1.10	0.44	1.54	.02	538.5	0	2250
	P12	1.12	0.44	1.56	.03	537.6	0	2250
	M2	1.12	0.44	1.56	.02	530.8	0	2260
SHUTDOWN BANK B	G3	1.10	0.42	1.52	.03	523.1	0	2090
	C9	1.06	0.48	1.54	.02	523.1	0	2090
	J13	1.09	0.45	1.54	.02	523.1	0	2090
	N7	1.09	0.45	1.54	.02	523.1	0	2090
	C7	1.12	0.43	1.55	.02	523.1	0	2090
	G13	1.09	0.45	1.54	.02	523.1	0	2090
	N9	1.08	0.45	1.53	.02	523.1	0	2090
	J3	1.10	0.46	1.56	.02	523.1	0	2090
SHUTDOWN BANK C	E3	1.10	0.45	1.55	.02	520.0	0	2090
	C11	1.10	0.44	1.54	.02	520.0	0	2090
	L13	1.08	0.45	1.53	.02	520.0	0	2090
	N5	1.11	0.43	1.54	.02	520.0	0	2090
SHUTDOWN BANK D	C5	1.12	0.45	1.57	.01	520.0	0	2090
	E13	1.09	0.44	1.53	.02	520.0	0	2090
	N11	1.10	0.45	1.55	.02	520.0	0	2090
	L3	1.11	0.47	1.58	.02	520.0	0	2090

Table 6.1.3-3 Rod Drops for Hot, No-Flow

RCCA BANK	RCCA Grid Location	Time From Start to Dash Pot t_1 (secs)	Time From Dash Pot to Bottom t_2 (secs)	Total Drop Time t_1+t_2 (secs)	Rod Release Time (secs)	RCS T_{avg} (°F)	RCS Flow (%)	RCS Press (psig)
CONTROL BANK A	H6	1.10	0.46	1.56	.02	520.0	0	2090
	H10	1.10	0.44	1.54	.02	520.0	0	2090
	F8	1.11	0.48	1.59	.02	520.0	0	2090
	K8	1.12	0.43	1.55	.02	520.0	0	2090
CONTROL BANK B	F2	1.11	0.44	1.55	.02	520.0	0	2090
	B10	1.10	0.46	1.56	.02	520.0	0	2090
	K14	1.10	0.43	1.53	.02	520.0	0	2090
	P6	1.10	0.46	1.56	.02	520.0	0	2090
	B6	1.10	0.45	1.55	.02	520.0	0	2090
	F14	1.10	0.46	1.56	.02	520.0	0	2090
	P10	1.12	0.46	1.58	.02	520.0	0	2090
	K2	1.12	0.44	1.56	.02	520.0	0	2090
CONTROL BANK C	H2	1.10	0.45	1.55	.02	520.0	0	2090
	B8	1.11	0.45	1.56	.02	520.0	0	2090
	H14	1.09	0.46	1.55	.02	520.0	0	2090
	P8	1.10	0.44	1.54	.02	520.0	0	2090
	F6	1.09	0.44	1.53	.02	520.0	0	2090
	F10	1.11	0.43	1.54	.02	520.0	0	2090
	K10	1.11	0.45	1.56	.02	520.0	0	2090
	K6	1.12	0.44	1.56	.02	520.0	0	2090
CONTROL BANK D	D4	1.10	0.46	1.56	.02	520.0	0	2090
	D12	1.11	0.43	1.54	.02	520.0	0	2090
	M12	1.11	0.47	1.58	.02	520.0	0	2090
	M4	1.11	0.46	1.57	.02	520.0	0	2090
	H4	1.11	0.47	1.58	.02	520.0	0	2090
	D8	1.10	0.44	1.54	.02	520.0	0	2090
	H12	1.10	0.46	1.56	02	520.0	0	2090
	M8	1.12	0.44	1.56	.03	520.0	0	2090
	H8	1.10	0.46	1.56	.02	520.0	0	2090

Table 6.1.3-3 Rod Drops for Hot, No-Flow

ROD NO. G3 (Fastest Drop Time)

RCS Temp. 510/537 °F
RCS Press. 2100/2150 psig
RCS Flow 0 %
Date 6-28-80

Drop No.	Time from Start To Dash Pot t_1 (seconds)	Time From Dash Pot To Rod Bottom t_2 (seconds)	Total Drop Time $t_1 + t_2$ (seconds)
1	1.11	.43	1.54
2	1.09	.44	1.53
3	1.09	.44	1.53
4	1.09	.44	1.53
5	1.09	.44	1.53
6	1.06	.42	1.48
7	1.07	.44	1.51
8	1.09	.42	1.51
9	1.09	.42	1.51
10	1.10	.41	1.51

Avg. Drop Time (seconds)	1.518
Max. Drop Time (seconds)	1.54
Min. Drop Time (seconds)	1.48

ROD NO. F8 (Slowest Drop Time)

RCS Temp. 537/520 °F
RCS Press. 2150/2120 psig
RCS Flow 0 %
Date 6-28-80

Drop No.	Time from Start To Dash Pot t_1 (seconds)	Time From Dash Pot To Rod Bottom t_2 (seconds)	Total Drop Time $t_1 + t_2$ (seconds)
1	1.10	.47	1.57
2	1.09	.48	1.57
3	1.10	.47	1.57
4	1.10	.48	1.58
5	1.10	.47	1.57
6	1.09	.47	1.56
7	1.09	.48	1.57
8	1.10	.47	1.57
9	1.09	.48	1.57
10	1.10	.48	1.58

Avg. Drop Time (seconds)	1.571
Max. Drop Time (seconds)	1.58
Min Drop Time (seconds)	1.56

Table 6.1.3 - 4 Rod Drops for Hot, Full - Flow

RCCA BANK	RCCA GRID LOCATION	TIME FROM START TO DASH POT t_1 (secs)	TIME FROM DASH POT TO BOTTOM t_2 (secs)	TOTAL DROP TIME $t_1 + t_2$ (secs)	ROD RELEASE TIME (secs)	RCS T_{avg} (°F)	RCS FLOW (%)	RCS PRESS (psig
SHUTDOWN BANK A	D2	1.31	.54	1.85	.02	544	100	2210
	B12	1.29	.48	1.77	.02	542	100	2230
	M14	1.37	.51	1.81	.02	542	100	2230
	P4	1.25	.50	1.75	.02	542	100	2230
	B4	1.24	.49	1.73	.02	542	100	2200
	D14	1.35	.51	1.86	.02	544	100	2210
	P12	1.27	.48	1.75	.02	544	100	2210
	M2	1.31	.49	1.80	.02	545	100	2200
SHUTDOWN BANK B	G3	1.27	.45	1.72	.03	542	100	2230
	C9	1.22	.50	1.72	.03	542	100	2230
	J13	1.25	.51	1.76	.02	546	100	2200
	N7	1.22	.50	1.72	.02	546	100	2200
	C7	1.21	.49	1.70	.02	546	100	2200
	G13	1.22	.51	1.73	.02	546	100	2200
	N9	1.22	.49	1.71	.02	546	100	2200
	J3	1.24	.50	1.74	.02	546	100	2200
SHUTDOWN BANK C	E3	1.26	.49	1.75	.02	546	100	2200
	C11	1.20	.50	1.70	.02	546	100	2200
	L13	1.27	.49	1.76	.02	546	100	2200
	N5	1.22	.48	1.70	.02	546	100	2200
SHUTDOWN BANK D	C5	1.23	.48	1.71	.02	546	100	2200
	E13	1.25	.50	1.75	.02	546	100	2200
	M11	1.21	.49	1.70	.02	546	100	2200
	L3	1.27	.51	1.78	.02	546	100	2200

Table 6.1.3-4 Rod Drops for Hot, Full-Flow

RCCA BANK	RCCA Grid Location	Time From Start to Dash Pot t_1 (secs)	Time From Dash Pot to Bottom t_2 (secs)	Total Drop Time t_1+t_2 (secs)	Rod Release Time (secs)	RCS T_{avg} (°F)	RCS Flow (%)	RCS Press (psig)
CONTROL BANK A	H6	1.22	.49	1.71	.02	545	100	~~545~~ 2200
	H10	1.22	.49	1.71	.04	545	100	2210
	F8	1.24	.52	1.76	.03	545	100	2210
	K8	1.24	.47	1.71	.02	545	100	2210
CONTROL BANK B	F2	1.32	.52	1.84	.02	545	100	2210
	B10	1.23	.48	1.71	.02	545	100	2210
	K14	1.31	.51	1.82	.02	545	100	2200
	P6	1.24	.49	1.73	.03	545	100	2200
	B6	1.22	.49	1.71	.02	545	100	2200
	F14	1.28	.54	1.82	.02	545	100	2200
	P10	1.22	.50	1.72	.02	545	100	2200
	K2	1.29	.50	1.79	.03	545	100	2210
CONTROL BANK C	H2	1.28	.49	1.77	.02	545	100	2200
	B8	1.22	.49	1.71	.02	545	100	2200
	H14	1.27	.51	1.78	.02	545	100	2200
	P8	1.21	.50	1.71	.03	545	100	2200
	F6	1.20	.489	1.69	.02	545	100	2200
	F10	1.23	.49	1.72	.02	545	100	2200
	K10	1.21	.50	1.71	.02	545	100	2200
	K6	1.23	.50	1.73	.03	545	100	2200
CONTROL BANK D	D4	1.21	.51	1.72	.02	545	100	2200
	D12	1.24	.49	1.73	.02	545	100	2210
	M12	1.24	.52	1.76	.02	545	100	2210
	M4	1.23	.51	1.74	.02	545	100	2210
	H4	1.25	.50	1.75	.03	545	100	2200
	D8	1.22	.48	1.70	.02	545	100	2200
	H12	1.22	.49	1.71	.02	545	100	2200
	M8	1.23	.48	1.71	.02	545	100	2200
	H8	1.22	.49	1.71	.02	545	100	2210

Table 6.1.3-4 Rod Drops for Hot, Full Flow

ROD NO. F6
(Fastest Drop Time)

RCS Temp. 545 °F
RCS Press. 2215 psig
RCS Flow 100 %
Date 6-27-80

Drop No.	Time from Start To Dash Pot t_1 (seconds)	Time From Dash Pot To Rod Bottom t_2 (seconds)	Total Drop Time $t_1 + t_2$ (seconds)
1	1.21	.49	1.70
2	1.20	.50	1.70
3	1.21	.47	1.68
4	1.21	.47	1.68
5	1.20	.50	1.70
6	1.22	.47	1.69
7	1.20	.48	1.68
8	1.20	.48	1.68
9	1.20	.48	1.68
10	1.21	.48	1.69

Avg. Drop Time (seconds)	1.688
Max. Drop Time (seconds)	1.70
Min. Drop Time (seconds)	1.68

ROD NO. M14
(Slowest Drop Time)

RCS Temp. 545 °F
RCS Press. 2210 psig
RCS Flow 100 %
Date 6-27-80

Drop No.	Time from Start To Dash Pot t_1 (seconds)	Time From Dash Pot To Rod Bottom t_2 (seconds)	Total Drop Time $t_1 + t_2$ (seconds)
1	1.36	.52	1.88
2	1.36	.52	1.88
3	1.36	.52	1.88
4	1.36	.52	1.88
5	1.36	.52	1.88
6	1.36	.52	1.88
7	1.36	.52	1.88
8	1.35	.51	1.86
9	1.35	.52	1.87
10	1.36	.52	1.88

Avg. Drop Time (seconds)	1.877
Max. Drop Time (seconds)	1.88
Min Drop Time (seconds)	1.86

6.0 PREOPERATIONAL TESTS PERFORMED AFTER FUEL LOADING (continued)

6.1.4 Pressurizer Spray and Heater Capability and Settings of Spray Flow (Test procedure W-1.5)

The post fuel load portion of this test verified the effectiveness of the pressurizer spray and heaters.

To determine the pressurizer spray effectiveness, the pressurizer pressure was established at ~2230 psig and the pressurizer heaters were deenergized. The pressurizer spray valves were then opened and the system depressurization rate was measured. The spray valves were closed after the pressurizer pressure was reduced to ~2000 psig. The result of the system depressurization test and the acceptance criterion are plotted on Figure 6.1.4-1. The acceptance criterion was satisfied.

To determine the pressurizer heater effectiveness, the pressurizer pressure was initially established at ~2200 psig. The pressurizer heaters were then energized and the system pressurization was measured. The heaters were deenergized after the pressurizer pressure reached ~2315 psig.

Acceptable pressurizer heater operation was not verified until the fourth time the test was performed. The first failure was attributed to excessive steam dumping from the steam generators and variations of charging flow; the second from excessive bypass spray flow; and the third due to one set of pressurizer heater elements not being energized. The fourth attempt at the test was successful. The result of the pressurizer heater test and the acceptance criterion are plotted on Figure 6.1.4-2. The acceptance criterion was satisfied.

FIGURE 6.1.4-1

RESPONSE TO OPENING OF BOTH PRESSURIZER SPRAY VALVES
(with allowable deviation)

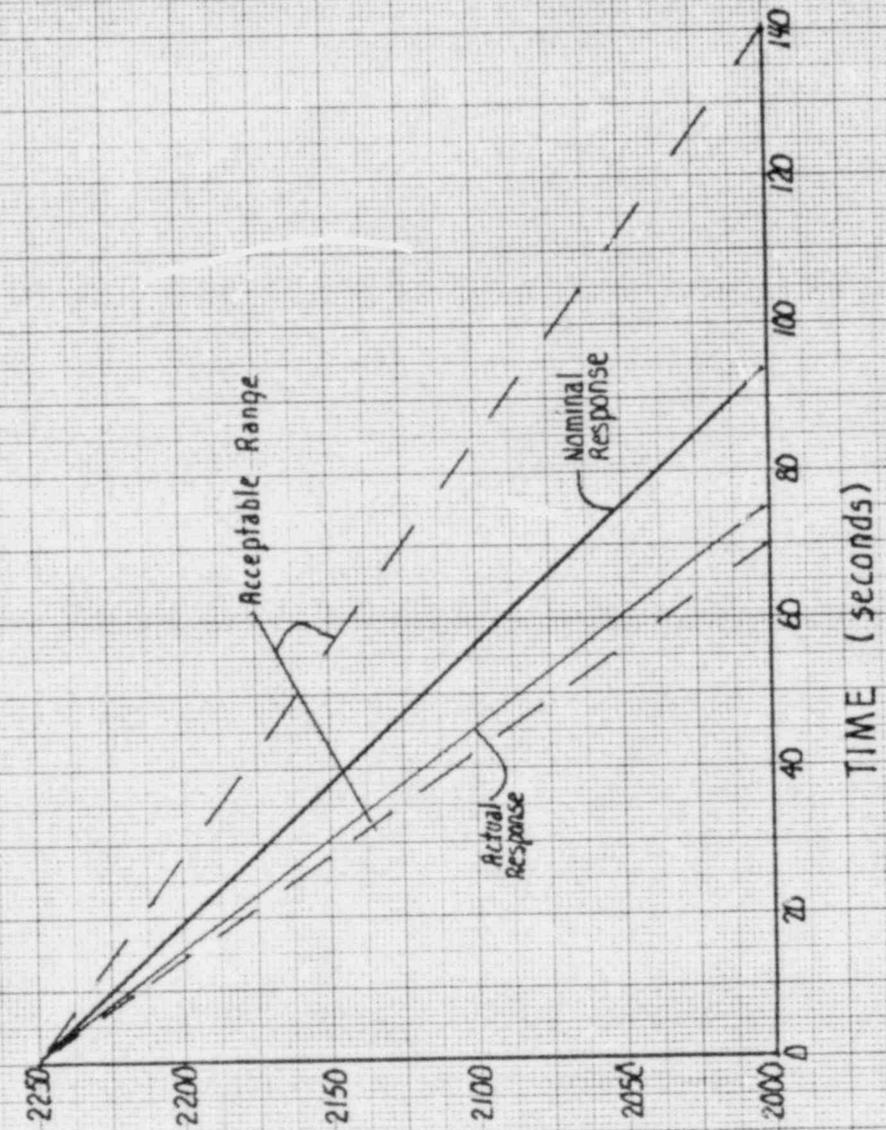
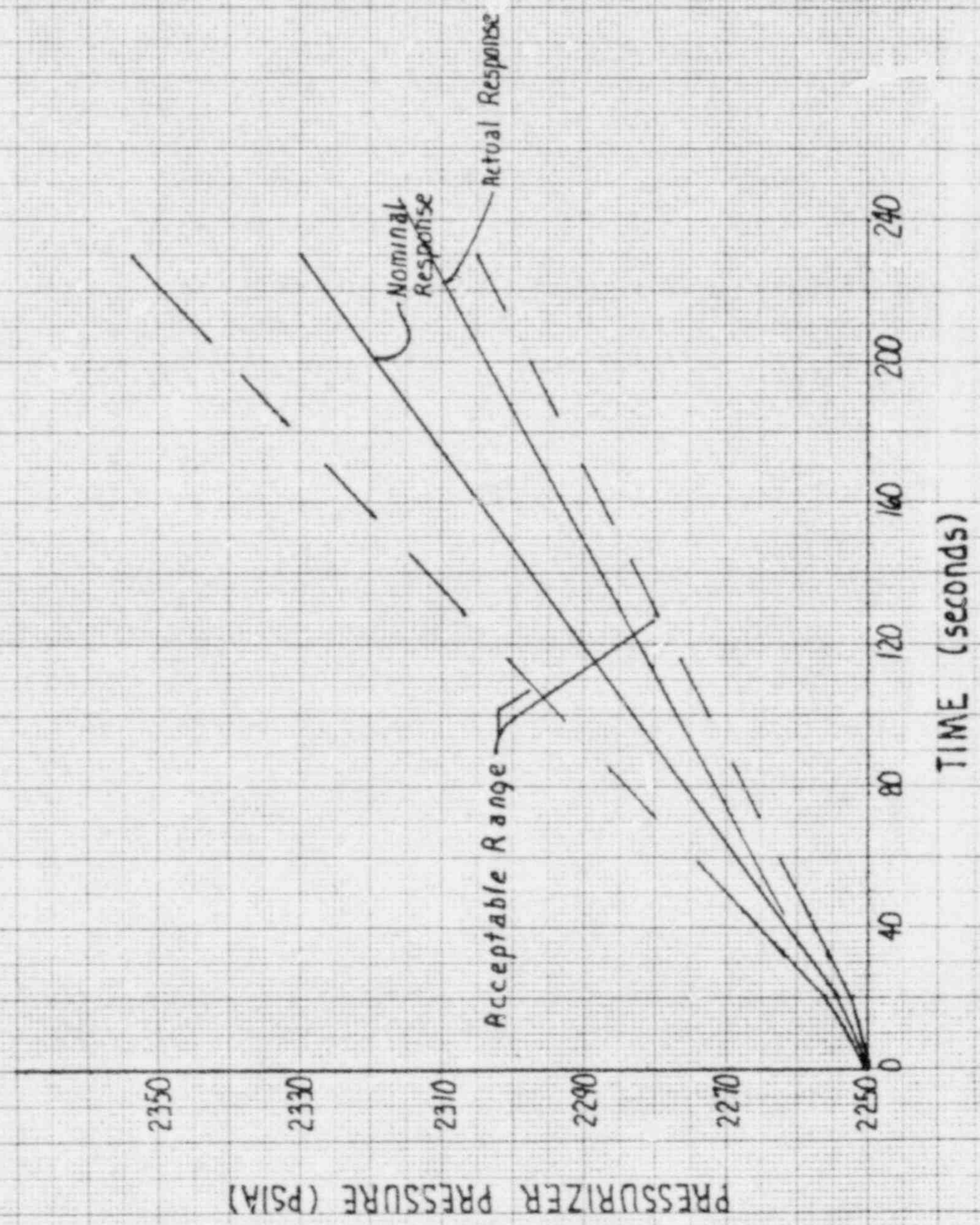


FIGURE 6.1.4-2

RESPONSE TO ACTUATION OF ALL PRESSURIZER HEATERS

(with allowable deviation)



6.1.5 Reactor Coolant System Flow Measurement (Test procedure W-1.6)

The purpose of this procedure was to determine the actual flow rate in each reactor coolant loop in order to verify that the actual flow was equal to or greater than the thermal design flow rate of 94,600 gpm/loop assumed in the safety analysis report.

The measured reactor coolant flow rates for all pumps in operation were 95,400 gpm for loop 1, 92,500 gpm for loop 2, 93,600 gpm for loop 3 and 92,000 gpm for loop 4. Loops 2, 3, and 4 did not meet the minimum flow requirements of the safety analysis report.

The method used to determine coolant pump flow rate at Sequoyah employed pump input power and elbow tap differential pressure, which is considered to be subject to large inaccuracies due primarily to the uncertainties in the slope of the flow vs input power curve used in the procedure. Although the average flow measurement at Sequoyah (93,300 gpm/loop) is low compared to the zero power best estimate flow of about 97,000 gpm, the difference is not significant considering the uncertainties of the measurement. Nevertheless, the measured value was still an adequate basis to permit power escalation to 90% power.

At 75% power a more accurate calorimetric flow measurement was obtained. The average loop flow at 75% power using the more accurate method was 96,046 gpm/loop. This value meets the safety analysis minimum flow criteria.

6.1.6 RTD Bypass Loop Flow Verification (Test procedure W-1.9)

The RTD bypass loop flow rate was measured and verified to be greater than the minimum flow rate required to obtain the design coolant transport time. The flow rate at which the RTD bypass loop low flow alarm actuated and reset was also measured.

The RTD bypass loop flow rate was measured under the following configurations: the hot leg manifold and cold leg manifold in-service (F_T), the hot leg manifold in-service with the cold leg manifold isolated (F_H), and the hot leg manifold isolated with the cold leg manifold in service (F_c). The minimum hot leg manifold flow rate (F_H^1) and minimum cold leg manifold flow rate (F_C^1) were calculated by the equations $F_H^1 = F_T - F_c$ and $F_c^1 = F_T - F_H$. The results were compared to the minimum RTD bypass loop flow rate required to obtain the design maximum reactor coolant transport time of one second. The test results and acceptance criteria are tabulated below.

6.1.6 RTD Bypass Loop Flow Verification (continued)

Loop	Measured Min Flow Rate (gpm)	Acceptance Criteria (gpm)
1-T_H	159	>59.9
1-T_c	71	>37.2
2-T_H	145	>66.7
2-T_c	78	>35.2
3-T_H	145	>67.0
3-T_c	65	>37.2
4-T_H	141	>66.4
4-T_c	81	>38.4

The RTD bypass loop low flow alarm was verified to actuate within 90± 2% of the loop total flow and reset within 6% of the alarm setpoint.

6.1.7 Rod Control System (Test procedure W-9.2)

Prior to initial criticality, the rod control system test demonstrated the operational readiness of the rod control system. The shutdown bank A was withdrawn ~40 steps, inserted ~35 steps, and then tripped into the core. During the rod movement, the rod group step counter, rod position indicators, rod in/out status lights, rod speed indicator, and manual reactor trip were verified to be operable. This procedure was repeated for each remaining shutdown and control bank. After the rod exercise, the rods were withdrawn to verify the control bank overlap.

The test acceptance criteria were the correct indication of the rod group step counter, rod position indicator, rod in/out status lights, and rod speed indicator. These criteria were satisfied.

6.1.8 Rod Position Indication System (Test procedure W-9.5)

The rod position indication (RPI) test was performed in three parts. The first portion of the test verified the initial (cold shutdown) channel calibration for each rod. The second portion of the test measured the voltages at which each rod bottom bistable trips and verified the appropriate control room annunciators and indicator lights. The final portion of the test exercised each rod bank and measured the RPI output voltages every 20 steps from zero to the fully withdrawn position.

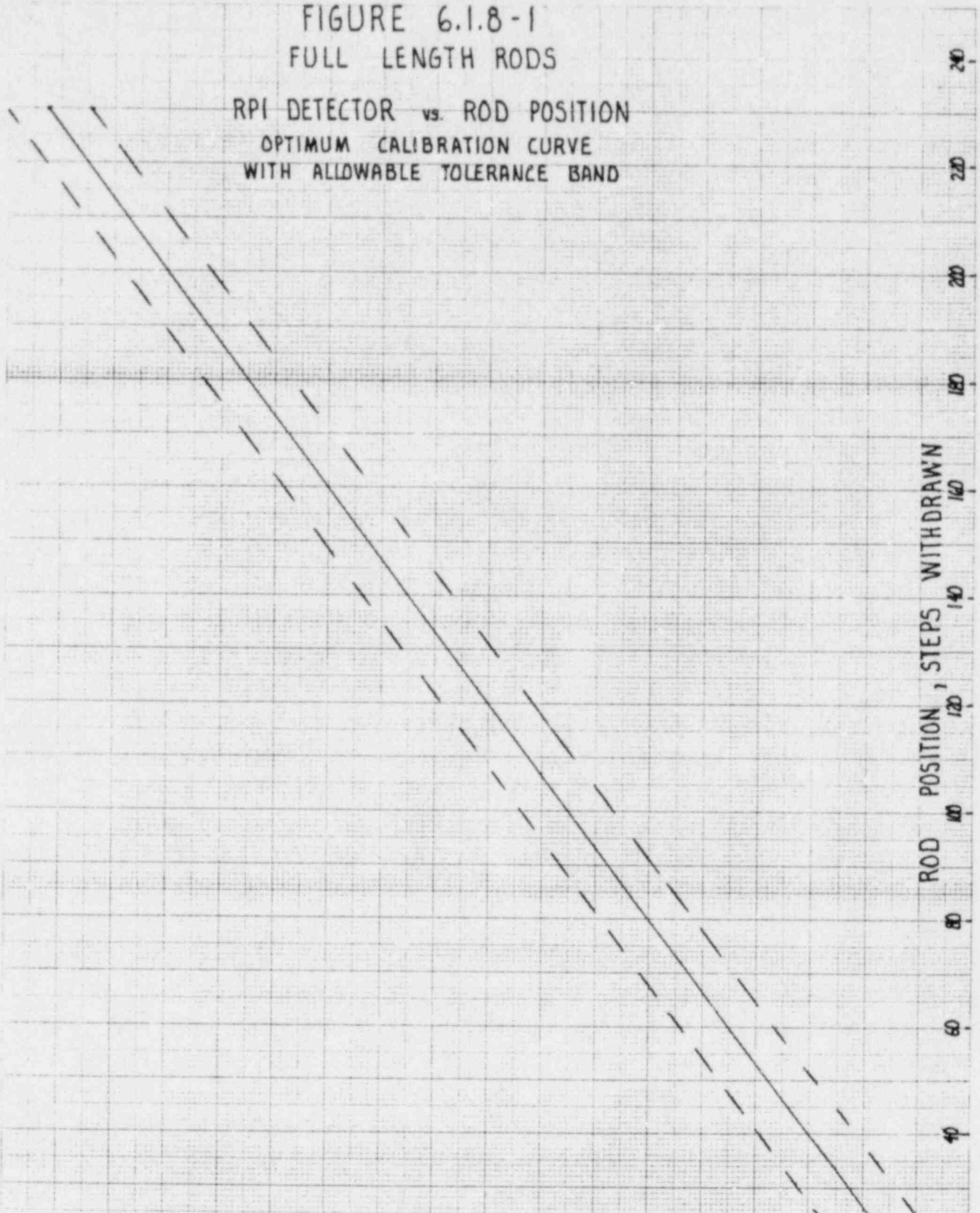
FIGURE 6.1.8-1

FULL LENGTH RODS

RPI DETECTOR vs. ROD POSITION

OPTIMUM CALIBRATION CURVE

WITH ALLOWABLE TOLERANCE BAND



6.1.8 Rod Position Indication System (continued)

The acceptance criteria were (1) Correct indication and alarm function of the rod position indication system and (2) The RPI output voltages were within the RPI calibration curve of Figure 6.1.8-1. These criteria were satisfied.

6.1.9 Reactor Coolant Flow Coastdown (Test procedure W-1.8)

The reactor coolant flow coastdown test measured the rate at which the reactor coolant flow decreased subsequent to various combinations of reactor coolant pump trips; measured the delay times associated with the loss of flow accident; and compared these results to the coastdowns assumed in the FSAR. The four cases examined were 4 out of 4, 2 out of 4, 3 out of 3, and 2 out of 3 RCP trips from hot standby conditions.

This test failed to meet two of its required acceptance criteria. During the 4 out of 4 RCP coastdown the slope of the inverse core flow curve was calculated to be .0945/second which is greater than the requirement of <.0865/sec. Also, the normalized core coastdown in three of the four cases of flow coastdowns tested did not exceed the values assumed in the FSAR for the first 10 seconds of flow coastdown.

Subsequent investigation showed that the coastdown acceptance criteria was based on the FSAR design flow rate of 88,500 gpm/loop. The design flow rate was later increased to 91,400 gpm/loop; however, the flow coastdown curves were not revised to reflect the higher loop flow rate. Therefore, the measured flow coastdown should be based upon the higher thermal design flow rate. The table below presents a comparison of the predicted and measured flow coastdowns with the differences in thermal design flows taken into consideration.

6.0 PREOPERATIONAL TESTS PERFORMED AFTER FUEL LOADING (continued)

6.1.9 Reactor Coolant Flow Coastdown (continued)

Time	4/4 flow coastdown		3/3 flow coastdown		2/4 flow coastdown		2/3 flow coastdown	
(sec.)	FSAR	Test	FSAR	Test	FSAR	Test	FSAR	Test
0.0	1.0	1.0328	1.0	1.0288	1.0	1.0328	1.0	1.0288
0.5	.9706	.9842	.9709	.9856	.9853	1.0121	.9806	.9959
1.0	.9319	.93[illegible]8	.9332	.9455	.9658	.9915	.9954	.9571
1.5	.8958	.9006	.8980	.9074	.9474	.9718	.9318	.9413
2.0	.8623	.8634	.8655	.8724	.9300	.9522	.9099	.9177
2.5	.8313	.8314	.8352	.8395	.9138	.9357	.8895	.8950
3.0	.8024	.8014	.8069	.8076	.8986	.9192	.8704	.8724
3.5	.7755	.7746	.7805	.7788	.8843	.9057	.8525	.8538
4.0	.7503	.7498	.7558	.7510	.8703	.8923	.8358	.8385
4.5	.7357	.7250	.7326	.7232	.8580	.8779	.8200	.8210
5.0	.7045	.7023	.7108	.6985	.8459	.8575	.8051	.8055
t_{min} (DNBR)	2.4		2.3		3.4		4.8	

Since the measured flow rate is faster than the predicted coastdown, the measured flow rate soon falls below the predicted flow rate, even when the higher thermal design flow is assumed for the initial flow rate. However, the measured flow rate remains higher than the predicted flow rate through the time the minimum DNB ratio is reached during each loss of flow case. Therefore, the loss of flow analysis in the FSAR remains valid.

6.0 PREOPERATIONAL TESTS PERFORMED AFTER FUEL LOADING (continued)

6.1.9 Reactor Coolant Flow Coastdown (continued)

All of the remaining acceptance criteria were satisfied as shown below.

	MEASURED	REQUIREMENT
4 Out of 4 Coastdown		
Time from first to last opening of "RC Pump Breakers"	15 ms.	<100 ms.
2 Out of 4 Coastdown		
T_1 = Low flow delay time.	1.50	$\leq$2.72 sec.
T_2 = Delay time from Reactor Trip to Rod Motion.	0.12	$\leq$0.15 sec.
Undervoltage trip delay time defined as the time from reaching undervoltage trip setpoint until RCCA's are free to fall. $T_2 + T_3$.	0.448	<1.2 sec.
Under frequency trip relay time defined as the time from reaching the under frequency trip setpoint until RCCA's are free to fall. $T_2 + T_4$.	0.200	<0.6 sec.
3 Out of 3 Coastdown		
Time from first to last opening of "RC Pump Breakers"	10 ms.	<100 ms.

6.0 PREOPERATIONAL TESTS PERFORMED AFTER FUEL LOADING (continued)

6.2 Preoperational Test Conducted After Initial Criticality

6.2.1 Automatic Reactor Control System (Test procedure W-10.1)

This test verified the performance of the automatic reactor control systems to maintain the reactor coolant average temperature within acceptable steady-state limits.

During plant startup at ~30% power, the RCS T_{avg} was disturbed from steady-state conditions by manual rod movement and the response of the automatic reactor control system to restore the T_{avg} was verified. No adjustments to the control systems were required.

At steady-state conditions, the control system maintained T_{avg} within $\pm 1.5^{o}F$ of T_{ref}. This satisfied the test acceptance criteria.

6.2.2 Automatic Steam Generator Level Control (Test procedure W-10.2)

This test verified the stability of the automatic steam generator level control system following simulated transients at low power conditions and verified the proper operation of the variable speed feature of the main feedwater pumps.

At ~30% power, steam generator level controllers were varied and the automatic response of the level control system, main feedpump ΔP setpoints, and the pump speed control system were verified. Adjustments to the control systems were made, as required, to improve system performance.

The following items were used to determine successful automatic steam generator level control and feedwater pump speed control, (1) steam generator level overshoot (undershoot) is less than $\pm$2.5 percent for a setpoint or level increase (decrease); (2) steam generator level returns to the programmed level setpoint within two minutes following a level or setpoint change; (3) feedwater pump speed oscillations are less than 3 percent of operating speed at steady state; (4) feedwater pump speed overshoot (undershoot) does not exceed 1 percent when a step speed change of 5 percent is introduced at the feedwater pump speed controller; and (5) feedwater pump speed stabilizes at the new value following a step change in pump speed within two minutes. All of these criteria were satisfied.

6.2.3 Calibration of Steam and Feedwater Flow Instrumentation at Power (Test procedure W-11.7)

This test, when completed, will calibrate the feedwater and steam flow instrumentation.

The output signals of the feedwater and steam flow transmitters and square root converters are measured at 0%, 30%, 50%, 75%, and 100% power for possible instrument gain adjustments. After gain adjustments are completed, the reproducibility of the feedwater and steam flow instrumentation will be verified.

The results of this test are not yet complete. The analysis and test results will be supplied in a supplemental test report.

6.2.4 Startup Adjustments of the Reactor Control System (Test procedure W-11.10)

This test, when completed, will determine the T_{avg} program resulting in the highest possible steam pressure and optimun plant efficiency without exceeding the pressure limitation of the turbine or the maximum allowable T_{avg}.

Since this test is not yet completed, the results of the test evaluation will be presented in a supplemental report.

6.2.5 Dynamic Automatic Steam Dump (Test procedure W-10.5)

This test verified the proper operation of the turbine trip and load rejection features of the steam dump control system. This test also verified the adequacy of the steam header pressure controller.

During the turbine trip controller test, the unit was established at ~1% power with T_{avg} at ~548°F, the turbine tripped, and the steam dump control system operating in the T_{avg} mode. The reactor power was then increased to ~6% and the ability of the steam dump valves to control T_{avg} at ~552°F was verified. The acceptance criteria required that there be no divergent oscillations in temperature. This criteria was satisfied.

During the test of the load rejection controller response, the unit was operating at ~3% power in the pressure control mode. With the turbine in normal operating conditions and T_{ref} ~543°F a sudden loss of load to activate C-7 was simulated.

The steam dump control was then placed in the T_{avg} mode. The ability of the steam dump valves to control T_{avg} at ~550°F was verified. The acceptance criteria required no divergent oscillations in temperature. This criteria was satisfied.

6.2.5 Dynamic Automatic Steam Dump (continued)

To test the steam header pressure controller, the controller was set for 1005 psig and reactor power was increased from ~1% power to ~5% power. The ability of the pressure controller to maintain the steam header pressure at 1005 psig would verify proper operation of the controller. During the test, however, the steam dump control was not in the pressure mode. Therefore, the operation of the pressure controller was not verified during this portion of the test. The response of the pressure controller, however, was evaluated when the system was in the pressure mode during the turbine trip controller test and load rejection controller test. Based on these evaluations and past experience with the controller, the pressure controller was determined to be operating satisfactorily.

6.2.6 Thermal Expansion of Piping Systems (Test procedure TVA-23B)

The Thermal Expansion of Piping Systems test is performed to demonstrate that the feedwater and secondary piping systems are capable of expanding and contracting without obstruction during heatup from ambient to 100 percent load temperatures and during cooldown to ambient. Displacement measurements are made at selected locations to insure that obstructions do not occur. Visual inspections are conducted at other locations to ensure that there is no interference due to thermal expansion.

This test has not been completed. Its results will be presented in a supplementary report.

6.2.7 Reactor Plant System Setpoints Verification (Test procedure W-8.5)

The purpose of this test was to verify that setpoint adjustments were in agreement with the Sequoyah Nuclear Plant setpoints for Westinghouse Nuclear Steam Supply System prior to initial startup and during the test program. Any setpoint discovered to be outside its allowable range was readjusted. Also, the completed test procedure will document any changes in setpoints which were required due to variances in actual plant conditions as compared with theoretical plant conditions.

Because this test is incomplete, its results will be presented in a supplementary report.