CYCLE 2 STARTUP PHYSICS TEST REPORT

INDIAN POINT UNIT NO. 2

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.

NUCLEAR AND EMISSIONS CONTROL ENGINEERING DEPARTMENT
REACTOR PHYSICS AND FUEL MANAGEMENT SUBSECTION

DECEMBER, 1976

ABSTRACT

This report summarizes the results of startup physics tests of Cycle 2 for Indian Point Unit No. 2 at Hot Zero Power conditions, and during reactor power level escalation. Results of these tests satisfied Technical Specifications and demonstrated adequate conservatism of design and analyses.

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1. INTRODUCTION

Indian Point Unit No. 2, Cycle 2, attained initial criticality on September 21, 1976. Subsequently, a series of physics tests, described in a letter to the U.S. Nuclear Regulatory Commission (NRC) dated July 19, 1976, were carried out. These tests are listed in Table 1.1. The objectives of these tests were: (a) to demonstrate that the core performance during reactor operation would not exceed FSAR, Reference 1, and Technical Specification, Reference 2, limits; (b) to verify the nuclear design calculations, Reference 3; and (c) to provide the bases for the calibration of reactor instrumentation. Section 2 of this report deals with a brief description of the reactor core and the core loading. Section 3 deals with measurement methods. In Section 4, results from Hot Zero Power (HZP) physics tests are presented and in Section 5, physics tests at different power levels are described. Reactor instrumentation response and calibration are treated in Section 6. The test results of the measured parameters have been compared with the design results. The latter are from the Indian Point Unit No. 2, Cycle 2 design report, Reference 3.

TABLE 1.1

Indian Point Unit No. 2

First Reload Startup Physics Test Program

(1) Pre-Criticality Tests:

Calibrations of the in-core thermocouples and RTDs will be performed.

(2) Hot Zero Power (HZP) and Beginning of Core Life (BOL) Condition Tests:

(A) A determination of the Isothermal Temperature Coefficient will be made for the following control rod configurations:

(i) All rods withdrawn out of the core
(ii) Control Bank D inserted
(iii) Control Banks D and C inserted
(iv) Control Banks D, C, and B inserted in an overlapping position at the HZP insertion limits.

(B) A determination of the differential & integral rod worths will be made for the following banks of control rods:

(i) Control Bank D
(ii) Control Bank C with Control Bank D inserted
(iii) Control D, C, and B inserted in overlapping positions at the HZP insertion limits.

Boron end-points for the above three test cases will also be measured.

(C) A movable in-core detector flux map will be performed with the reactor at 3 to 5% of full thermal power and all the rods withdrawn to a position out of the core.

(3) Power Ascension Tests at 75% of Full Thermal Power

(A) Ex-core and in-core instrumentation calibrations will be performed.

(B) A power coefficient test will be performed.

(4) Power Ascension Tests at 90% of Full Thermal Power

(A) A movable in-core detector flux map will be performed.

(B) A power coefficient test will be performed.

2. REACTOR CORE DESCRIPTION

Indian Point Unit No. 2 core consists of 193 fuel assemblies of slightly enriched uranium dioxide. Each fuel assembly contains 204 fuel rods with zirconium alloy cladding, 20 rod cluster control (RCC) guide tubes for inserting control rods, and a central instrumentation thimble. Burnable poison rods, depleted from Cycle 1 and composed of Pyrex, a borosilicate glass, are inserted in selected assemblies to provide a negative moderator temperature coefficient during reactor operation, to control excess reactivity early in the life of Cycle 2, and to improve power distributions.

2.1 Reactor Core Control

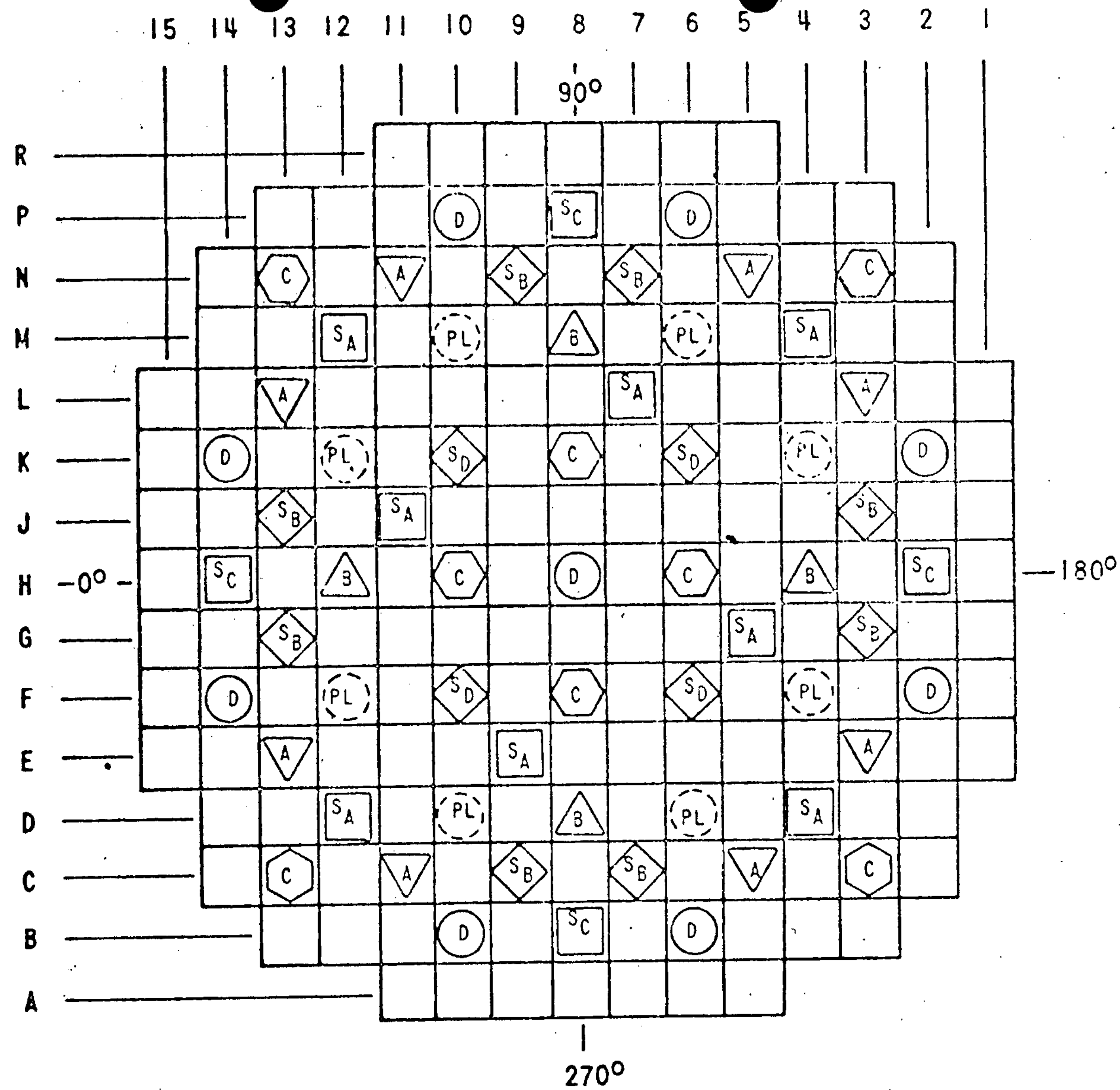
In addition to the chemical shim control by boric acid dissolved in the coolant water, control and shutdown of the reactor is accomplished by 53 full-length Rod Cluster Control Assemblies (RCCAs). The latter consists of four control and four shutdown banks. The reactor also has 8 part length rods but the use of these is prohibited by Technical Specifications. Figure 2.1 is an X-Y cross section of the reactor core containing RCC bank positions. Figure 2.2 provides the Cycle 2 loading pattern.

2.2 Reactor Core Instrumentation

The reactor core instrumentation consists of four excore detectors, six moveable incore detectors (M/D) capable of scanning up to 50 fuel assemblies through their central thimble guide tubes, 65 incore thermocouples (T/C) to monitor exit coolant temperatures, and 32 fixed in core detectors in eight assemblies. Figure 2.3 shows the incore and excore instrumentation.

2.3 Cycle 2 Core Loading

The Indian Point Unit No. 2, Cycle 2, core loading, Figure 2.2, was accomplished by May 27, 1976. The core loading was in agreement with the core loading pattern as developed by Westinghouse and described on Westinghouse Drawing #1212E31 (Revision 4). The verification is based on the visual observation of Con Edison (Nuclear Power Generation) and Westinghouse personnel.



BANK	SYMBOL	NUMBER OF ROD CLUSTERS
S_A	□	8
S_B	◇	8
S_C	□	4
S_D	◇	4
A	▽	8
B	△	4
C	⬡	8
D	○	9
PL	◌	8

Figure 2-1. Control Rod Locations

	15	14	13	12	11	10	9		7	6	5	4	3	2	1
R					D-06 4 43	D-30 4 39	D-35 4 40	D-53 4 A6P1(9)	D-55 4 41	D-03 4 42	D-67 4 35				
P			D-13 4 36	D-46 4 123	D-48 4 A6P7(8)	B-27 2 R-19(CD)	D-40 4 12P26(20)	B-56 2 R-24(SC)	D-44 4 12P33(20)	B-18 2 R-38(CD)	D-29 4 B6P7(8)	D-32 4 31	D-01 4 32		
N		D-52 4 33	D-27 4 R-21(CC)	C-44 3 103	B-20 2 R-48(CA)	D-15 4 12P20(20)	B-26 2 R-51(SB)	C-29 3 B6P10(7)	B-08 2 R-12(SB)	D-61 4 12P37(20)	B-05 2 R-03(CA)	C-48 3 78	D-59 4 34(CC)	D-50 4 28	
M		D-72 4 29	C-52 3 83	B-17 2 R-44(SA)	C-25 3 57	C-03 3 RS-4(PL)	C-47 3 72	B-32 2 R-23(CB)	C-57 3 77	C-11 3 RS-5(PL)	C-22 3 54	B-40 2 R-49(SA)	C-39 3 84	D-49 4 30	
L	D-45 4 24	D-57 4 A6P6(8)	B-25 2 R-26(CA)	C-36 3 58	B-15 2 44	C-13 3 66	B-41 2 110	C-19 3 126	B-58 2 R-27(SA)	C-20 3 129	B-36 2 59	C-30 3 49	B-30 2 R-13(CA)	D-14 4 B6P5(8)	D-63 4 25
K	D-12 4 26	B-60 2 R-16(CD)	D-31 4 12P34(20)	C-08 3 RS-3(PL)	C-15 3 65	B-31 2 R-(OFSD)	C-40 3 109	B-59 2 R-52(CC)	C-42 3 99	B-43 2 R-42(SD)	C-18 3 104	C-07 3 RS-6(PL)	D-56 4 12P31(20)	B-54 2 R-03(CD)	D-38 4 27
J	D-60 4 19	D-62 4 12P27(20)	B-03 2 R-17(SB)	C-62 3 130	B-53 2 R-20(SA)	C-60 3 107	C-06 3 100	C-31 3 51	C-05 3 96	C-54 3 111	B-62 2 112	C-58 3 114	B-37 2 R-35(SB)	D-71 4 12P21(20)	D-07 4 20
H	D-70 4 B6P2(9)	B-63 2 R-30(SC)	C-41 3 SS2(7)	B-02 2 R-47(CB)	C-32 3 34	B-55 2 R-41(CC)	C-09 3 45	B-06 2 R-37(CD)	C-37 3 113	B-50 2 R-05(CC)	C-33 3 62	B-24 2 R-32(CB)	C-46 3 SS1(7)	B-39 2 R-53(SC)	D-08 4 B6P3(9)
G	D-22 4 22	D-11 4 12P23(20)	B-10 2 R-31(SB)	C-63 3 101	B-49 2 87	C-59 3 98	C-01 3 106	C-14 3 55	C-23 3 105	C-55 3 38	B-52 2 R-39(SA)	C-61 3 88	B-13 2 R-10(SB)	D-23 4 12P17(20)	D-37 4 23
F	D-36 4 15	B-57 2 AR-48(CC)	D-16 4 12P24(20)	C-02 3 RS-8(PL)	C-16 3 63	B-61 2 R-14(SD)	C-51 3 56	B-45 2 R-09(CC)	C-45 3 21	B-51 2 R-15(SD)	C-24 3 67	C-04 3 RS-1(PL)	D-54 4 12P28(20)	B-64 2 R-43(CD)	D-42 4 16
E	D-64 4 17	D-39 4 B6P6(8)	B-29 2 R-35(CA)	C-38 3 52	B-47 2 118	C-21 3 76	B-46 2 R-46(SA)	C-27 3 64	B-48 2 68	C-17 3 61	B-35R 2 48	C-34 3 46	B-33 2 R-07(CA)	D-17 4 A6P9(8)	D-28 4 18
D		D-10 4 12	C-49 3 119	B-12 2 R-33(SA)	C-28 3 47	C-12 3 RS-7(PL)	C-50 3 102	B-21 2 R-04(CB)	C-43 3 80	C-10 3 RS-2(PL)	C-26 3 50	B-16 2 AR-18(SA)	C-56 3 120	D-09 4 13	
C		D-19 4 14	D-51 4 R-28(CC)	C-64 3 95	B-11 2 R-06(CA)	D-65 4 12P40(20)	B-19 2 R-29(SB)	C-35 3 B6P9(7)	B-04 2 AR-11(SB)	D-20 4 12P25(20)	B-34 2 R-02(CA)	C-53 3 86	D-04 4 R-45(CC)	D-02 4 9	
B			D-26 4 10	D-69 4 11	D-66 4 B6P8(8)	B-23 2 R-50(CD)	D-68 4 12P18(20)	B-42 2 R-40(SC)	D-25 4 12P35(20)	B-01 2 R-22(CC)	D-24 4 A6P5(8)	D-47 4 5	D-43 4 6		
A					D-34 4 7	D-18 4 8	D-05 4 1	D-58 4 A6P4(9)	D-41 4 2	D-33 4 3	D-21 4 4				

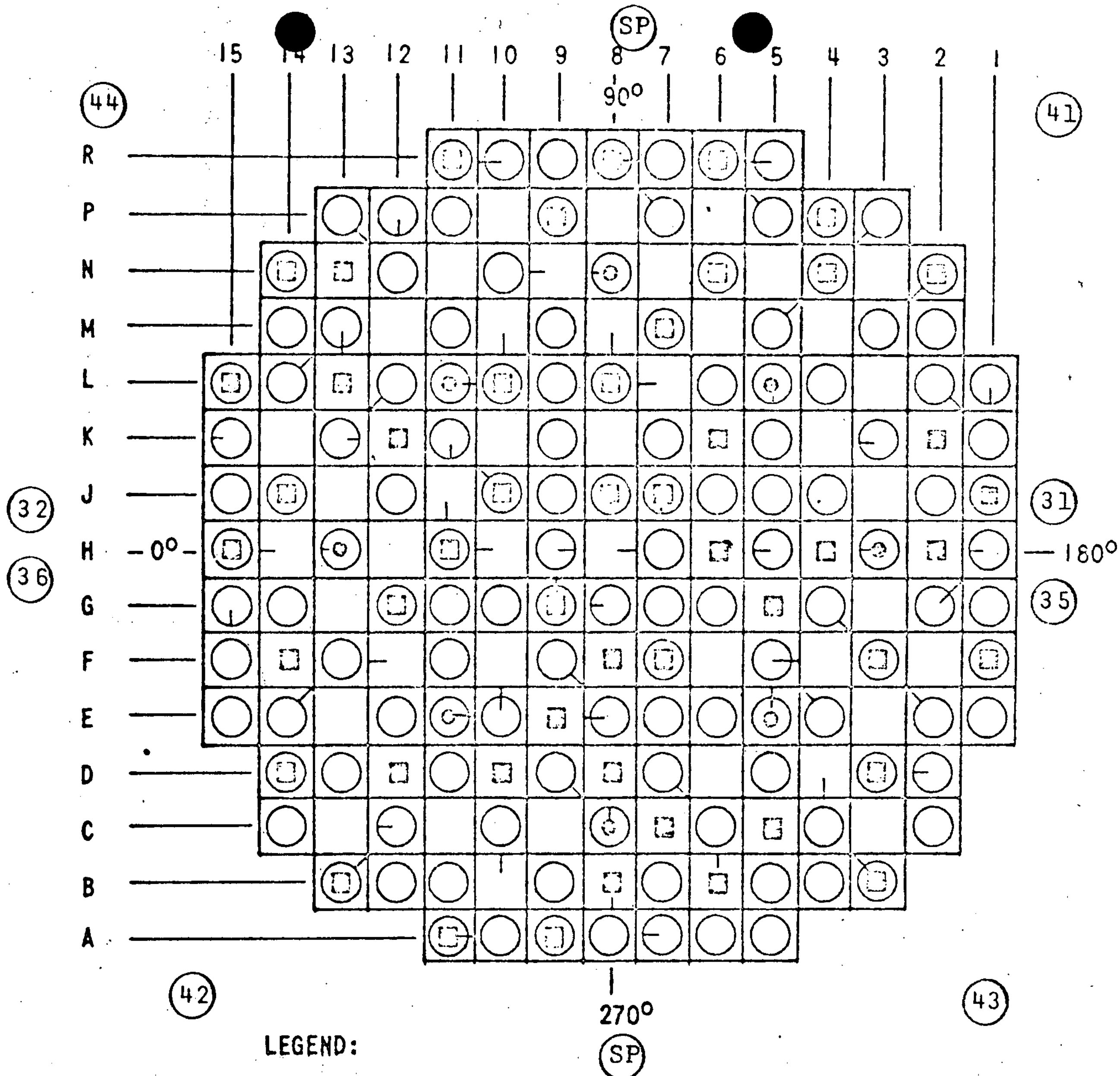
EXAMPLE, ASSEMBLY G-11

Box	Legend
2	REGION
B-49	ASSEMBLY #
87	PLUG DEVICE #

INDIAN POINT 2 · CYCLE 2 LOADING PATTERN

Figure 2.2

9/1/76
T.S



LEGEND:

THERMOCOUPLE

MOVABLE DETECTOR

FLOW-MIXING DEVICE

FIXED DETECTOR

31, 32 Source Range Detectors

35, 36 Intermediate Range Detectors

41, 42, 43, 44 Power Range Detectors

SP Spare Detector Wells

Figure 2-3. In-Core Instrumentation, Thermocouples and Movable Detectors

3. MEASUREMENT METHODS

The reactor was kept at the just critical state during the physics measurements and the reactor power was held constant via control rod/boron exchanges and/or control rod/coolant temperature exchanges. Small changes in core reactivity during the tests were indicated by the reactivity trace provided by the reactivity computer.

The axial power distributions were obtained using the moveable incore detectors.

3.1 Reactivity Computer

The absolute measurement of small changes in reactivity was provided by the on-line solution of the point-reactor kinetics equations using an analog computer. The latter was checked out by comparing the reactivity obtained from the reactor period with that given directly by the reactivity computer. This comparison is shown in Table 3.1. A good agreement between reactivities obtained from two sources ensured the reliability of delayed neutron data, given in Table 3.2. This data was used as an input to the solution of neutron kinetics equations by the reactivity computer.

During HZP tests, an output signal from an excore detector, N-Channel 41, as shown in Figure 3.1, was fed into the reactivity computer. However, during the power ascension tests, signals from the top and bottom sections of all four excore detectors were first summed and then fed into the reactivity computer, see Figure 3.1.

3.2 Moveable In-core Detectors

The axial core power distributions provided by the moveable incore detectors were integrated over the Z-variable (axial) to obtain the radial or (X-Y) power distributions of the instrumented assemblies. The relative assembly power distributions in the core were finally obtained using the INCORE code, References 4 and 5. The analysis of the incore flux maps also provided measured hot channel factors - $F^N_{\Delta H}$ and F^N_Q.

TABLE 3.1

PERIOD TO REACTIVITY COMPARISON

Doubling Time (sec)	Reactor Period (sec)	Reactivity (pcm)	Reactivity Meas. (pcm)	Difference (M-P) (pcm)
172	248	25	25.0	0
73	105	53	51.0	-2.0
46	66	75.5	73.5	-2.0

TABLE 3.2

DELAYED NEUTRON DATA

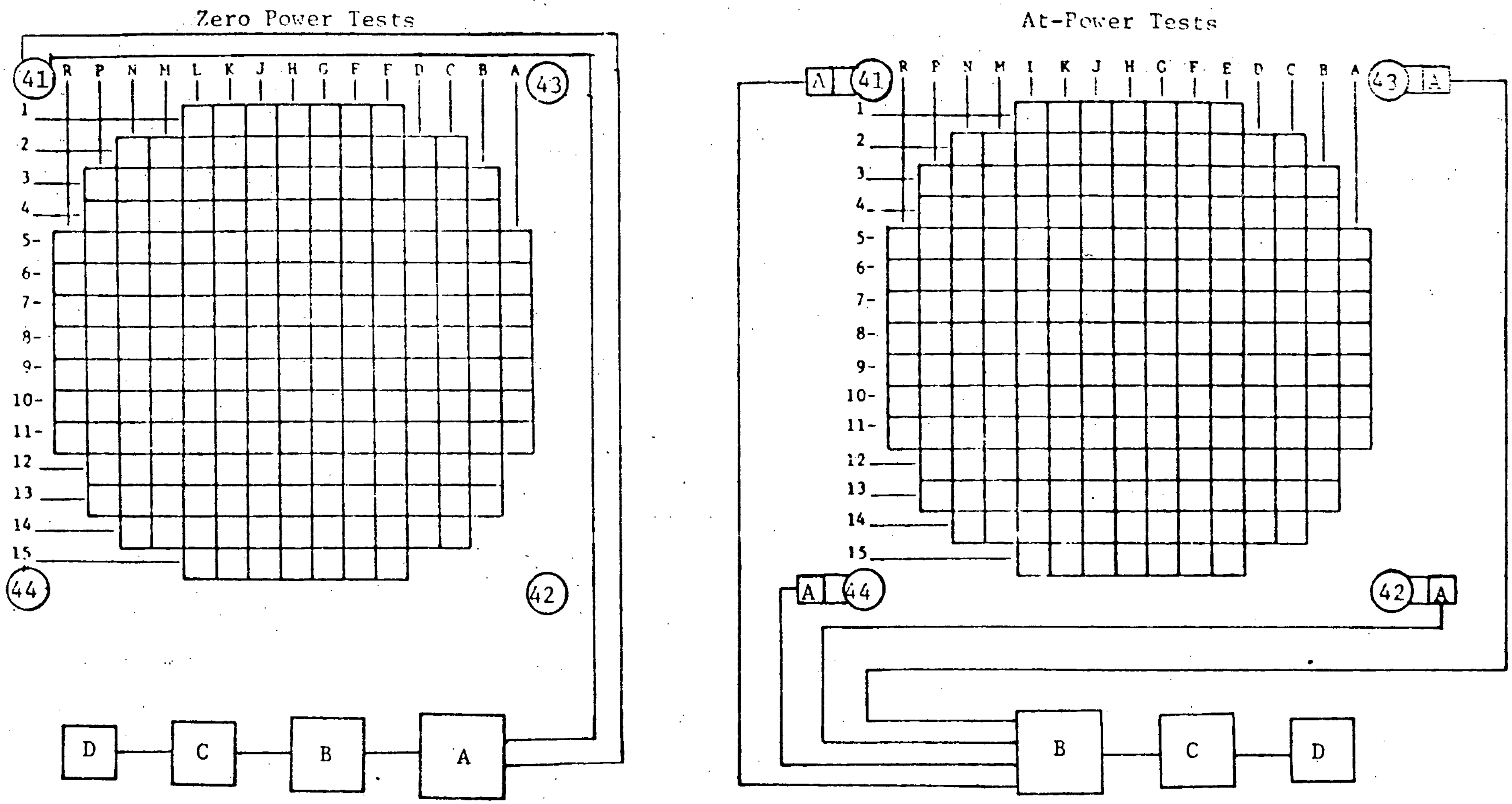
Group	$\bar{\beta}_{ieff}$	λ_i(sec)
1	0.00018	0.013
2	0.00127	0.031
3	0.00115	0.117
4	0.00235	0.315
5	0.00081	1.252
6	0.00028	3.340

$\Sigma \bar{\beta}_{ieff} = 0.00604$

$\ell^* = 16.3\ \mu$ sec

$\bar{I} = 0.970$

$\bar{\beta}_{ieff} = \bar{I}\,\bar{\beta}$



A = Summing Junction
B = Picoammeter
C = Reactivity Computer
D = Strip Chart Recorder

A = Isolation Amplifier
B = Summing Junction
C = Reactivity Computer
D = Strip Chart Recorder

Figure 3.1 Process Instrumentation Arrangements for Reactivity Measurements

4. HOT ZERO POWER (HZP) TESTS

4.1 Initial Criticality

The Indian Point Unit No. 2 reactor attained Cycle 2 initial criticality on September 21, 1976. The criticality, at beginning of life (BOL) and HZP condition, was obtained by the sequential withdrawal of the RCC shutdown and control banks and by subsequently diluting the borated reactor coolant. During the approach to criticality, ICRR (Inverse Count Rate Ratio) plots versus time, integrated primary water addition, reactor coolant boron concentration, and control rod position (Figures 4.1 to 4.5) were kept. Measured critical boron concentration, at BOL, HZP, and ARO (All Rods Out) core condition, was equal to 1445 ppm compared to the design result of 1476 ppm, Reference 3. The difference of 31 ppm between measured and design boron concentrations was less than 50 ppm, the acceptance limit for this measurement. HZP physics tests included the following measurements: (a) end-point boron concentrations for several configurations of RCC banks; (b) differential and integral worths of RCC banks during normal insertion/withdrawal sequence, for both with and without bank overlap cases; and (c) isothermal temperature coefficients for different RCC bank configurations.

In addition to the above tests at HZP, a core power distribution measurement at low reactor power (2%

Power) was made for the all rods out condition. This measurement is described in Section 5.

4.2 End-Point Boron Concentrations

In Table 4.1, measured end-point boron concentrations, for different control and shutdown RCC bank configurations, are presented. The corresponding design values, from Reference 3, are also listed. The maximum deviation, as shown in Table 4.1, is 31 ppm. This satisfies acceptance criteria of $\pm$ 50 ppm.

4.3 RCC Bank Differential and Integral Worths

Measurements of the differential and integral worth of individual RCC control and shutdown banks were carried out via boron/RCC exchange, with the reactor in the critical state. The reactivity computer trace provided the change in reactivity during insertion/withdrawal of an RCC bank. The differential worth of a bank, $\Delta\rho/\Delta H$ is defined as the amount of change in reactivity per unit step of bank position, about an average bank position. The integral control bank worth was obtained by summing the differential worths for the bank positions during the insertion or withdrawal of the RCC bank.

In Table 4.2, the integral worths of individual control banks and overlapped banks are presented along with the design values. The cumulative worths are also given in Table 4.2.

In Figures 4.6 through 4.9, differential and integral worths of control banks C and D are shown.

Figures 4.10 and 4.11 show differential and integral worths of RCC control banks in overlap to the zero power insertion limit.

Measured integral worths in all cases are within ± 10% of design values (Reference 3). The latter constitutes the acceptance criteria for the integral worths of RCC banks.

4.4 Isothermal Temperature Coefficient

Isothermal temperature coefficient measurements were carried out for several RCC bank configurations. Measurements involved heatup and cooldown of the reactor coolant. In Table 4.3, measured as well as design values of isothermal temperature coefficients for four RCC bank configurations are presented.

Measured values are obtained from the reactivity versus temperature curves provided by an X-Y plot recorder and the design values are from Reference 3. Measured isothermal temperature coefficients were all negative and within the acceptance criteria of ± 3 pcm/°F.

TABLE 4.1

End-Point Boron Concentrations

Configuration	(1) Measured (ppm)	(2) Design (ppm)	(1)-(2) Deviation (ppm)
All Rods Out	1445	1476	-31
C/D In	1345	1360	-15
C/D and C/C In	1256	1260	-4
C/D in C/C at 80 C/B at 210	1273	1275	-2

TABLE 4.2

CONTROL ROD BANK INTEGRAL WORTH SUMMARY

BANK	CONFIGURATION	PREDICTED RTH (pcm)	MEASURED* WORTH (pcm)	PREDICTED TOTAL WORTH ± 10%	MEASURED* TOTAL WORTH
D		980 ± 98	891	980 ± 98	891
C	D in	880 ± 88	933	1860 ± 186	1823
B,C,D	Overlap to Insertion Limit	1800 ± 180	1682		

* Note: All measurements were done at HZP, BOL, no xenon

TABLE 4.3

ISOTHERMAL TEMPERATURE COEFFICIENT

Configuration	$\partial\rho/\partial T$ Measured pcm/°F	$\partial\rho/\partial T$ * Predicted pcm/°F	Difference M-P pcm/°F
ARO D @ 220	-0.84	-1.60	0.76
D @ O, C @ 198	-2.27	-3.33	1.06
C, D @ O B @ 207	-3.96	-5.18	1.22
D @ O, C @ 75, B @ 204	-5.12	-4.10	1.02

* Based on design values interpolated for the measured boron concentrations.

FIGURE 4.1

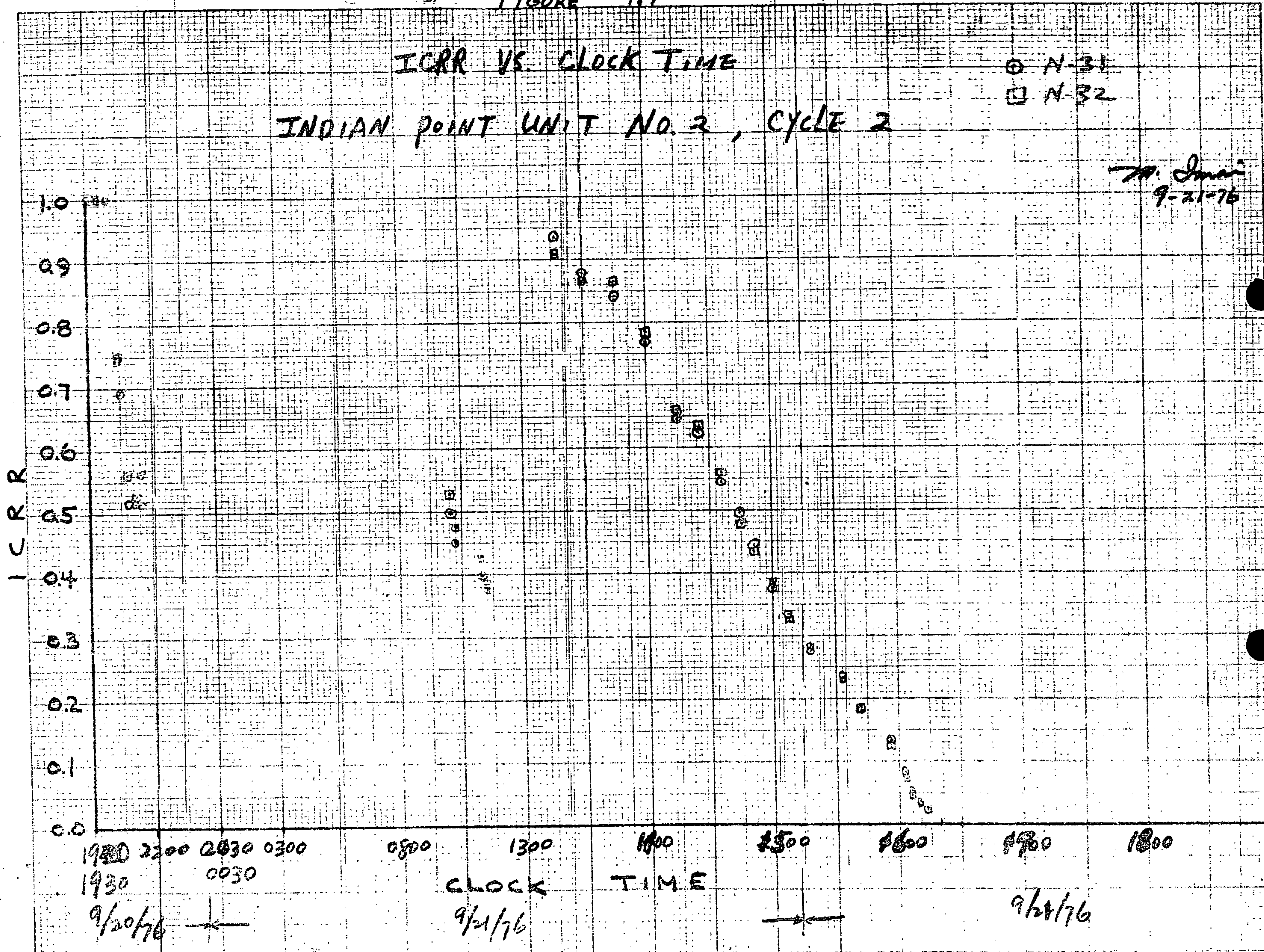

ICRR VS. CLOCK TIME
INDIAN POINT UNIT NO. 2, CYCLE 2
N-31
N-32
9-21-76
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
ICRR
1930
2200
0030
0300
0800
1300
1400
1500
1600
1700
1800
CLOCK TIME
9/20/76
9/21/76

FIGURE 4.2

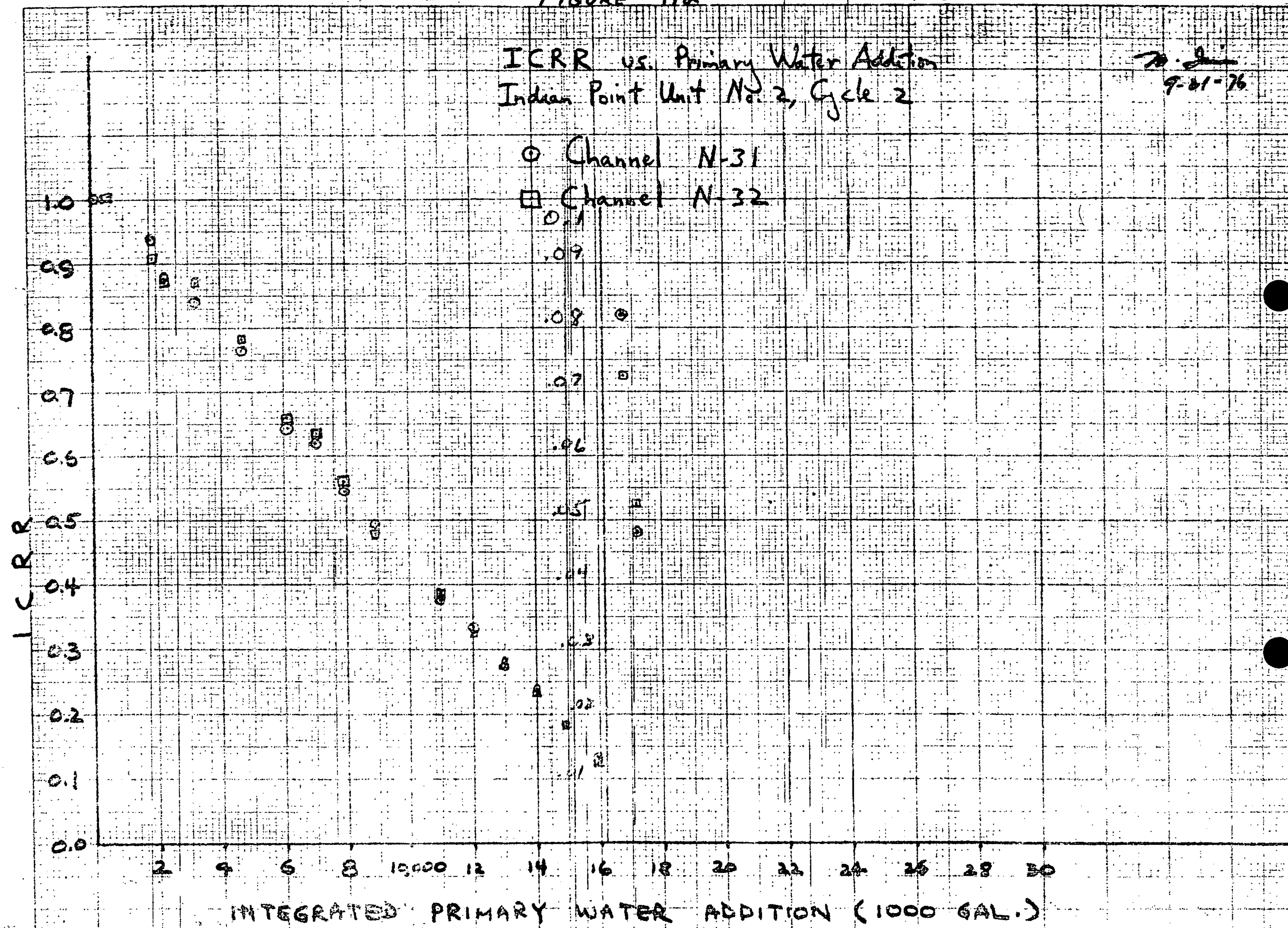

ICRR vs. Primary Water Addition
Indian Point Unit No. 2, Cycle 2
9-21-76
Channel N-31
Channel N-32
ICRR
INTEGRATED PRIMARY WATER ADDITION (1000 GAL.)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
2
4
6
8
10,000
12
14
16
18
20
22
24
26
28
30

FIGURE 4.3

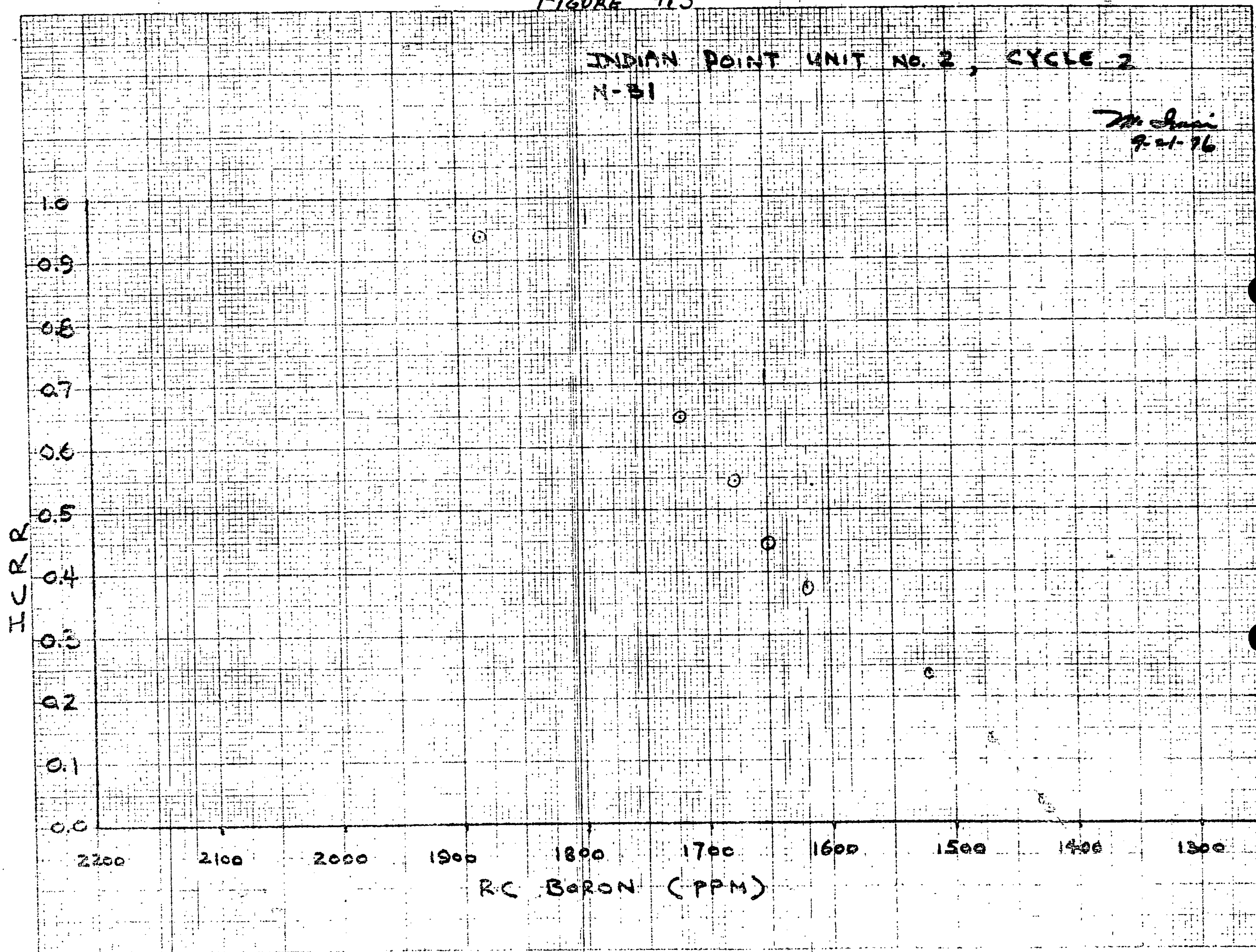

INDIAN POINT UNIT NO. 2, CYCLE 2
N-31
ICRR
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
R.C BORON (PPM)

FIGURE 4.4

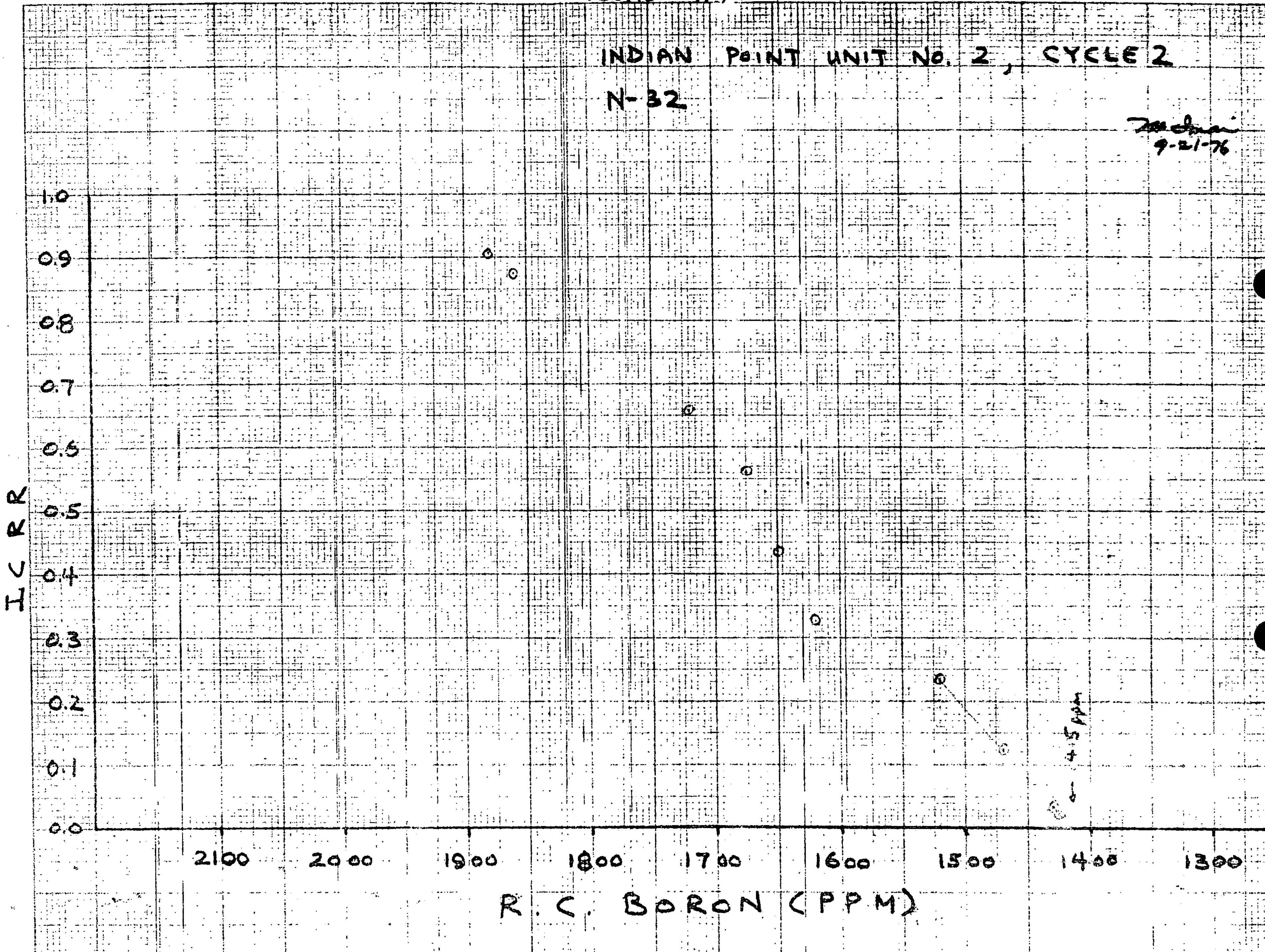
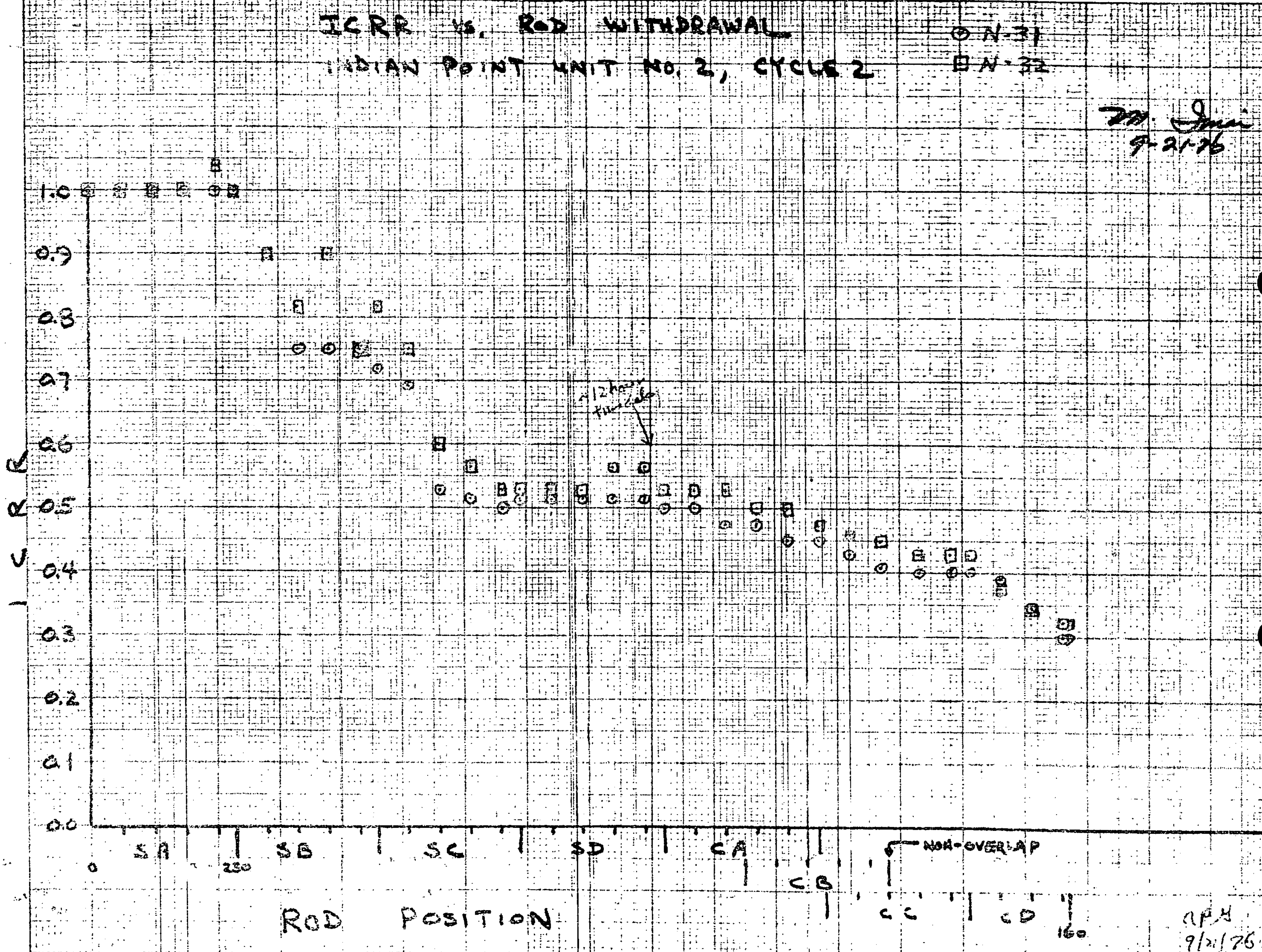
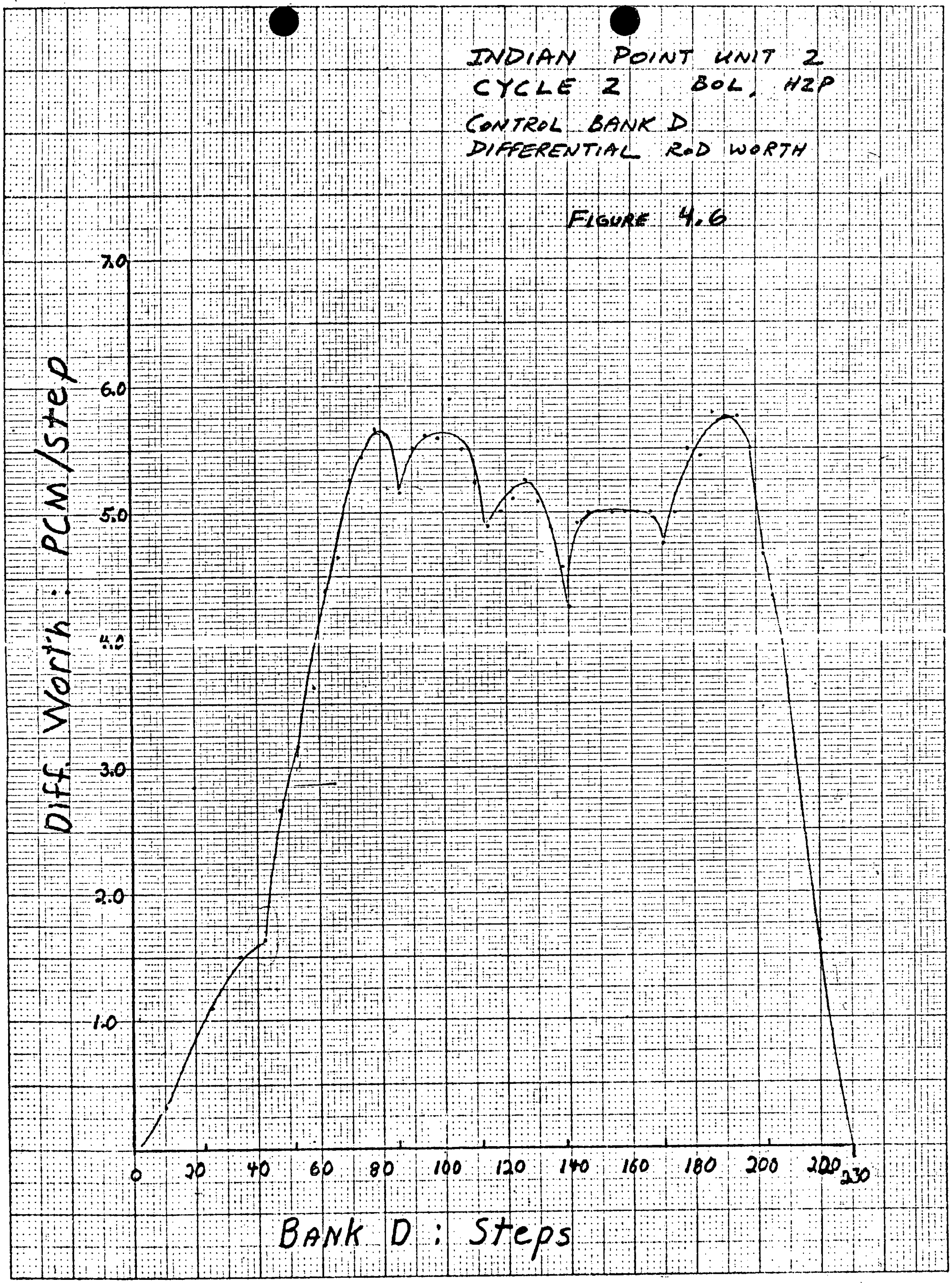
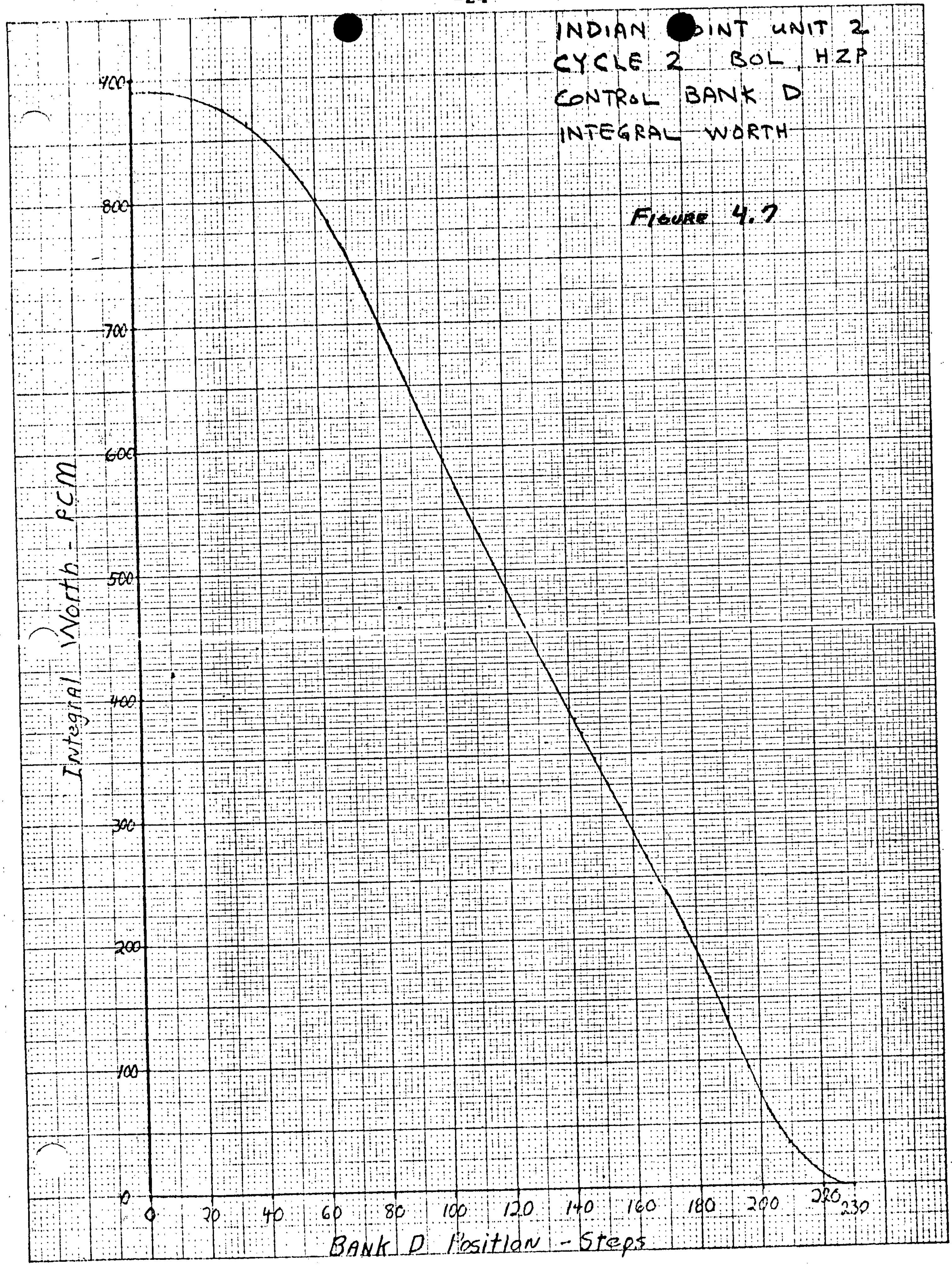

INDIAN POINT UNIT NO. 2, CYCLE 2
N-32
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
ICRR
2100
2000
1900
1800
1700
1600
1500
1400
1300
R. C. BORON (PPM)

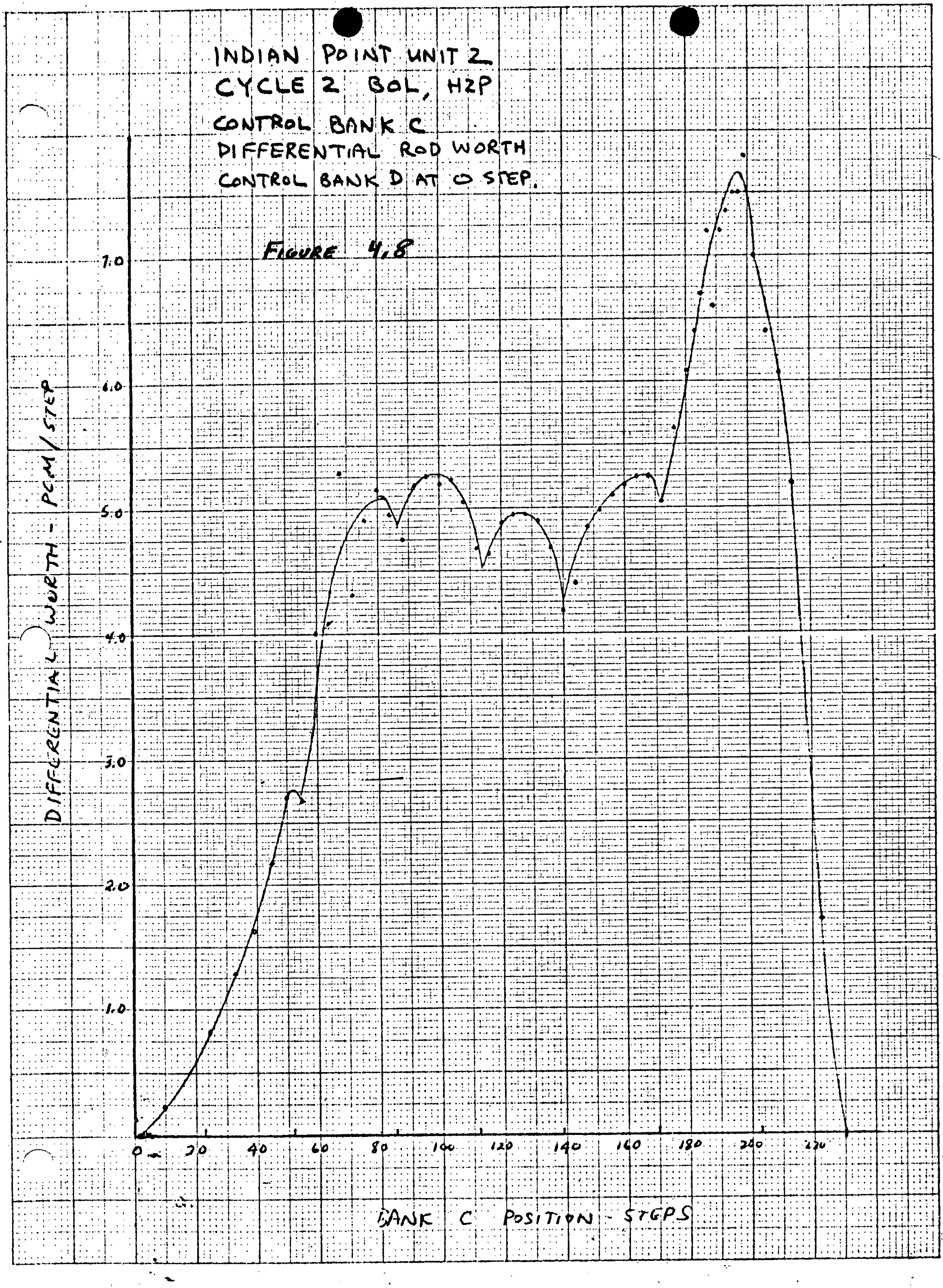
FIGURE 4.5

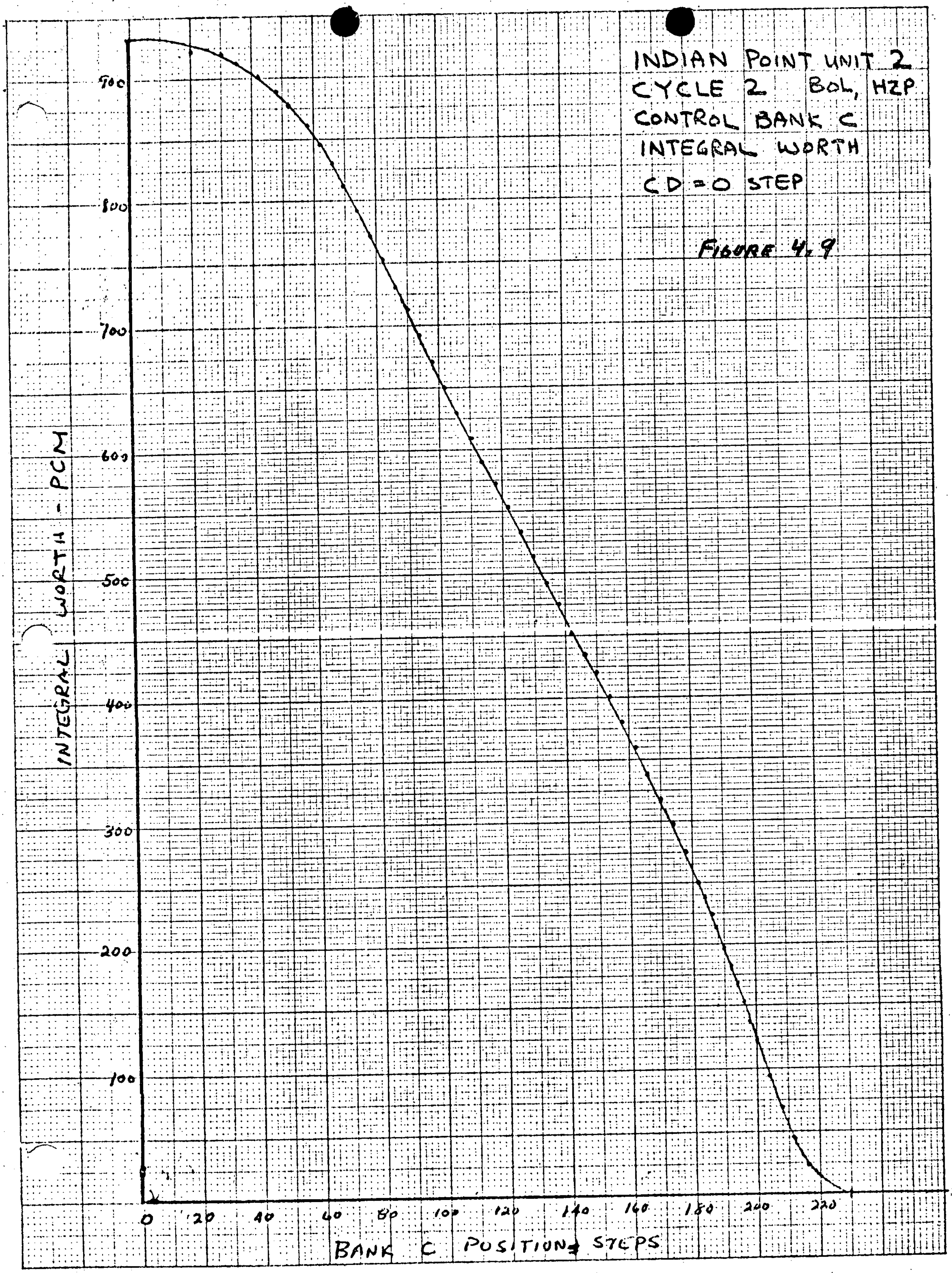

ICRR vs. ROD WITHDRAWAL
INDIAN POINT UNIT NO. 2, CYCLE 2
⊙ N-31
⊡ N-32
9-21-76
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
ICRR
~12 hours
SA
SB
SC
SD
CA
CB
CC
CD
NON-OVERLAP
0
230
160
ROD POSITION
9/21/76

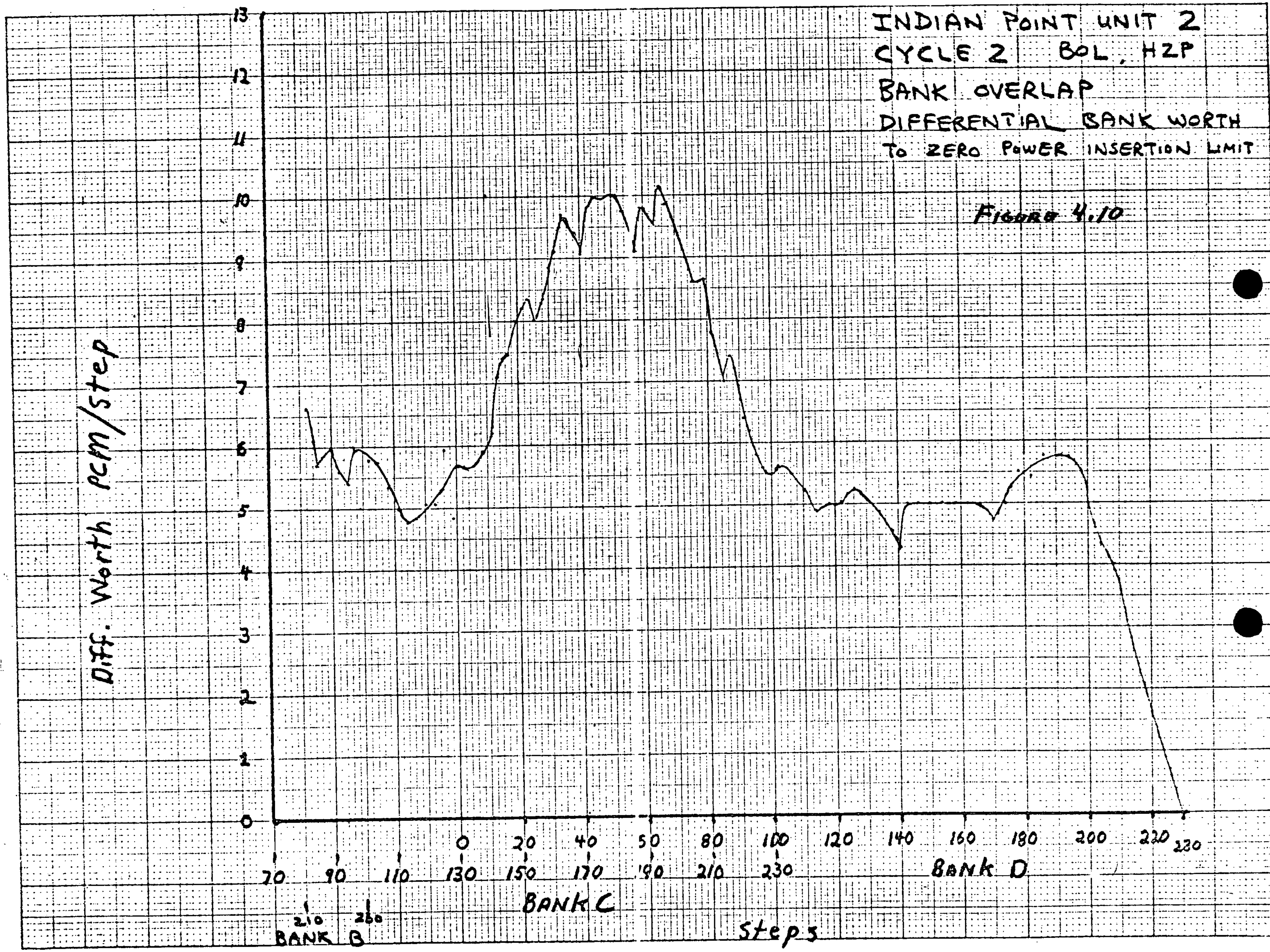


NO. 318. 20 DIVISIONS PER INCH BOTH WAYS. 150 BY 200 DIVISIONS.
codex GRAPH PAPER IN STOCK DIRECT FROM CODEX BOOK CO. INC. NORWOOD, MASS. 02062 PRINTED IN U.S.A.


INDIAN POINT UNIT 2
CYCLE 2 BOL HZP
CONTROL BANK D
INTEGRAL WORTH
FIGURE 4.7
Integral Worth - PCM
Bank D Position - Steps
0
100
200
300
400
500
600
700
800
900
0
20
40
60
80
100
120
140
160
180
200
220
230

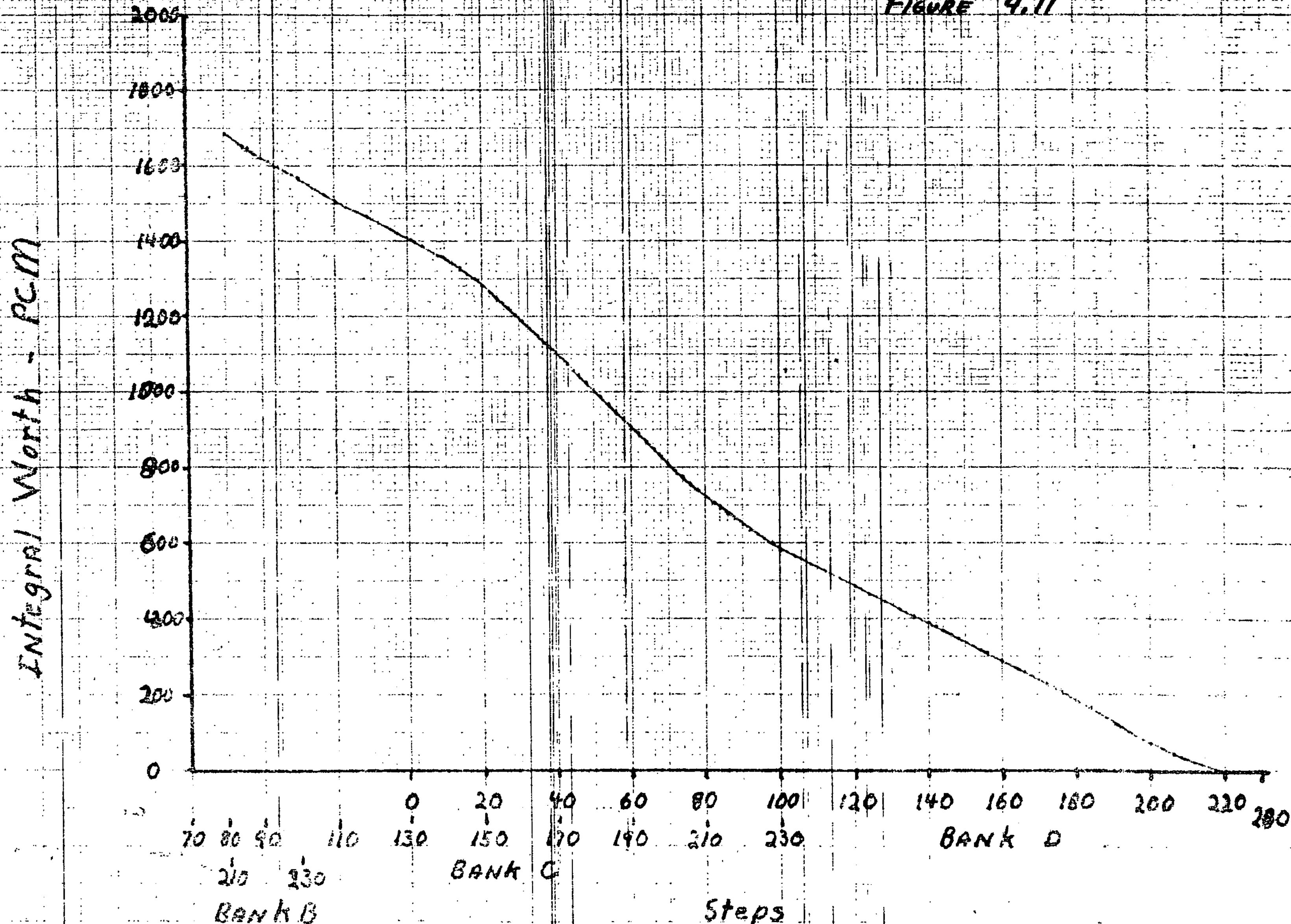

INDIAN POINT UNIT 2
CYCLE 2 BOL, H2P
CONTROL BANK C
DIFFERENTIAL ROD WORTH
CONTROL BANK D AT 0 STEP.
FIGURE 4.8
DIFFERENTIAL WORTH - PCM/STEP
1.0
2.0
3.0
4.0
5.0
6.0
7.0
0
20
40
60
80
100
120
140
160
180
200
220
BANK C POSITION - STEPS


INDIAN POINT UNIT 2
CYCLE 2 BOL, HZP
CONTROL BANK C
INTEGRAL WORTH
CD = 0 STEP
FIGURE 4.9
INTEGRAL WORTH - PCM
900
800
700
600
500
400
300
200
100
0
20
40
60
80
100
120
140
160
180
200
220
BANK C POSITION STEPS


INDIAN POINT UNIT 2
CYCLE 2 BOL, HZP
BANK OVERLAP
DIFFERENTIAL BANK WORTH
TO ZERO POWER INSERTION LIMIT
FIGURE 4.10
Diff. Worth pcm/step
0
1
2
3
4
5
6
7
8
9
10
11
12
13
0 20 40 50 80 100 120 140 160 180 200 220 230
BANK D
70 90 110 130 150 170 190 210 230
BANK C
210 230
BANK B
Steps

INDIAN POINT UNIT 2
CYCLE 2 BOL, HZP
BANK OVERLAP
INTEGRAL BANK WORTH

FIGURE 4.11



5. AT POWER TESTS

The power measurement tests consisted of: (a) relative assembly power distributions at low power (~2%), 35%, 70%, and 90% of full power; (b) determination of power coefficient versus reactor power; and (c) reactor coolant flow determination.

5.1 Core Power Distributions

Measurements of the core power distributions were carried out with the moveable incore detectors. The INCORE code, References 4 and 5, was employed to analyze the in core flux maps to provide the relative assembly power and hot channel factors. The analysis required: (i) the calculated ratio between the power and the fission reaction rate at the locations of the moveable incore detectors, and (ii) calculated (X-Y) power distributions for the all rods out (ARO) condition and the D bank in case. The latter were employed to obtain the power distribution of the partially rodded core by the flux synthesis method. Results from the analyses of 7 incore full core flux maps and 7 quarter core flux maps taken during the startup tests are presented in Table 5.1. Relative assembly power distributions derived for HZP and 90% power cases are shown in Figures 5.1 and 5.2.

For the Hot Zero Power (~2%) map, 2 out of 193 assemblies (core locations B-11 and B-12) had power fractions outside the acceptance criteria ($\pm$ 10%, $p_i \geq 0.9$; $\pm$ 15%, $p_i < 0.9$) as indicated on the power map Figure 5.1 (Hot Zero Power). These two assemblies were not measured directly but represent extrapolations from neighboring assemblies with high measured, compared with design, but acceptable power fractions. All subsequent maps taken at significant power levels (35%→90%) had all power fractions within the acceptance criteria as illustrated in Figure 5.2 (90% Power). This one anomaly did not repeat itself and the map that produced it was taken at a low power level (~2%). In addition the highest measured errors on all maps are at the corners where the design calculations are more prone to error. It was therefore concluded that this single event did not represent a deviation from acceptance criteria sufficient to impact on plant performance.

In all cases, the measured values of F_Q^N and $F_{\Delta H}^N$, even after being increased by their respective measurement uncertainty factors, were within the Technical Specification limits.

5.2 Power Coefficient

The "differential" power coefficient, $(\Delta\rho/\Delta Q)_Q$ at a specific power level, Q, is defined as the change in reactivity, (ρ), per percent change in reactor power, Q, at that power level.

Measurement of the power coefficient involved:

(a) The determination of reactivity compensation carried out during the increase and the decrease of reactor power by control bank movement. This was obtained from the output of the reactivity computer.

(b) Determination of reactor power level changes from the recording of secondary plant calorimetric data - steam pressure, feedwater temperatures, and feedwater flow rates. Steam pressure was obtained directly from the local gauges. Feedwater temperatures were obtained from the precision thermometer installed at the feedwater header, and the feedwater flow from manometers installed across the feedwater line venturi elements.

In addition to the above data, the analysis of power coefficient measurements included corrections due to xenon changes caused by power level variations.

Differential and integral power defects were obtained from the following equations.

Differential Power Coefficient

$$(\Delta\rho/\Delta Q) = 1/\Delta Q\left[(\Delta\rho)_{CR} + (\Delta\rho)_{Xe} + (\Delta\rho)_{B} + (\Delta\rho)_{T}\right]$$

Integral Power Defect

$$\rho_{P.D} = \int_{P_0}^{P_F} \frac{\Delta\rho}{\Delta Q}\, dQ$$

where

$(\Delta\rho)_{CR}$ = Reactivity Compensation due to Control Rod

$(\Delta\rho)_{Xe}$ = Reactivity Defect due to Xenon Change

$(\Delta\rho)_{B}$ = Reactivity Defect due to Boron Change

$(\Delta\rho)_{T}$ = Reactivity Defect due to Temperature Change

ΔQ = Change in Reactor Power

Table 5.2 gives the measured power coefficients and the design power coefficients (Reference 3). The measured values are within the acceptance criteria of $\pm$ 2 pcm/%Q. The integral power defect was calculated from the measured data by a least squares fit and is 1121 pcm compared with the design value of 1055 pcm.

5.3 Reactor Coolant Flow Determination

Based on elbow tap DP measurements, the Reactor Coolant Flow was verified to be 379,250 gpm (1σ = 1435 gpm) which is greater than design (358,800 gpm).

Table 5.3 provides the power levels and the percent increased reactor coolant flow above design. These results demonstrate compliance with Technical Specification Criteria on Reactor Coolant System Total Flow Rate.

TABLE 5.1

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.

DATA SHEET

NO. 102

DATE

LOCATION

PREPARED BY

SUBJECT IP2 Cycle 2
Summary of Incore Flux Maps for Start-up Physics Tests

① $F_Q^T = F_Q^N \times 1.03 \times 1.05$
② $F_{\Delta H}^T = F_{\Delta H}^N \times 1.04$
③ At Location of F_Q^N, $F_{xy} = F_Q^T / F_z$

				Control Bank Position (Steps)						Avg. Core		Incore Hot Channel Factors							Incore Quadrant Tilt			
MAP #	Date	Time	% Power	A	B	C	D	P/L	RCC	F_z	A.O.	F_Q^N	F_Q^T ①	F_Q LOC	$F_{\Delta H}^N$	$F_{\Delta H}^T$ ②	LOC $F_{\Delta H}$	F_{xy} ③	N41	N42	N43	N44
LP.Q2	9-22-76	10:20	~0	230	230	230	224	228	—	1.703	35.38	2.654	2.870	C10IH	1.531	1.592	N13JL	1.558	1.0042	0.9757	1.0253	0.9857
2R6	9-30-76	10:23	~35	230	230	230	179	228	—	1.240	-0.77	2.119	2.292	L4LJ	1.522	1.583	N13JL	1.709	1.0020	1.0021	1.0036	0.9874
3R2	10-3-76	14:56	~70	230	230	230	214	228	—	1.279	9.36	1.829	1.978	N10HI	1.427	1.484	N13JL	1.431	1.0045	0.9761	1.0101	0.9892
4R3	10-3-76	21:09	~70	230	230	230	180	228	—	1.296	-10.28	1.990	2.152	N13JL	1.466	1.525	N13JL	1.536	1.0060	1.0013	1.0078	0.9850
QC1R2	10-4-76	23:50	~70	230	230	230	214	228	—	1.183	-0.28	1.705	1.844	C3FD	1.377	1.432	C3FD	1.441				
QC2	10-4-76	02:23	~70	230	230	230	214	228	—	1.221	5.75	1.674	1.810	C3FD	1.375	1.430	F3GH	1.371				
QC3	10-4-76	04:34	~70	230	230	230	214	228	—	1.300	10.53	1.771	1.914	C6HG	1.379	1.434	F3GH	1.362				
QC4	10-4-76	06:03	~70	230	230	230	214	228	—	1.345	13.42	1.830	1.979	G4DF	1.377	1.432	F3GH	1.361				
5R2	10-4-76	09:20	~70	230	230	230	214	228	—	1.394	16.65	2.050	2.217	N10HI	1.416	1.473	N13JL	1.470	1.0070	0.9946	1.0087	0.9897
QC5	10-4-76	14:25	~70	230	230	230	214	228	—	1.356	14.37	1.848	1.999	G4DF	1.374	1.429	F3GH	1.363				
Q-6	10-4-76	17:15	~70	230	230	230	214	228	—	1.292	10.39	1.743	1.885	F3GH	1.374	1.429	F3GH	1.349				
QC7	10-4-76	19:37	~70	230	230	230	214	228	-	1.230	6.00	1.674	1.810	F3GH	1.369	1.424	F3GH	1.361				
6R2	10-5-76	00:11	~70	230	230	230	214	228	-	1.180	2.81	1.775	1.920	N13JL	1.438	1.496	N13JL	1.503	1.0052	0.9941	1.0117	0.9890
7PDQ	10-11-76	9.39	90	230	230	230	212	228	-	1.206	4.27	1.738	1.880	N13JL	1.419	1.476	N13JL	1.441	1.0007	0.9975	1.0121	0.9896

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TABLE 5.1 (CONT.)

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.

DATA SHEET

No. 2 of 2

DATE ____________

LOCATION ____________

PREPARED BY ____________

SUBJECT: IP2 - Cycle 2
Summary of Incore Flux Maps for Start-up Physics Tests

	Incore Quadrant Tilt (Bottom)				Incore Axial Offset				Excore Axial Offset			
	NW N44	NE N41	SW N42	SE N43	NW N44	NE N41	SW N42	SE N43	NW N44	NE N41	SW N42	SE N43
1PDQ2	1.0148	0.9688	1.0305	0.9859	34.922	35.687	35.534	35.331				
2R6	1.0108	0.9904	1.0081	0.9907	-1.210	-0.187	-0.748	-0.941	-0.0476	-0.0320	-0.0548	-0.0271
3R2	1.0174	0.9927	1.0053	0.9847	8.729	9.527	9.597	9.588	0.0061	0.0419	0.0054	0.0375
4R3	1.0156	0.9927	1.0033	0.9884	-10.753	-9.851	-10.061	-10.454	-0.1042	-0.0883	-0.1053	-0.0915
QC1R2									-0.0539	-0.0243	-0.0539	-0.0304
QC2									-0.0185	0.0183	-0.0148	0.0129
QC3									0.0128	0.0514	0.0105	0.0424
QC4									0.0277	0.0685	0.0280	0.0624
5R2	1.0029	0.9948	1.0084	0.9939	16.848	16.639	16.661	16.441	0.0493	0.0893	0.0462	0.0830
QC5									0.0350	0.0760	0.0312	0.0695
QC6									0.0104	0.0474	0.0097	0.0427
QC7									-0.0094	0.0224	-0.0114	0.0188
6R2	1.0090	0.9936	1.0057	0.9917	2.625	2.835	3.106	2.672	-0.0344	-0.0031	-0.0350	-0.0072
7PDQ	1.0095	0.9939	1.0039	0.9927	3.836	4.454	4.675	4.119	-0.0220	0.0128	-0.0457	-0.0066

	Unnormalized Excore Detector Currents (μa)											
	N-41			N-42			N-43			N-44		
	TOP	BOT.	SUM	TOP	BOT.	SUM	TOP	BOT.	SUM	TOP	BOT.	SUM
1PDQ2												
2R6	133.2	142.0	275.2	134.6	150.2	284.8	148.7	157.1	305.8	136.0	149.6	285.6
3R2	295.6	271.8	567.4	288.2	285.1	573.3	324.1	300.7	624.8	290.8	287.3	578.1
4R3	256.2	305.8	562.0	259.5	320.6	580.1	282.6	339.5	622.1	262.5	323.6	586.1
QC1R2	281.3	295.3	576.6	278.0	309.7	587.7	307.7	327.0	634.7	280.7	312.7	593.4
QC2	286.0	275.7	561.7	280.3	288.7	569.0	313.0	305.0	618.0	281.7	292.3	574.0
QC3	296.7	267.7	564.4	288.0	282.0	570.0	323.3	297.0	620.3	291.7	284.3	576.0
QC4	304.0	265.0	569.0	294.0	278.0	572.0	332.0	293.0	625.0	297.0	281.0	578.0
5R2	314.1	262.6	576.7	302.3	275.6	577.9	341.1	288.8	629.9	305.6	276.9	582.5
QC5	304.3	261.3	565.6	292.7	275.0	567.7	330.7	287.7	618.4	295.7	275.7	571.4
QC6	298.3	271.3	569.6	290.3	284.7	575.0	326.0	299.3	625.3	292.7	286.7	579.4
QC7	296.7	283.7	580.4	290.0	296.7	586.7	325.0	313.0	638.0	293.7	299.3	593.0
6R2	275.2	276.9	552.1	270.5	290.1	560.6	302.0	306.4	608.4	274.0	293.5	567.5
7PDQ	340.5	331.9	672.4	330.0	361.6	691.6	368.8	369.3	738.1	335.6	350.7	686.3

Table 5.2

Power Coefficient ($\Delta\rho/\Delta Q$)

Average Power (%)*	Measured pcm/%Q	Design pcm/%Q	Difference pcm/%Q
63.0	-9.85	-9.3	-0.55
77.4	-8.80	-9.0	+0.20

* Average power over the test power range

Table 5.3

Reactor Coolant Flow

% POWER	% INCREASED RC FLOW (above design)
0	6.5
35	5.7
50	5.6
69	5.7
90	5.2
96	5.7
	AVG. = 5.7%

[illegible]

Row		15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
R	MEAS					.646.	.835.	.878.	.807.	[illegible]	.855.	.645.				
	DIFF					-1.9.	-3.6.	-7.8.	-8.0.	[illegible]	-1.3.	-1.5.				
P	MEAS			.734.	1.020.	1.151.	.992.	1.198.	.946.	1.231.	1.004.	1.133.	.969.	.668.		
	DIFF			8.1.	.5.	-2.0.	-3.6.	-7.6.	-7.8.	-3.0.	-2.4.	-3.5.	-4.5.	-1.5.		
N	MEAS		.737.	1.318.	1.178.	1.025.	1.268.	1.003.	1.040.	1.019.	1.287.	1.000.	1.068.	1.202.	[illegible]	
	DIFF		8.6.	7.9.	3.0.	-2.0.	-5.4.	-5.4.	-4.9.	-4.0.	-3.9.	-4.3.	-4.9.	-1.5.	[illegible]	
M	MEAS		1.079.	1.205.	.949.	1.233.	1.128.	1.129.	.888.	1.096.	1.059.	1.139.	.865.	1.126.	[illegible]	
	DIFF		6.3.	5.4.	1.5.	2.2.	2.2.	-1.4.	-4.7.	-4.4.	-4.9.	-5.6.	-7.6.	-1.4.	[illegible]	
L	MEAS	.713.	1.223.	1.058.	1.222.	.929.	.959.	.871.	.951.	.861.	.929.	.927.	1.115.	1.016.	[illegible]	.839.
	DIFF	6.3.	4.2.	1.2.	1.3.	2.5.	2.3.	-1.4.	-4.7.	-2.5.	-1.0.	2.2.	-7.6.	[illegible]	-3.0.	-3.0.
K	MEAS	.891.	1.048.	1.340.	1.119.	.971.	.805.	.884.	.767.	.883.	.802.	[illegible]	1.072.	1.301.	.973.	[illegible]
	DIFF	2.9.	1.9.	-.0.	1.4.	3.5.	4.0.	1.2.	.6.	1.2.	3.5.	2.2.	[illegible]	-2.9.	-5.4.	-3.6.
J	MEAS	.942.	1.280.	1.059.	1.184.	.920.	.916.	.858.	.916.	.853.	.905.	.902.	1.152.	1.018.	1.206.	.885.
	DIFF	-1.1.	-1.3.	-.2.	3.3.	4.2.	4.9.	3.9.	3.5.	3.3.	3.7.	2.1.	[illegible]	-4.1.	-7.0.	-7.1.
H	MEAS	.869.	1.015.	1.100.	.971.	1.045.	.803.	.927.	.796.	.917.	.776.	1.001.	.920.	1.043.	.933.	.799.
	DIFF	-1.0.	-1.2.	.6.	4.1.	4.6.	5.3.	4.7.	4.2.	3.6.	1.8.	.2.	-1.3.	-4.6.	-9.1.	-9.0.
G	MEAS	.946.	1.287.	1.073.	1.193.	.920.	.919.	.860.	.925.	.856.	.889.	.883.	1.128.	1.012.	1.239.	.913.
	DIFF	-.7.	-.7.	1.2.	4.1.	4.1.	5.2.	4.1.	4.5.	3.7.	1.9.	-.1.	-1.5.	-4.6.	-4.4.	-4.1.
F	MEAS	.848.	1.006.	1.353.	1.149.	.977.	.791.	.890.	.784.	.906.	.784.	.904.	1.064.	1.338.	1.042.	.878.
	DIFF	-2.1.	-2.2.	1.0.	4.2.	4.2.	2.2.	2.0.	2.9.	3.8.	1.3.	-3.6.	-3.6.	1.3.	1.3.	1.3.
E	MEAS	.675.	1.204.	1.071.	1.230.	.930.	.944.	.902.	1.029.	.925.	.994.	.871.	1.118.	.970.	1.140.	[illegible]
	DIFF	2.6.	2.6.	2.4.	2.0.	2.6.	.6.	2.1.	3.0.	4.7.	5.9.	-3.9.	-7.3.	-7.2.	-2.9.	[illegible]
D	MEAS		1.086.	1.195.	.954.	1.237.	1.112.	1.176.	.934.	1.152.	1.051.	1.159.	.883.	[illegible]	[illegible]	
	DIFF		7.1.	4.5.	2.0.	2.6.	.8.	2.6.	.2.	.6.	-4.7.	-3.9.	-5.7.	-7.3.	-7.2.	
C	MEAS		.743.	1.308.	1.222.	1.073.	1.332.	1.097.	1.099.	1.051.	1.273.	1.003.	1.149.	1.255.	[illegible]	
	DIFF		9.5.	7.1.	6.9.	2.6.	3.1.	3.4.	.5.	-1.0.	-4.6.	-4.1.	.5.	2.6.	2.3.	
B	MEAS			.760.	1.137.	1.316.	1.095.	1.303.	1.012.	1.255.	.981.	1.125.	1.063.	.767.		
	DIFF			12.0.	12.1.	12.1.	6.5.	.5.	-1.4.	-3.2.	-4.7.	-4.1.	4.7.	12.9.		
A	MEAS					.738.	.922.	.957.	.882.	.934.	.828.	.630.				
	DIFF					12.1.	6.4.	.5.	.5.	-2.0.	-4.4.	-4.4.				

MEAS
DIFF

FIGURE 5.1

[illegible] OF PDHF [illegible] CY-2,[illegible]7,10-11-76,[illegible]=212.90 PCT [illegible]

Row		15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
R	MEAS					.656.	.843.	.909.	.844.	.906.	.826.	.643.				
R	DIFF					3.1.	2.1.	1.3.	1.3.	.9.	.1.	.8.				
P	MEAS			.699.	.999.	1.144.	.993.	1.223.	.995.	1.214.	.971.	1.106.	[illegible]	.673.		
P	DIFF			5.1.	2.8.	3.0.	2.2.	1.2.	1.2.	.5.	-.2.	-.4.	[illegible]	1.2.		
N	MEAS		.700.	1.224.	1.138.	1.050.	1.283.	1.048.	1.077.	1.031.	1.263.	1.012.	1.097.	1.180.	.702.	
N	DIFF		5.4.	5.0.	2.6.	2.9.	.9.	.8.	-.1.	-.7.	-.7.	-.8.	-1.1.	1.2.	5.6.	
M	MEAS		.999.	1.139.	.942.	1.172.	1.031.	1.151.	.964.	1.161.	1.102.	1.182.	.910.	1.123.	1.028.	
M	DIFF		2.7.	2.7.	.3.	-2.6.	-2.6.	-1.6.	-.8.	-.7.	-.7.	-1.8.	-3.1.	1.3.	5.7.	
L	MEAS	.652.	1.111.	.994.	1.171.	.920.	.975.	.944.	1.075.	.947.	.985.	.927.	1.166.	1.005.	1.093.	.628.
L	DIFF	2.1.	.1.	-2.6.	-2.7.	-2.9.	-2.6.	-1.6.	-.7.	-1.2.	-1.6.	-2.2.	-3.1.	-1.5.	-1.6.	-1.6.
K	MEAS	.837.	.976.	1.250.	1.079.	.932.	.856.	.987.	.876.	.934.	.850.	.979.	1.093.	1.252.	.965.	.820.
K	DIFF	1.4.	.4.	-1.7.	-2.8.	-1.9.	-1.1.	.1.	.5.	-.2.	-1.8.	-2.2.	-1.5.	-1.5.	-.7.	-.7.
J	MEAS	.913.	1.227.	1.024.	1.158.	.955.	.995.	.970.	1.031.	.953.	.977.	.959.	1.155.	1.032.	1.196.	.889.
J	DIFF	1.7.	1.5.	-1.4.	-.9.	-.4.	.9.	-1.8.	.9.	.0.	-.9.	-.0.	1.4.	-.7.	-1.0.	-1.0.
H	MEAS	.848.	.999.	1.089.	.988.	1.097.	.877.	1.031.	.883.	1.029.	.867.	1.085.	.973.	1.076.	.975.	.827.
H	DIFF	1.7.	1.6.	1.0.	1.7.	1.3.	.5.	.9.	-.1.	.7.	-.6.	.3.	.1.	-.2.	-.9.	-.8.
G	MEAS	.911.	1.226.	1.049.	1.189.	.976.	.992.	.951.	1.015.	.951.	.980.	.961.	1.168.	1.036.	1.203.	.894.
G	DIFF	1.5.	1.4.	1.0.	1.7.	1.7.	.6.	-.2.	-.7.	-.2.	-.6.	.2.	-.1.	-.2.	-.4.	-.5.
F	MEAS	.826.	.971.	1.234.	1.130.	1.019.	.856.	.979.	.865.	.9?0.	.854.	.987.	1.100.	1.268.	.975.	.831.
F	DIFF	.0.	-.1.	.9.	1.8.	1.9.	-1.2.	-.7.	-.8.	-.6.	-1.4.	-1.4.	-.9.	-.3.	.3.	.7.
E	MEAS	.655.	1.139.	1.036.	1.196.	.930.	.975.	.950.	1.077.	.959.	.987.	.935.	1.166.	1.00?.	1.10?.	.6?3.
E	DIFF	2.6.	2.6.	1.5.	-.6.	-1.8.	-2.5.	-1.0.	-.5.	-.1.	-1.4.	-1.4.	-1.4.	-1.3.	[illegible]	.7.
D	MEAS		1.019.	1.132.	.934.	1.101.	1.080.	1.153.	.959.	1.155.	1.072.	1.174.	.917.	1.082.	.949.	
D	DIFF		4.8.	2.1.	-.6.	-1.8.	-2.6.	-1.4.	-1.3.	-1.2.	-3.4.	-2.4.	-2.5.	-2.4.	-2.4.	
C	MEAS		.705.	1.212.	1.147.	1.001.	1.231.	1.023.	1.061.	1.015.	1.225.	.981.	1.136.	1.193.	.636.	
C	DIFF		6.1.	3.9.	3.4.	-1.9.	-3.2.	-1.6.	-1.6.	-2.3.	-3.6.	-3.9.	2.4.	2.4.	2.4.	
B	MEAS			.715.	1.031.	1.156.	1.000.	1.203.	.963.	1.170.	.936.	1.068.	1.043.	.712.		
B	DIFF			7.5.	6.0.	4.3.	2.9.	-.5.	-1.5.	-3.2.	-3.7.	-3.8.	7.3.	7.2.		
A	MEAS					.666.	.849.	.895.	.829.	.871.	.794.	.614.				
A	DIFF					4.3.	2.3.	-.3.	-.5.	-3.0.	-3.8.	-3.8.				

FIGURE 52

MEAS

DIFF

6. REACTOR INSTRUMENTATION CALIBRATION

The calibration of excore power range detectors, overpower and overtemperature ΔT setpoints and incore resistance temperature detectors and thermocouples is presented in this section.

6.1 Excore Detector Calibration

The variation in total excore detector current (sum of currents for top and bottom detectors) versus reactor power for four excore detectors is presented in Figure 6.1. Reactor power in these measurements was obtained from the plant calorimetric data.

Incore axial offsets were obtained from the analysis of incore flux maps with the INCORE Code, References 4 and 5.

In Figures 6.2 through 6.5, variation in top and bottom detector currents versus incore axial offsets are given. These data serve as the basis for excore NIS calibration.

6.2 Incore Thermocouple and Wide Range Resistance Temperature Detector Calibration

Incore thermocouple data provide a continuous on-line monitoring of 65 evenly distributed assembly powers throughout the core. This requires calibration of in core thermocouples and wide range resistance temperature detectors (RTDs). The enthalpy hot channel factor

$F_{\Delta H_i}^{T/C}$ for assembly thermocouple, i, is given by the following expression.

$$F_{\Delta H_i}^{T/C} = M_i \Delta H_i \Big/ \frac{(E_{OUT}-E_{IN})}{1-B}$$

where, ΔH_i is enthalpy rise in assembly i, $E_{out}-E_{in}$ is the core average enthalpy rise, B is the fractional bypass flow, and M_i is the normalization factor.

The bypass flow correction is required if the loop RTD's are used to measure vessel outlet temperatures.

However, if the thermocouples are used to provide the outlet temperatures, then B is set equal to zero. The normalization factor, M_i, was provided by taking the ratio of $F_{\Delta H}$ obtained from thermocouple and moveable incore detector data.

The thermocouple output can be obtained from the computer (PRODAC) or in the case of computer malfunction, the Honeywell meter can be used.

Thermocouple (PRODAC and Honeywell) and wide range RTD calibrations are obtained by comparing their temperature readings to the narrow range RTD's at the time each reading was taken during the heatup of the primary system. Table 6.1 lists the Correction Factors at 547°F.

6.3 ΔT Setpoint Calibration

The axial offset versus detector currents at 100% power for four excore detectors are shown in Figures 6.2 through 6.5. This information provided the current to voltage relationship required for F(Δ Q) circuit. The function, F(Δ Q), is defined to be that function for which no reactor power penalty is paid for full-power axial offset variations between -12% and +7%. Outside these limits, for every 1% of full power axial offset greater than +7%, a penalty of 2% power is assigned, and for every 1% of full-power axial offset more negative than -12%, a penalty of 4.5% is imposed. In Table 6.2, information for over-power and over-temperature Δ T setpoints is presented.

6.4 ΔT Versus Reactor Power

Plots of four reactor coolant loop ΔT's versus reactor power (obtained from plant calorimetric data) are presented in Figures 6.6 through 6.9. Extrapolated Δ T's for full power are also shown. The Δ T's for the Loops 21 through 24 are 52.7^{o}F, 51.5^{o}F, 52.8^{o}F, 52.1^{o}F, respectively. Average full power Δ T was equal to 52.3^{o}F.

Table 6.1

List of Thermocouple Correction Factors at T ref 547°F

T/C#	Core Location	Prodac	Honeywell	T/C#	Core Location	Prodac	Honeywell
1	A-7	+2.1	-10.5	34	A-11	-0.8	-12.8
2	B-3	-0.7	-10.2	35	B-6	-2.8	-13.6
3	B-10	-	-	36	B-8	-5.3	-13.4
4	B-13	+4.0	-9.5	37	C-12	+1.6	-13.8
5	C-8	+0.2	-9.8	38	D-4	-1.9	-12.9
6	D-2	-4.1	-10.0	39	D-7	-5.5	-12.9
7	E-4	+3.8	-9.7	40	D-9	-	-
8	E-8	-1.6	-10.9	41	E-2	-2.7	-13.5
9	E-10	-3.8	-10.1	42	E-5	-4.5	-12.2
10	F-12	+4.5	-9.8	43	E-11	+1.0	-13.3
11	G-2	-0.8	-10.0	44	E-14	-2.0	-13.1
12	G-9	-3.8	-9.9	45	F-5	-4.8	-14.1
13	G-15	+3.8	-10.3	46	F-9	+0.2	-14.5
14	H-1	+0.2	-8.2	47	G-4	-2.3	-13.3
15	H-3	-2.5	-9.7	48	G-8	-4.0	-13.5
16	H-8	+4.0	-9.2	49	H-5	+1.8	-12.3
17	H-10	-0.1	-10.2	50	H-9	-3.1	-13.1
18	H-13	-4.0	-10.3	51	H-14	-4.0	-13.0
19	J-10	-	-	52	J-7	+1.0	-12.9
20	J-11	-0.2	-9.3	53	K-11	-2.8	-13.5
21	K-3	-2.9	-8.6	54	K-13	-4.7	-13.5
22	K-15	+4.4	-9.6	55	L-2	+1.3	-12.7
23	L-1	-	-	56	L-5	-3.6	-13.3
24	L-12	-3.6	-9.9	57	L-7	-3.8	-13.1
25	M-5	+5.3	-9.5	58	L-11	-	-
26	M-8	-0.3	-10.0	59	L-14	-3.1	-14.3
27	M-10	-3.5	-9.9	60	N-2	-4.4	-12.7
28	M-13	+4.4	-10.5	61	N-9	+0.8	-13.9
29	N-8	+0.1	-9.4	62	P-7	-2.7	-13.5
30	P-3	-3.9	-10.5	63	P-12	-0.4	**
31	P-5	+5.0	-9.6	64	R-5	+0.6	-13.3
32	P-13	-0.9	-10.5	65	R-10	-2.0	-13.0
33	R-8	-3.3	-9.8				

Loop Wide Range RTD Correction Factors at T ref 547°F

1	2	3	4
+0.2	+0.2	-0.1	-0.2

Correction Factor = Narrow Range RTD - Temperature reading (T/C or Wide Range RTD)

- T/C removed or defective

** Honeywell defective

TABLE 6.2

INDIAN POINT UNIT NO. 2 F(ΔQ) SETPOINTS

EXCORE	INCORE AXIAL OFFSET	POWER LEVEL (MWT)	% FULL POWER	I TOP (μa)	I BOT (μa)	V-TOP (VOLTS)	V-BOT (VOLTS)	V VOLTS	ΔT PENALTY (%)	I TOTAL (μa)	V/I SLOPE (Top/Bot)o ao	FLUX INDICATOR (%)
Ch-41	0	2758	100%	369	384	8.33	8.33	0	0	753	0.02257	0
Ch-41	-12	2758	100%	338	414	7.63	8.98	-1.35	0			-12
Ch-41	+7	2758	100%	386	367	8.71	7.96	+0.75	0			+7
Ch-41	-17	2758	100%	326	427	7.36	9.26	-1.90	22.5		0.02169	-17
Ch-41	+17	2758	100%	411	341	9.28	7.40	+1.88	20.0			+17
Ch-42	0	2758	100%	365	403	8.33	8.33	0	0	768	0.02282	0
Ch-42	-12	2758	100%	338	430	7.71	8.89	-1.18	0			-12
Ch-42	+7	2758	100%	380	387	8.67	8.00	+0.67	0			+7
Ch-42	-17	2758	100%	327	441	7.46	9.12	-1.66	22.5		0.02067	-17
Ch-42	+17	2758	100%	402	365	9.17	7.54	+1.63	20.0			+17
Ch-43	0	2758	100%	402	423	8.33	8.33	0	0	825	0.02072	0
Ch-43	-12	2758	100%	370	456	7.67	8.98	-1.31	0			-12
Ch-43	+7	2758	100%	421	404	8.72	7.96	+0.76	0			+7
Ch-43	-17	2758	100%	356	470	7.38	9.26	-1.88	22.5		0.01969	-17
Ch-43	+17	2758	100%	448	377	9.28	7.42	+1.86	20.0			+17
Ch-44	0	2758	100%	364	403	8.33	8.33	0	0	767	0.02288	0
Ch-44	-12	2758	100%	337	431	7.71	8.91	-1.20	0			-12
Ch-44	+7	2758	100%	380	387	8.70	8.00	+0.70	0			+7
Ch-44	-17	2758	100%	325	442	7.44	9.14	-1.70	22.5		0.02067	-17
Ch-44	+17	2758	100%	403	364	9.22	7.52	+1.70	20.0			+17

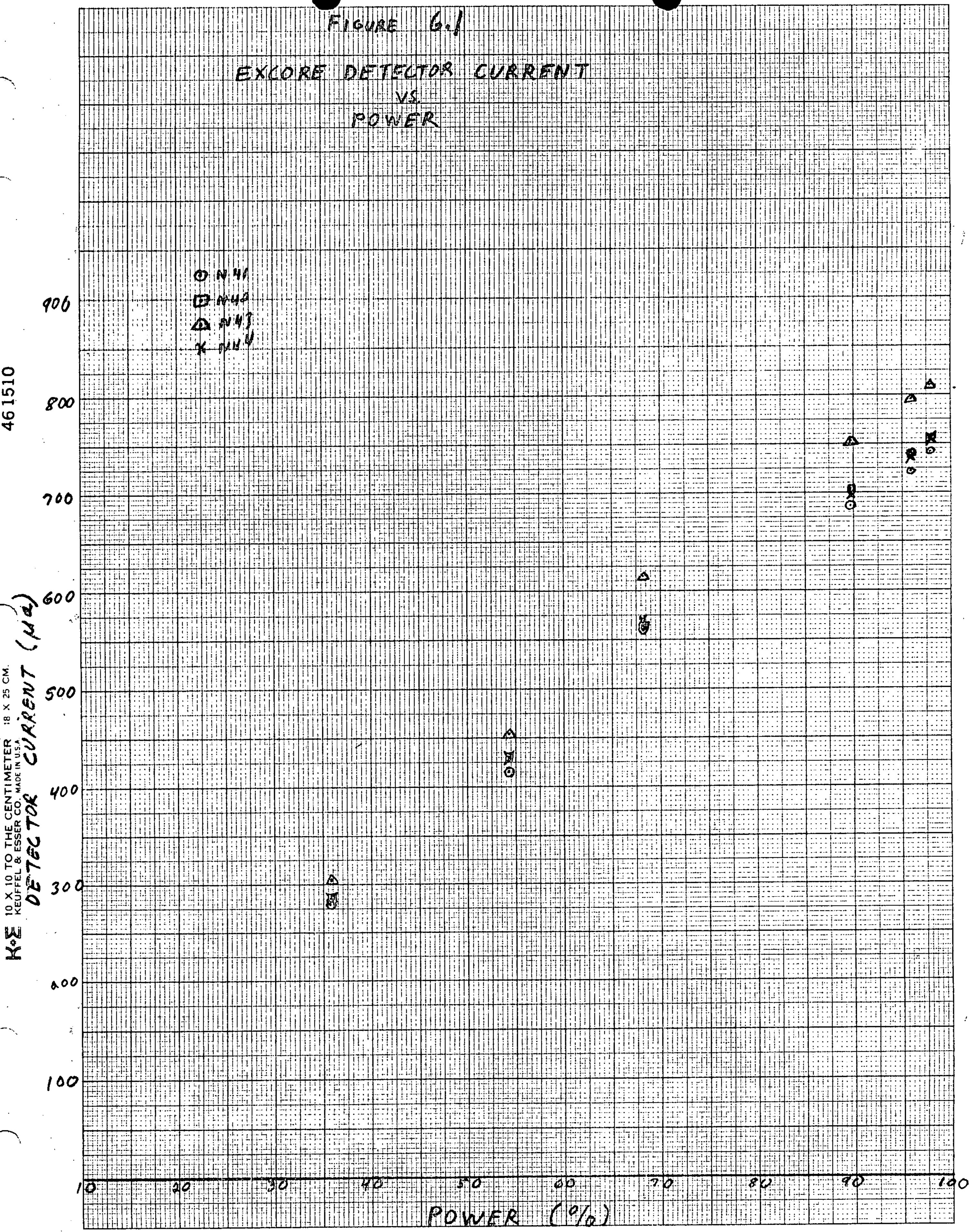


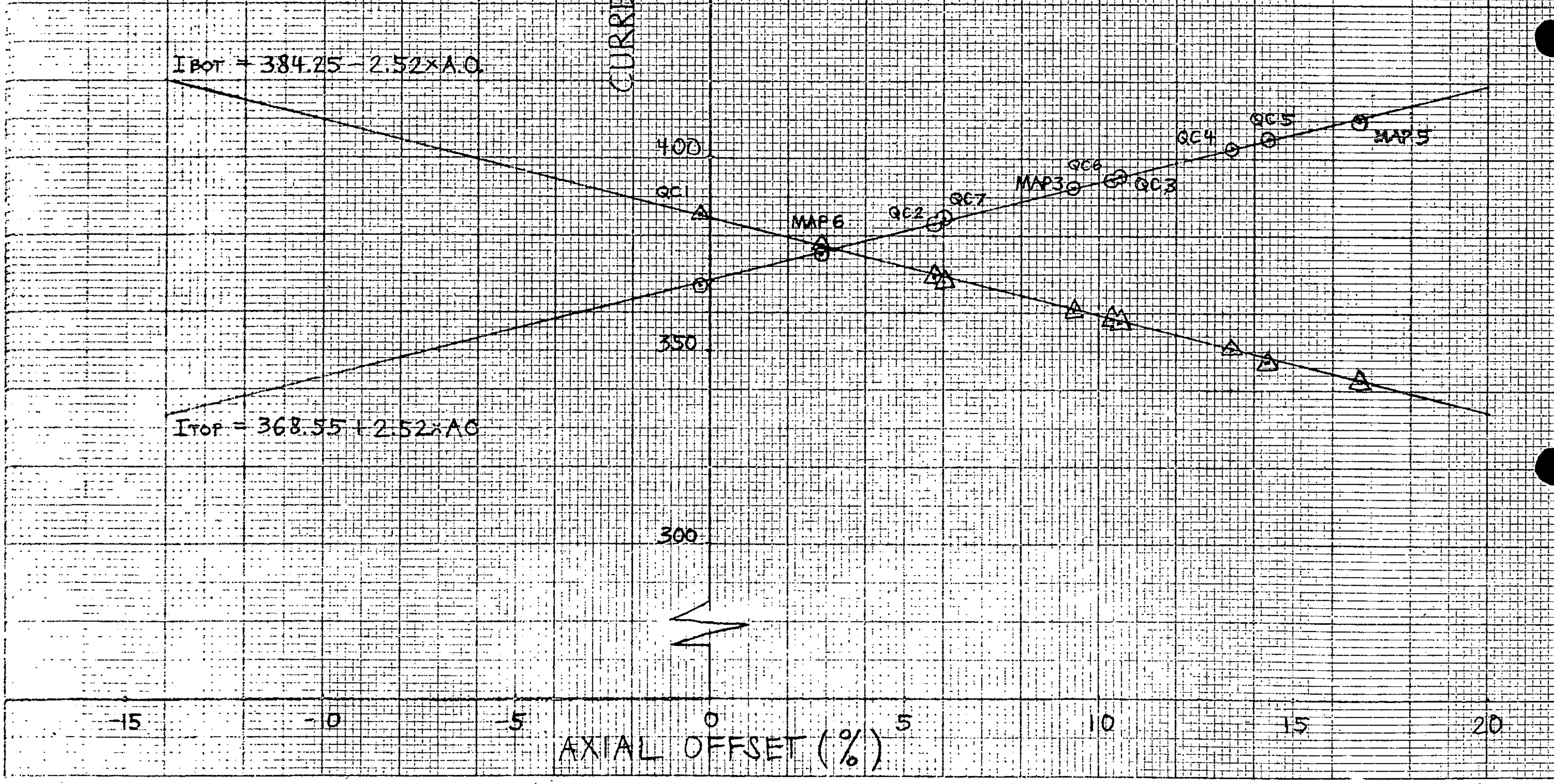
FIGURE 6.1
EXCORE DETECTOR CURRENT
VS.
POWER
N41
N42
N43
N44
900
800
700
600
500
400
300
200
100
DETECTOR CURRENT (μA)
10
20
30
40
50
60
70
80
90
100
POWER (%)
461510
K+E 10 X 10 TO THE CENTIMETER 18 X 25 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.

IP2 CY-2

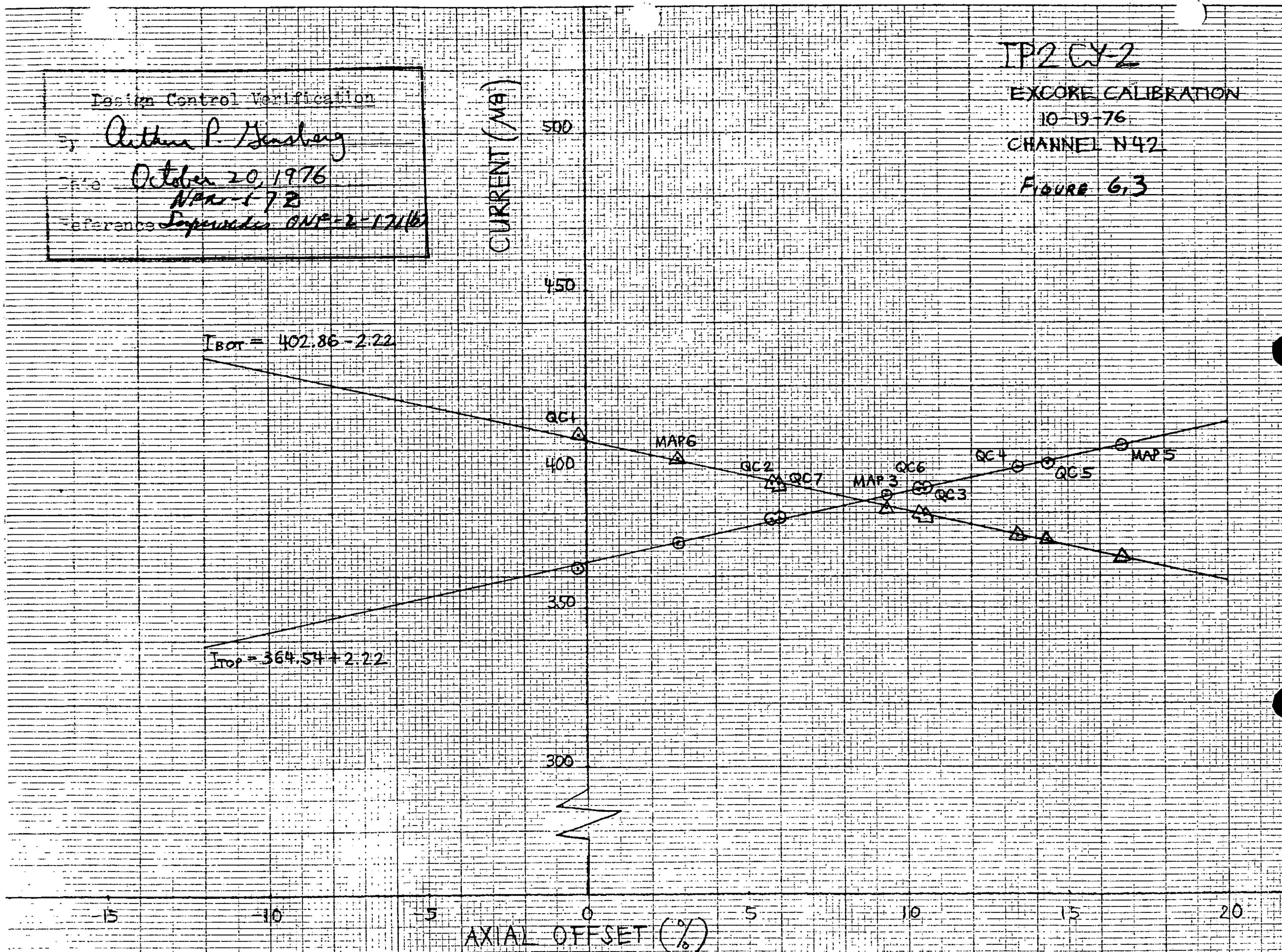
EXCORE CALIBRATION
10-19-76
CHANNEL N41

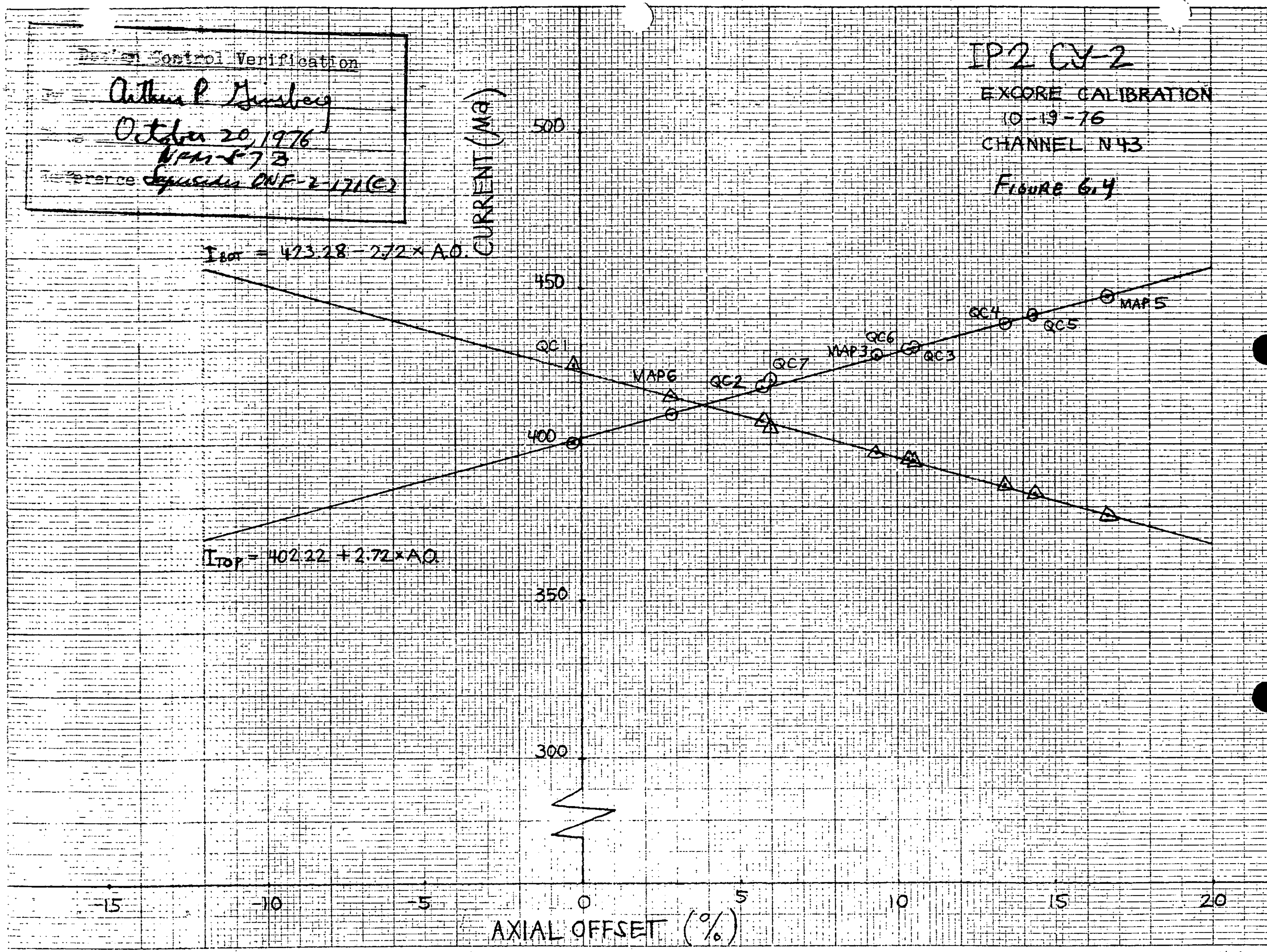
FIGURE 6.2

Design Control Verification
By Arthur P. Ginsberg
Date October 20, 1976
Reference Supersedes ONF-2-171(4)

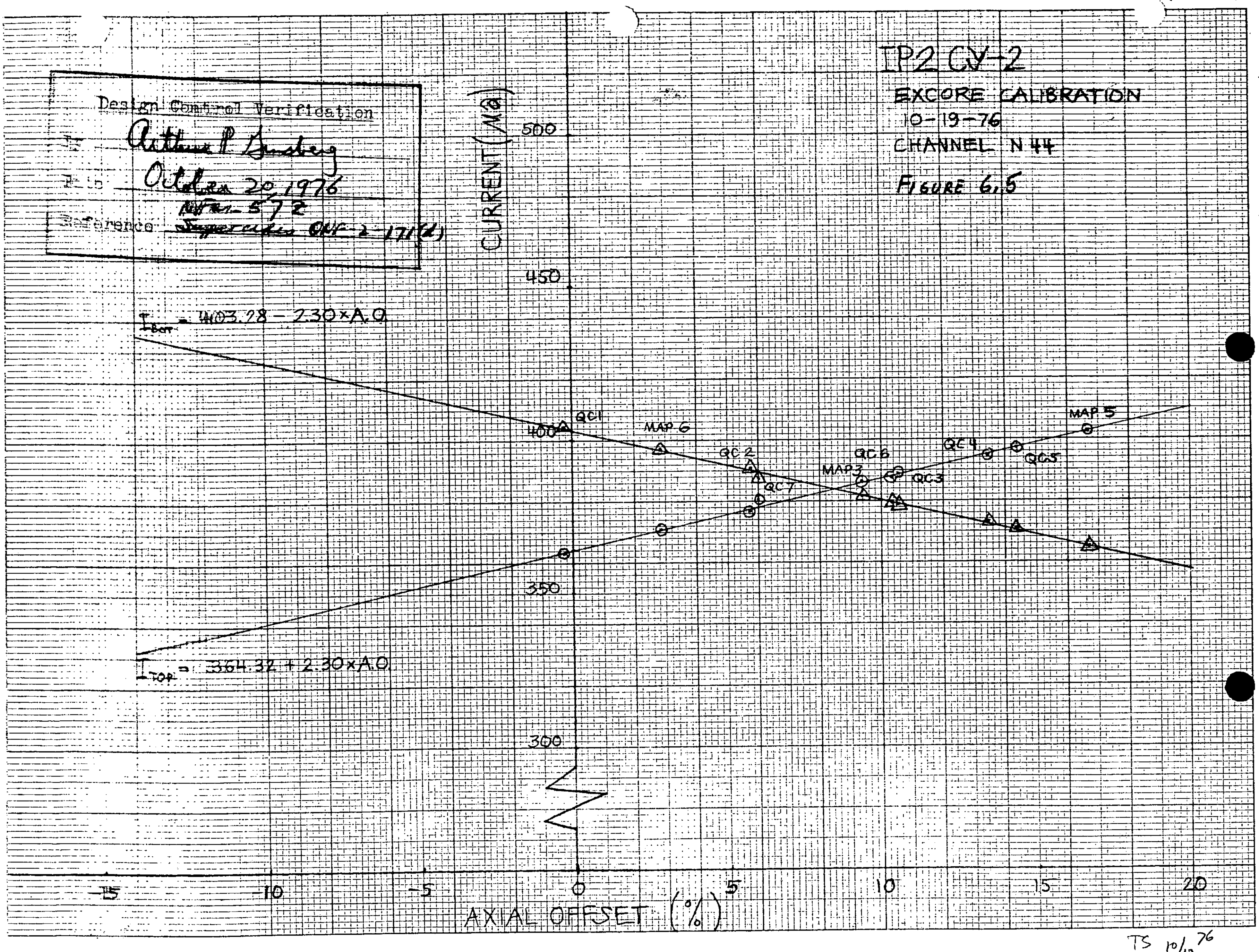


TS 10/19/76


TP2 CY-2
EXCORE CALIBRATION
10-19-76
CHANNEL N42
FIGURE 6.3
Design Control Verification
Arthur P. Ginsberg
October 20, 1976
Reference
CURRENT (MA)
500
450
400
350
300
IBOT = 402.86 - 2.22
ITOP = 364.54 + 2.22
QC1
MAP6
QC2
QC7
MAP 3
QC6
QC3
QC4
QC5
MAP 5
-15
-10
-5
0
5
10
15
20
AXIAL OFFSET (%)


Design Control Verification
Arthur P. Ginsberg
October 20, 1976
Reference
IP2 CY-2
EXCORE CALIBRATION
10-19-76
CHANNEL N43
FIGURE 6.4
I_{BOT} = 423.28 − 2.72 × A.O.
I_{TOP} = 402.22 + 2.72 × A.O.
CURRENT (Ma)
500
450
400
350
300
QC1
MAP6
QC2
QC7
MAP3
QC6
QC3
QC4
QC5
MAP5
-15
-10
-5
0
5
10
15
20
AXIAL OFFSET (%)

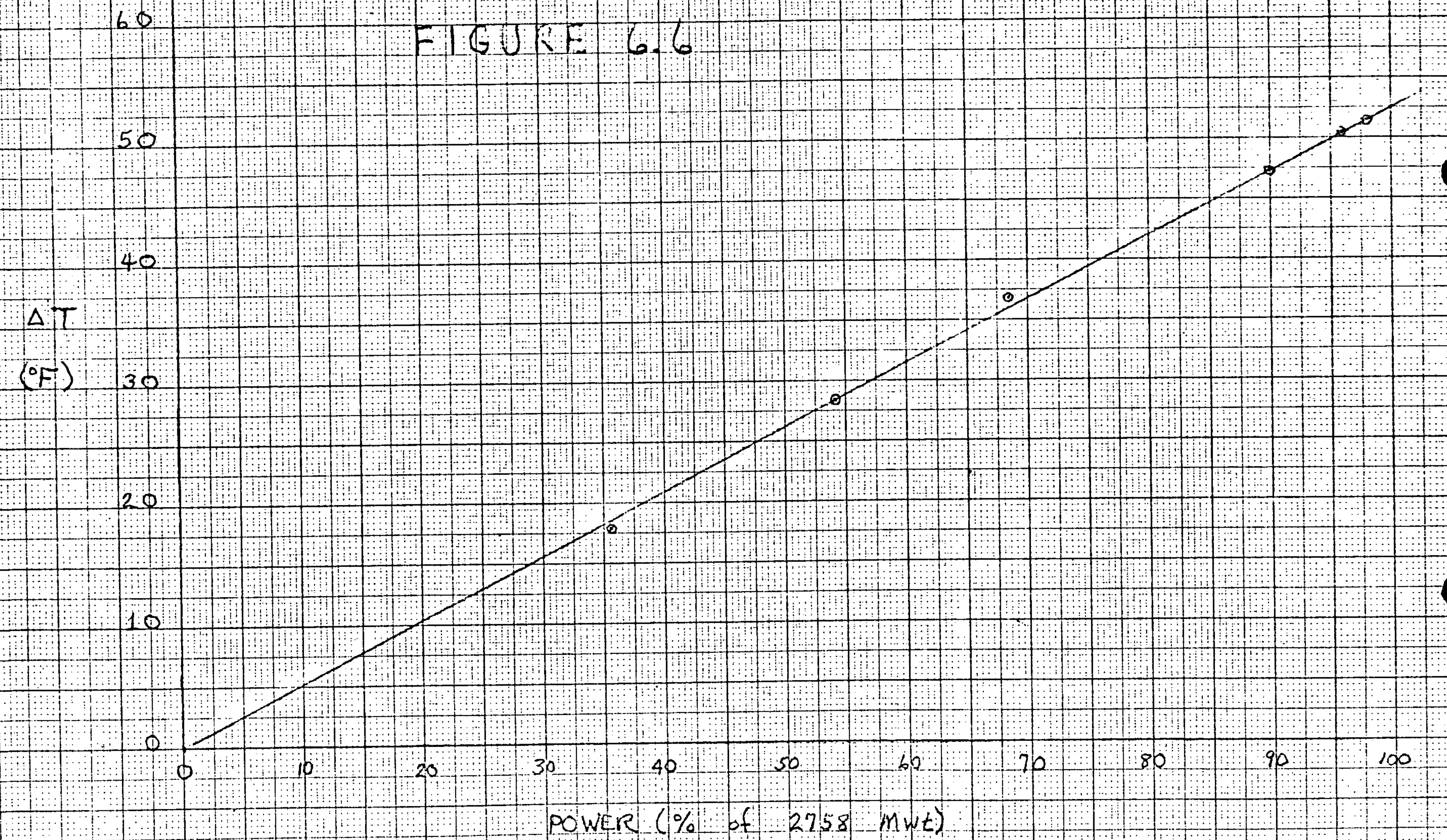
TS 10/19/76

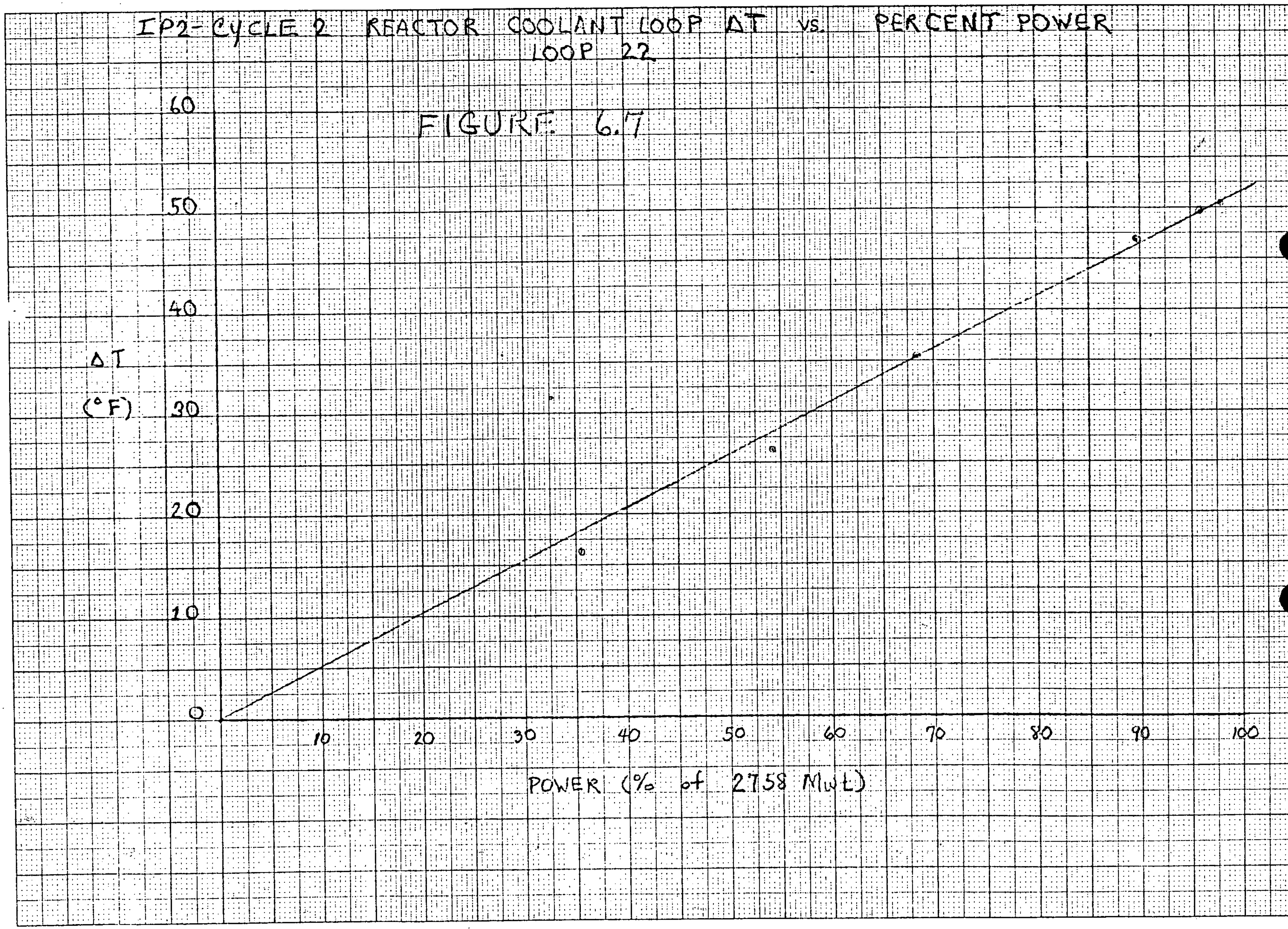


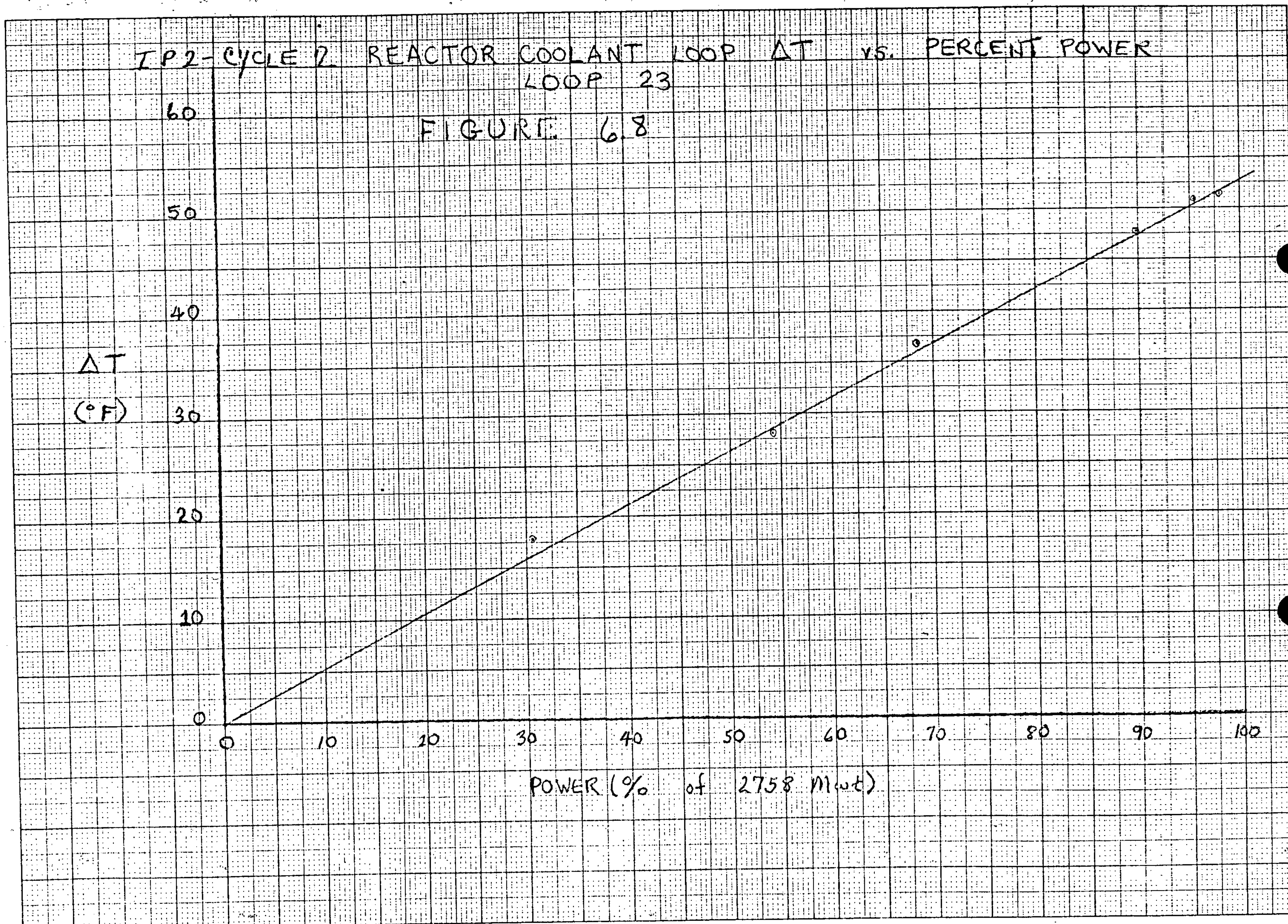
Design Control Verification
Arthur P. Ginsberg
October 20, 1976
NFI-572
Reference Superseded OVF-2-171(d)
IP2 CY-2
EXCORE CALIBRATION
10-19-76
CHANNEL N44
FIGURE 6.5
CURRENT (μA)
500
450
400
350
300
I_{BOT} = 403.28 − 2.30×A.O.
I_{TOP} = 364.32 + 2.30×A.O.
QC1
MAP 6
QC2
QC7
MAP3
QC6
QC3
QC4
QC5
MAP 5
−15
−10
−5
0
5
10
15
20
AXIAL OFFSET (%)
TS 10/19/76

IP2-CYCLE 2 REACTOR COOLANT LOOP ΔT vs. PERCENT POWER
LOOP 21

FIGURE 6.6

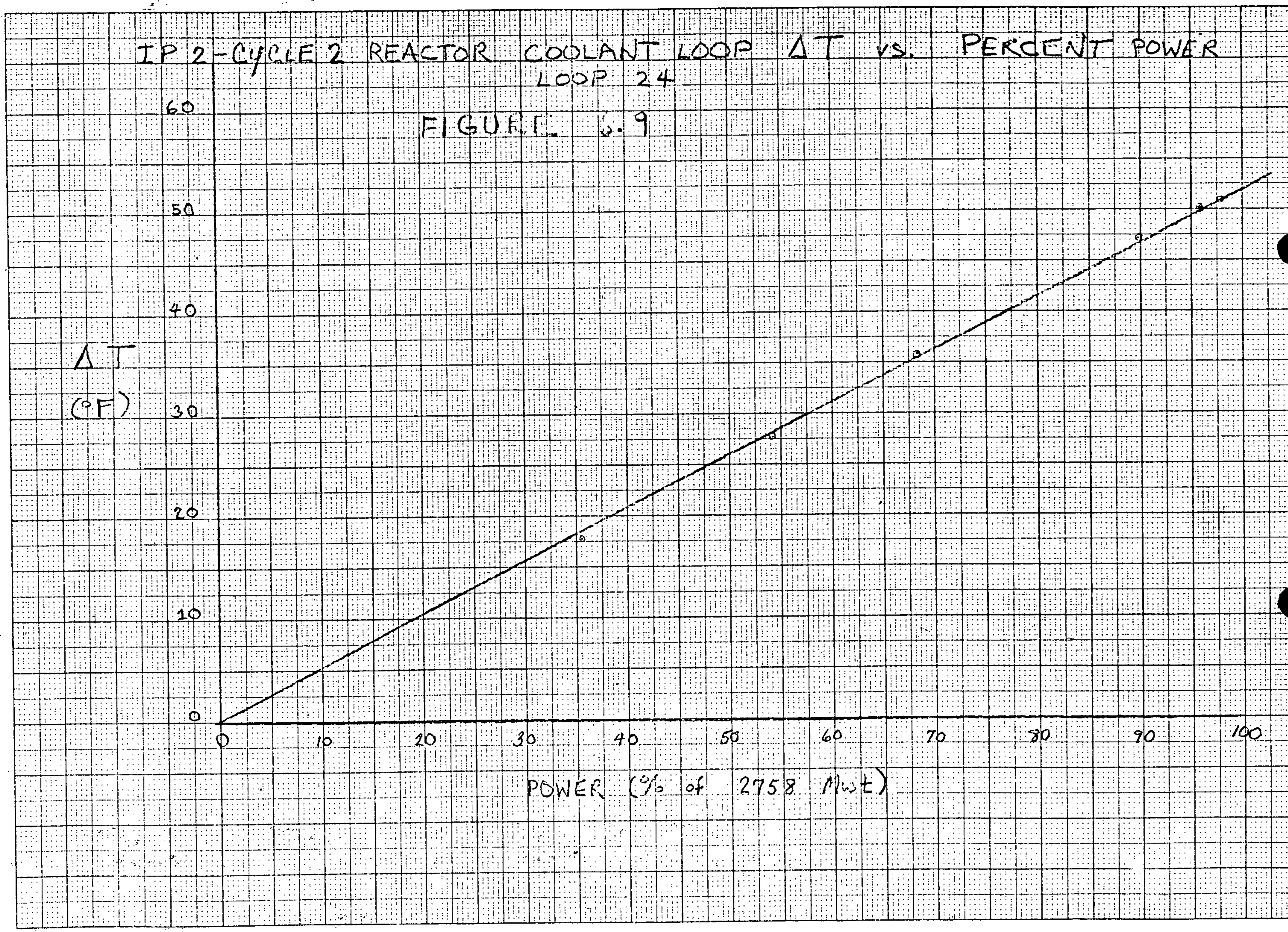



IP2-CYCLE 2 REACTOR COOLANT LOOP ΔT vs. PERCENT POWER
LOOP 22
FIGURE 6.7
ΔT
(°F)
0
10
20
30
40
50
60
10
20
30
40
50
60
70
80
90
100
POWER (% of 2758 MWt)



IP2-CYCLE 2 REACTOR COOLANT LOOP ΔT vs. PERCENT POWER
LOOP 23

FIGURE 6.8


IP 2-CYCLE 2 REACTOR COOLANT LOOP ΔT vs. PERCENT POWER
LOOP 24
FIGURE 6.9
ΔT
(°F)
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
POWER (% of 2758 Mwt)

7. REFERENCES

1. Docket No. 50-247, Final Facility Description and Safety Analyses Report, Consolidated Edison Company of New York Inc., Indian Point Nuclear Generating Unit No. 2.

2. Docket No. 50-247, Technical Specifications as amended through Amendment No. 20, Facility Operating License No. DPR-26 (Appendix A), Consolidated Edison Company of New York, Inc., Indian Point Nuclear Generating Unit No. 2.

3. Private communication, C.E. Meyer et al., (February, 1976).

4. Private communication, A.J. Harris et al., (July, 1972).

5. WCAP-8498, Incore Power Distribution in Westinghouse Pressurized Water Reactors, C.E. Meyer and R.L. Stover, (July, 1975).

William J. Cahill, Jr.
Vice President

Consolidated Edison Company of New York, Inc.
4 Irving Place, New York, N Y 10003
Telephone (212) 460-3819

December 10, 1976

Re: Indian Point Unit No. 2
Docket No. 50-247

Director of Nuclear Reactor Regulation
ATTN: Mr. Robert W. Reid, Chief
Operating Reactors Branch # 4
Division of Operating Reactors
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Sir:

In accordance with my letter to you of July 19, 1976, enclosed are three (3) copies of a report entitled, "Cycle 2 Startup Physics Test Report, Indian Point Unit No. 2". This report contains a complete summary of those startup physics tests performed during the return to service following the first refueling outage.

Very truly yours,

William J. Cahill, Jr.
Vice President

LFL/mmg

Copy to: Mr. James P. O'Reilly, Director (2 copies)
Office of Inspection and Enforcement
Region 1
U.S. Nuclear Regulatory Commission
631 Park Ave.
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Director of Nuclear Reactor Regulation
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