SPECIAL REPORT No. 9
PALISADES CYCLE II START UP
REPORT - August 27, 1976
rec'd w/ltr dtd 8-30-76
CN# 8984 50-255

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RECORDS FACILITY BRANCH

SPECIAL REPORT NO 9

CONSUMERS POWER COMPANY

PALISADES

CYCLE II

START-UP REPORT

August 27, 1976

RGC'd w/ltr dtd
8-30-76
CN8964 50-255

PURPOSE AND SCOPE

The purpose of this report is to fulfill the requirements of Paragraph 6.9.1.a of the Palisades Technical Specifications. The report describes the results of testing performed at zero power and during power escalation at the start of the second cycle of operation.

The following plant operating parameters were measured during the course of the testing.

1. Critical boron concentrations.
2. Control rod bank worths in nonoverlapping sequence.
3. Regulating control rod bank worth in overlapping sequence.
4. Dropped rod worths.
5. Ejected rod worths.
6. Boron differential worth.
7. Moderator temperature coefficients.
8. Power coefficient.
9. Shutdown margin.
10. Power distributions.
11. Incore detector performance.

Test Instrumentation

Reactivity measurements at zero power were made through use of a reactivity computer. The scaler output from the two intermediate range power channels was summed and put into a wide range linear channel. This channel provided a 0-10 V linear input for the reactivity computer. See the schematic diagram shown as Figure 1. The reactivity computer uses precalculated 6-group delayed neutron fractions and decay constants to translate variations in input signal to reactivity in cents. A multichannel recorder was used to simultaneously record flux level, control rod position, average moderator temperature, boron concentration (from the boronometer) and reactivity.

Upon reaching criticality, the reactivity meter response was checked against stable period measurements from the plant log rate recorders. The resulting response as a function of reactivity is shown in Figure 2. Most of the incremental reactivity measurements were in the range of -5 to +5¢ with the notable exception of the shutdown bank scram test which is mentioned later. The random noise level in the reactivity meter trace amounted to as much as 2.5¢ peak to peak.

Measurements

1. Critical Boron Concentration

With the reactor critical and all rods out except Group 4 at 100" withdrawn, the boron concentration was measured as 1205 ppmB. The Group 4 rods were withdrawn all the way out with a corresponding reactivity change of +9¢ or 0.062% (β_{eff} = 0.0069). Using a reciprocal boron worth of 76.5 ppmB/%Δρ (as determined later in this report), the reactivity change corresponds to 5 ppmB. Thus, the critical boron concentration is 1210 ppmB for all rods out (ARO), which is within ± 120 ppmB of the predicted value of 1222 ppmB as required by the acceptance criteria.

2. Dropped Rod Worths

With the reactor critical and at an ARO configuration, dropped rod worth measurements were performed. A constant dilution rate was established and the reactivity was permitted to increase slightly (∿4¢). The reactivity was then made slightly negative by inserting rod 8 several inches. The reactivity changes for each rod insertion were measured on the reactivity computer and summed for a total rod worth. With rod 8 fully inserted and the reactor stable (dilution stopped), rod 6 was "traded" with rod 8 by withdrawing rod 8 and inserting rod 6. This "trading" was done with all the control rods to be measured with the results listed in Table 1. The dropped rod worths are all less than 0.2%ρ as required by acceptance criteria.

Table 1 - Dropped Rod Worths

Control Rod	Measured Dropped Rod Worth, %Δρ*	Exxon Calculated Dropped Rod Worth, %Δρ
5	.111	.1125
6	.110	.1125
7	.124	.1125
8	.110	.1125
12	.047	.0693
20	.104	.0974
26	.095	.0904
31	.109	.1095
35	.076	.1035
37	.083	.0803
38	.099	.1044
39	.109	.1004
40	.094	.1004
41	.112	.1004

*Acceptance Criteria: Measured Dropped Rod Worth <0.2%

3. Moderator Temperature and Pressure Coefficients

With all rods out, the system was heated and then cooled at a constant rate with corresponding reactivity changes recorded. Reactor power was kept constant with Group 4 rods. From this data, the moderator temperature coefficient (MTC) was calculated. Later in the test, the same measurement was made with Groups 3 and 4 fully inserted and Group 2 at approximately 80 inches. The results are listed in Table 2. There was an observed bias between the measurements and calculations of about $0.27 \times 10^{-4} \Delta\rho/^{\circ}F$. This was not unexpected as a similar bias was noted at the start of Cycle I in the first core calculations. The hot zero power measurement (HZP) was corrected to hot full power (HFP) using the method described in the Palisades Technical Specifications Section 3.12 (see Table 2). The MTC is required by the acceptance criteria to be greater than $-2.5 \times 10^{-4} \Delta\rho/^{\circ}F$ and less than $+0.5 \times 10^{-4}$. As seen in Table 2, this condition was met.

With all rods out and the reactor stabilized, the primary system pressure was decreased 74 psi and a reactivity of increase of 1¢ was measured, resulting in a negative pressure coefficient opposite in sign to the moderator temperature coefficient as required by the acceptance criteria.

Table 2 - Moderator Temperature Coefficient (MTC)

Boron Concentration ppmB	Temp Change °F	Reactivity Change 10^{-4} Δρ	MTC Measured (HZP) $10^{-4}\Delta\rho/^{\circ}F$	MTC Exxon Calculated (HZP) $10^{-4}\Delta\rho/^{\circ}F$	MTC[1,2] Corrected Measured $10^{-4}\Delta\rho/^{\circ}F$
1210 (ARO)	9.1	1.9	.209	-.062	.23
1210 (ARO)	-11.3	-2.24	.198	-.062	.22
1080 (Grp 2,3,4 in)	-12.4	1.9	-.153	-.427	
1080 (Grp 2,3,4 in)	12.5	-1.73	-.138	-.427	

1. From Palisades Technical Specifications

$$\text{MTC (HFP)} = \text{MTC (HZP)} + 0.1 \times 10^{-4} \times 0.16 \times 10^{-4} - 0.11 \times 10^{-4} - 0.15 \times 10^{-6} (\Delta\text{ppmB}) - 0.23 \times 10^{-6} (\Delta^{\circ}F)$$

$$= \text{MTC (HZP)} + .021 \times 10^{-4}/^{\circ}F.$$

Where ΔppmB is the difference in the critical boron concentration (ARO) between HFP and HZP (no xenon or samarium). It is equal to the power defect at 100% FP expressed in ppmB. Using the measured reciprocal boron worth of 76.5 ppmB/%ρ and the calculated power defect of 0.88%Δρ, ΔppmB = 67.32 ppmB, where Δ°F is the difference in T_{av} between HFP and HZP = 544°F - 532°F = 12°F.

2. MTC acceptance criteria: $-2.5 \times 10^{-4} \Delta\rho/^{\circ}F <$ MTC (measured, corrected) $< +.5 \times 10^{-4} \Delta\rho/^{\circ}F$.

4. Regulating Rod Worth in Overlapping Sequence

With the reactor stable, the four regulating groups were then inserted into the core in the sequential overlapping mode. Insertions were performed by diluting in the groups in the same manner as was rod 8 in the dropped rod measurements. The reactivity change at each rod insertion was measured and the results compiled to give the integral worth curve in Figure 3. The maximum reactivity insertion rate for the regulating groups in the sequential mode was determined, using Figure 3, to be 0.26×10^{-4} $\Delta\rho/s$ for the rods above the full power insertion limit (Group 4 at 97") and 0.87×10^{-4} $\Delta\rho/s$ for the rods above the zero power insertion limit (Group 2 at 75"). These numbers are based upon a 46 inch-per-min rod drive speed and are less than the maximum rates of 6.0×10^{-4} $\Delta\rho/s$ and 3.0×10^{-4} $\Delta\rho/s$, respectively, as set forth in the acceptance criteria.

5. Ejected Rod Worth

With Groups 3 and 4 fully inserted and Group 2 at approximately 80", ejected rod worths were measured by borating out rod 41 and then "trading" with rods 34 and 35. The results listed in Table 3 show that the ejected worths were less than 0.963%$\Delta\rho$ as required by the acceptance criteria.

Table 3 - Ejected Rod Worth

Control Rod	*Measured Rod Worth, %$\Delta\rho$
34	.097
35	.129
41	.626

*Acceptance Criteria: Measured Ejected Worth < 0.963%$\Delta\rho$

6. Reciprocal Boron Differential Worth

During the physics test, chemical samples were taken before and after all dilutions and borations in order to determine reciprocal boron worths. The results are listed in Table 4. The reciprocal boron worth calculated for dilution of the regulatory group in the sequential mode is considered to be the most accurate since this dilution produces the greatest change in boron concentration and reactivity. Thus, the reciprocal boron worth is taken as 76.5 ppmB/%$\Delta\rho$. Note that all of the values were less than 100 ppmB/%$\Delta\rho$ as required for acceptance. The calculated value of reciprocal boron worth is 86 ppmB/%$\Delta\rho$.

Table 4: Reciprocal Boron Worths*

Case	Initial ppmB	Final ppmB	Total Reactivity %Δρ	Reciprocal Boron Worth ppmB/%Δρ
Rod 8, Dilute In	1205	1198	.11	63.6
Rod 41, Borate Out	1075	1120	.626	71.9
Group 1, Borate Out	890	1035	1.825	79.5
Group 2, Borate Out	1035	1095	.799	75.1
Group 3, Borate Out	1095	1160	.868	74.9
Group 4, Borate Out	1160	1205	.63	71.4
Reg Groups, Sequential, Dilute In	1205	900	3.985	76.5
Group A, Borate Out	1095	1217	1.32	92.4
Group B, Dilute In	900	780	1.463	82.0

*Acceptance Criteria: Measured Reciprocal Boron Worth < 100 ppmB/%Δρ

7. Individual Control Rod Bank Worths

Starting at all regulating rod groups inserted, Group B was diluted in and its integral worth was compiled as shown in Figure 4. With the regulating groups and Group B fully inserted, the worth of Group A was measured by manually tripping and dropping the group into the core.

Following the Group A drop, the reactor was borated to the critical boron concentration for the regulating groups inserted, Group A withdrawn, and Group B at 120". Groups A and B were then withdrawn and the reactor was brought critical. A constant boration rate was established and Group 1 was withdrawn from the core in the sequential nonoverlapping mode. An integral group worth as function of rod insertion was compiled and shown in Figure 5. A constant boration rate was again set up and Groups 2, 3 and 4 were withdrawn in the nonoverlapping mode in the same manner as Group 1. The group worths are listed in Table 5 and integral worth curves shown in Figures 6, 7 and 8.

A summary of the group rod worth measurement results are presented in Table 5. All of the values in the column labeled "Measured Worth" were measured by the reactivity computer in small increments using the boron trading method except shutdown Group A. The worth actually recorded by the reactivity computer during the rod bank scram test was -2.4%Δρ, a deviation from the expected value of -3.37%Δρ of 29%. This difference is much larger than observed in any of the measurements using the incremental boron-trading measurement method, and was attributed to measurement uncertainty rather than calculational error for reasons discussed below. As a check on the calculation for this rod group, its worth was measured out of sequence using the boron trading method. This measurement deviated from a corresponding calculation by .06%Δρ or 4.3% of the calculated value.

Table 5 - Measured Group Rod Worths

Control Rod Group	Measured Worth %Δρ	Calculated Worth %Δρ	Difference %Δρ	Difference/ Calculated Worth, %
4	.63	.70	-.07	-10.0
3	.87	.95	-.08	-8.4
2	.80	.72	+.08	+11.1
1	1.82	2.20	-.38	-17.3
Total Regs	4.12			
Regs (Overlap)	3.98			
Regs (Average)	4.05	4.57	-.52	-11.4
B	1.46	1.55	-.11	-7.1
Regs + B	5.51	6.12	-.63	-10.3
A	3.02*	3.37	-.35	-10.4
All Rods	8.53	9.49	-.98	-10.3
A (Out of Sequence)	1.32	1.38	-.06	-4.3

*The Group A worth was estimated from the calculation and the total observed calculation/measurement difference for Groups 1, 2, 3, 4 and B.

$$3.37 \times (1-.103) = 3.02$$

The differences between predictions and measurements of the regulating rod banks were somewhat scattered with a maximum individual deviation of 0.38%Δρ (17.3%). The overall difference of all the rods measured in sequence (regs plus B) using the incremental method compared to the calculation was 0.63%Δρ or 10.3% of the calculated value. This bias of 10.3% was applied to the results of calculations to estimate the worth of shutdown Group A in sequence.

Both the maximum difference between the measurements and predictions of individual rod bank worth and overall rod worth were slightly outside the predetermined acceptance criteria of 15% and 10%, respectively. Accordingly, an evaluation of the accuracy of both measurements and calculations was undertaken to determine whether or not there was an impact on plant safety. Sources of error in the measurement include:

a. Errors in meter calibration (see Figure 2).

b. Stated experimental errors in the values of delayed neutron fraction for uranium (∿4%).

c. Meter noise and error introduced by manual reduction of strip chart data.

d. Point-kinetics approximation inherent in reactivity measurement technique. This theory assumes that the power distribution in the core is constant during reactivity changes and the detector output is exactly proportional to the average flux in the core (detector sees the core as a point), neither of which was the case.

The ability to check the measurements with boron endpoints is limited to the accuracy of the boron sampling and chemical analysis technique. Based on the above, it is unreasonable to assume an experimental error less than ± 10%. Since the quoted accuracy of the calculations is ± 10%, differences between the two of up to 20% for individual measurements can be expected. Concerning the 17.3% error in regulating Group 1, an independent calculation by Consumers Power of the worth of Group 1 indicates that the original predicted worth could be high by 0.16%$\Delta\rho$. Inspection of the reactivity computer output associated with the measurements for Group 1 reveals abnormal behavior during the insertion and withdrawal of the last 20% of Group 1. Such abnormal behavior, which is attributed to the proximity of the Group 1 rods and the nuclear detectors, indicates an unusually large uncertainty in the measured value.

Most of the experimental uncertainties listed above are magnified in analyzing the rod drop measurement of shutdown Group A. The calibration of the meter and linearity in the wide range channel over several decades is critical. In addition, it was found that the time constants of the electronic circuits are significant compared to the speed of the reactivity insertion; both are on the order of 1 to 1.5 seconds. Also, the power distribution change during the scram is large. We understand that at other plants where this test is used, large correction factors (>30%) are required to adjust the results to known values.* For these reasons, this test was considered unreliable and the results disregarded.

8. Shutdown Margin

Shutdown margin was reevaluated using the results of the control rod worth measurements. The total available rod worth is assumed to be 8.53%$\Delta\rho$ as quoted in Table 5. Since the measured rod worths overall were 10% lower than calculations, the calculated value of stuck rod worth is conservative and was unchanged. The calculated end-of-life total rod worth was lowered by the 10.3% measurement/calculational bias determined from the BOC testing. A shutdown margin table based on the revised figures for beginning- and end-of-life is shown as Table 6.

*Reference 4

Table 6 - Palisades Cycle II Shutdown Margin

	BOC		EOC	
	HZP	HFP	HZP	HFP
Doppler Defect	0	1.0	0	1.0
Moderator Temperature Defect	0	.2	0	.8
Moderator Void Defect	0	0	0	.1
PDIL Rod Insertion Worth	1.68	.1	1.68**	.1
Axial Flux Redistribution	0	0	0	.5
Total Reactivity Allowances	1.68	1.3	1.68	2.5
Total Measured Full-Length Rod Worth	8.53	8.53	8.68*	8.68*
Stuck Rod Worth	3.22	3.22	3.52	3.52
Net Available Worth	5.31	5.31	5.16	5.16
Shutdown Margin	3.63	4.01	3.48	2.66
Required Margin	3.40	2.00	3.40	2.00

$$\text{*EOC Rod Worth} = \text{EOC (Calculated)} \times \frac{\text{BOC (Measured)}}{\text{BOC (Calculated)}}$$

**Based on BOC Integral Rod Worth Curve

Power Testing

Following the zero power testing, the reactor was escalated to power. Testing was conducted at 25%, 80%, and 100% of rated power at equilibrium xenon.

1. Moderator Temperature Coefficient

The MTC was measured at the three reference power levels by inserting and withdrawing Group 4 control rods to vary T_{avg} about 5°, while maintaining a constant power level. The worth of Group 4 control rods was then measured. Using the temperature defect at constant power level and the control rod worth inserted or withdrawn from the core, the value of the moderator temperature coefficient can be determined. The measured MTC for each power level is given in Table 7. Refer to Figure 9 for a plot of MTC vs PCS boron concentration compared with calculated values.

Table 7

Percent Power	PCS Boron (Ppm)	Measured MTC ($\Delta\rho$/°F)
25	1,032	$+0.020 \times 10^{-4}$
80	911	-0.16×10^{-4}
100	860	-0.25×10^{-4}

2. Power Coefficient

The power coefficient was measured by varying the turbine load and matching the reactor power with the turbine by adjusting Group 4 control rods while maintaining T_{avg} constant. The value of the power coefficient at each power level was then determined from the rod worth inserted or withdrawn and the change in reactor power. The values are given in Table 8 below. These values are averages of more than one test at each power level, and the plot of these points in Figure 10 implies more precision than is inherent in the tests. Uncertainties in rod worth and the magnitude of small power changes make the accuracy no better than ± 20%.

Table 8

Percent Power	Power Coeff $\Delta\rho$/% Pwr
25	-1.05×10^{-4}
80	$-.69 \times 10^{-4}$
97	$-.56 \times 10^{-4}$

By calculating the area under the curve in Figure 10, the power defect from zero to 100% power was found to be $-.88 \times 10^{-2}$ $\Delta\rho$. The average power coefficient of $-.88 \times 10^{-4}$ $\Delta\rho/\%$ agrees well with the Exxon prediction of $-.88 \times 10^{-4}$ $\Delta\rho/\%$ and falls within the acceptance criteria of 1.0×10^{-4} $\Delta\rho/\% \pm 30\%$ as given in Reference 2.

3. Worth of Group 4 Regulating Rods

The worth of a small portion of Group 4 rods was measured by diluting the group in from some reference position while maintaining constant power level. The worth of the group is then calculated by using the reciprocal boron worth. For the purposes of power escalation testing, the worth of Group 4 was measured between 100 and 131 inches (full out). The results of these measurements are shown in Figure 11 of this report. The 80% power and 100% power rod worth data can be represented by the same curve.

The acceptance criteria for the small portion of Group 4 control rods that is calibrated at power are any number that allows reasonable control of the plant. The values obtained in this test are considered to be reasonable since the portion of Group 4 that was calibrated allows control of the plant during normal load changes.

4. Excore Channel Decalibration

By maintaining constant reactor power (as determined by generator output) and varying T_{avg}, the excore channel decalibration was found to be .57%/°F. The end-of-core testing for Core 1 reported a value for excore decalibration of .58%/°F. Previous measurements from Cycle I tests used a decalibration of 0.5%/°F to 0.57%/°F.

5. Incore Detector Power Distribution Measurements

During the refueling outage, 22 incore assemblies were removed and replaced maintaining 41 incore assemblies inserted out of a possible 45. One hundred forty-three individual rhodium detectors are operable at present of the 164 detectors installed. At low power levels, significant differences were noted between the radial power distribution measured by the incore detectors and the predicted power distribution. Inspection of the individual detector outputs from symmetric assemblies revealed a 17% bias between detectors of different manufacture (Belfab and Reuter-Stokes). No significant core tilt was measured by the symmetric sets of the same manufacture. Detectors of both types had been used in Cycle I and no discrepancy was noted at that time. All the Belfab detectors in Cycle II, however, are new and were delivered at the same time and are, therefore, suspect. The bias is constant and does not seem to be a function of time or power level, so that a common design or manufacturing technique causing a loss in sensitivity is considered to be the likely cause of the low signals. Efforts to discover the particular source of the problem have been unsuccessful.

Figure 12 shows the normalized radial power distribution determined from the incore system. In this figure, the assembly powers measured by the Belfab detectors have been increased by the observed 17% bias factor. The result of this was to improve the agreement between measurements and calculations substantially. Since the limiting assemblies in the core (D assemblies not on the periphery) show very good agreement between calculations and measurements, no peaking factor penalty is required because of the incore sensitivity problem. Figures 13, 14 and 15 show the measured core average axial power distributions at various power levels. The full power margin to thermal limits using the incore power distribution (conservatively neglecting the Belfab incore correction) including uncertainty factors was 3%.

6. Plant Performance

Figures 16 through 21 show various primary and secondary system performance characteristics measured during the power escalation. Included are:

a. Reactor thermal power vs time.
b. Gross electrical output vs time.
c. PCS boron vs time.
d. Feed-water flows vs power level.
e. Core ΔT vs power level.
f. Steam generator pressure vs power level.
g. Governor valve position vs power level.

REFERENCES

1. Palisades Special Test Procedure T-84, Rev 0, "Zero Power Test Program," and T-93, Rev 1, "Power Escalation Testing for Palisades Cores," including test data.

2. Letter from D. A. Bixel of Consumers Power Company to R. A. Purple, "Palisades Plant - Answers to Reload 2/ECCS Questions," dated March 20, 1976.

3. Letter from Exxon Nuclear Company to Consumers Power Company, "Palisades Cycle 2 Physics Data," dated April 19, 1976. Contains Exxon proprietary information.

4. Letter to N. C. Moseley from A. C. Thies, "Oconee Nuclear Station Unit 3 Start-Up Report," dated March 14, 1975, Docket No 50-287.

FIGURE 1
REACTIVITY COMPUTER HOOKUP

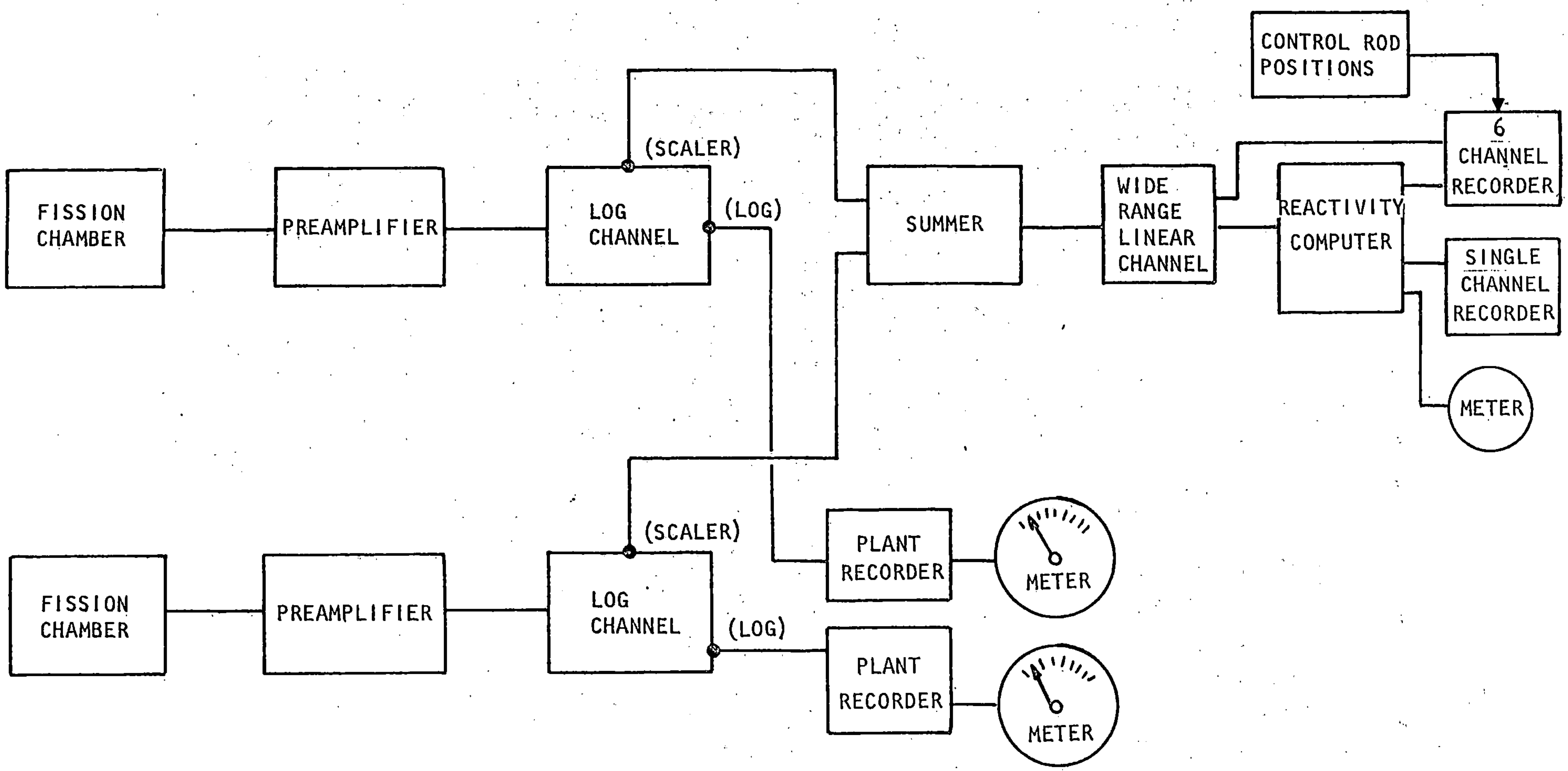


FIGURE 2
REACTIVITY METER RESPONSE

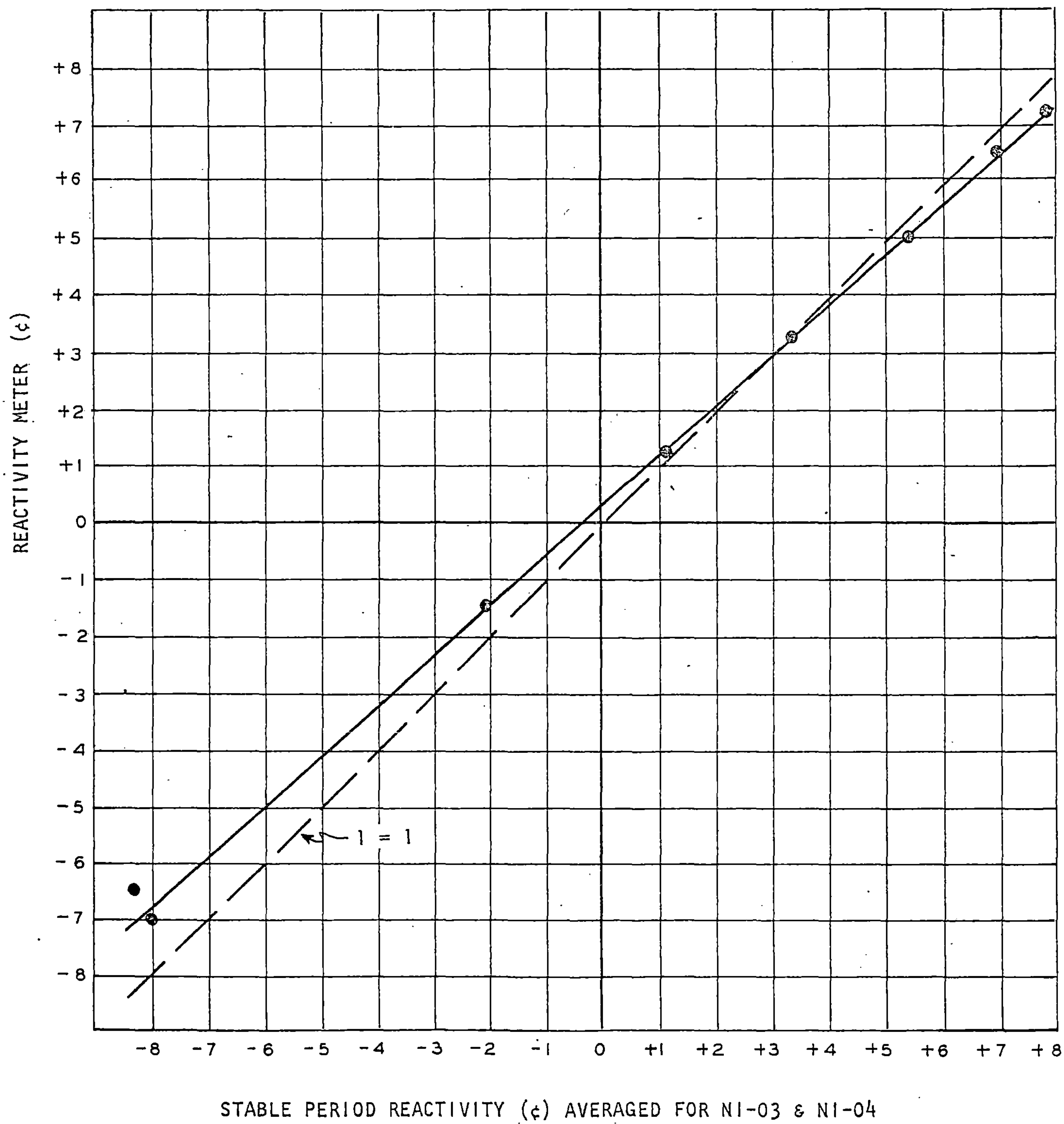


FIGURE 3
CORE 2
REGULATING INTEGRAL ROD WORTH
OVERLAPPING - SEQUENTIAL
532°F

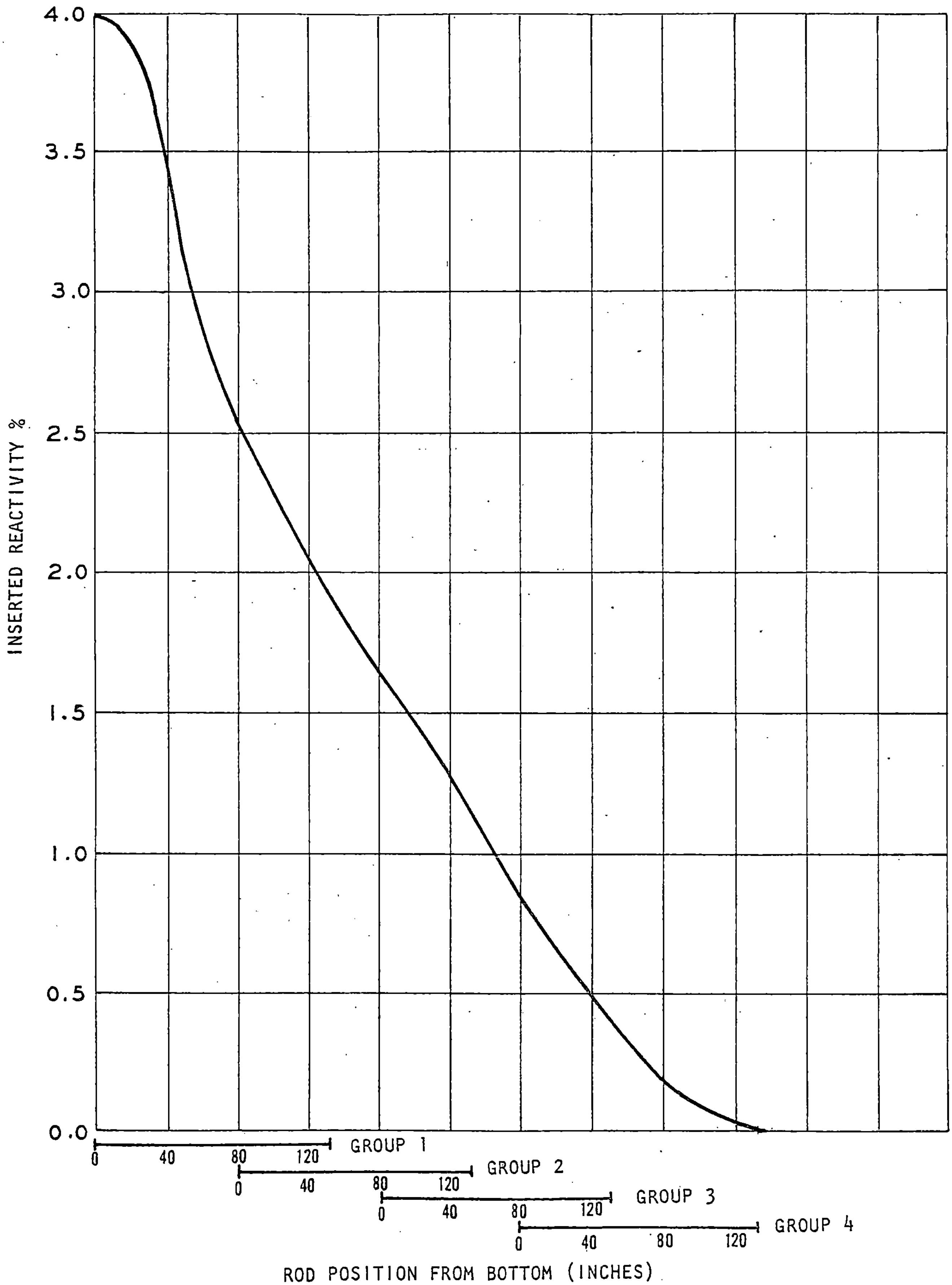


FIGURE 4
CORE 2
INTEGRAL ROD WORTH
GROUP B
532°F

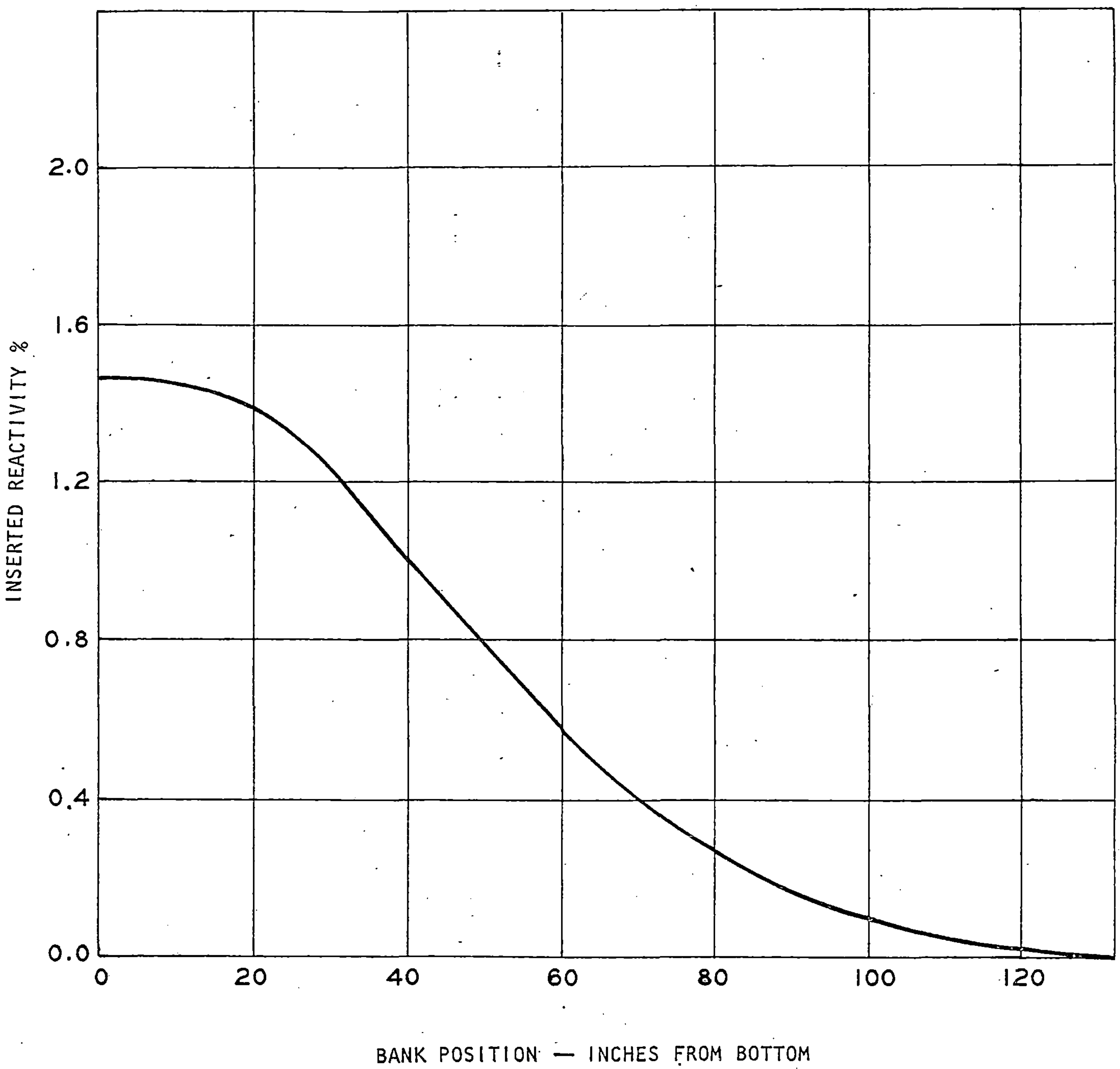


FIGURE 5
CORE 2
INTEGRAL ROD WORTH
GROUP 1
532°F

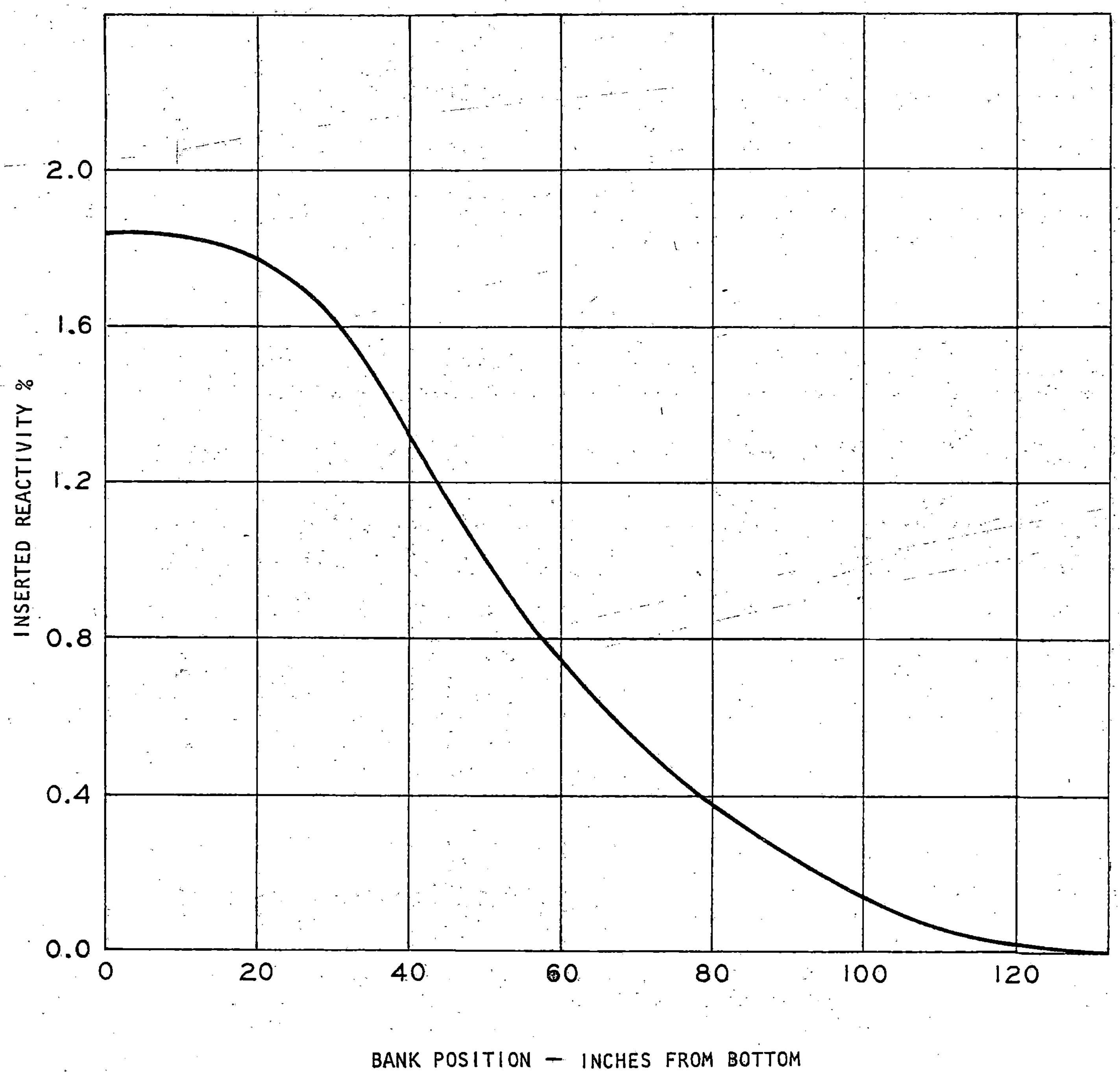


FIGURE 6
CORE 2
INTEGRAL ROD WORTH
GROUP 2
532°F

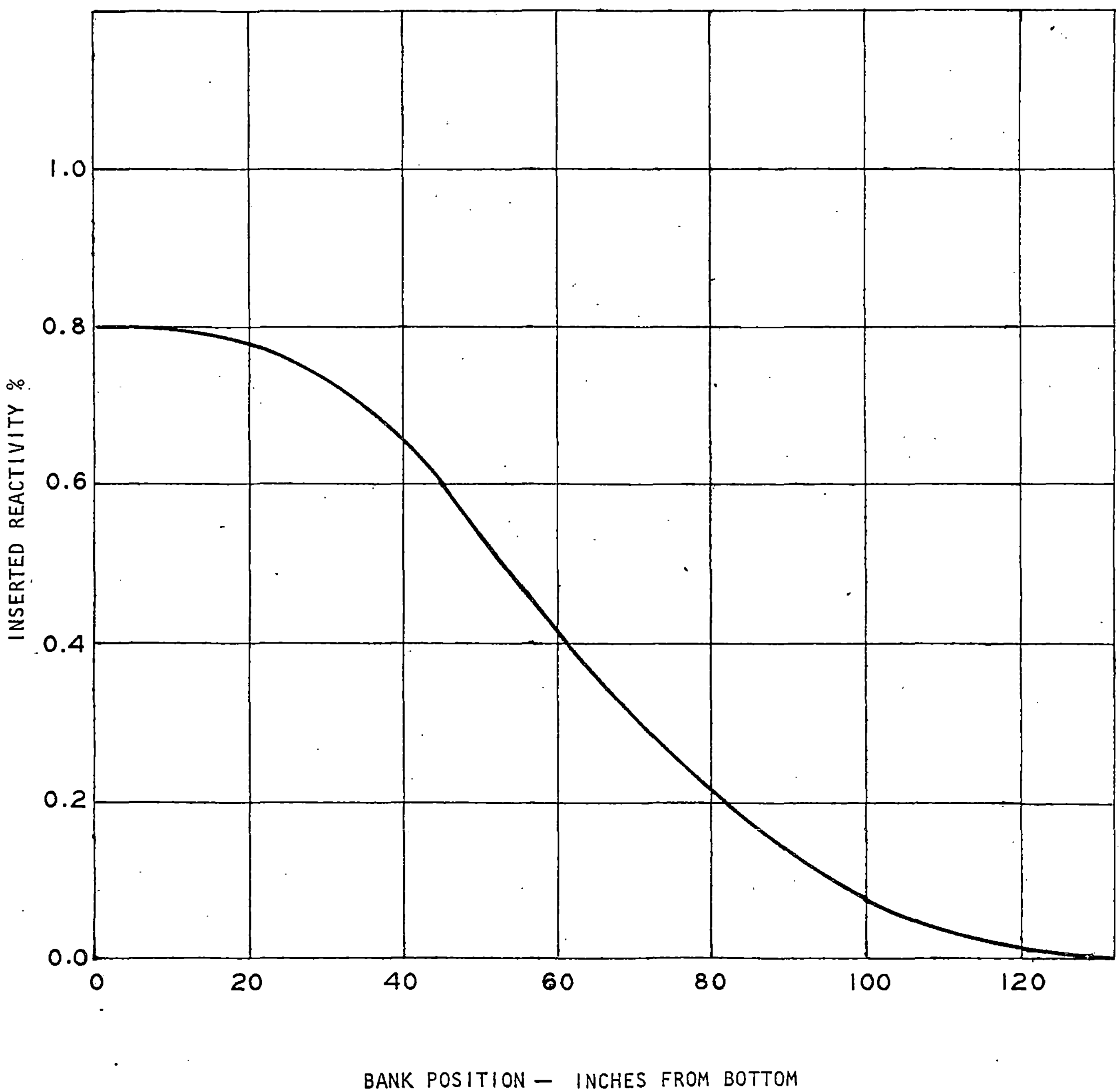


FIGURE 7
CORE 2
INTEGRAL ROD WORTH
GROUP 3
532°F

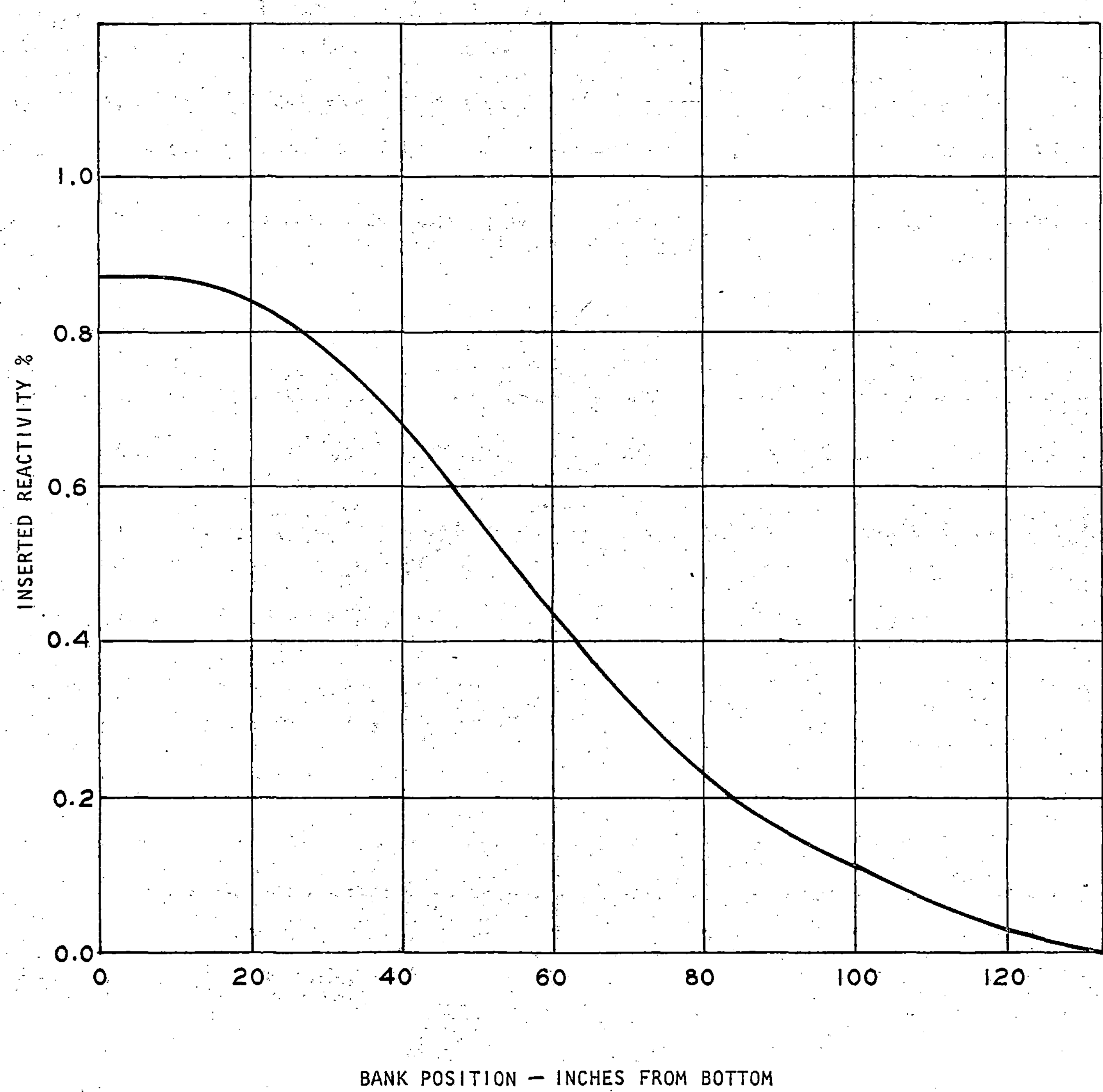


FIGURE 8
CORE 2
INTEGRAL ROD WORTH
GROUP 4
532°F

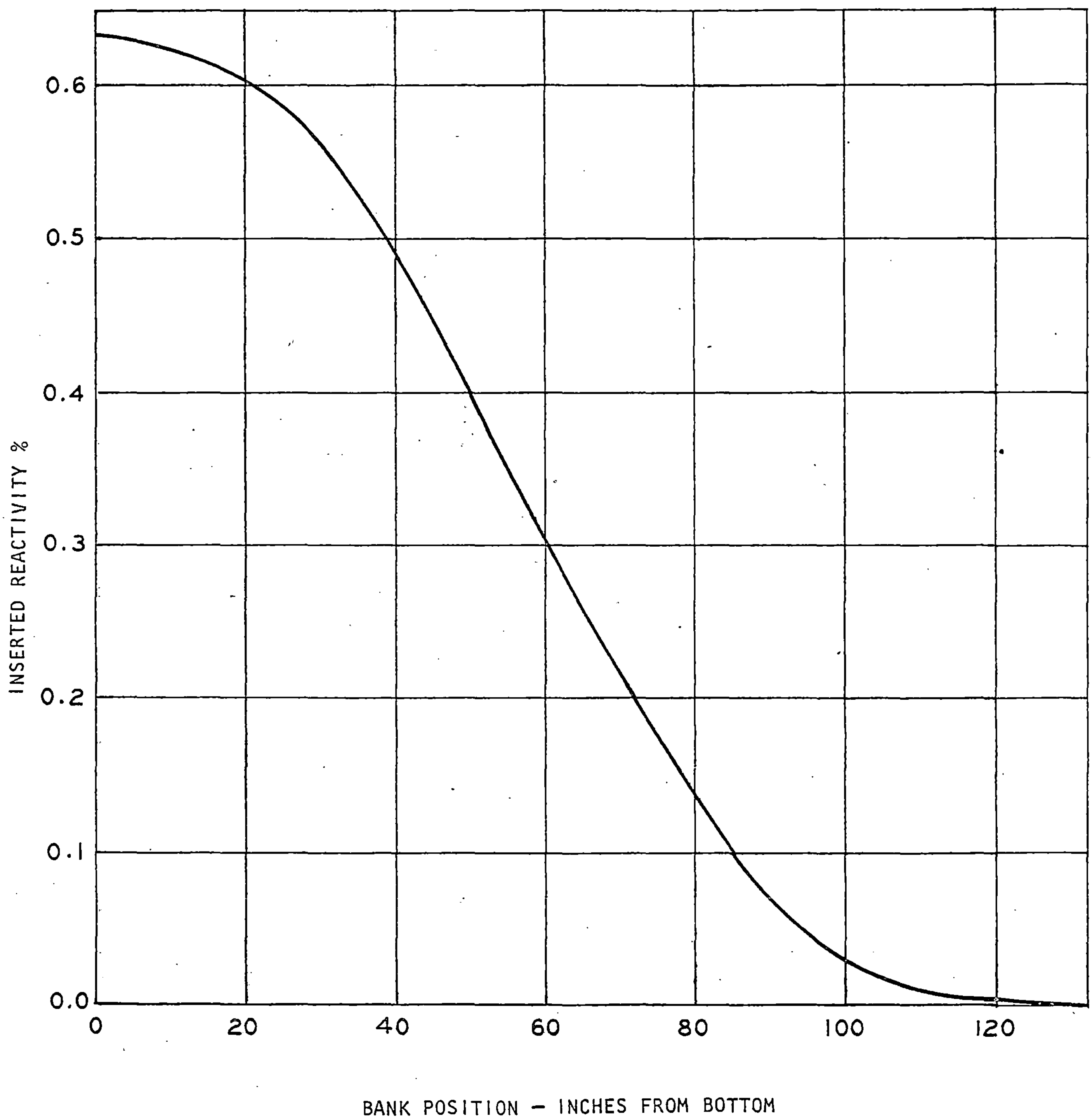


FIGURE 9
MODERATOR TEMPERATURE COEFFICIENT
VS
BORON CONCENTRATION

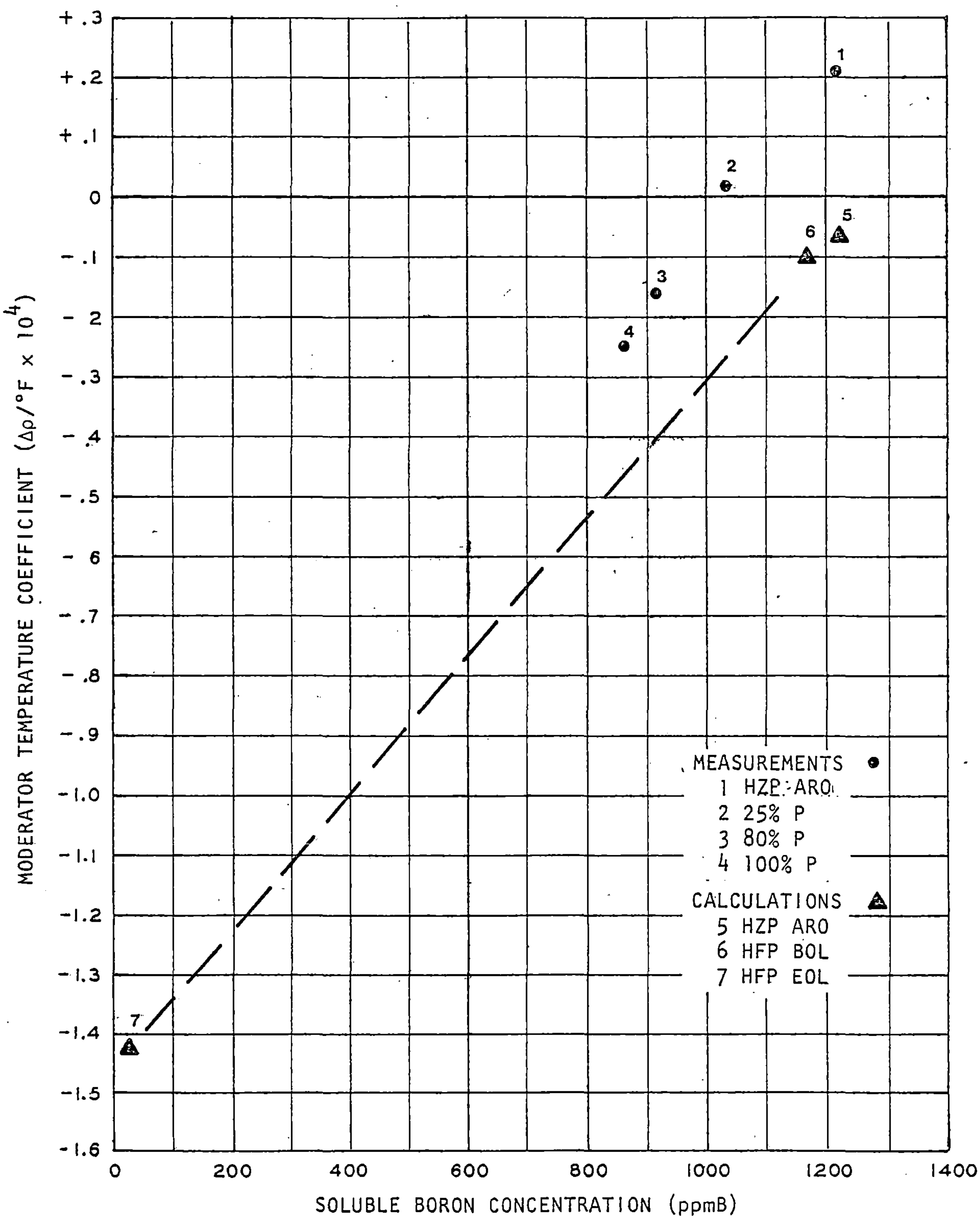


FIGURE 10
POWER COEFFICIENT
VS.
PERCENT POWER

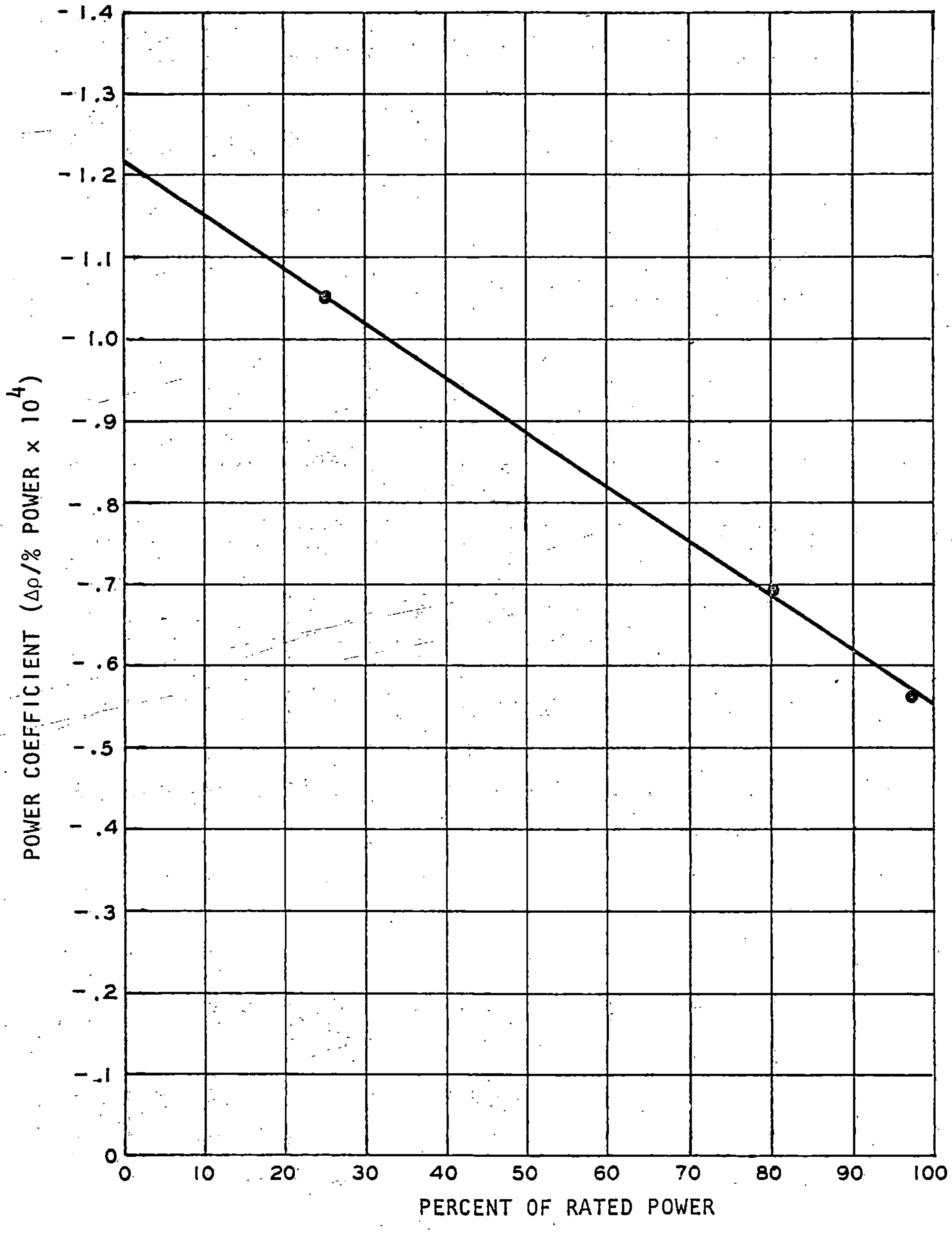


FIGURE 11
GROUP 4
ROD WORTH FOR POWER TESTING

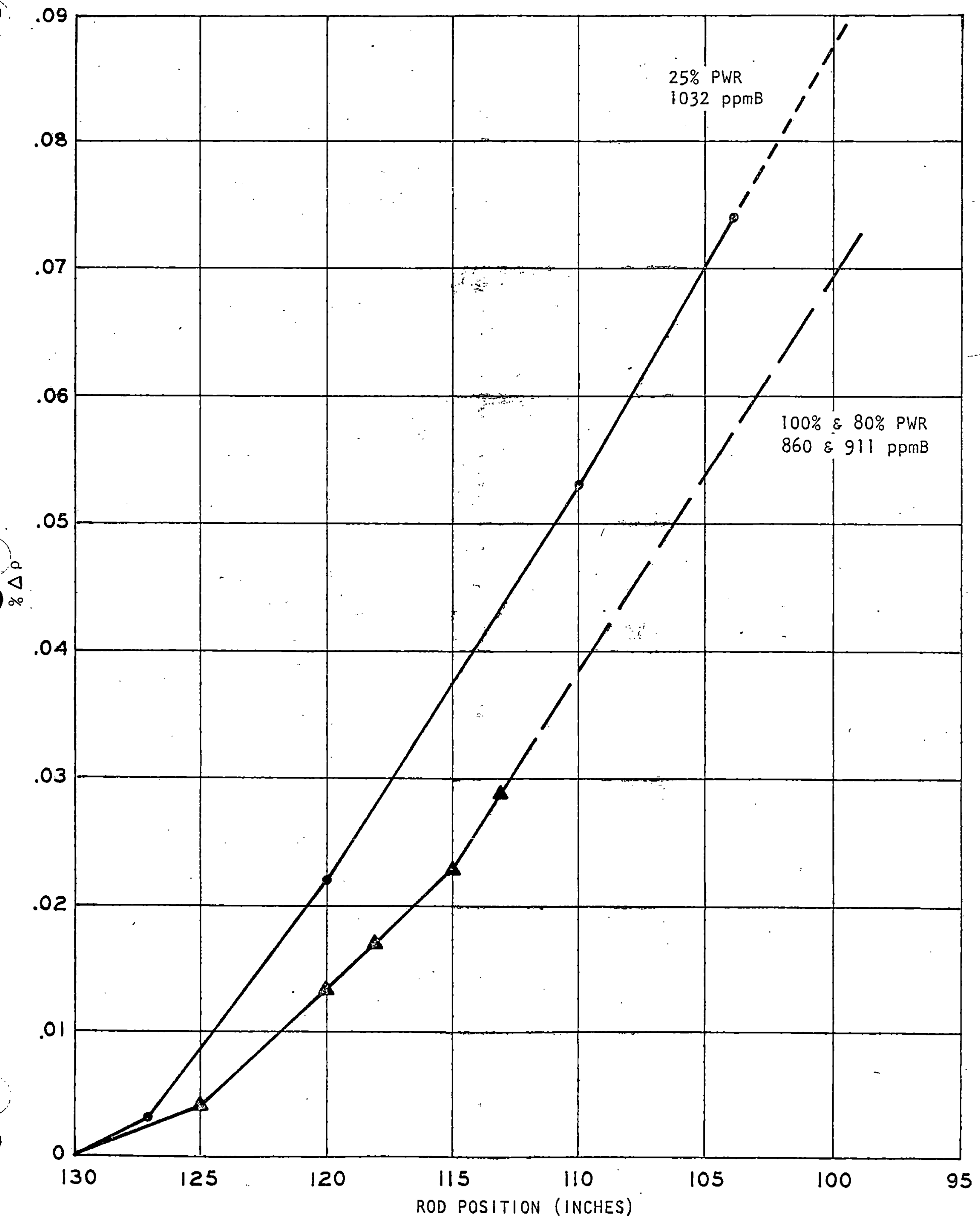


FIGURE 12 - NORMALIZED ASSEMBLY POWERS - 100% POWER

CALCULATION 100% POWER, 830 PPM, 700 MWD/MT, ARO

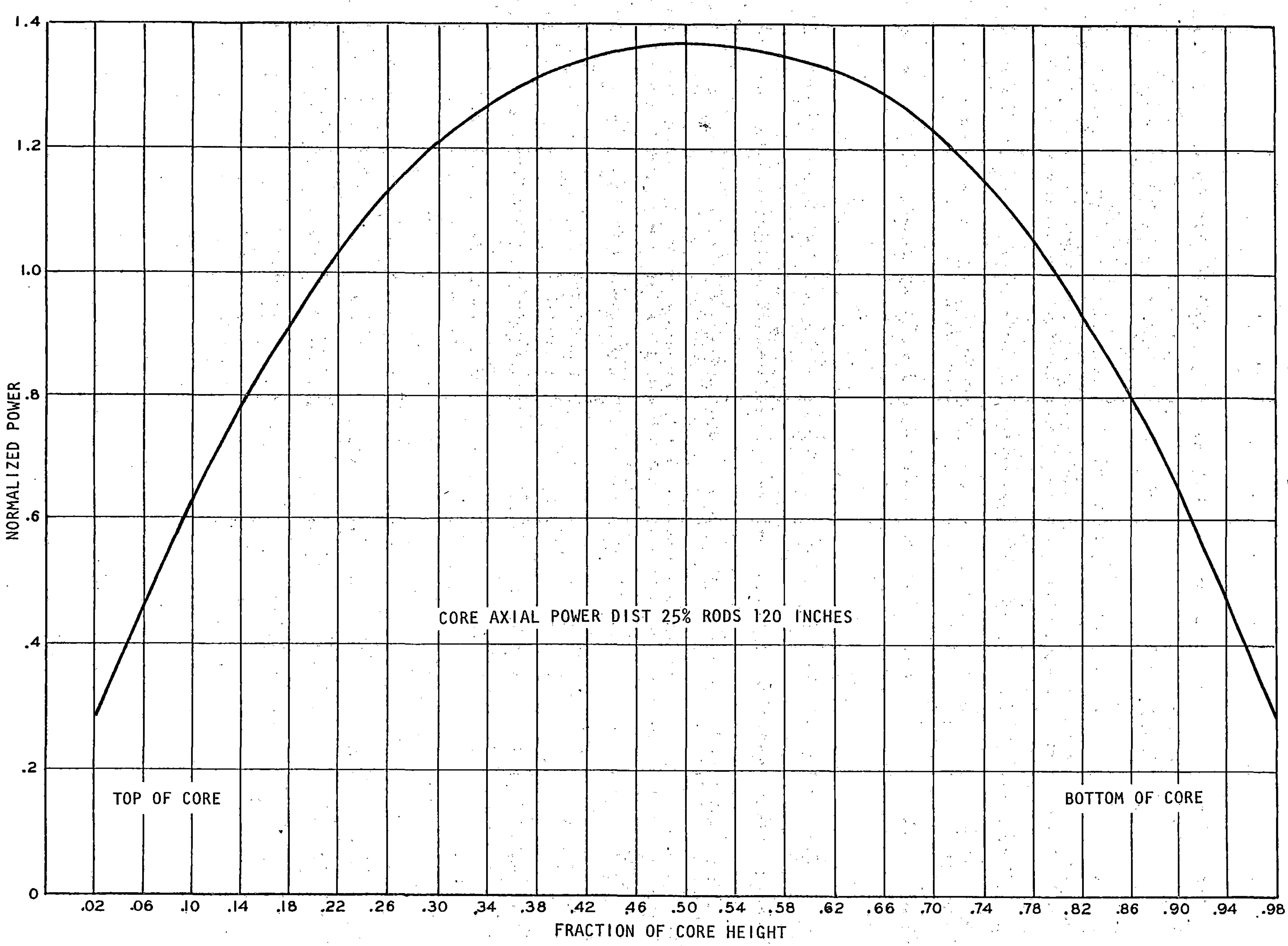
MEASUREMENT 100% POWER, 837 PPM, 750 MWD/MT, GRP 4-8% INSERTED

F .843 .845* +.002	E 1.140 1.176** +.032	E 1.140 1.221 +.071	F .871 .857* -.016	E 1.141 1.230 +.078	F .939 .871 -.072	E 1.094 1.135 +.037	D .782 .818 +.046
	F .897 .900* +.003	E 1.136 1.253* +.103	F .891 .906** +.017	F .946 .896* -.053	D 1.409 1.400 -.006	F .900 .814 -.096	D .759 .748 -.014
		F .909 .884* -.028	E 1.187 1.203** +.013	E 1.228 1.238 +.008	F .989 .903* -.087	D 1.183 1.147 -.031	D .602 .620 +.030
			E 1.239 1.292 +.043	F .987 .896* -.092	E 1.168 1.178 +.009	D .909 .902 -.008	
				D 1.312 1.293* -.014	D .961 .949 -.012	D .537 .533* -.007	
CALC MEAS DIFF/ CALC							

$\sigma = .050$

*BELFAB DETECTOR SENSITIVITIES ADJUSTED BY 17% TO NORMALIZE TO REUTER-STOKES DETECTORS

**NO DETECTOR, VALUE DERIVED FROM CALCULATIONS AND ADJACENT DETECTOR READINGS



NORMALIZED POWER
1.4
1.2
1.0
.8
.6
.4
.2
0
CORE AXIAL POWER DIST 25% RODS 120 INCHES
TOP OF CORE
BOTTOM OF CORE
.02 .06 .10 .14 .18 .22 .26 .30 .34 .38 .42 .46 .50 .54 .58 .62 .66 .70 .74 .78 .82 .86 .90 .94 .98
FRACTION OF CORE HEIGHT

FIGURE 13

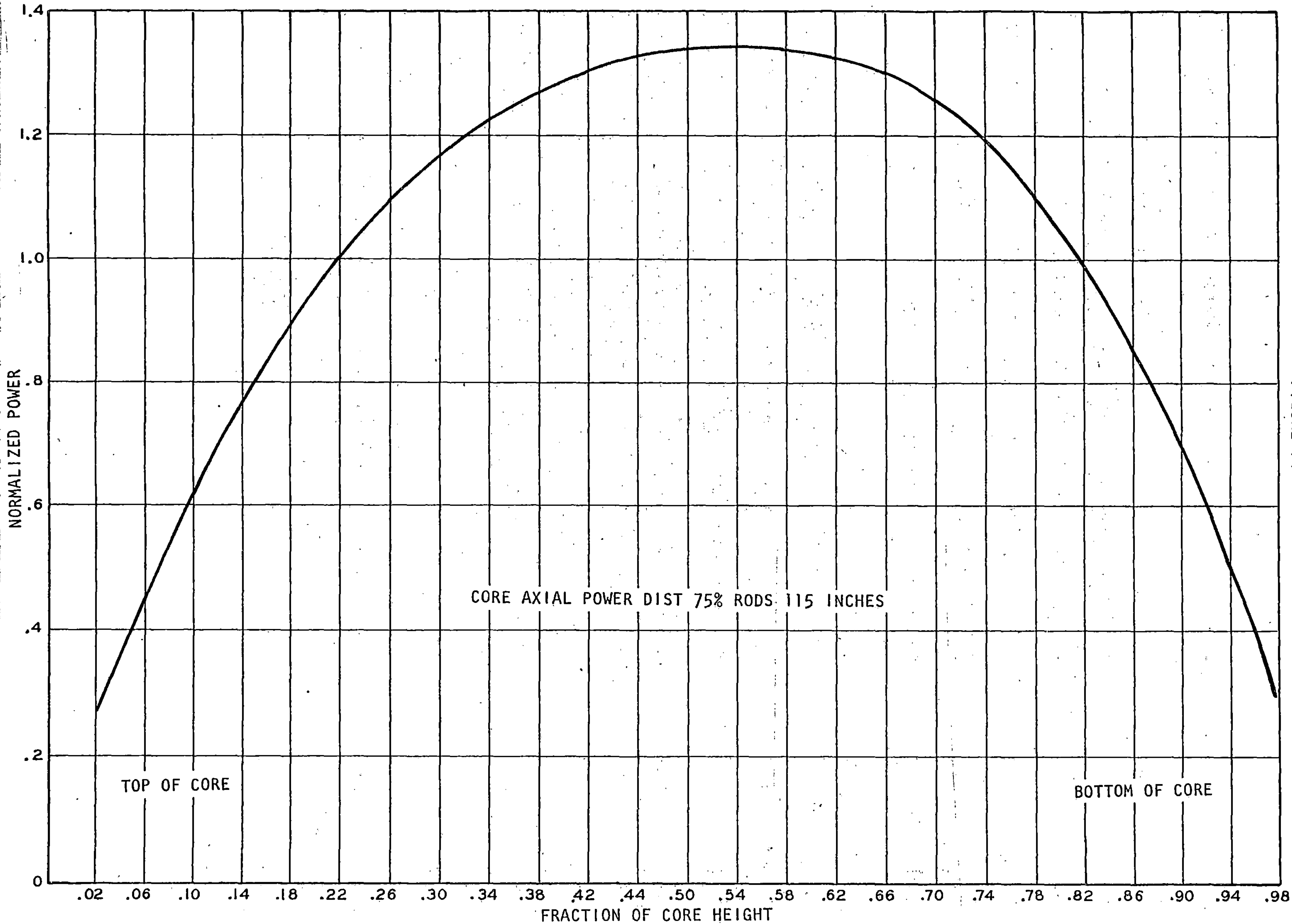
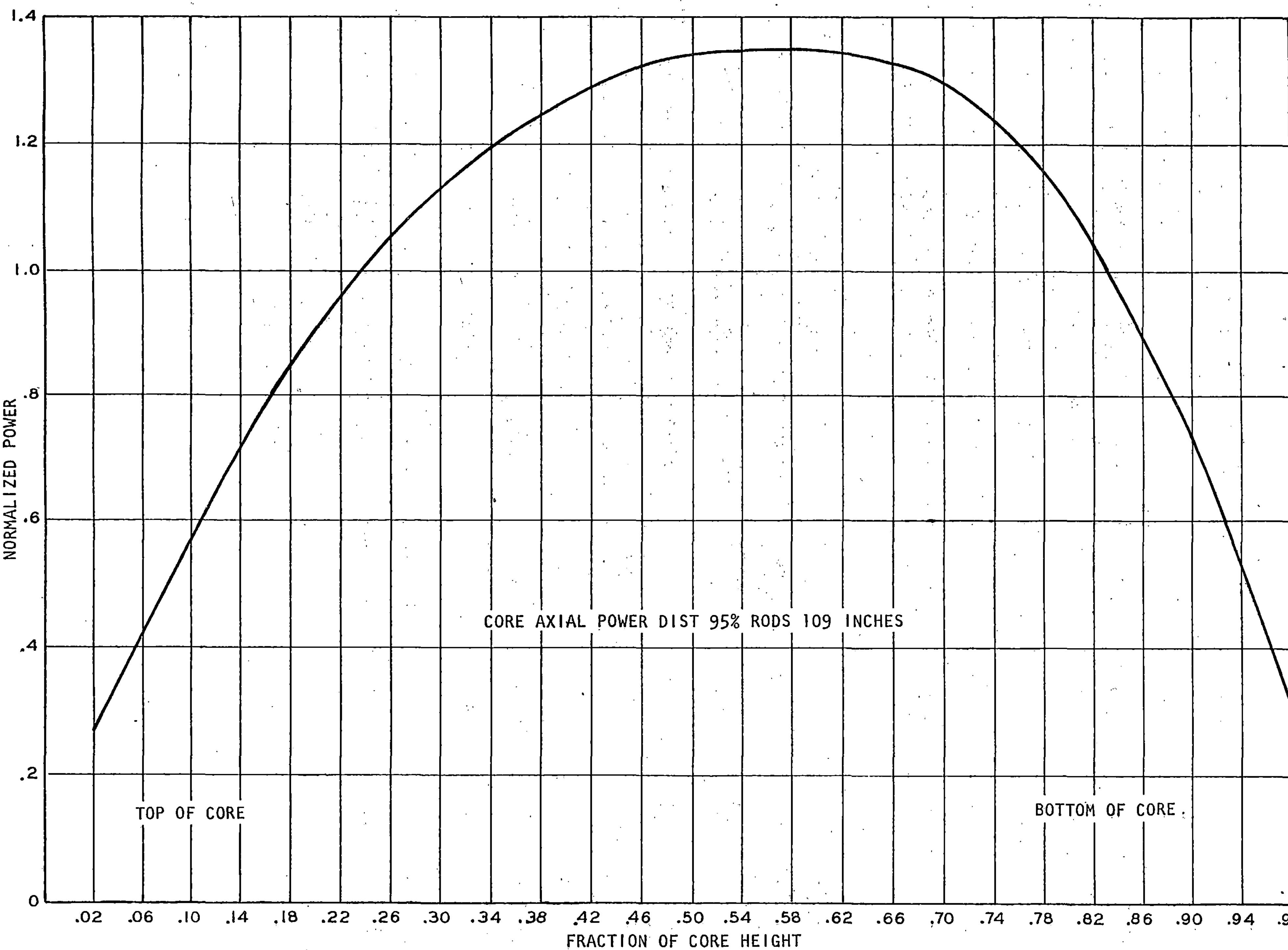

1.4
1.2
1.0
.8
.6
.4
.2
0
NORMALIZED POWER
CORE AXIAL POWER DIST 75% RODS 115 INCHES
TOP OF CORE
BOTTOM OF CORE
.02 .06 .10 .14 .18 .22 .26 .30 .34 .38 .42 .44 .50 .54 .58 .62 .66 .70 .74 .78 .82 .86 .90 .94 .98
FRACTION OF CORE HEIGHT

FIGURE 14



NORMALIZED POWER
1.4
1.2
1.0
.8
.6
.4
.2
0
CORE AXIAL POWER DIST 95% RODS 109 INCHES
TOP OF CORE
BOTTOM OF CORE
.02 .06 .10 .14 .18 .22 .26 .30 .34 .38 .42 .46 .50 .54 .58 .62 .66 .70 .74 .78 .82 .86 .90 .94 .98
FRACTION OF CORE HEIGHT

FIGURE 15

FIGURE 16 - GOVERNOR VALVE POSITION VS POWER

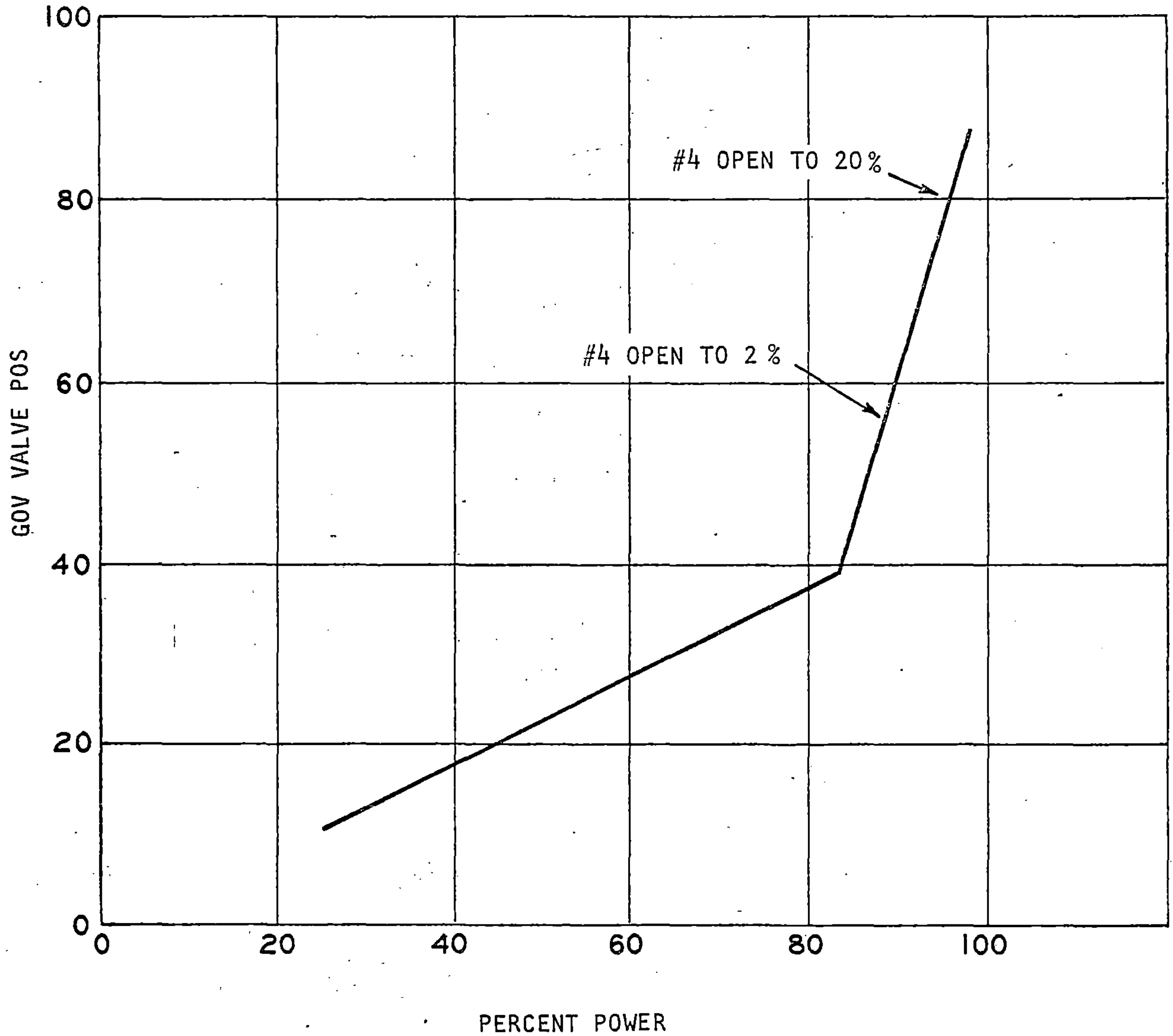
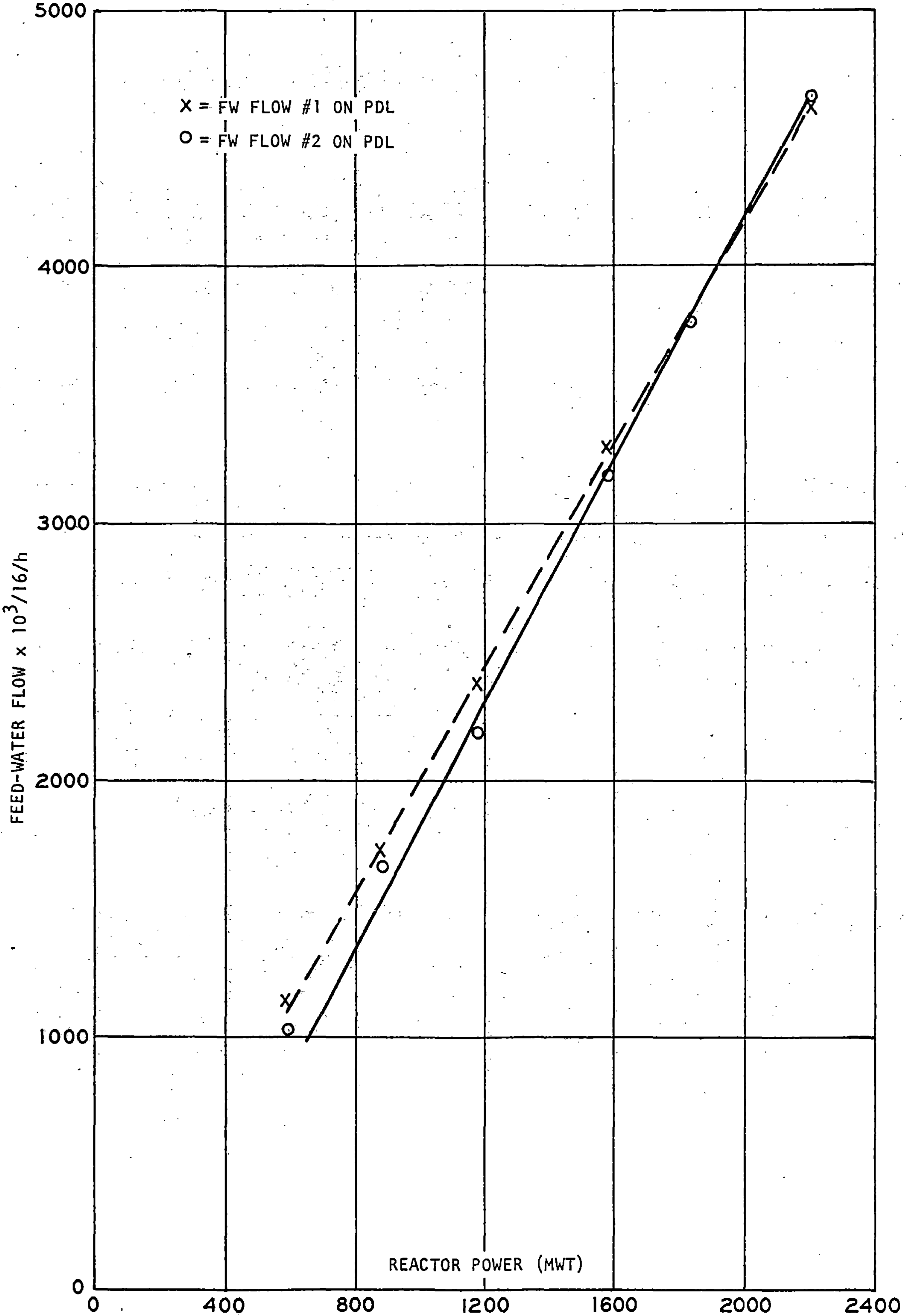


FIGURE 17 - FEED-WATER FLOW VS REACTOR POWER



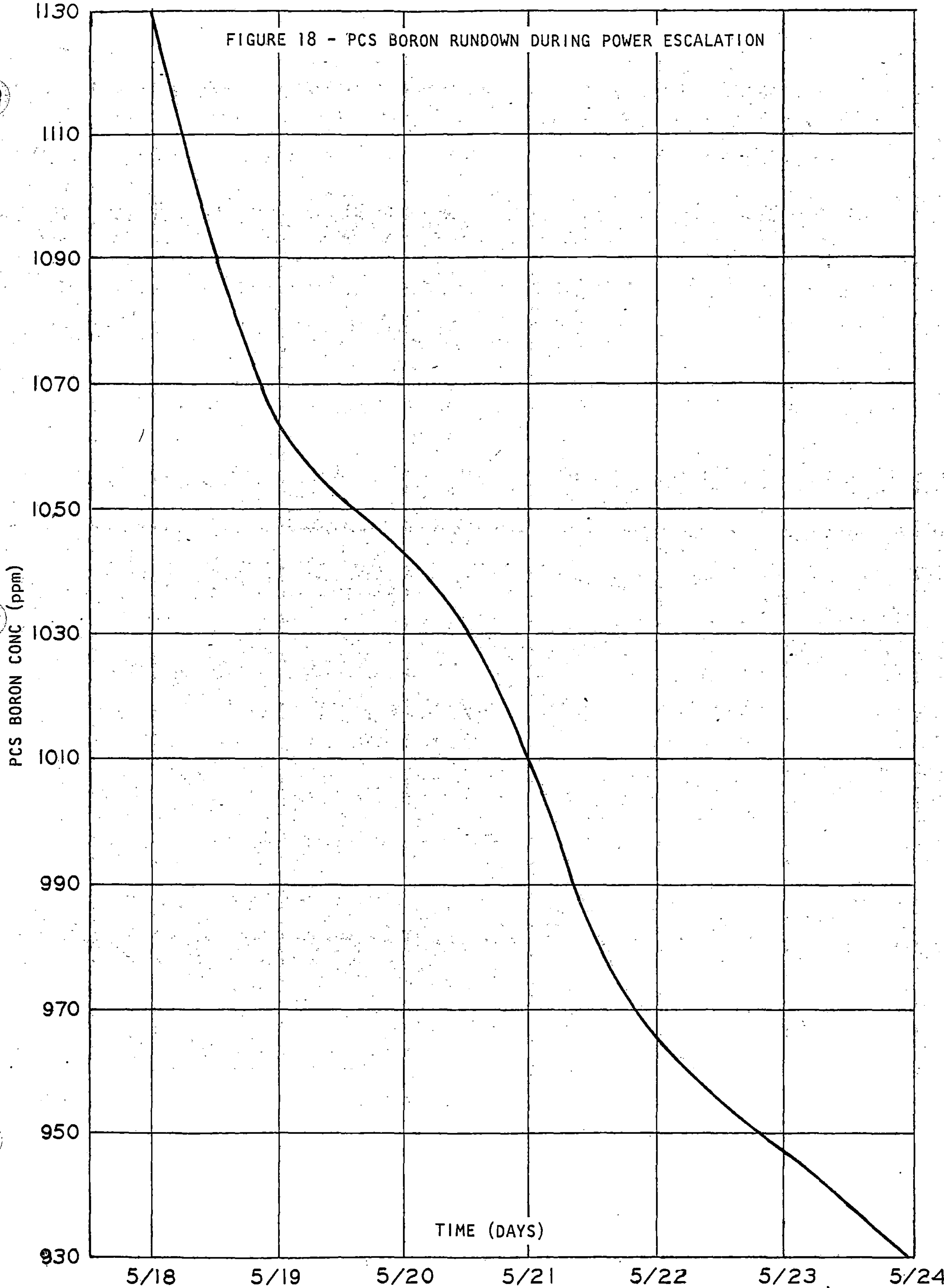


FIGURE 18 - PCS BORON RUNDOWN DURING POWER ESCALATION
PCS BORON CONC (ppm)
1130
1110
1090
1070
1050
1030
1010
990
970
950
930
TIME (DAYS)
5/18
5/19
5/20
5/21
5/22
5/23
5/24

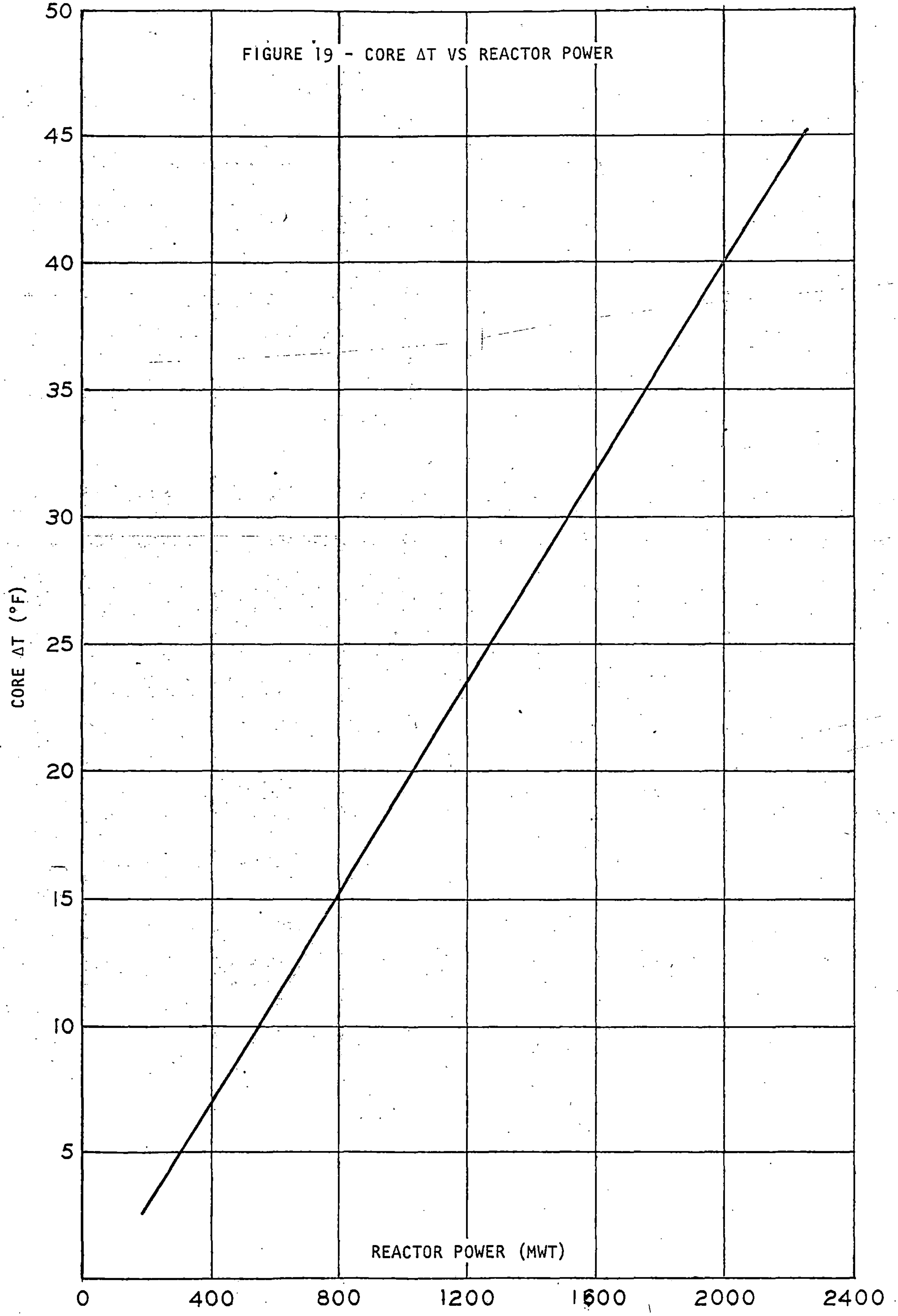


FIGURE 19 - CORE ΔT VS REACTOR POWER
CORE ΔT (°F)
REACTOR POWER (MWT)
50
45
40
35
30
25
20
15
10
5
0
400
800
1200
1600
2000
2400

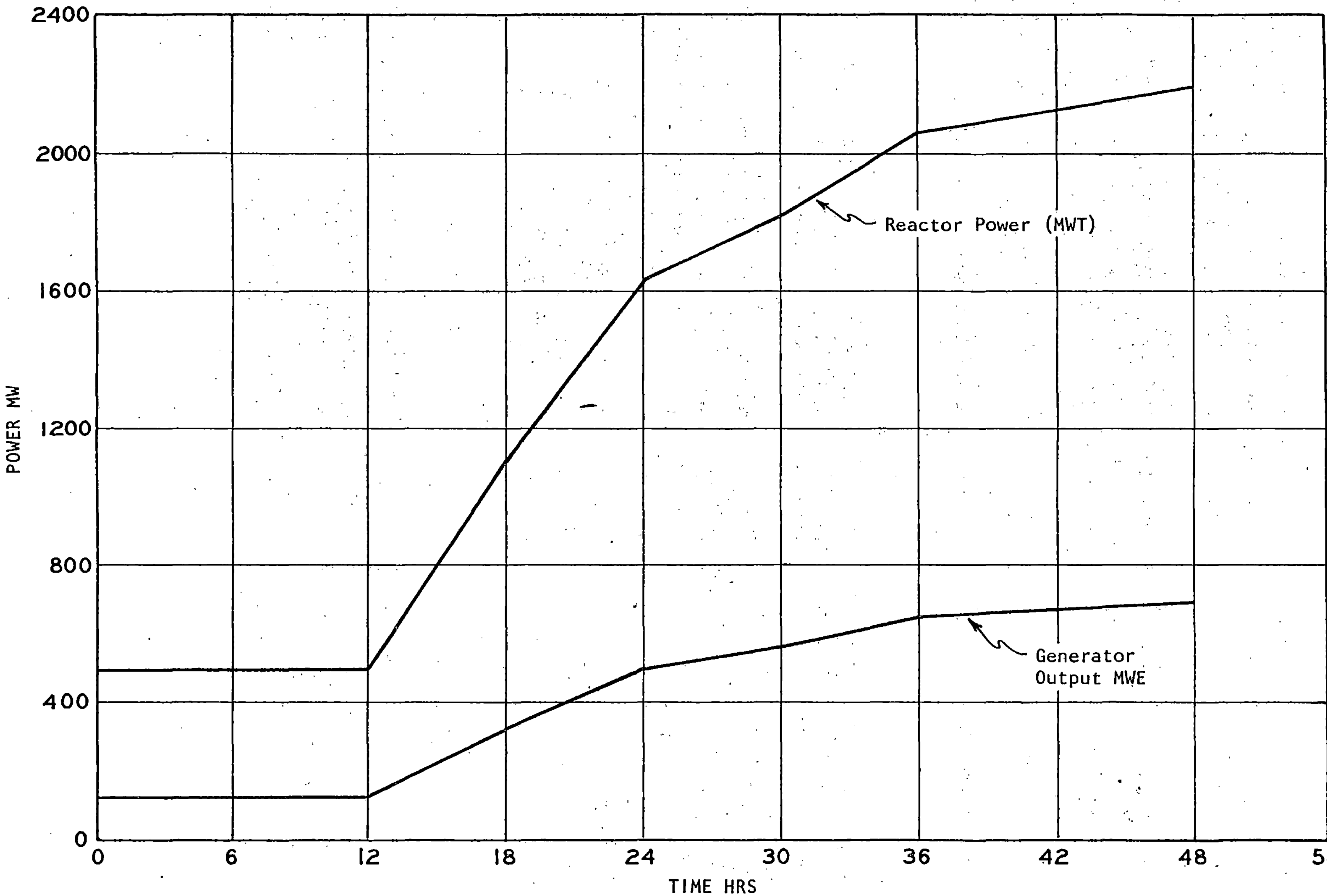


FIGURE 20 - UNIT POWER VS TIME

FIGURE 21 - STEAM GENERATOR PRESSURE VS REACTOR POWER