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February 6, 1978

Director of Nuclear Reactor Regulation
Att: Mr Albert Schwencer, Chief
Operating Reactors Branch No 1
US Nuclear Regulatory Commission
Washington, DC 20555

DOCKET 50-255 - LICENSE DPR-20 -
PALISADES PLANT - POWER
INCREASE TEST REPORT

Amendment No 31 to the Provisional Operating License DPR-20 for the Palisades Plant required that the results and comparison with predictions and acceptance limits for the power increase physics tests be submitted within 90 days of completion.

The attached report entitled, "Palisades Power Increase to 2530 MW_t Report," December 14, 1977, documents the test results. All acceptance criteria and limits were met.

David P Hoffman
Assistant Nuclear Licensing Administrator

CC: JGKeppler, USNRC

A001S
1/40

PALISADES

POWER INCREASE TO 2530 MW_t

REPORT

DECEMBER 14, 1977

A. PURPOSE

The purpose of this report is to fulfill the requirements of Paragraph 6.9.1.a of the Palisades Technical Specifications requiring a start-up report when an amendment to the license involving a planned increase in power is issued. A description of the power increase, the physics parameters measured and plant operating parameters are described in this report.

B. SUMMARY OF POWER INCREASE

On November 6, 1977, the procedure to increase the reactor power from 2200 MW_t to 2530 MW_t was begun after Amendment 31 to the Palisades Plant Technical Specifications was issued. The power increase was procedurally controlled by Special Test Procedure T-102, "Increasing Reactor Power From 2200 MW_t to 2530 MW_t." The first step in increasing power, after changing the appropriate instrument set points, was to increase the average primary coolant system temperature and pressure. This, in turn, increased the steam generator secondary side pressure providing the excess flow capacity through the turbine governor valves, while maintaining the reactor inlet temperature and steam generator primary to secondary differential pressure within Technical Specifications limits. On November 7, 1977, the power increase to 2530 MW_t was started. The power was increased to 95% power at an average rate of 1/2% per hour. Conditions were stabilized at 95% and held until xenon equilibrium was attained to provide suitable conditions for performing Moderator Temperature and Power Coefficient Measurement Tests. On November 9, 1977, T-98, Measurement of the Moderator Temperature Coefficient at Power" and T-101, "Measurement of the Power Coefficient" were performed. The description of these tests and results are discussed in Section C.

At this point, the data from the power increase up to this point and the results from T-98 and T-101 were evaluated and used in computing the 100% power final temperature and pressure for the primary coolant system of T_{avg} = 559.5°F and pressure = 2010 psia. The power increase commenced again at an average rate of one-half percent power per hour until 100% power was reached on November 10, 1977. Conditions were stabilized and alarm and controllers set points were changed for continuous operation at 2530 MW_t. The gross electric output of the unit increased from 676 MWe to 773 MWe during the time of the test.

C. REACTOR PHYSICS MEASUREMENTS

Included in the power escalation program were tests to measure the moderator temperature coefficient and power coefficient. These were done at a nominal reactor power of 95% of 2530 MW_t. The plant was held at 95% power for approximately 38 hours to reach stable conditions prior to the actual testing.

The Moderator Temperature Coefficient Test (MTC) was performed first. The average primary coolant temperature was lowered approximately 4°F by inserting control rods while maintaining constant power. The temperature was then returned to the original value by withdrawing rods. The core reactivity changes were derived from the change in the control rod position using a

calculated rod worth curve. (See Figure 8.) The MTC was measured to be -1.53×10^{-4} $\Delta\rho/F^\circ$. The acceptance criteria was $+ 0.5 \times 10^{-4}$ to $- 3.5 \times 10^{-4}$ $\Delta\rho/F^\circ$. The predicted (by Exxon Nuclear) MTC at 95% was $- 1.38 \times 10^{-4}$ $\Delta\rho/F^\circ$, which is 0.15×10^{-4} $\Delta\rho/F^\circ$ more positive than the measured MTC, which is an acceptable agreement.

The Power Coefficient Test was performed immediately after the MTC Test. While maintaining the temperature as constant as possible, the reactor power was decreased by approximately 4% using the control rods. The reactor power was then returned to 95%. The reactivity change was computed by converting the change in control rod position between the two power levels to reactivity using Figure 8. This measurement of the isothermal power coefficient (approximately Doppler) was calculated to be $- .66 \times 10^{-4}$ $\Delta\rho/\%$ power. The predicted (by Exxon Nuclear) Doppler Coefficient at 95% power was $- .58 \times 10^{-4}$ $\Delta\rho$, which is 0.08×10^{-4} more positive than the measured value. Knowing the MTC and Doppler Coefficient, along with the programmed rise in the average primary coolant temperature, one can calculate the power coefficient by combining the Doppler and Moderator Temperature Coefficients (in terms of $\Delta\rho/\%$ power). The MTC, when converted into terms of $\Delta\rho/\%$ power for a 0 to 100% power temperature rise of 27.5F° (559.5° - 532°), is $- .42 \times 10^{-4}$ $\Delta\rho/\%$ power. Adding this to the Doppler Coefficient gives a measured Power Coefficient of $- 1.08 \times 10^{-4}$ $\Delta\rho/\%$ power. Similarly combining Exxon Nuclear's values for MTC and Doppler gives a predicted value of $.96 \times 10^{-4}$ $\Delta\rho/\%$ power which is 11% below the measured value. The acceptance criteria for Power Coefficient was $- 1.0 \times 10^{-4}$ $\Delta\rho/\%$ power ± 30%, so the measured value is well within the acceptance criteria.

D. POWER DISTRIBUTION

Before, during and after the power increase, power distributions were calculated. Figure I shows the normalized power distribution for a core octant at 2200 MW_t just before the power increase and after just reaching 2530 MW_t. Also shown is the percentage change between the two powers. The largest positive change was 1% in two "F" bundles and the largest negative change was - 1.8% in an "E" bundle. The acceptance criteria was bundle peaking factor for any bundle would not increase more than 10% from the 2200 MW_t condition. This acceptance criteria was met.

Figure 2 shows the Linear Heat Generation Rates (LHGR) (analogous to F_q) and bundle powers for operation at 2530 MW_t. The LHGR is limited by the Plant Technical Specifications to 14.12 kW/ft, but this limit is reduced by engineering and uncertainty factors to 11.8 kW/ft, 12.12 kW/ft and 11.76 kW/ft for D, E and F fuel, respectively. The maximum allowed bundle power is 17.14 MW. Figure 2 shows operation at 2530 MW_t was within both these limits.

Figure 3 shows the peak pin powers (analogous to F_r) for the 28 bundles in the core octant. The limits for peak pin power are 96.81 kW, 99.72 kW and 96.81 kW for D, E and F fuel, respectively. Figure 3 shows none of these limits were exceeded.

E. OTHER PLANT PARAMETERS

The following figures were made from data taken during the power escalation and during a plant start-up on December 12, 1977. Figure 4 shows the programmed primary coolant temperatures from 0 to 100% power. Figure 5 shows the gross electric output versus power. The electric output is low by approximately 18 MWe because one feed-water heater was bypassed due to a tube leak. Figure 6 shows the decrease in steam generator secondary side pressure as power increases. This figure represents an average for the two steam generators. Figure 7 shows the governor valve position versus power for the power escalation from 2200 MW_t to 2530 MW_t. Due to difficulty in setting the controller, Governor Valve 4 (GV 4) is open before GV 1, 2 and 3 are fully open.

F. CONCLUSIONS

The power increase was performed in an orderly manner using an approved procedure to maintain the reactor in a safe condition. In addition to the limits and acceptance criteria that were previously mentioned as being met, reactor vessel inlet temperatures and steam generator differential pressures were also closely monitored during and after the power increase to assure they remained within the Technical Specifications limits. All acceptance criteria were met and no operating limits were violated and an increase of approximately 100 megawatts - electric was realized from the power increase.

PALISADES PLANT

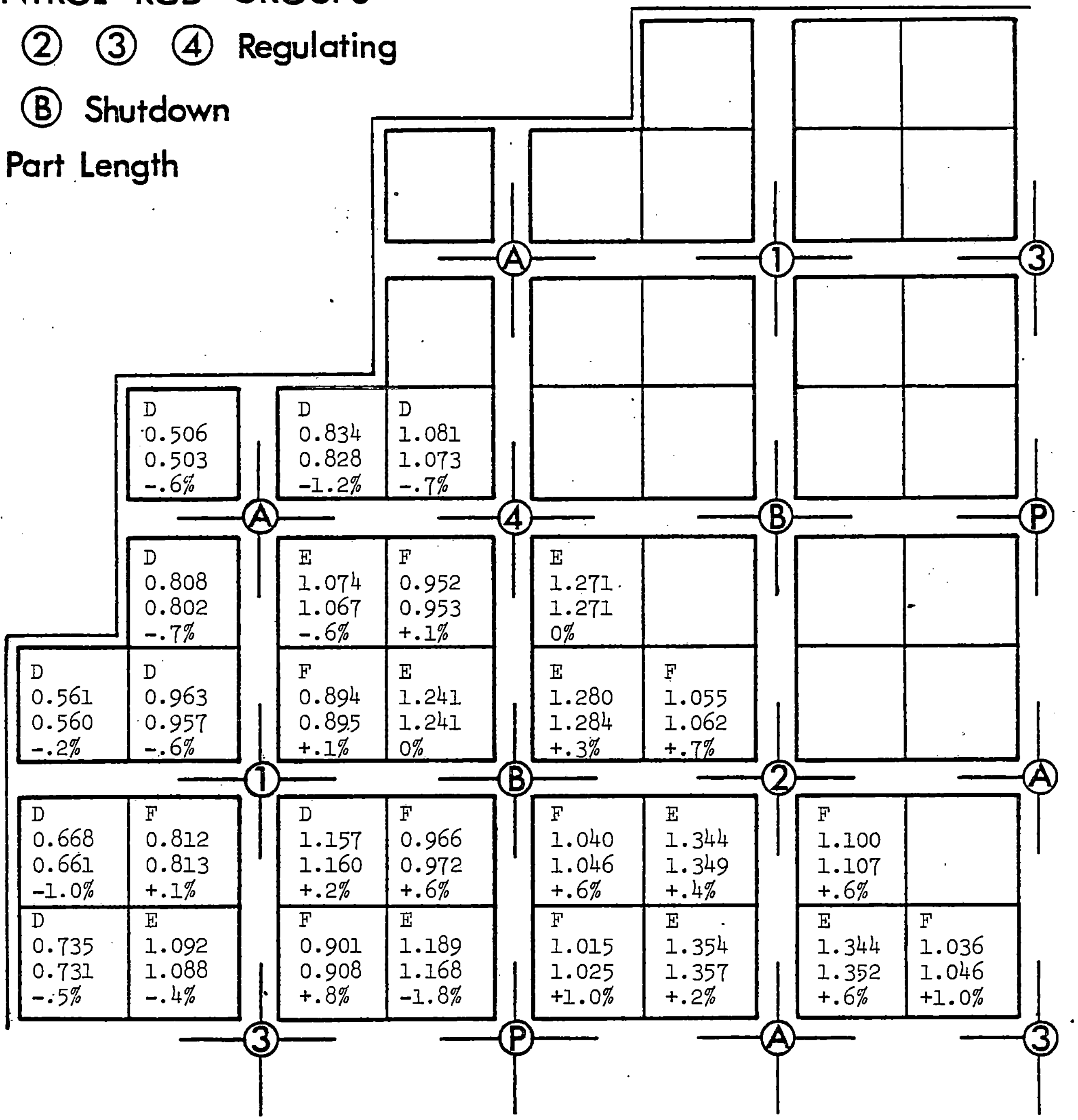
Normalized Power Distributions

CONTROL ROD GROUPS

① ② ③ ④ Regulating

Ⓐ Ⓑ Shutdown

Ⓟ Part Length



Center of Core

X	Batch
Y	2200 MW_t Normalized Power Tape 3498 11/6/77
Z	2530 MW_t Normalized Power Tape 3516 11/10/77
D	% Difference

FIGURE 1

PALISADES PLANT

Linear Heat Generation Rate and Bundle Power
2530 MW_t Operation

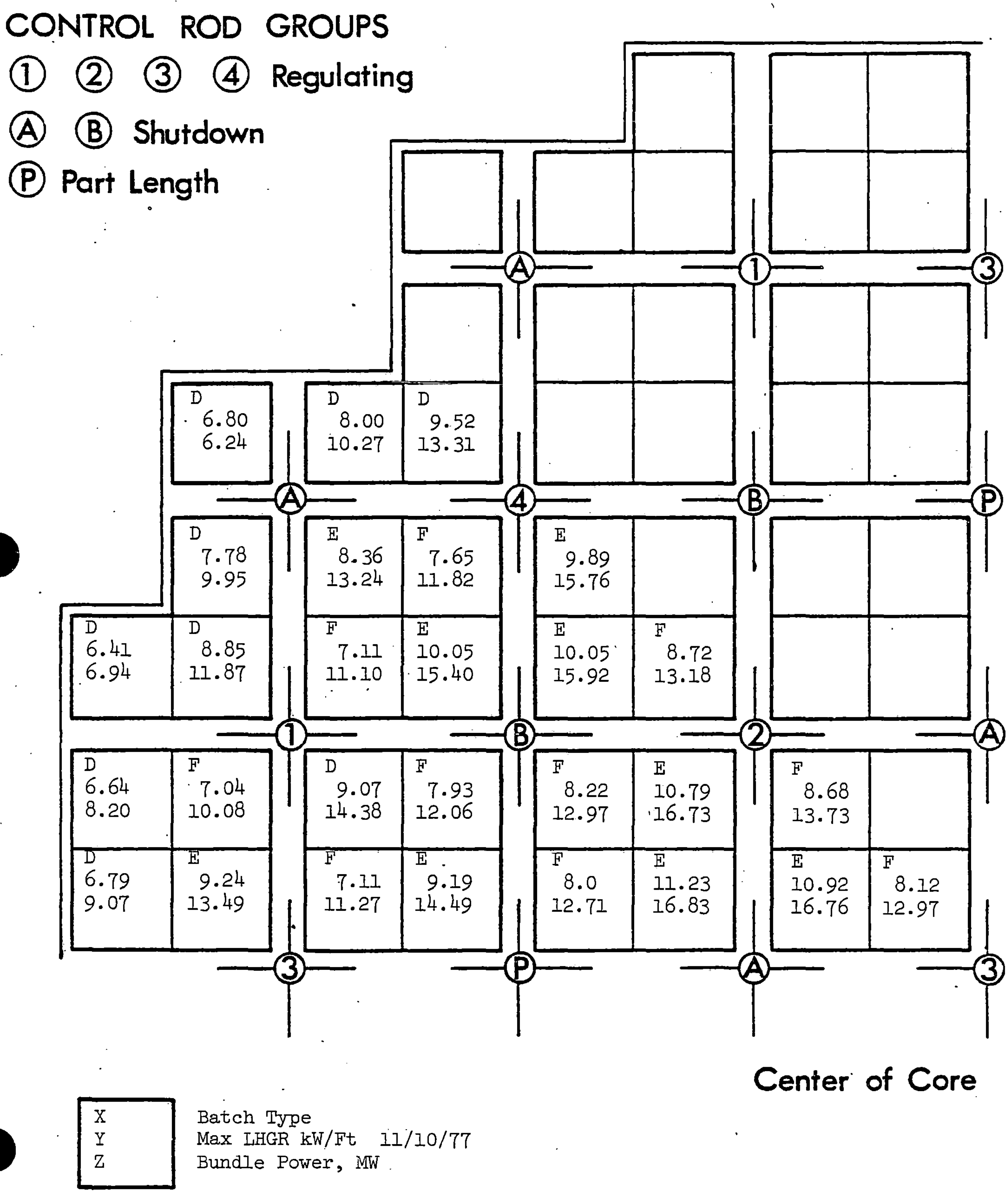


FIGURE 2

PALISADES PLANT

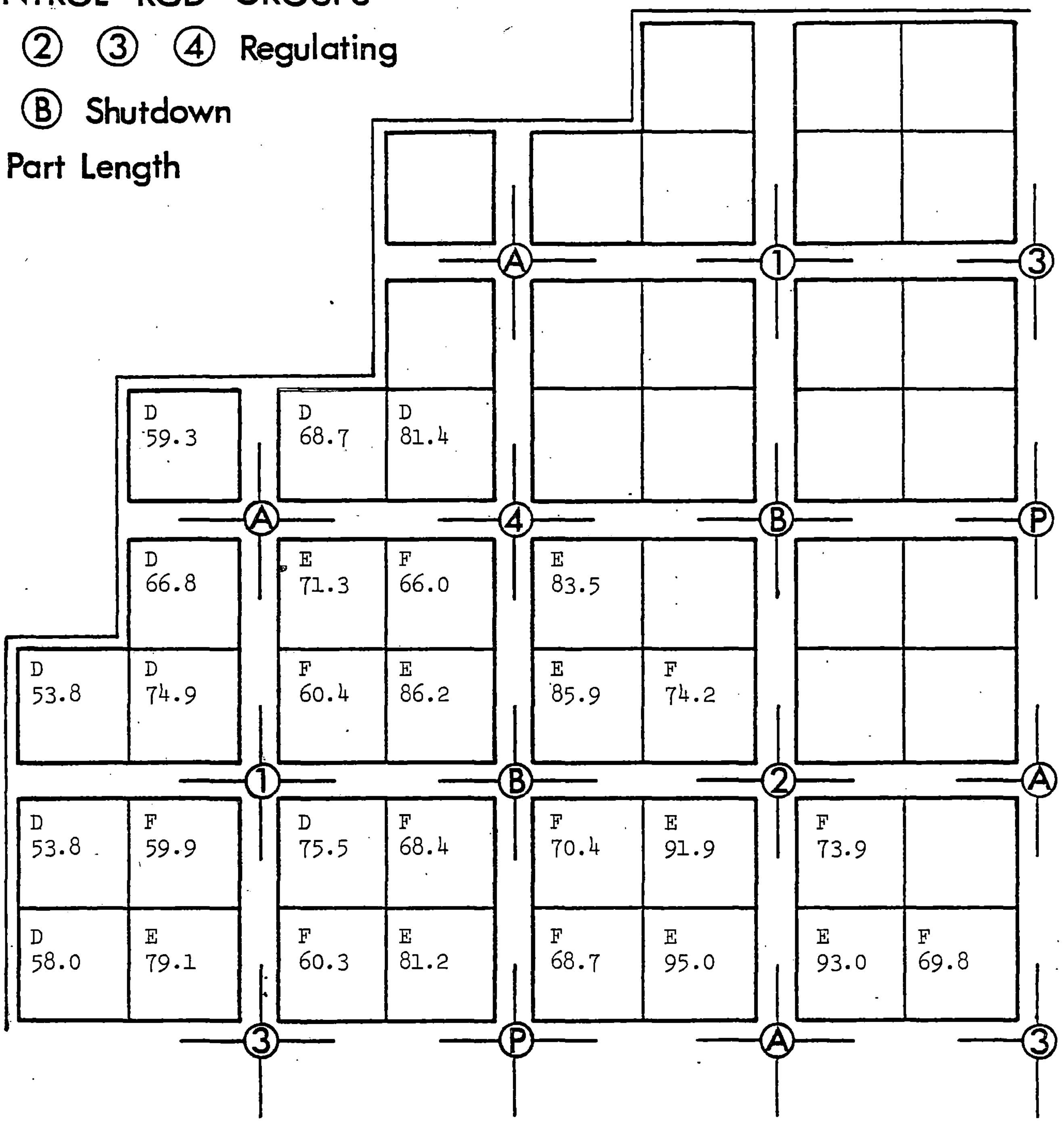
Peak Rod Power at 2530 Operation

CONTROL ROD GROUPS

① ② ③ ④ Regulating

Ⓐ Ⓑ Shutdown

Ⓟ Part Length



Center of Core

X	Batch
Y	Peak Rod Power, kW

FIGURE 3

PROGRAMMED P.C.S. TEMPERATURE
vs
REACTOR POWER (% OF 2530 MWt)

PCS PRESSURE = 2010 psia

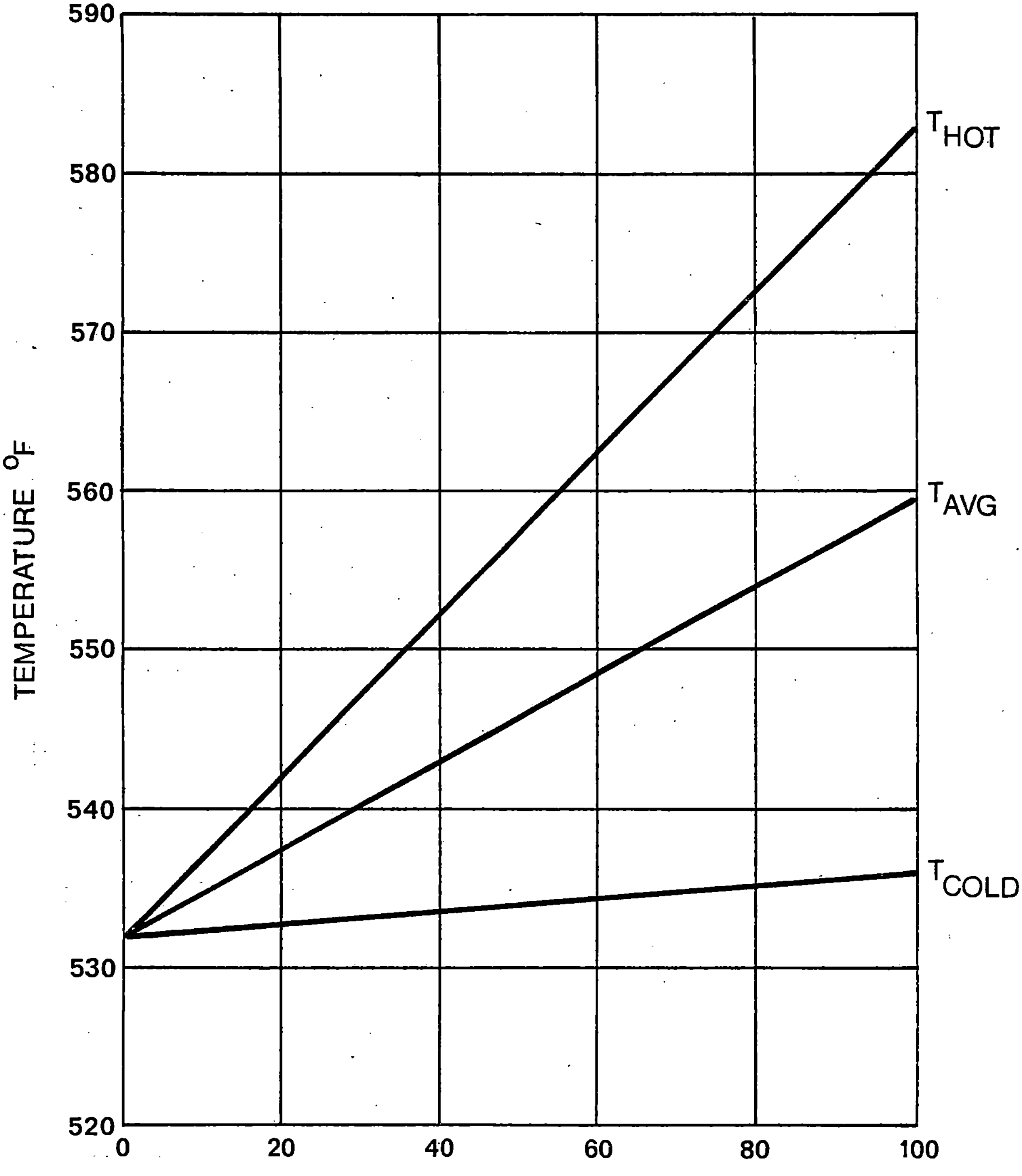


Figure 4

GROSS ELECTRIC PRODUCTION
vs
REACTOR POWER (% OF 2530 MWt)

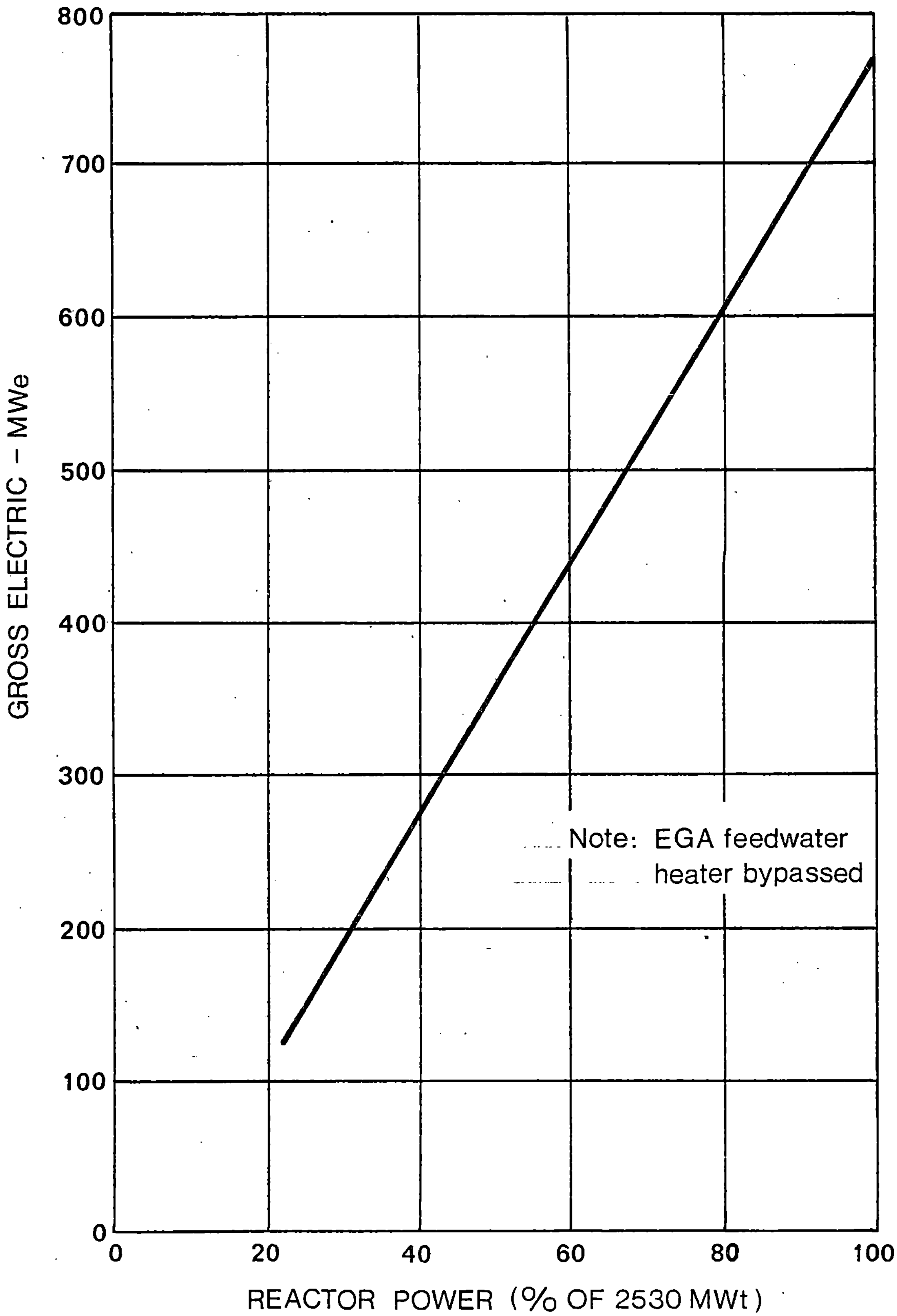


Figure 5

STEAM GENERATOR PRESSURE
vs
REACTOR POWER (% OF 2530 MWt)

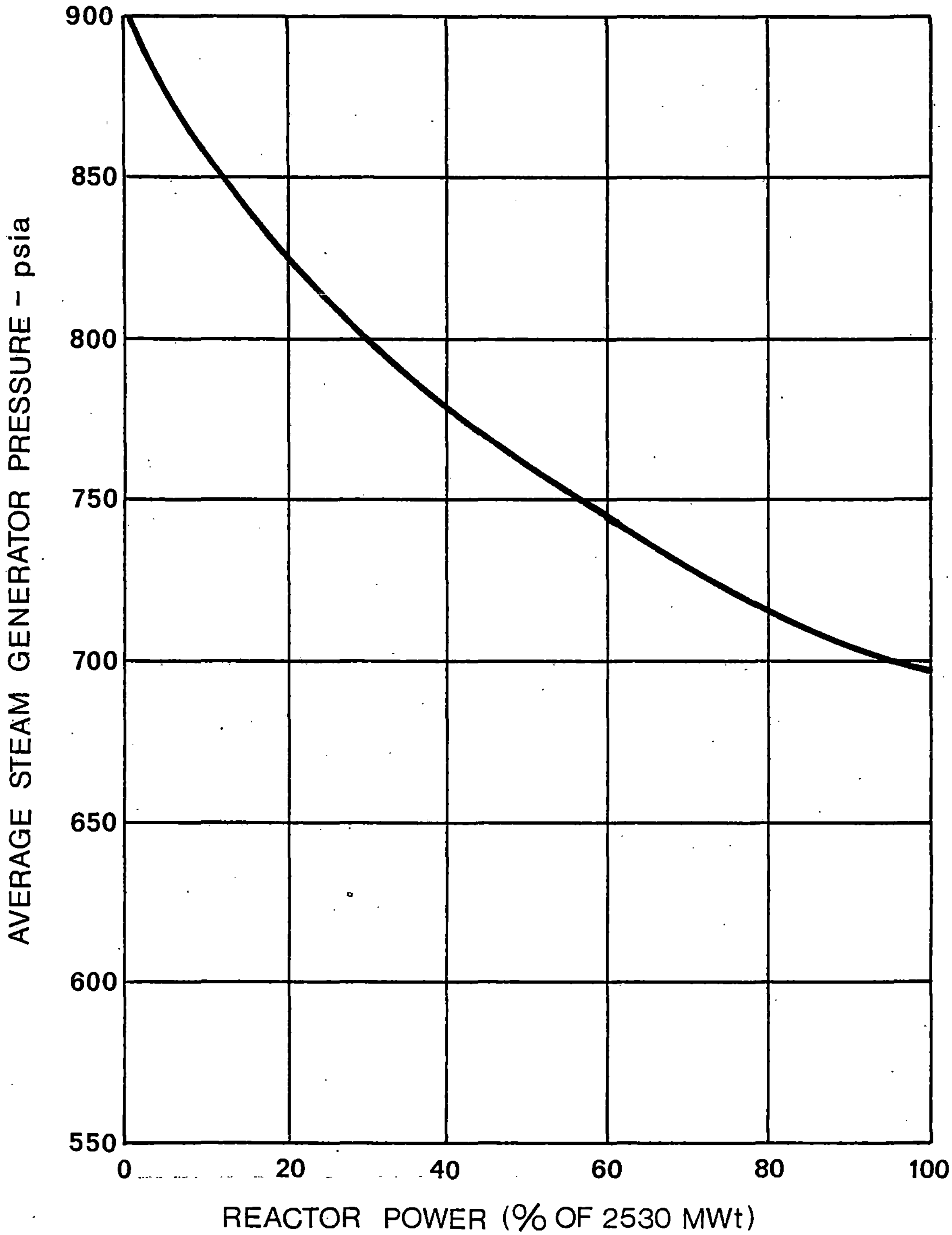


Figure 6

TURBINE GOVERNOR VALVE POSITION
vs
REACTOR POWER (% OF 2530 MWt)

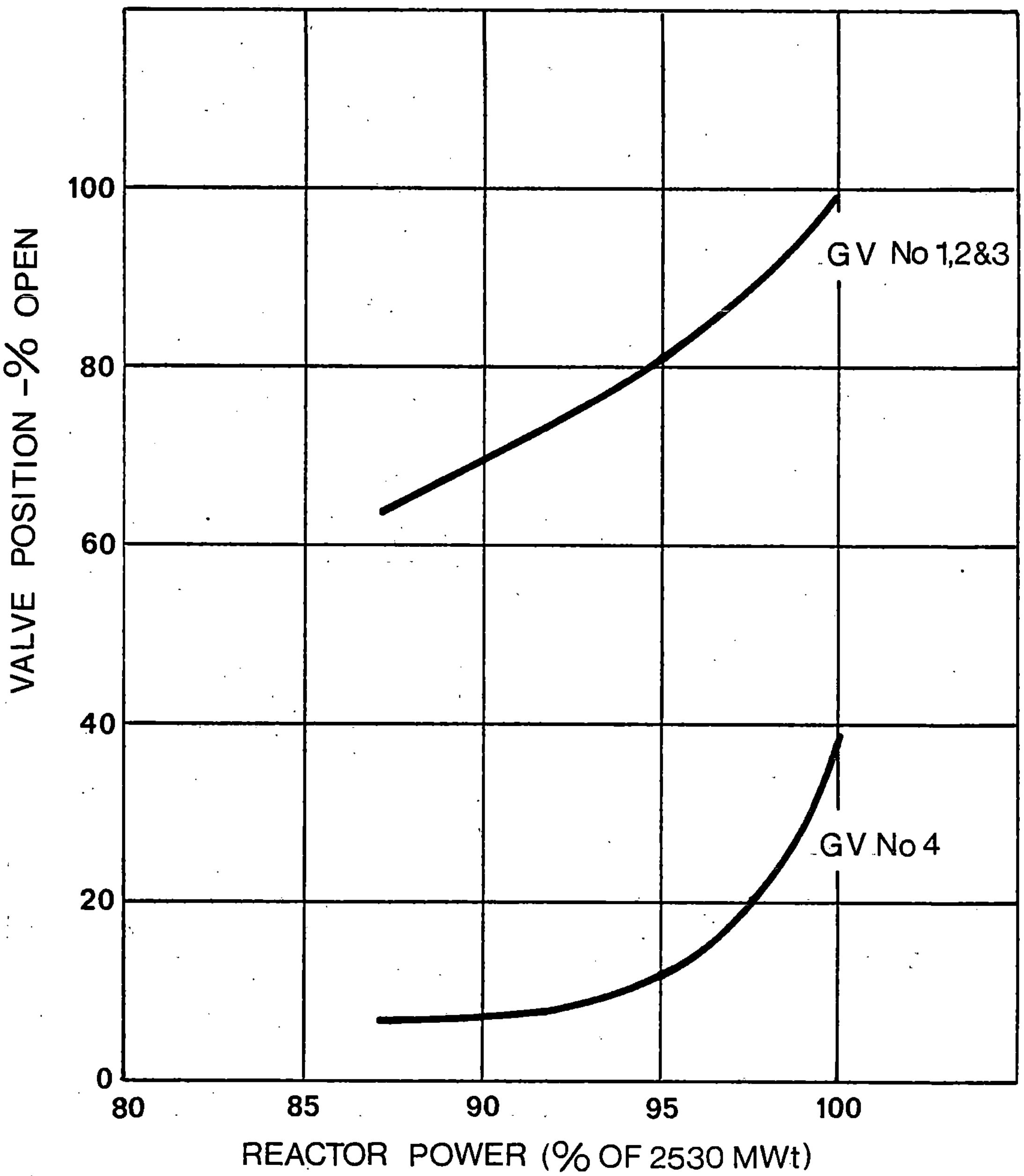


Figure 7

INTEGRAL ROD WORTH CURVE
GROUP – 4

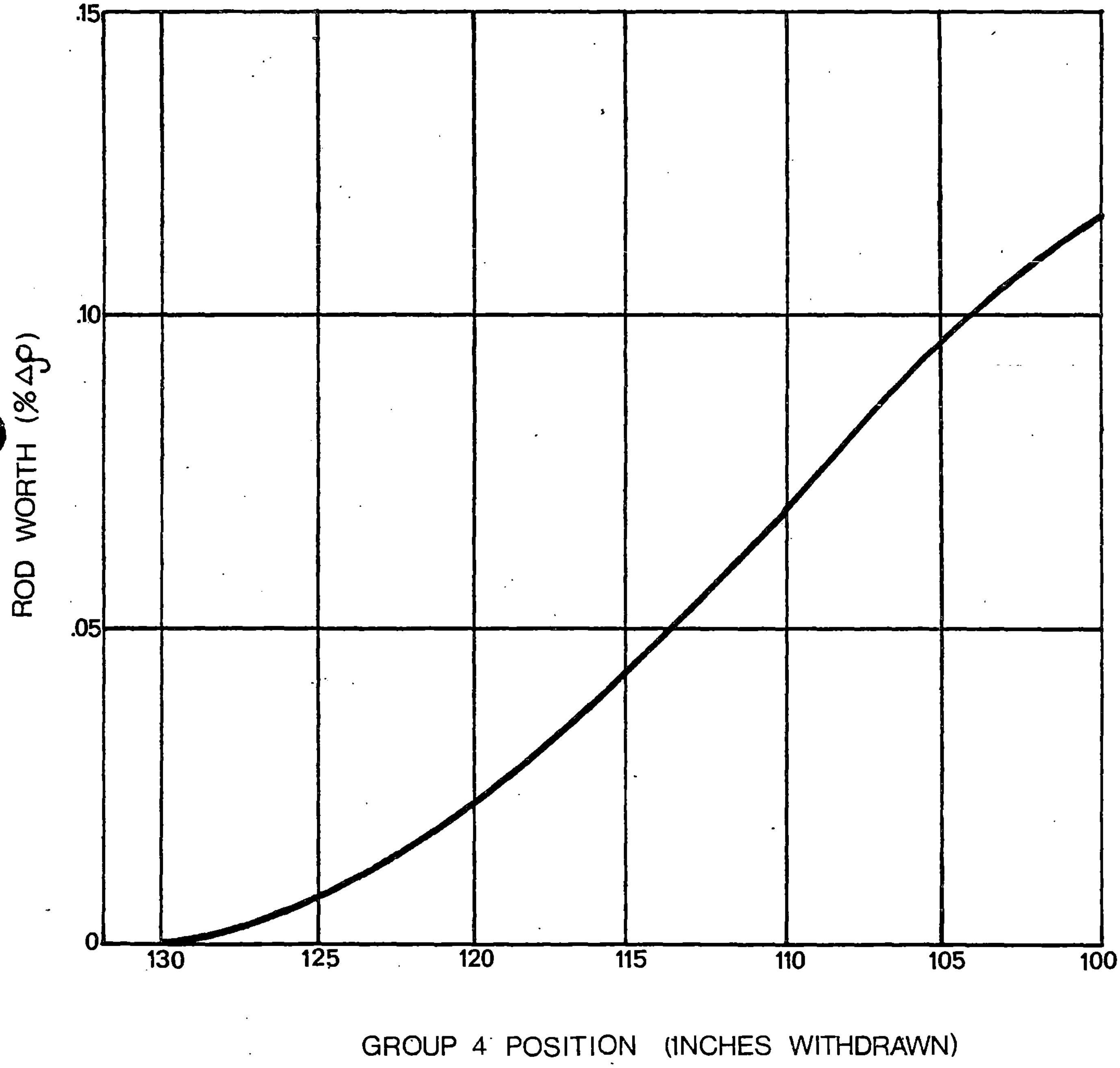


Figure 8