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FACIL:50-316 Donald C. Cook Nuclear Power Plant, Unit 2, Indiana & 05000316

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DENTON,H.R. Office of Nuclear Reactor Regulation

SUBJECT: Forwards amended & addl date supporting changes to T-average Ech Specs discussed in 791102 & 1211 ltrs.Also forwards info from ACAP-9566, "Nuclear Design & Core Mgt of Facility."

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March 18, 1980
AEP:NRC:00297D

Donald C. Cook Nuclear Plant Unit No. 2
Docket No. 50-316
License No. DPR-74
Subject: Additional Support Data For Technical Specification Changes

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Denton:

Attachment A to this letter contains amended and additional data submitted in support of changes to the T-average Technical Specifications for Unit 2 of the Cook Plant discussed in our letters of November 2, 1979 (AEP:NRC:00297) and December 11, 1979 (AEP:NRC:00297A). These data were discussed with your staff in a conference call on February 5, 1980. Included in this attachment are corrected versions of page 14.0-16 and Figures 14.2.5-4 and 14.2.5-5. In addition, Figures 14.1.2-1 through 14.1.2-7 are attached. These figures relate to the analysis of uncontrolled rod withdrawal events and were inadvertently omitted from the original support data submittal. It is our understanding that the transmittal of this new information will allow the staff to complete its review of the proposed changes.

In our letter of February 12, 1980 (AEP:NRC:00297C) we committed to submitting a document containing information from WCAP-9566 ("The Nuclear Design and Core Management of the Donald C. Cook Unit 2 Nuclear Power Plant Cycle 2") which was used by the staff in evaluating recent changes to the power peaking limits of Unit 2. Attachment B to this letter contains that document. The submittal of this document will allow you to return WCAP-9566 to us as previously requested in our letter No. AEP:NRC:00297C.

Very truly yours,

John E. Dolan

John E. Dolan
Vice President

A001 s/1

JED:em

cc: Attached

P

8003250 517

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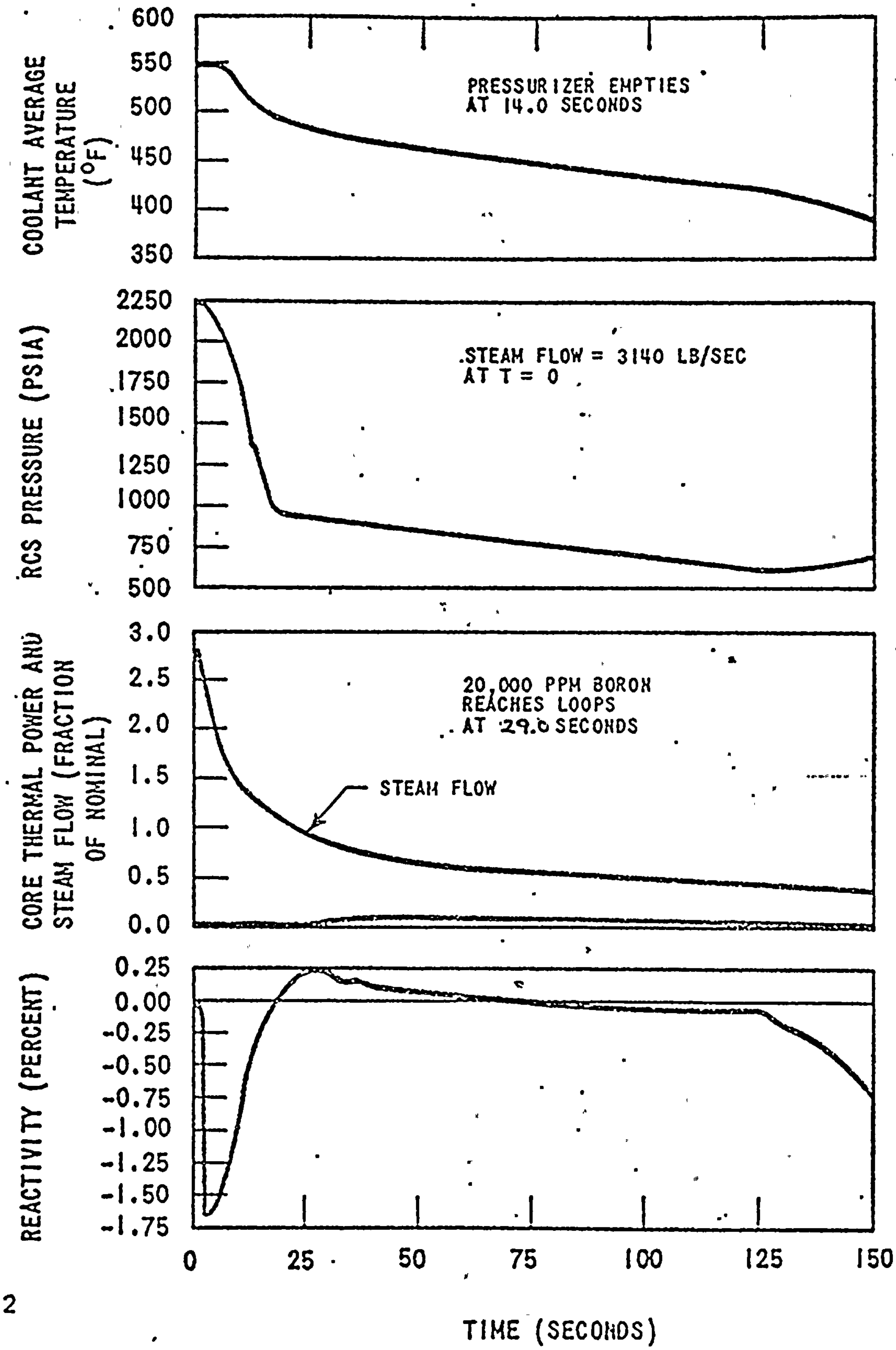
D. V. Shaller-Bridgman-w/attachment

Attachment A
To
AEP:NRC:00279D

TABLE 14.0-2 (Continued)

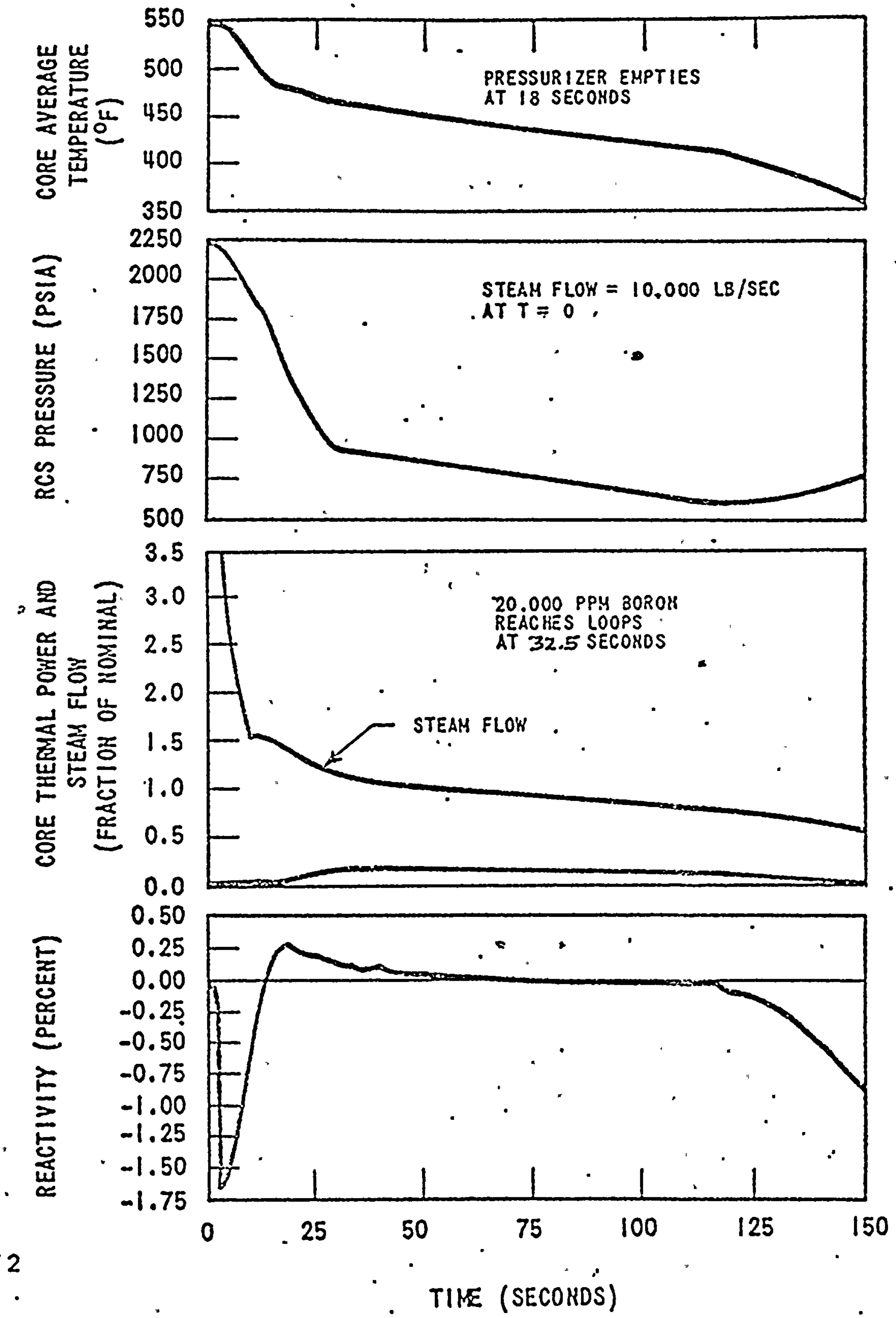
TIME SEQUENCE OF EVENTS

Accident	Event	Time (Seconds)
Rupture of a Steam Line		
1. Case A	Steam line ruptures	0
	Criticality attained	18
	Pressurizer empty	14
	20,000 ppm boron reaches loops	29.0
2. Case B	Steam line ruptures	0
	Criticality attained	13.5
	Pressurizer empty	18
	20,000 ppm boron reaches loops	32.5
3. Case C	Steam line ruptures	0
	Criticality attained	18.5
	Pressurizer empty	14
	20,000 ppm boron reaches loops	36.5
4. Case D	Steam line ruptures	0
	Criticality attained	14
	Pressurizer empty	18
	20,000 ppm boron reaches loops	39.5



UNIT 2

Figure 14.2.5-4 Steam Line Break Downstream of Flow Measuring Nozzle with Safety Injection and Outside Power (Case a)



UNIT 2

Figure 14.2.5-5 Steam Line Break at Exit of Steam Generator with Safety Injection and Outside Power (Case b)

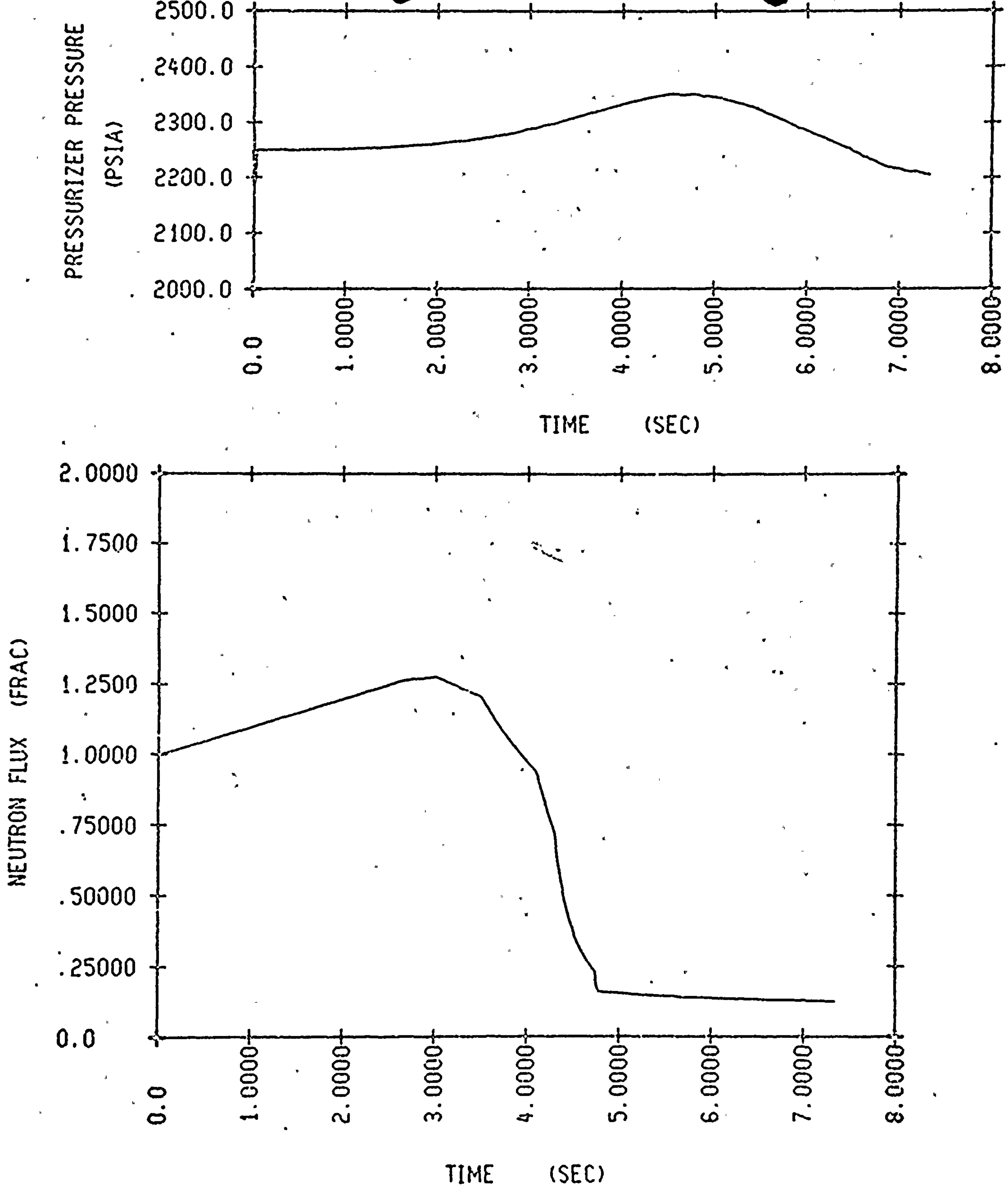
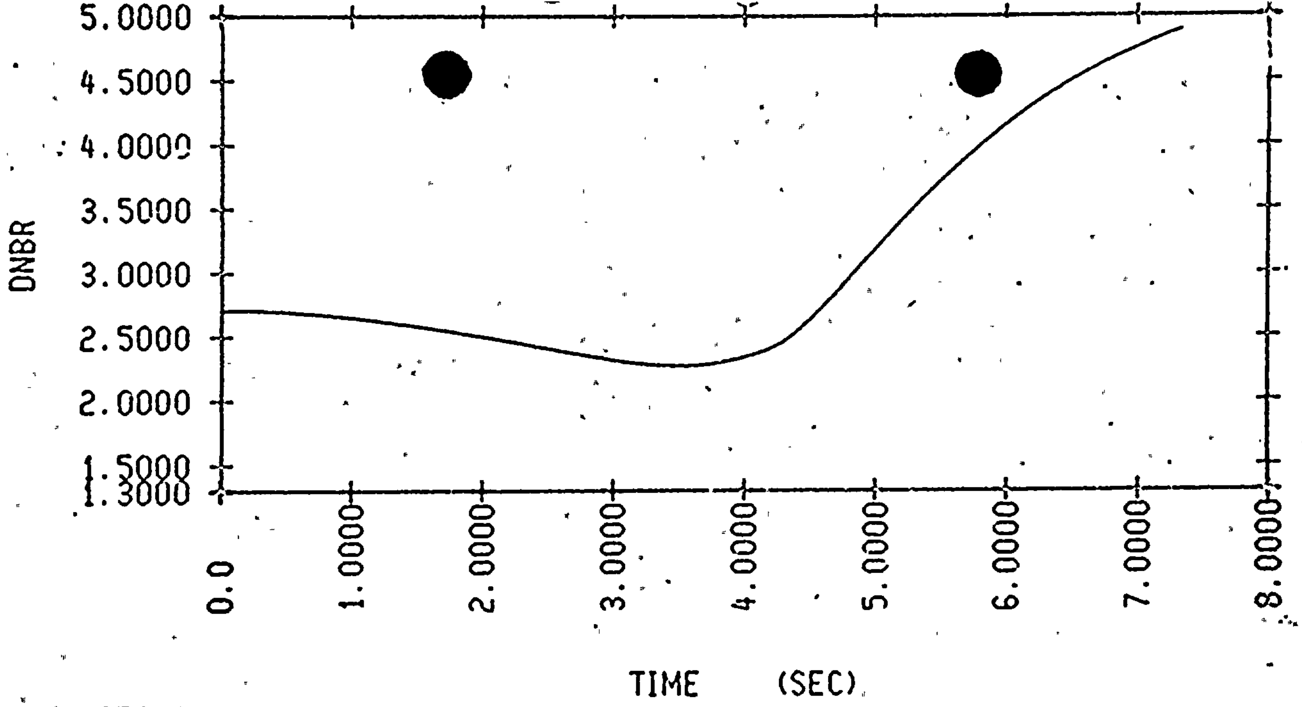


Figure 14.1.2-1 Pressurizer Pressure Transient and Nuclear Power Transient for Uncontrolled RCCA Bank Withdrawal from Full Power with Minimum Feedback and 70 PCM/SEC Withdrawal Rate



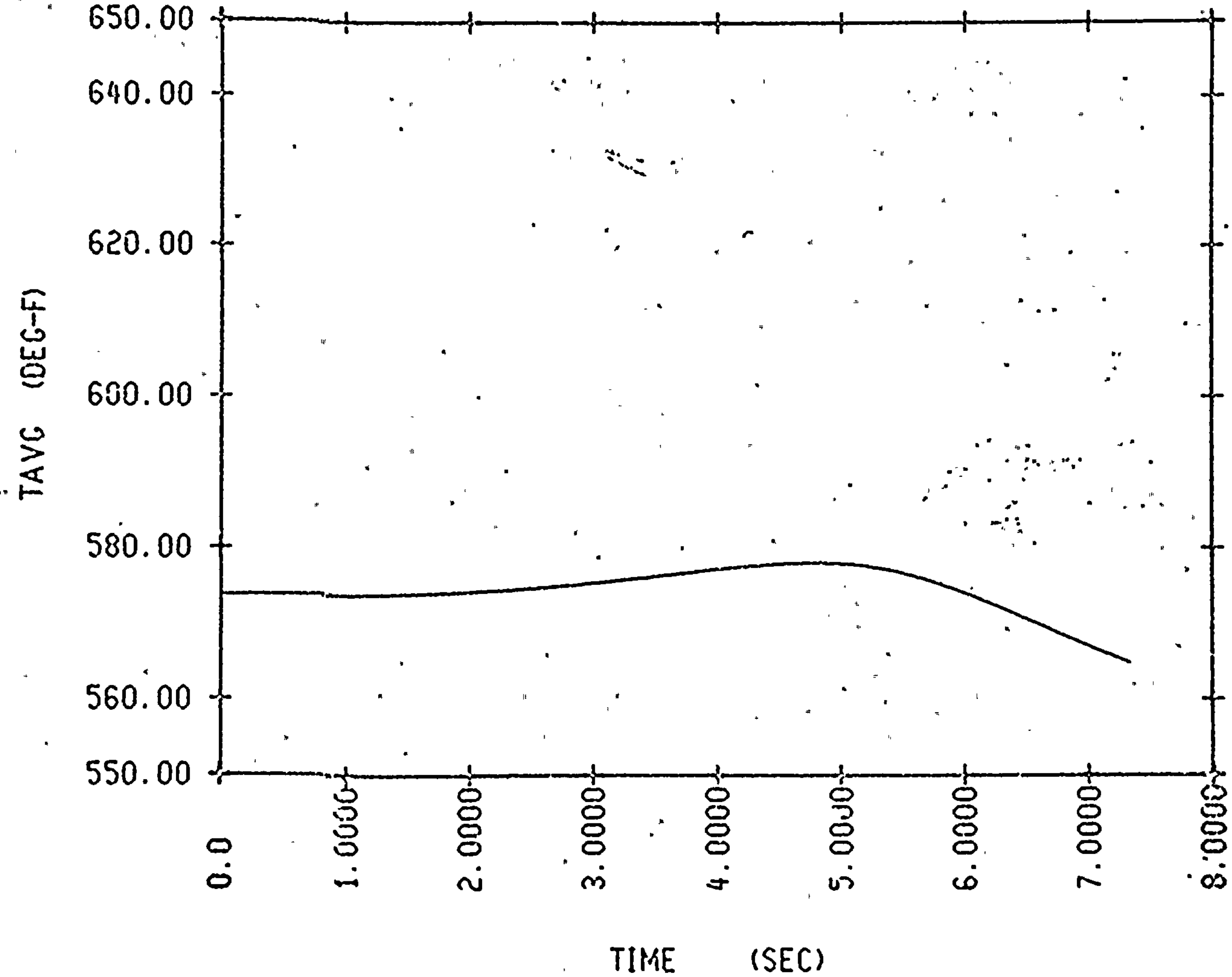


Figure 14.1.2-2 DNBR Transient and Core Average Temperature Transient for Uncontrolled RCCA Bank Withdrawal from Full Power with Minimum Feedback and 70 PCM/SEC Withdrawal Rate

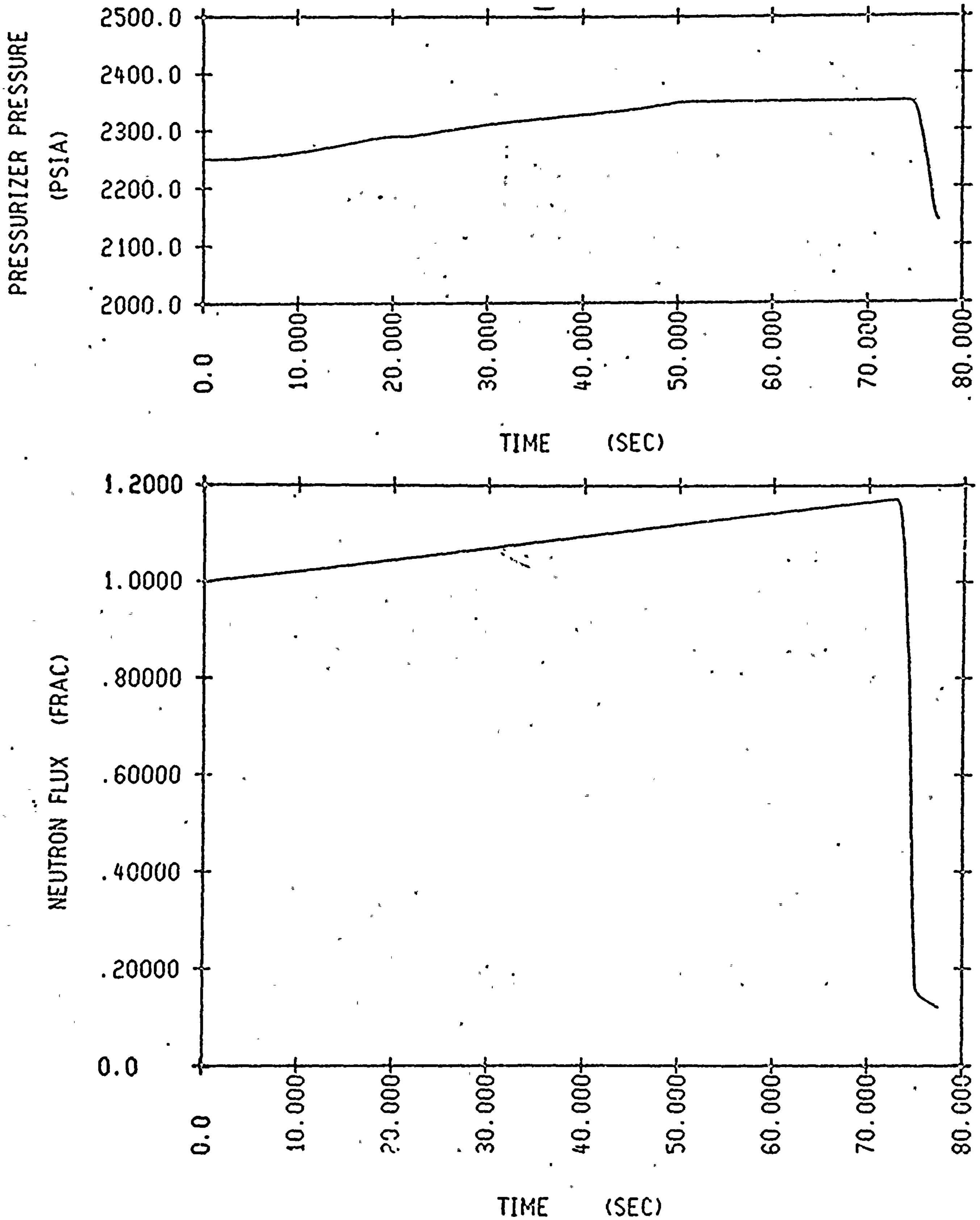


Figure 14.1.2-3 Pressurizer Pressure Transient and Nuclear Power Transient for Uncontrolled RCCA Bank Withdrawal from Full Power with Minimum Feedback and 2 PCM/SEC Withdrawal Rate

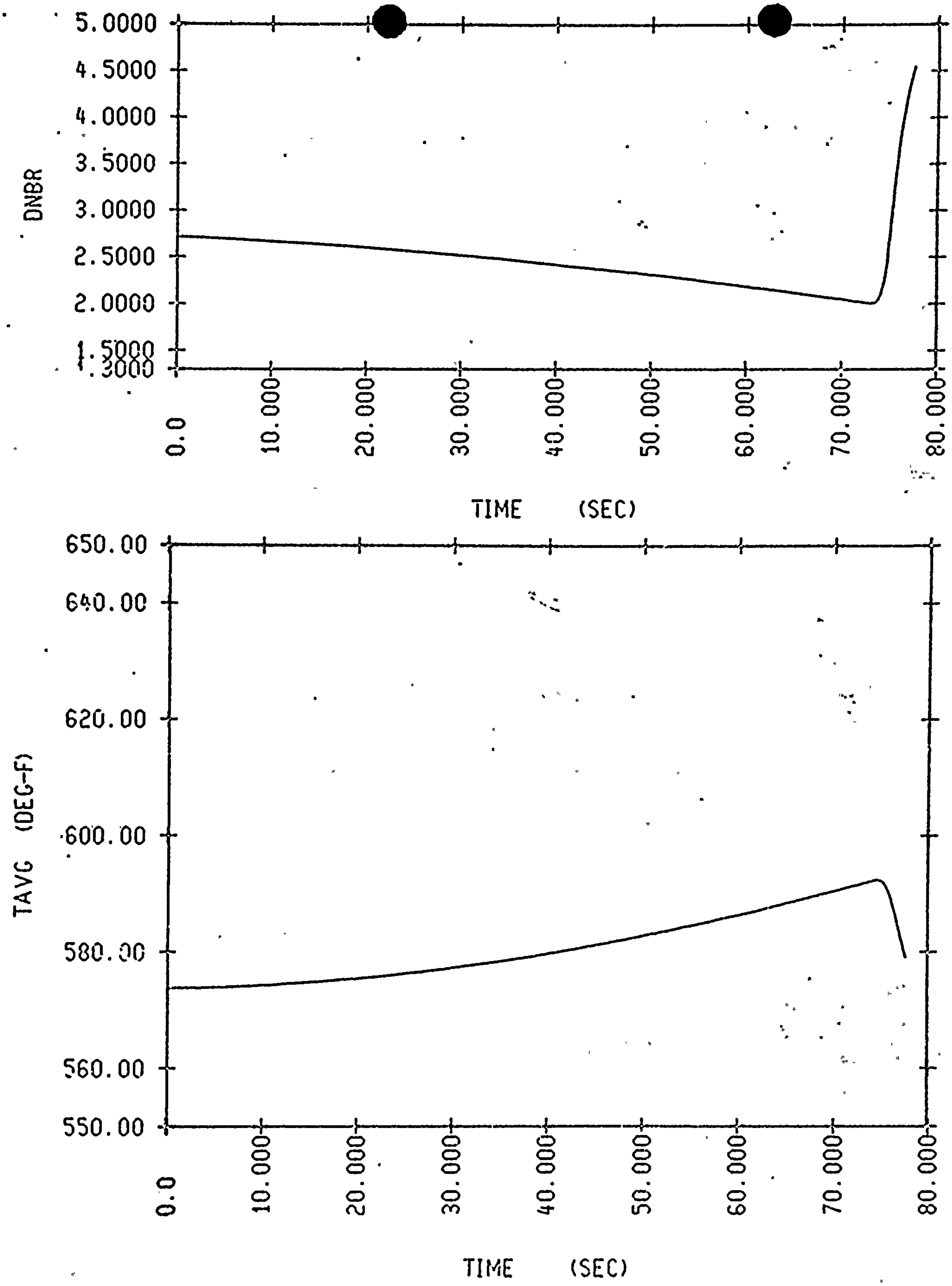


Figure 14.1.2-4 DNBR Transient and Core Average Temperature Transient for Uncontrolled RCCA Bank Withdrawal from Full Power with Minimum Feedback and 2 PCM/SEC Withdrawal Rate

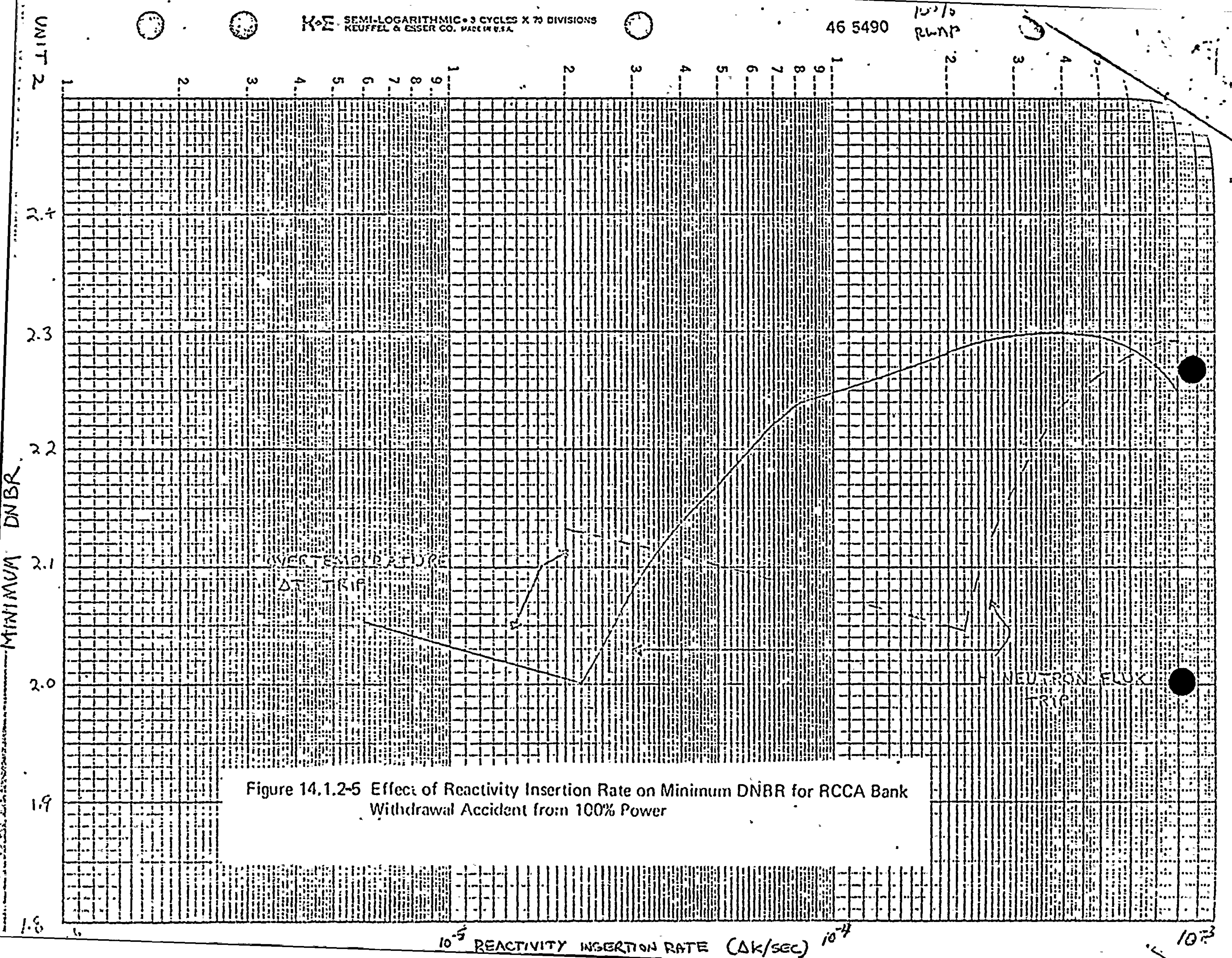


Figure 14.1.2-5 Effect of Reactivity Insertion Rate on Minimum DNBR for RCCA Bank Withdrawal Accident from 100% Power

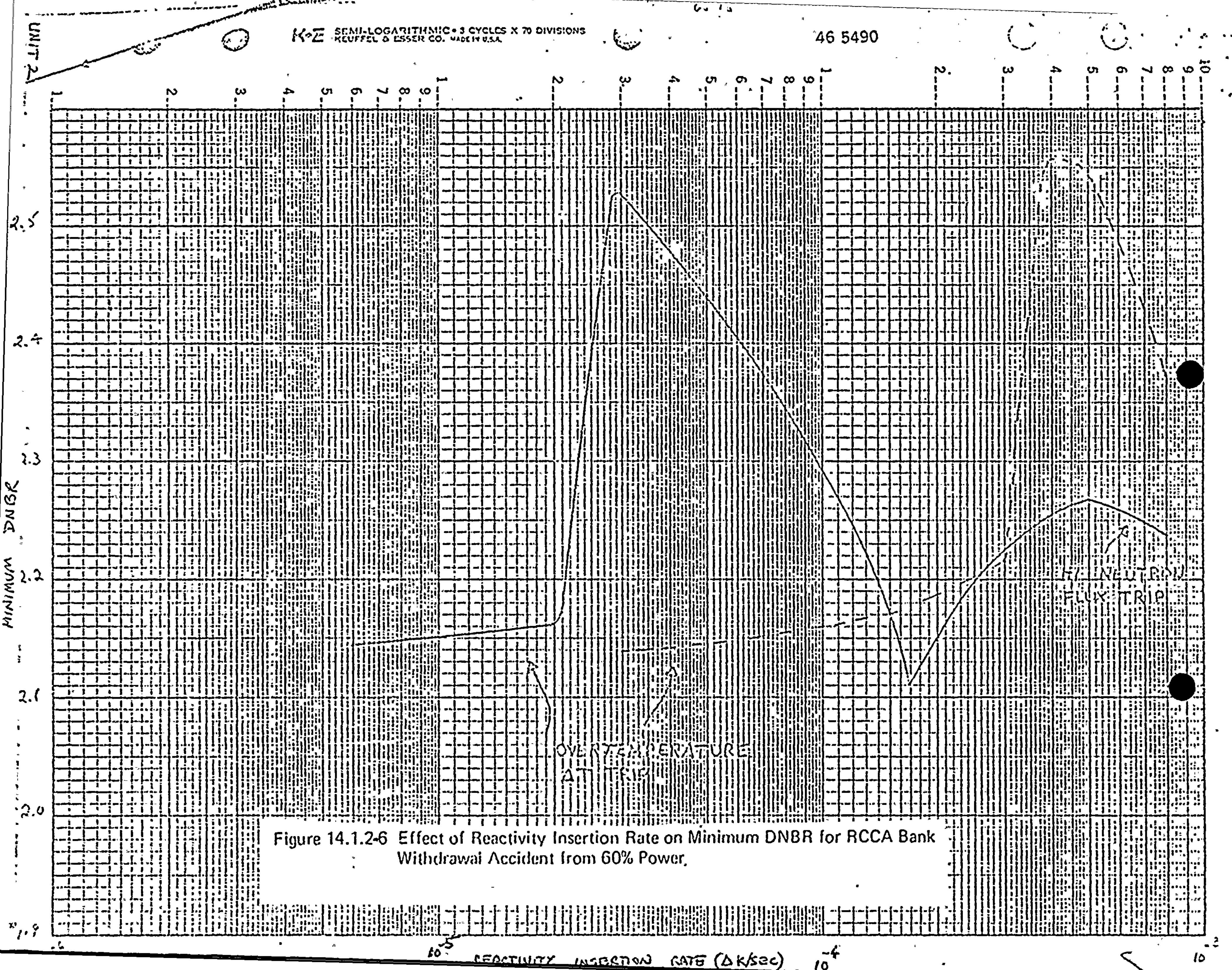


Figure 14.1.2-6 Effect of Reactivity Insertion Rate on Minimum DNBR for RCCA Bank Withdrawal Accident from 60% Power.

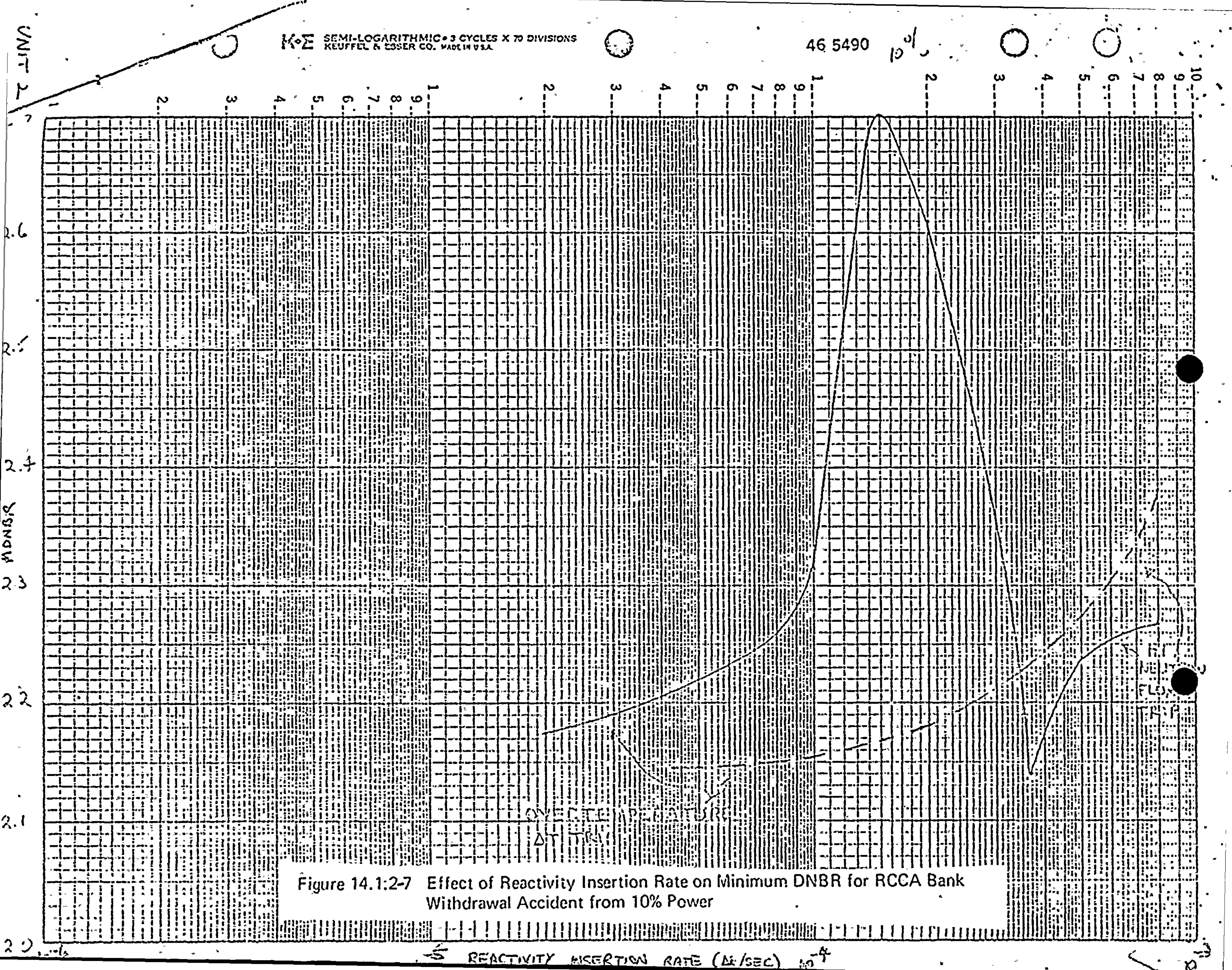


Figure 14.1:2-7 Effect of Reactivity Insertion Rate on Minimum DNBR for RCCA Bank Withdrawal Accident from 10% Power

Attachment B
To
AEP:NRC:00279D

CORE CAPABILITY
D. C. COOK UNIT 2 CYCLE 2

1. GENERAL

The power capability of a plant is governed by the control of core power distributions within the following limits:

1. Loss-of-coolant accident (LOCA) limits, thereby assuring adequate core cooling during postulated LOCA;
2. Departure from nucleate boiling (DNB) in anticipated transients, thereby preventing excessive clad temperature due to degradation of heat transfer from fuel to coolant;
3. Local power (kw/ft) limits during normal operation, thereby assuring clad stress and strain limits are met; and
4. Fuel melting in anticipated transients thereby preventing expansion during the phase change which might rupture fuel cladding.

Following the procedures outlined in the Technical Specifications, it is shown in this section that the core is capable of operating at 100% of rated power during Cycle 2.

2. CORE POWER CAPABILITY

The four design criteria listed above include both normal operation and anticipated transients. Normal operation also has a bearing on the LOCA limits since the power distribution during normal operation is assumed to be the initial condition for LOCA. Anticipated transients lead to the overpower conditions. The core is protected against overpower conditions by setpoints discussed later in this section.

2.1 Normal Operation

Local power density is related to the maximum operating power through the total peaking factor F_Q^T. For full power operation, it is necessary to maintain F_Q^T at an acceptable value during normal operation to satisfy LOCA and local power requirements. Both radial and axial power distributions determine the peaking factor F_Q^T. Radial power distributions are relatively fixed and easily bounded with upper limits while axial power distributions are controlled by well defined procedures as outlined

in Technical Specifications discussed in Reference 1. Following these procedures for D. C. Cook Unit 2 and studying different histories encountered during normal plant operation, F_Q^T is determined to be less than 2.11 as shown in Figure 1 for Cycle 2.

F_Q^T was determined by calculations performed for normal operation of the reactor including load following maneuvers. Beginning, middle and end of cycle conditions were included in the calculations. Different histories of operation were assumed prior to calculating the effects of load follow transients on the axial power distribution. These different histories assumed base loaded operation and extensive load following. The procedures specified in the Technical Specifications* are followed during the load follow maneuvers. These are:

1. Control rods in a single bank move together with no individual rod insertion differing by more than 13 steps (indicated) from the bank demand position;
2. Control banks are sequenced with overlapping banks;
3. The full length control bank insertion limits are not violated;
4. Axial power distribution procedures recommended by Westinghouse, which are given in terms of flux difference control and control bank positions, are observed.

The axial power distribution procedures referred to above are part of the required operating procedures which are followed in normal operation. Briefly they require control of the axial offset (flux difference/fractional power) at all power levels within a permissible operating band of a target value corresponding to the equilibrium full power value. The calculated target axial offset value varies through the life of the cycle in the range of +3% at its most positive value (at BOL, equilibrium xenon conditions) to about -4% at its most negative value (at about MOL). This minimizes xenon transient effects on the axial power distribution.

F_Q^T was calculated as a function of height by imposing various load follow transients on the reactor through the insertion and removal of Banks D and C, and considering the effects of the accompanying variations in the axial xenon and power distributions. Results of these calculations are shown for Cycle 2 in Figure 1. Only the limiting

*See Reference 1 for discussion.

values at each elevation are shown. The calculated points have been synthesized from axial calculations combined with radial factors appropriate for rodded and unrodded planes. The calculated values have been increased by a factor of 1.05 for conservatism and a factor of 1.03 for the engineering factor F_Q^E. As seen in Figure 1, F_Q^T x relative power is maintained below the value of 2.11 x K(Z). The densification spike penalty is not included in these calculations. The core height dependent function K(Z) is shown in Figure 2.

2.2 Overpower Requirements

Overpower protection prevents fuel damage and maintains fuel integrity during overpower transients caused by either operator errors or control rod malfunctions. The exact overpower protection setpoints are described in the Technical Specifications. To meet the overpower requirements, the linear power density during transients should not exceed 22.8 kw/ft limit.

Two categories of overpower transients are considered. The first category involves control rod malfunctions as well as operator errors in positioning full length control rods. Control rod malfunctions also include rod withdrawal accidents. The second category involves accidental boration and dilution accidents. These accidents are assumed to occur following any normal operations during any time in life and during normal load follow procedures. The results show that the linear power does not exceed 16.9 kw/ft during postulated overpower transients. Thus, the maximum linear power during overpower is significantly lower than the limiting value of 22.8 kw/ft.

3. CONTROL ROD INSERTION LIMITS

Restructions on full length rod insertion are necessary to maintain acceptable power distributions and to insure an acceptable DNB ratio under various core conditions.

3.1 Control Rod Operation Limits

Insertion limits for Cycle 2 are shown in Figure 3. These limits are determined so as to maintain acceptable power distribution during normal operation and acceptable consequences following a postulated rod ejection accident. They also

insure a minimum shutdown margin of 1.60% $\Delta\rho$ which is required to prevent return to criticality during the credible steambreak accident. A one hundred step overlap between control banks helps in maintaining acceptable power peaking during control rod motion.

3.2 Control Bank D Position for Normal Operation

The recommended position for D bank in steady state operation is at the "bite" position.. The bite position is the point of insertion which just provides a differential rod worth of 2×10^{-5} $\Delta\rho$ per step. In a reload fuel cycle this will change from about 220 steps withdrawn to about 225 steps withdrawn through the cycle.

Temperature control is still adequate at the bite position. Should an unscheduled rapid load rejection occur the differential worth available at bite is adequate for the control systems to respond as designed. The consequences of withdrawing the rods farther than the bite position are quite minor since so little travel is involved and this may be necessary if the low insertion limit alarm is set very high.

The apparent advantages of leaving rods farther inserted than the bite position are outweighted by the disadvantages. The ability to add core reactivity quickly by withdrawing rods is not required during long term steady state operation. The ability to change flux difference in the positive direction is similarly not required, indeed the flux difference is more stable with the rods fully withdrawn.

The major disadvantages of operation with rods more deeply inserted than the bite position result from the "shadowing" of fuel burnup in the top of the core. This leads to relatively worse axial power distributions in the subsequent fuel cycles and will restrict the permissible flux difference operating band. A small effect is a loss of reactivity and therefore of cycle lifetime in the current cycle due to less than optimum axial burnup distribution. Further, the consequences of amny accidents are actually worst starting from deep rod insertion, even though these worst cases have already been assumed in the accident analysis.

References

1. T. Morita, et. al., "Topical Report - Power Distribution Control and Load Following Procedures," WCAP-8403 (Non Proprietary), September, 1974.

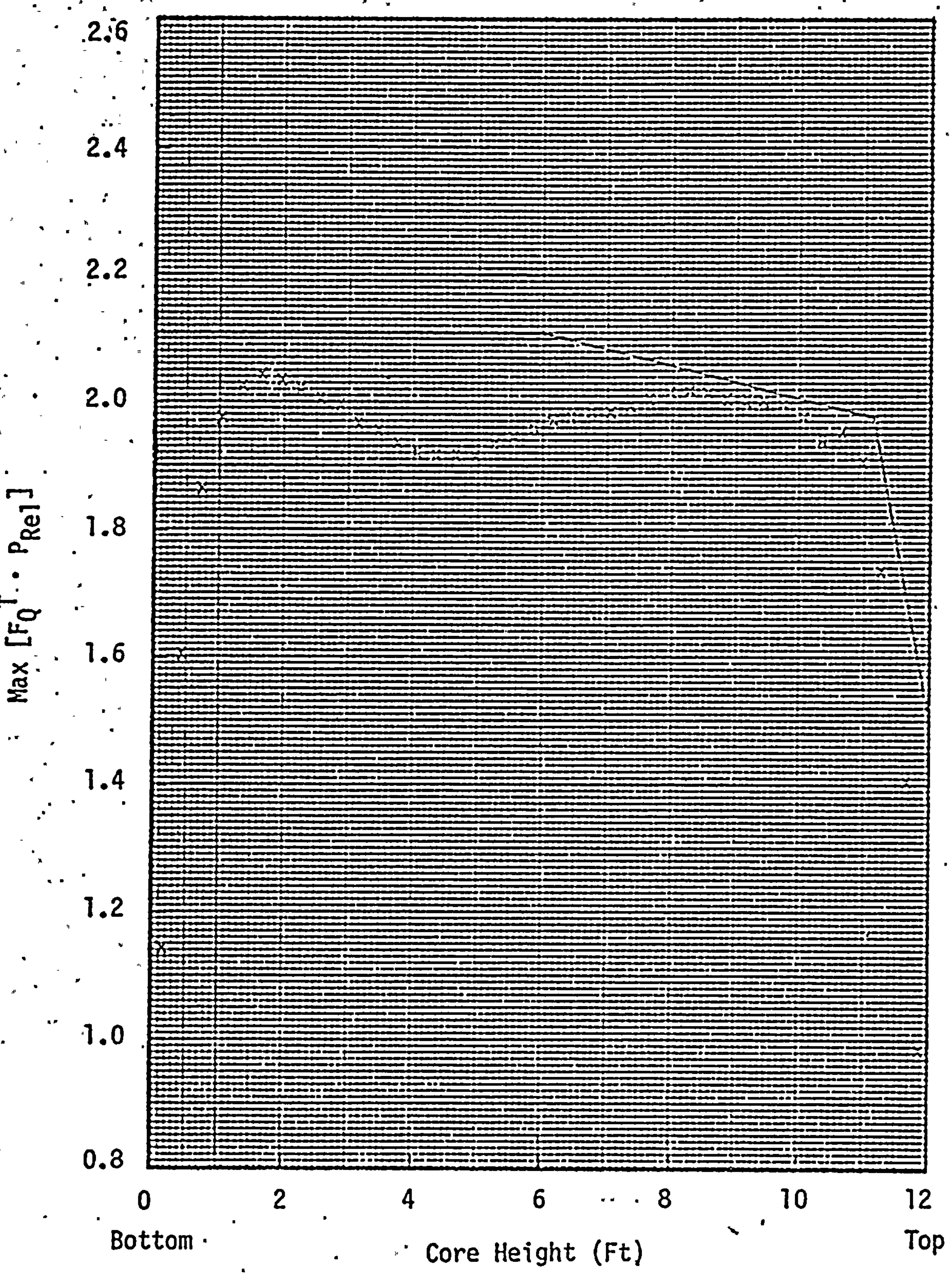


Figure 1 Maximum $F_Q^T \cdot P_{Rel}$ vs. Axial Core Height During Normal Core Operation

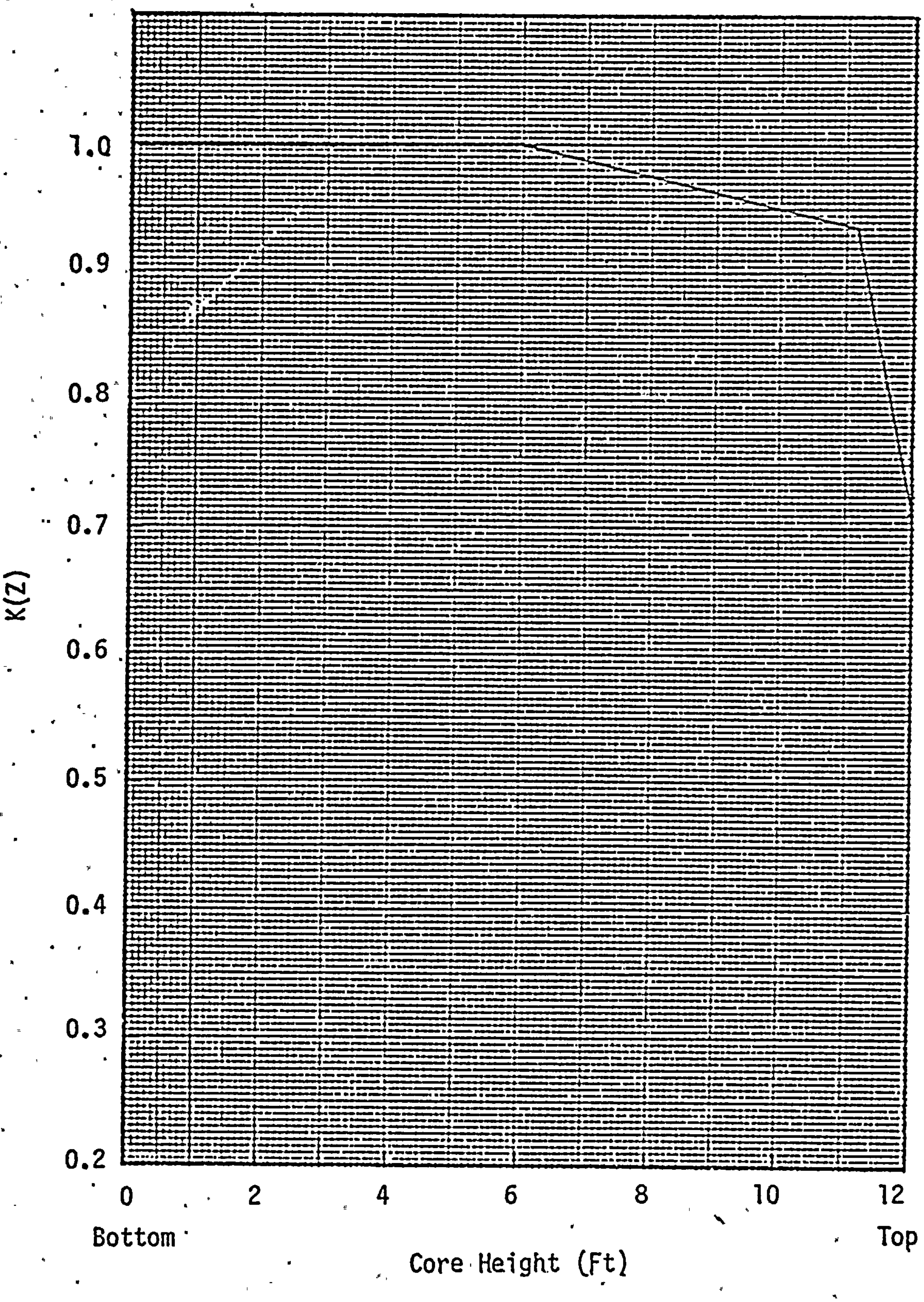


Figure 2 F_Q^T Normalized Operating Envelope, K(Z)

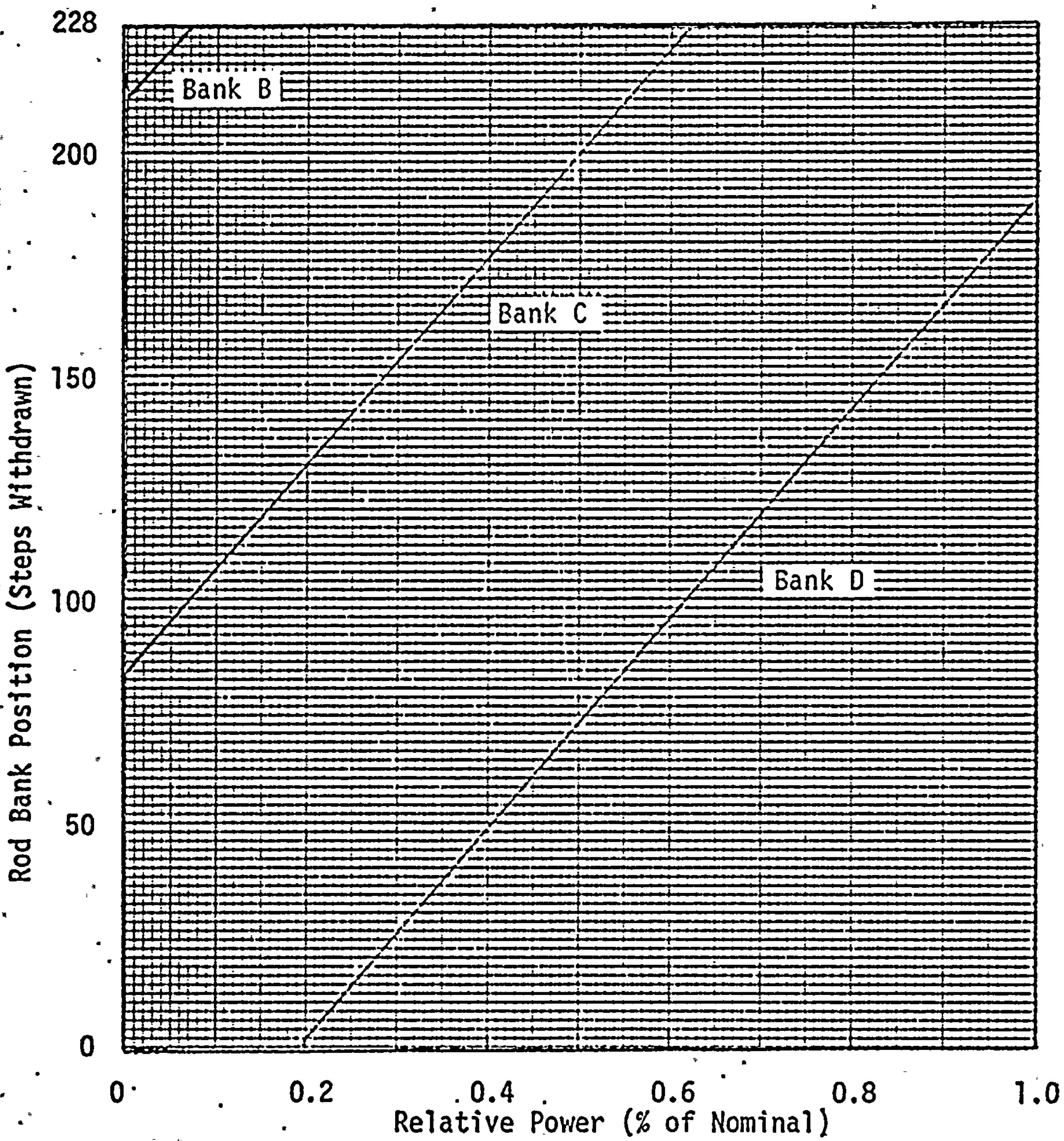


Figure 3 - Control Rod Insertion Limits
As A Function of Power