PALO VERDE NUCLEAR GENERATING STATION
UNIT 1

DOCKET STN 50-528

CEN-297(V)-NP Rev.1-NP

RESPONSE TO NRC QUESTIONS ON PVNGS-1 REV. 01 CPC SOFTWARE

FEBRUARY 1985

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INTRODUCTION

During the NRC review of the PVNGS-1 Revision 01 CPC software, four questions arose. The answers to these NRC questions were discussed in a meeting between the NRC staff, ANPP, and C-E on February 6, 1985. This document provides the formal responses to the NRC questions.

PVNGS-1, CYCLE 1

RESPONSE TO NRC REQUEST FOR ADDITIONAL CPC INFORMATION

ROUND #1

Question 1

CEN-251(V)-P, Revision 1, "PVNGS-1 Cycle 1 CPC and CEAC Data Base Listing," provides the values of flow constants associated with flow resistances through the core, pump line and steam generator, and curve fit coefficients for pump characteristics. Those values are different from the values provided in Revision 0 of CEN-251(V)-P. It is indicated that these values were amended to reflect design modifications to the reactor coolant pump. Provide your analysis to show the correctness of the flow constants in the Revision 1 of CEN-251(V)-P.

Response

As a result of design modifications to the reactor coolant pumps, pump characteristics, such as pump head, changed. Although these changes were not significant, it was determined to revise the flow constants to be consistent with the revised characteristics. Figures 1 through 4 show the change in pump head for four PVNGS reactor coolant pumps. These curves have been evaluated and it has been determined that they are representative of the pump head characteristics for the 12 PVNGS reactor coolant pumps.

The effect of these changes was to alter slightly certain pump-related flow constants. The differences in the constants are shown in Table 1. In the revised flow constants analysis, which followed the same format as for the original constants, the constants were also evaluated for various pump-coastdown configurations. The results indicate that the calculated coolant mass flow rates between the two versions are approximately the same. An example of this is shown in Table 2, which is a comparison of the 4-pump coastdown case.

TABLE 1

CONSTANTS BASED ON PUMP CHARACTERISTICS

Parameter		Rev. 00 Value	Rev. 01 Value
Core Flow Resistance			
Pump Line Forward Resistance			
Pump Line Reverse Resistance			
Steam Generator Forward Resistance			
Steam Generator Reverse Resistance			
Curve Fit Coefficients:	AA1		
	AA2		
	AA3		
	AA4		
	AA5		
	AA6		
	AA7		
	AA8		
	AA9		
	AA10		
Inverse Inertial Coefficients			

TABLE 2
COMPARISON OF 4-PUMP COASTDOWN

	Rev. 00		Rev. 01	
Time (sec)	Core Flow	Design Flow*	Core Flow	Design Flow*

*Based on reactor coolant pump coastdown analysis using the COAST code.

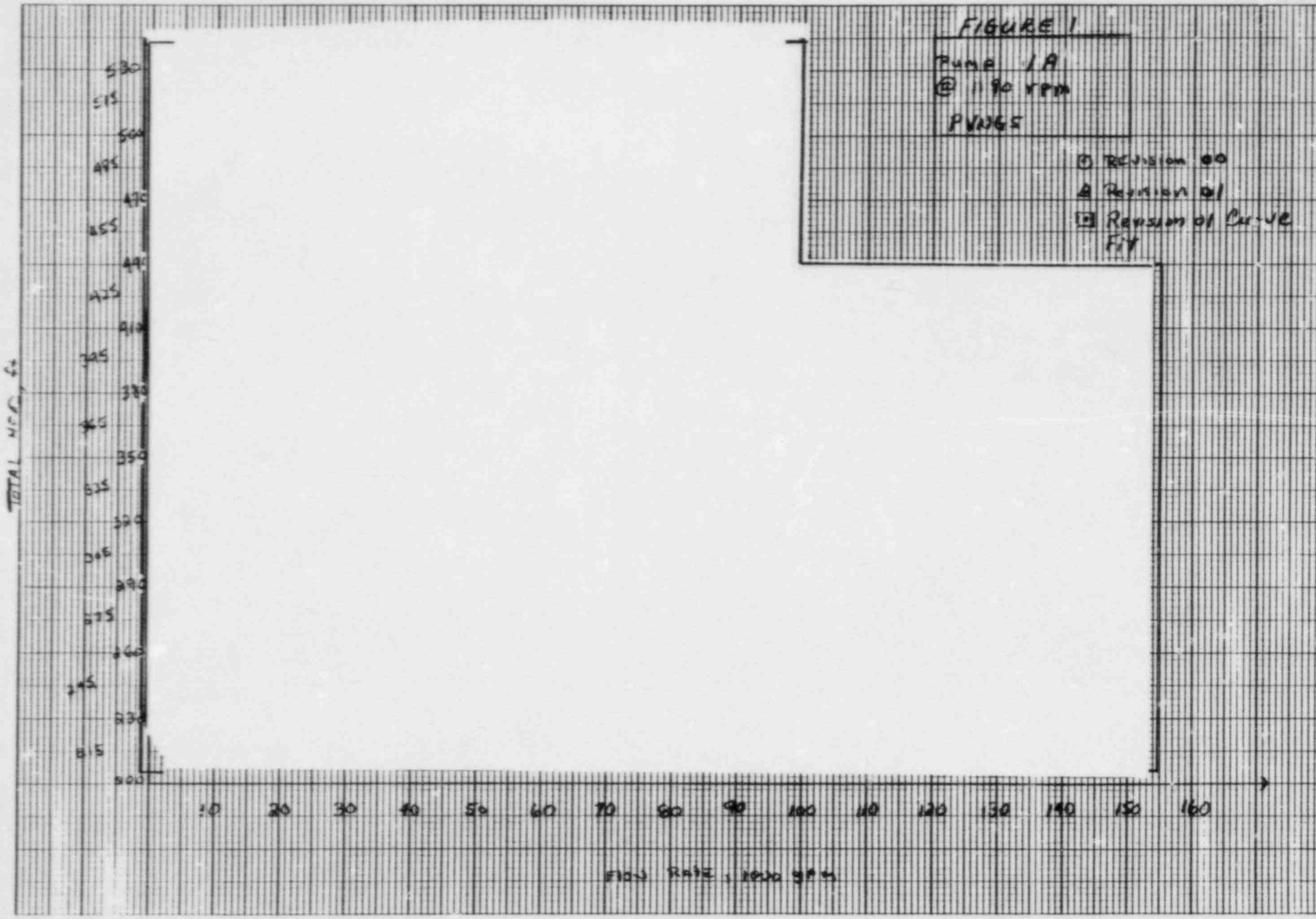


FIGURE 1
Pump 1A
@ 1190 rpm
PVNGS
Revision 00
Revision 01
Revision of Curve Fit
TOTAL HEAD, ft
530
515
500
485
470
455
440
425
410
395
380
365
350
335
320
305
290
275
260
245
230
215
200
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
FLOW RATE, 1000 gpm

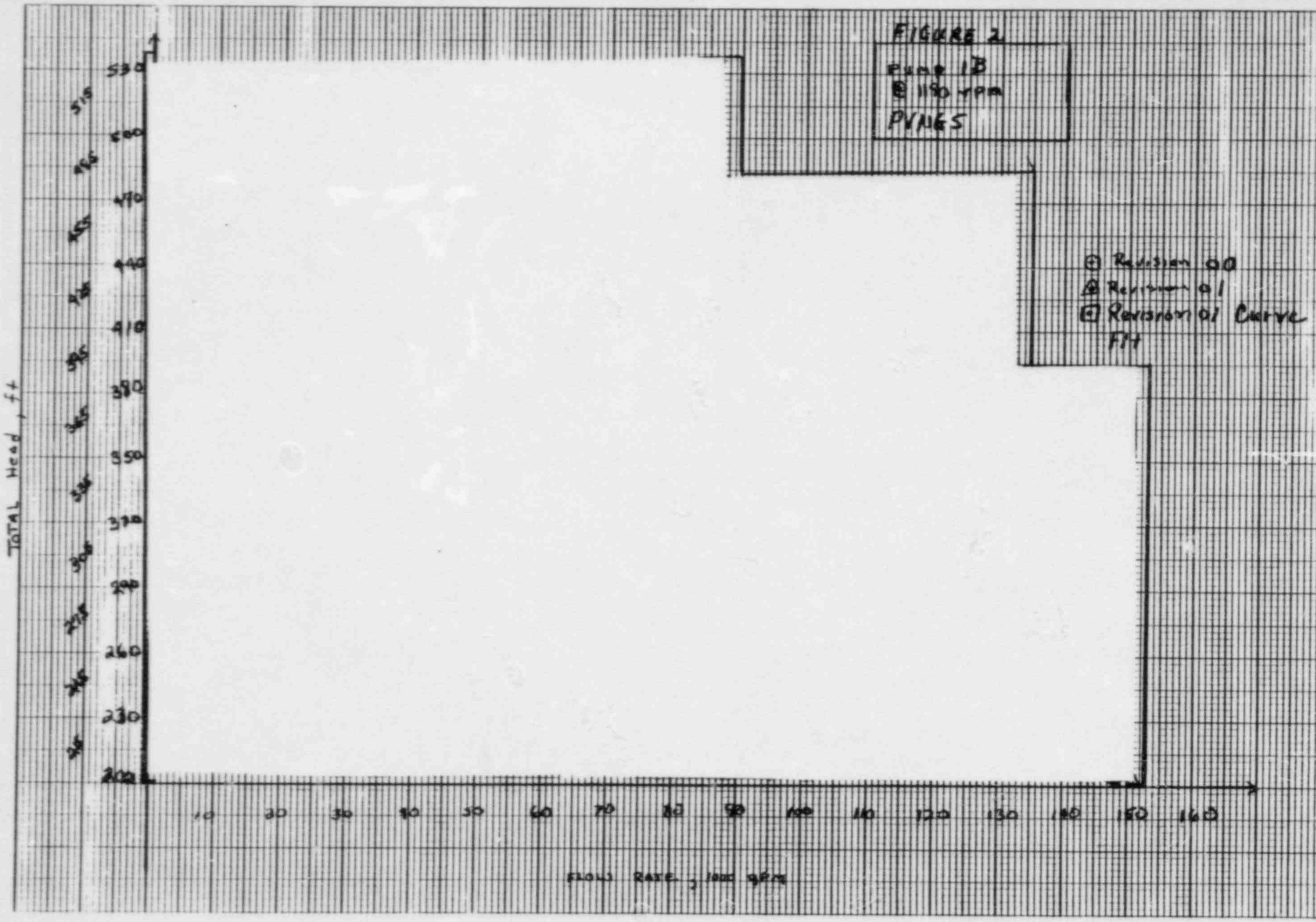


FIGURE 2
Pump 1B
@ 1190 rpm
PVNGS
⊙ Revision 00
△ Revision 01
⊡ Revision 01 Curve Fit
TOTAL Head, ft
530
500
470
440
410
380
350
320
290
260
230
200
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
FLOW RATE, 1000 gpm

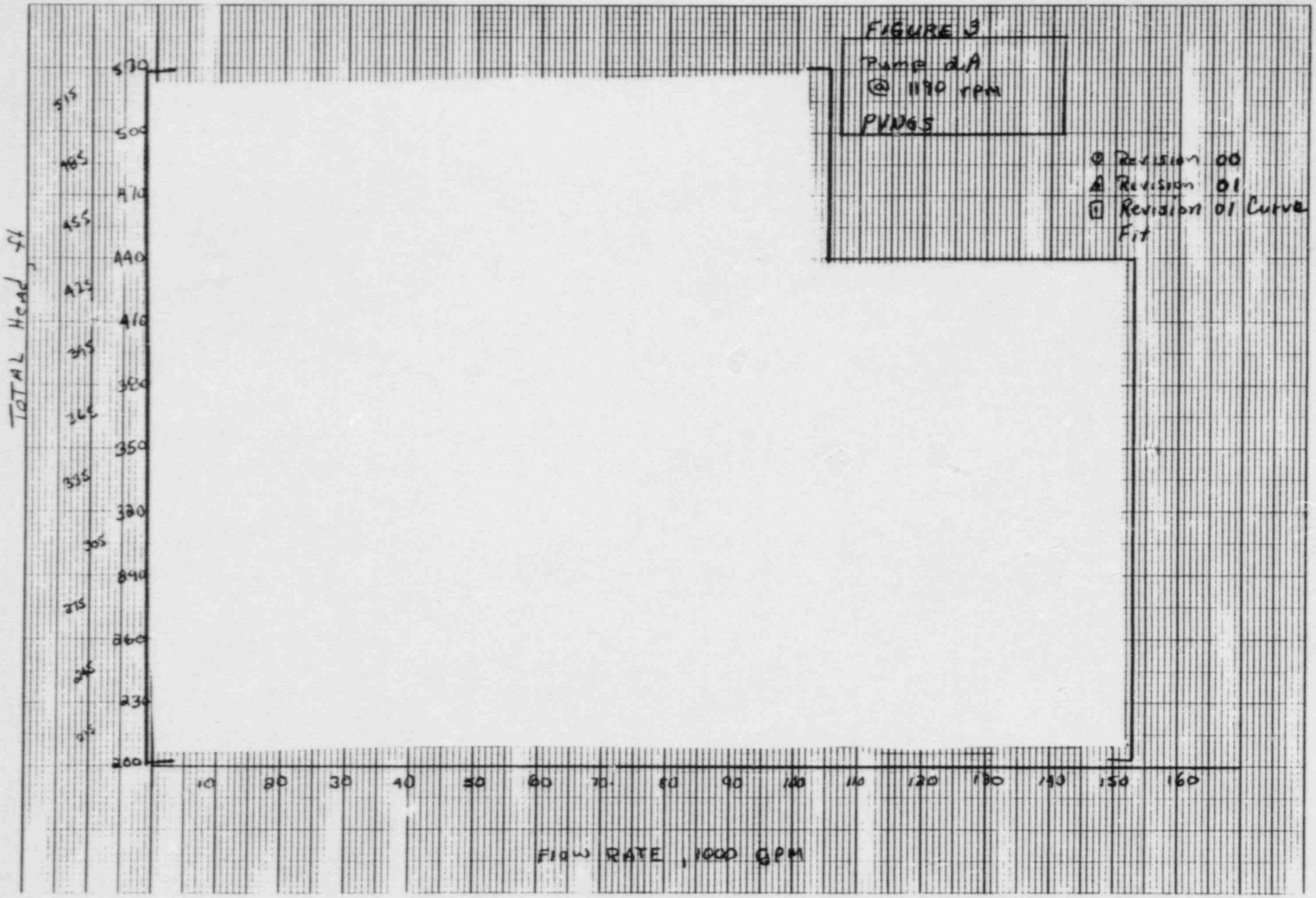


FIGURE 3
Pump 2A
@ 1190 rpm
PVNGS
Revision 00
Revision 01
Revision 01 Curve Fit
TOTAL Head, ft
530
500
470
440
410
380
350
320
290
260
230
200
515
485
455
425
395
365
335
305
275
245
215
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
FlOW RATE, 1000 GPM

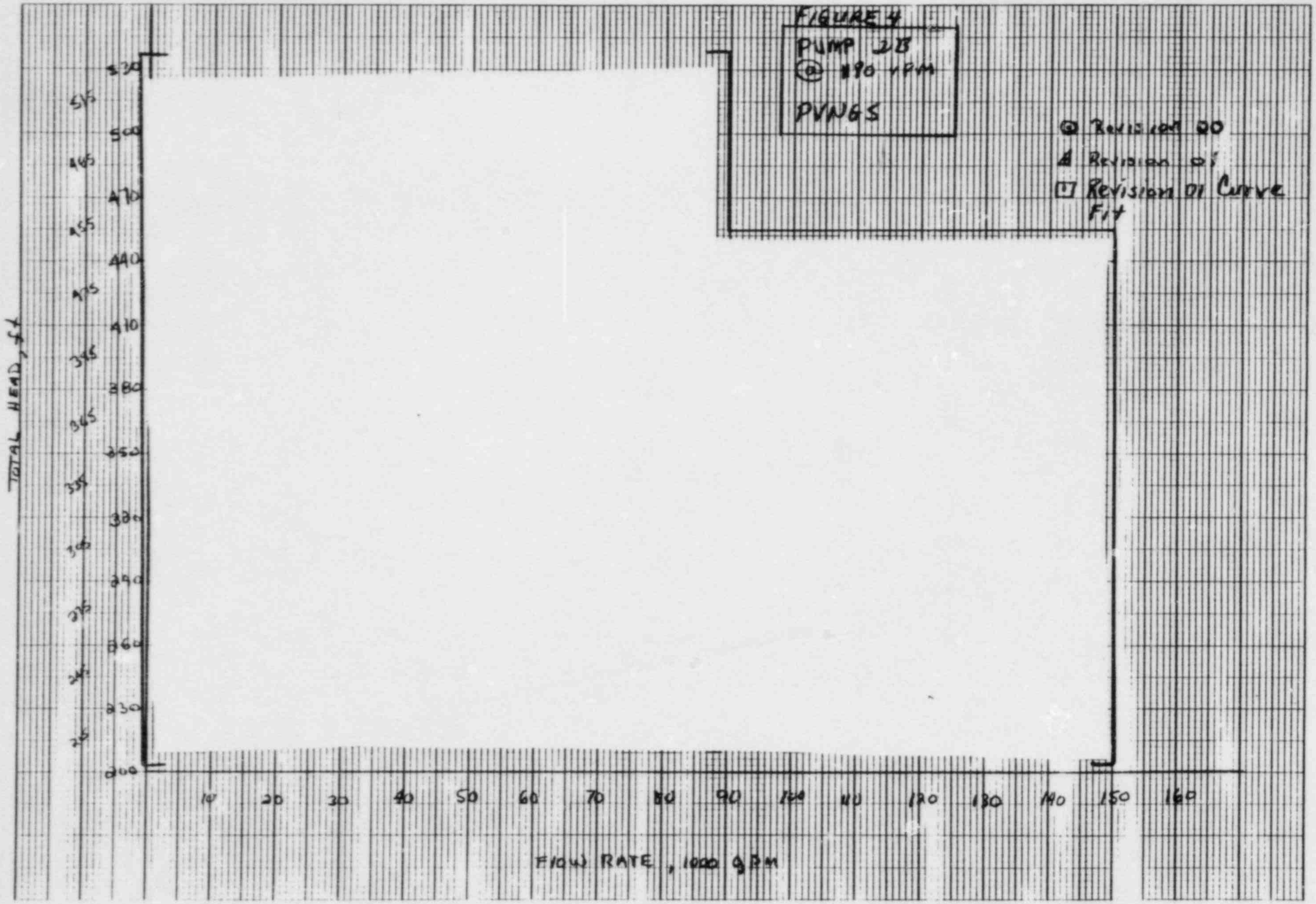


FIGURE 4
PUMP 2B
@ 890 rpm
PVNGS
Revision 00
Revision 01
Revision 01 Curve Fit
TOTAL HEAD, ft
530
500
470
440
410
380
350
320
290
260
230
200
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
FLOW RATE, 1000 gpm

Question 2

The values in Revision 1 of CEN-251(V)-P for the maximum DNBR and LPD (local power density) penalty factors, PF_{MAXD} and PF_{MAXL}, and DNBR and LPD penalty factors for CEAC out of service, PF_{PRD} and PF_{PRL}, are lower than those listed in the Revision 0. As indicated in E. E. VanBrunt's letter of December 3, 1984, the lower PF values reflect the action requirement in Action 6 of Table 3.3-1 of Technical Specification 3.3.1 where a power reduction of 15 percent is required within one hour of CEA misalignment with both CEACs out of service. Provide your analysis to show that the PF reduction accompanied with the required power reduction provides adequate protection with respect to the DNB and fuel melt limits.

Response:

When both CEACs are declared inoperable, Action 6 of Table 3.3-1 of Technical Specification 3.3.1 requires that lead control rod bank insertion be limited to no more than 15% inserted. Penalties are applied to COLSS (Figure 3.3-1) and to CPC (PF_{PRD} and PF_{PRL}). In addition, action 6.b.4 requires a power reduction of 15% of the initial power within one hour following a CEA misalignment.

The calculations of the Revision 1 penalty factors credited the power reduction now required by the Technical Specifications. The component in the CPC CEA deviation penalty factors due to xenon redistribution, therefore, was reduced.

PF_{MAXD} is the maximum possible CEAC DNBR penalty factor. PF_{MAXL} is the maximum possible CEAC LPD penalty factor. These penalties would be applied if both CEACs failed.

PF_{MAXL} has not been changed for Revision 1. PF_{MAXD} was determined to be [ ] for Revision 1 as a result of the CEAC sensitivity study.

With both CEACs out of service, the CPCs would not detect the withdrawal of a single CEA. However, the PF_{PRD} and PF_{PRL} penalties ensure that the radial peaks used in the calculation of DNB and LPD are conservative.

The maximum increase in planar radial peaking resulting from a single CEA withdrawal was calculated by 3-D ROCS to be less than [ ]. This increase is bounded by the PF_{PRL} of [ ]. PF_{PRL} was reduced from the Revision 0 value for the follwoing two reasons: 1) a [ ] reduction resulted from the use of 3-D ROCS rather than 2-D ROCS to calculate core peaking during CEA misalignment, and 2) a [ ] reduction resulted from removal of the xenon redistribution factor.

C-E's thermal hydraulics code was used to find the effect on DNB overpower of the increased peaking calculated by ROCS. PF_{PRD} was calculated conservatively to be [ ] PF_{PRD} was reduced from the Revision 0 value for the following two reasons: 1) a [ ] reduction resulted from the use of 3-D ROCS rather than 2-D ROCS to calculate core peaking during CEA misalignment, and 2) a [ ] reduction resulted from removal of the xenon redistribution factor.

In contrast to the Revision 0 calculation, no penalty component was applied in Revision 1 to PF_{PRL} and PF_{PRD} to account for xenon redistribution. Instead a Technical Specification power reduction of 15% of initial power is required. This reduction is sufficient to account for the maximum one-hour xenon redistribution during any CEA misalignment.

Question 3

The CEA inward deviation PFs listed in the Revision 1 of CEN-251(V)-P are 1.0. The reduction of those PFs from the original values is in connection with the added restrictions in the approved Technical Specifications where CEA insertion limits are imposed in Technical Specifications 3.1.3.1 and 3.1.3.6 and a power reduction for CEA deviation event is required per Figure 3.1-2B. A similar PF reduction has been approved for San Onofre Units 2 and 3. During our review of the Palo Verde Technical Specifications, the staff was told that a plant specific analysis was performed in this regard.

Provide your analysis showing that the CEA insertion limits and power reduction specified in the Technical Specifications provide adequate protection that the specified acceptable fuel design limits on DNBR and PLD will not be violated using the reduced PFs.

Answer 3

The reduction of some inward CEA deviation penalty factors to [ ] will not provide a CPC generated reactor trip for these particular CEA drop events. The analysis in FSAR Chapter 15.4.3 shows an approach to the DNB SAFDL without generation of a reactor trip in the event of a single CEA drop. This analysis is still valid and the results given are limiting for the reduced penalty factors.

The basis for the reduction of the inward CEA deviation penalties to [ ] is the ability to credit the Required Overpower Margin (ROPM) reserved in COLSS. The COLSS system preserves sufficient margin in terms of core flow (i.e., biasing the steady state flow by a multiplier) to the DNB SAFDL so that DNB would not occur during any AOO. The four pump loss of flow event is the most limiting such event and determines the minimum required margin. This margin, is equivalent to a penalty multiplier on core power of at least [ ], although more margin is reserved at most conditions. The core flow multiplier (Under Flow Fraction) for PVNGS-1 Cycle 1 is [ ] within the COLSS range of ±.3 ASI. The CEA deviation penalty factors are reduced to [ ] only for those cases where the ROPM is sufficient to accommodate the particular static deviation penalty factor and 10 minutes of xenon penalty. After 10 minutes a power reduction in accordance with Figure 3.1-2B of the Technical Specifications is required to accommodate the remaining xenon penalty for 1 hour. The penalty factors that cannot be accommodated by this method are not reduced from the Values in CEN-251(V)-P revision 0.

Typically, the CEA deviation penalty factors are larger for operation at heavier rod insertion, only allowed at less than full power. At these lower power levels, the margin set aside by the Under Flow Fraction to accommodate the LOFA event may be insufficient to completely compensate for the increased penalty factor. Since the CEA deviation penalty factor is calculated from the change in POL due to the deviation, this excess margin requirement can be set aside through the COLSS POL bias term. The COLSS Power Operating Limit (POL) bias term automatically sets aside thermal margin in the COLSS system. It is implemented as a function of core power level. The following equation illustrates its use in COLSS:

$$POL_{COLSS} = POL_{ACTUAL} - DPOL$$

Where:

POL_{COLSS} = POL displayed to the operator and used to test against alarm limits.

POL_{ACTUAL} = actual POL calculated by COLSS for present conditions of power shape, flow, temperature, etc..., and

DPOL = COLSS POL bias term which is a function of power.

Figure 1 shows the values of DPOL implemented in Palo Verde. The magnitude of the DPOL term would encompass any excess margin requirement needed for a CEA drop or withdrawal event without compromising the plant's power capability.

For a single PLR drop it is possible that a power increase will occur. In order to accommodate this effect the part-length CEA is restricted to the insertion limit shown in Figure 3.1-2A in the technical specifications. This

PLCEA insertion restriction will prevent a positive reactivity insertion for a single PLR drop at all power levels above 50% power. Single PLR drops from allowed positions below 50% power will have a positive reactivity insertion due to the drop of less than [ ]$\Delta\rho$ starting from an initial worst case negative ASI within the LCO space. For PLR drops from power levels above 50% power the minimum [ ] ROPM set aside for the 4 pump loss of flow accident is more than adequate to accommodate the power redistribution due to a PLR drop since there is no power increase. For PLR drops from power levels below 50% power, the minimum [ ] ROPM is augmented by margin available due to the low initial power. The minimum power at which POL can be reached in the LCO space has been demonstrated to be at least [ ] of rated power. Thus the actual ROPM available to accommodate a PLR drop from below 50% power is at least

[( )] ([ ] power)/(50% power) = [ ]

This is sufficient to accommodate the power increase from a PLR drop with positive reactivity insertion in conjunction with a hypothetical [ ] $\Delta\rho$/°F MTC.

When COLSS is out of service a separate PDIL will restrict rod motion to the short term insertion limits. In addition, the COLSS out-of-service DNBR limit specification limit curve (Figure 3.2-2) should not be violated. This DNBR limit specification preserves the ROPM when COLSS is out of service. At power levels above [ ] of rated power the ROPM reserved along with the PDIL restriction and the power reduction curve is sufficient to accommodate the modified single CEA inward deviations. Thus no further analysis is required at these power plateaus. At power levels below [ ] of rated power the single CEA drop penalty factors are typically larger than those at above [ ] power. The restricted PDIL, by limiting the number of CEA configurations to be analyzed will reduce the penalty factor. Also, the increased margin available at lower powers can be used to offset the penalty factors. Below [ ] power it has been determined that the plant cannot be at a POL. Thus the actual ROPM available below [ ] of rated power will be as follows:

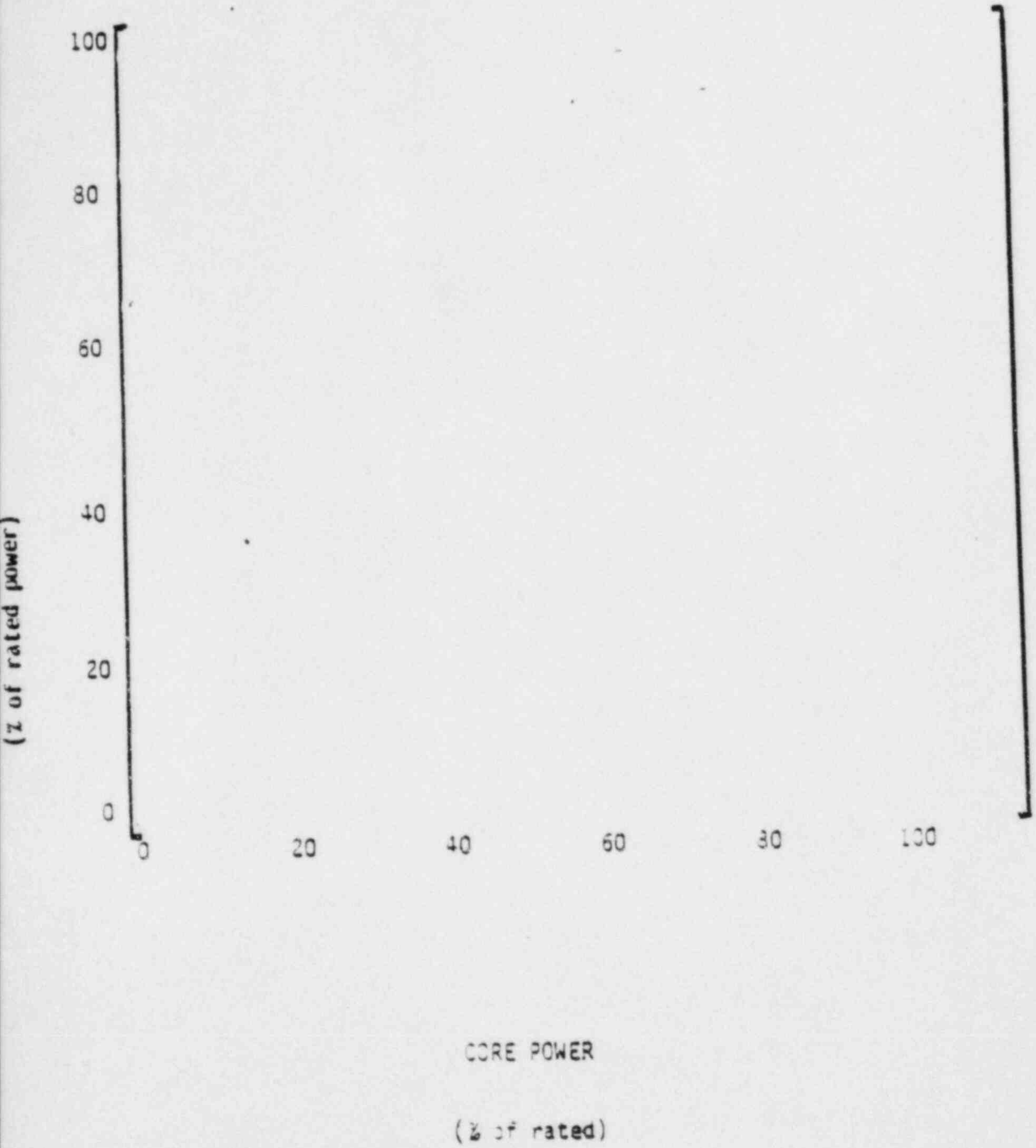
$ROPM_{available}$ = [ ] ([ ] power)/(x% power)

where:

x = core power level

This additional ROPM availability will adequately compensate for the CEA deviation penalty factors below [ ] of rated power.

Figure 1: Values of the COLSS POL bias term (DPOL) implemented in Palo Verde .



Question 4

Provide a more detailed description with regard to the proposed EXECUTIVE changes for power-up and CEAC display problems.

Response

The EXECUTIVE changes made in the Rev. 01 CPC Software does not have an effect on safety. Previous information on these changes was provided in ANPP's letter of December 3, 1984 to the staff. However, the following additional data is provided for your information.

Power-up:

In the Rev. 00 Software the operator's module (OM) would store random spurious data in the Point ID table of the non-selected calculator if the non-selected calculator was being started up while the selected calculator was being monitored on the OM. For Rev. 00, the OM scan routine called up the 8-bit OM status word, waited approximately 60 microseconds before re-reading the status word, and then compared this with the initial read in. If any bit changes were detected, the program was exited before processing the point ID information. For Rev. 01, the OM scan routine calls up the 8-bit status word and selects out the calculator select bit. It re-executes this process, compares the two bit values, and exits the program only if there's a change in the value. This change has resulted in a more compatible interface with the OM firmware.

CEAC Display:

In the Rev. 00 Software the assigned color code for a deviated CEA caused the deviated CEA color to change status to blink black on a black background. This resulted in the deviated CEA appearing to be invisible. The assigned color codes have been changed so that the deviated CEA will blink white on a black background on the CRT. The constants that define the color options are listed in the CEAC Display Constants Program.