Duquesne Light

Nuclear Division
P.O. Box 4
Shippingport, PA 15077-0004

Telephone (412) 456-6000

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Director of Nuclear Reactor Regulation
United States Nuclear Regulatory Commission
Attn: Mr. Steven A. Varga, Chief
Operating Reactors Branch No. 1
Division of Licensing
Washington, D. C. 20555

Reference: Beaver Valley Power Station, Unit No. 1
Docket No. 50-334, License No. DPR-66
Cycle 3 Reload Safety Evaluation

Gentlemen:

This letter responds to your staff request that we provide additional technical information related to the Rod Position Indication Technical Specifications forwarded to the Staff by our letter dated February 23, 1982 concerning the Cycle 3 Reload Safety Evaluation for Beaver Valley Power Station. As I indicated in that conversation, we are developing an alternate Technical Specification which responds to the Staff's desire that maximum rod deviation be limited to ± 24 steps including instrument error. A draft copy of that alternate Technical Specification is included with this letter for your review. I must point out that this draft Specification has not yet undergone the reviews required to be conducted by Duquesne Light Company prior to formal submittal to the NRC. We are very interested in arriving at an appropriate solution to this issue as soon as possible and I assure you that we will cooperate in any way we can to achieve this end.

Our February 23, 1982 submittal contained a request for Technical Specification amendment which basically extended the present Technical Specification to include Cycle 3 and following Cycles of operation. This Technical Specification basically allows a total deviation of rods (including instrument inaccuracy) of ± 32 steps and includes provision for use of primary voltage measurements to determine rod position as a backup method. We contracted with Westinghouse to perform a safety analysis which considered the ± 32 step deviation and the analysis which Westinghouse performed assumed a single rod misalignment from the group indication at this maximum deviation. The Westinghouse analysis was similar to that used in Cycle 2 to determine the peaking factor penalties resulting from ± 32 step misalignments of single C and D Bank rods. Together with

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fine mesh 2D-TURTLE computer model, a TURTLE benchmarked 3D-PALADON model was employed, using 2x2 meshes per assembly radially and 20 meshes axially. Calculations were made at various power levels with control rods positioned at the appropriate insertion limits (Figure 1). Single D and C bank rods were misaligned by 32 steps and the resulting effects on peaking factors determined.

The following factors were considered and adequate margin was found to exist when this analysis was reviewed:

Moderator Coefficient
Doppler Coefficient
β_{eff} and Prompt Neutron Lifetime
Normalized Trip Reactivity vs. Position
Trip Reactivity Worth
Shutdown Margin
Overpower kw/ft
Rod Insertion Limits
Boron Dilution During Refueling
Rod Withdrawal From Subcritical
Single Rod Withdrawal
Rod Withdrawal at Power
Rod Out of Position
Dropped RCCA
Rod Ejection
Steamline Break

In addition to the reviews conducted above, examination of rod misalignment $F_{\Delta H}$, rod misalignment F_{xy} and rod misalignment $F_Q(Z)$ were performed. With respect to rod misalignment $F_{\Delta H}$, calculations were done at BOL with both equilibrium xenon and non-xenon conditions considered. $F_{\Delta H}$ limit values were compared to a limit described by the following equation $F_{\Delta H}(P) = 1.55 [1 + 0.3(1-P)]$ where "P" is the fraction of rated thermal power.

As in Cycle 2, at significant power levels where DNB is a concern, the rod misalignment $F_{\Delta H}$ is smaller than the design basis $F_{\Delta H}$ limit. For power levels below 20%, the rod misalignment $F_{\Delta H}$ values exceed the proposed Technical Specification limit by 2.5% or less. For these low power levels, however, the core limits are vessel exit boiling limited and are not a function of peaking factors. Consequently, there is no safety concern. Figure 3, attached, provides a plot of $F_{\Delta H}$ as a function of Rated Thermal Power.

Worst case $F_{xy}(Z)$ values were collected for each axial mesh from the three-dimensional misalignment calculations. Figures 4 and 5 show the maximum calculated $F_{xy}(Z)$ values for power levels of 100% and 45%, respectively. These F_{xy}'s lie below the proposed F_{xy} limits and include an 8% uncertainty factor. For very low power levels and deep rod insertion, the F_{xy} limits could be exceeded. At low power levels, however, the F_Q limit is very large, 4.64 below 50% power, and power peaking is not a concern. The F_{xy} limits proposed are as follows:

1. For unrodded core planes:

   $F_{xy}^{RTP} < 1.68$ up to 2.4 ft. elevation

   $F_{xy}^{RTP} < 1.68$ from 2.4 ft. to 7.8 ft. elevation

   $F_{xy}^{RTP} < 1.65$ above 7.8 ft. elevation

2. $F_{xy}^{RTP} < 1.71$ for all core planes containing D Bank

The power dependence of the F_{xy} limits will become:

$$F_{xy}^{Limit}(P) = F_{xy}^{RTP}[1 + 0.3(1-P)]$$

where "P" is the fraction of Rated Thermal Power.

With respect to rod misalignment $F_Q(Z)$, these values were conservatively generated for steady state conditions by synthesizing the limiting $F_{xy}(Z)$ with the largest axial relative power for each axial plane. The $F_Q(Z)$ values for the reference case, i.e. the HFP case with Bank D inserted to the full power insertion limit, are shown on Figure 6. Also shown on Figure 6 are the limiting $F_Q(Z)$ values associated with the limiting rod misalignment $F_{xy}(Z)$ values discussed above. HFP equilibrium xenon conditions were assumed for both the reference case and the misalignment case. The values plotted on Figure 6 include the 1.05 and 1.03 Technical Specification uncertainty factor. Note that the misalignment penalty occurs at the top of the core (in the rodded region) and that considerable margin to the LOCA F_Q envelope exists at all core elevations.

For load follow operation, the limiting points from the Cycle 3 FAC analysis are also shown in Figure 6. These points were generated using the Technical Specification F_{xy} values which are conservative by 5 to 10% with respect to as calculated values (including uncertainties) and by 16 to 21% with respect to best estimate F_{xy}'s. All of the limiting F_Q x Power points occurred during full power time steps. Furthermore, in the upper part of the core where the misalignment penalty is the largest, the limiting points occurred for D Bank insertions of < 24 steps. Typically, D Bank is inserted only 12 steps for these points. Consequently, upward rod misalignments would fall within range of the standard misalignment (24 step) Technical Specification which Beaver Valley used prior to the Technical Specification change in Cycle 2. Therefore, for upward misalignments, no additional F_Q x Power increase will result from the proposed Technical Specification. Downward rod misalignments result in only small (approximately 3%) F_Q increases in the vicinity of the misalignment. There is sufficient conservatism in the analysis to accomodate these small increases.

Duquesne Light Company pursued expanded rod deviation limits because of the extensive testing which we have performed on the analog Rod Position Indication system at Beaver Valley before and during Cycle 2 operation. We were convinced that a Technical Specification which limited the allowable inaccuracy of the Rod Position Indication System to $\pm$ 12 steps would not be suitable for Beaver Valley Power Station. We are not convinced that this problem is generic to Westinghouse plants since there are many plant specific aspects to the problem including variations in equipment characteristics within manufacturer's tolerances and spatial variations in the installed RCCA cooling system.

We believe that the temperature related phenomena which influence the accuracy of the Rod Position Indication system do not indicate a state of failure or malfunction but are manifesting characteristics of the instrumentation which we have measured and evaluated. The characteristics of the instruments are such that they display a degree of nonlinearity in the steady state response and a transient (time dependent) drift which is due to thermal effects in the detector assembly.

With respect to the steady state nonlinearity, it appears that all control rods can be calibrated to remain within the $\pm$ 12 step band of the group demand position in the range of from 20 steps to 228 steps. Below 20 steps, it appears that additional margin is required to allow the calibration to be performed in a practical manner. There is some variation in the degree of nonlinearity from rod to rod but all rods at our facility appear to be enveloped as described above.

With respect to the time-dependent transient response of the Rod Position Indication System, we believe that this response is due to changes in the magnetic circuit within the detector itself over time which causes the detector output to rise with increasing temperature. The component having the most impact on the magnitude and duration of this transient response is postulated to be the lead screw and extension as it is influenced by conduction from the primary coolant at the upper head temperature. This transient is most pronounced when a control rod is withdrawn and rod withdrawal appears to cause the channel to read high until the mechanism cools down. A one hour waiting time appears to be sufficient to allow stabilization to approximately the calibration curve value of output.

Another thermally induced source of inaccuracy not addressed by the proposed generic Westinghouse Technical Specification for Rod Position Indication Systems is the fact that there is an upward shift in the calibration curve as a function of increasing reactor power. This shift is believed to be caused by conduction of heat from the reactor vessel as upper head temperature increases with higher power levels. This thermal response is a steady state effect not observable at zero power where rod calibrations are performed. The impact of this phenomena is to cause the detector response curves to drift high and outside the ± 12 step limits imposed by the Specifications. This effect is not significant with the rods near the fully withdrawn position since ample margin exists in the calibration curve at that point. However, when rods are near the insertion limit, this thermal effect will place us into the ACTION statement unless the Specification recognizes this effect.

To aid in the understanding of this complex phenomena, I have attached two figures which represent the calibration of a rod which is characteristic of a typical rod exhibiting these characteristics. Figure 1 shows the entire range of the calibration curve along with a representation of the reference position and the ± 12 step limits. Also shown is the hypothetical curve for the rod at 100 percent power, illustrating the drift in calibration which occurs. This curve is hypothetical in that we only have data within the insertion limits which represent this phenomena. The portion of the curve shown below the insertion limit is an extrapolation of existing data and is probably irrelevent to the problem being discussed here. Figure 2 is the same information as is depicted in Figure 1 but is expanded to show the characteristics of the Rod Position Indication System in the area of interest (above 150 steps). Our concern is related to the shaded area above the ± 12 step limit which we expect to encounter at higher power levels when rods are partially inserted.

We have determined by testing that thermal effects are less pronounced on the Rod Position Indication System primary voltage than they are when measurements are taken from the Rod Position analog indicators. This could be due to the lessor impact which thermal effects in the magnetic circuit have on reluctance associated with the primary coil as opposed to the impact which these thermal effects have on the magnetic circuit when the Rod Position Indicator coils are used as transformers. It is for this reason that we have elected to include the use of Rod Position Indication primary voltage measurements.

We believe that we will need to rely on backup indication based upon calibration curves of Rod Position Indication primary voltage versus group demand. These calibration curves should be referenced to a constant power supply voltage and should include the 100 percent power voltage measurements. Obviously, data cannot be developed for power operation until after startup and, obviously, we cannot violate the Technical Specifications to record the data.

It is because of the above stated technical complexities which we believe that a restriction to ± 12 steps is not warranted. Furthermore, from a human factors standpoint, we would be making the reactor operator's job much more complex by adopting a Technical Specification which must rely upon test instruments and test methods to carry out a normal operational function. We believe that the Westinghouse proposed Technical Specification is not adequate, unless modified, and that the modifications necessary to make the specification acceptable will cause the specification to be more complex that need be to accomplish a relatively simple task. Lastly, it is extremely difficult to work within Technical Specification limits to acquire the data to develop the 100 percent power calibration curve for the Rod Position Indication System. We believe that a ± 12 step curve will result in restricted operation and could be the cause of Licensee Event Reports which we endeavor to prevent, as a matter of Company policy. It was for these reasons that the Company contracted with Westinghouse to perform the analysis to allow relaxation of the Technical Specification to ± 16 steps.

In accordance with your request, however, we have modified the proposed Westinghouse generic Technical Specification for Rod Position Indication Systems to make it applicable to our facility. The areas of modification are as follows:

1) We have expanded the limits of the Rod Position Indication System to ± 16 steps from 0 to 30 steps to permit shifting the calibration curves on several group C and D rods to permit remaining within the ± 12 step limit from 150 to 228 steps. We have no data to show whether this fix is enough to permit calibration of the remaining banks of rods but we are led to believe that it will be sufficient.

2) We have deleted reference to part-length rods since they are not installed at Beaver Valley Power Station.

3) We have retained language in 3.1.3.2 which recognizes the use of Rod Position Indication detector voltages.

4) We have modified the BASES to reflect the use of Rod Position Indicator detector voltages.

5) We have deleted the APPLICABILITY of Technical Specification 3.1.3.3 for Modes 4 and 5 to avoid a situation where the Reactor Coolant System could be depressurized and non-condensible gases accumulate in the control rod housings, preventing lubrication of the RCCAs when the SURVEILLANCE REQUIRED in Section 4.1.3.3 is performed.

We fully appreciate the Staff's position that it does not desire to approve a change to ± 16 steps, both from the standpoint of the strain which this larger allowed rod deviation places on traditional analytical techniques for rod misalignment and upon the increased burden placed upon the Staff by reviewing plant specific, cycle dependant analytical results. Perhaps this brief explanation of our operational experience will provide insight as to why we submitted proposed Technical Specifications which called for the ± 16 step deviation.

We are certain that the proposed Westinghouse generic specification does not fully address the thermal phenomena which we have observed at our plant. We believe that the changes we have made to that proposed specification go a long way toward addressing the inadequacies which we perceive - at the expense of human factors considerations. These changes do not address the acquisition of the Rod Position Indicator calibration curve at 100 percent power. We believe that this data acquisition effort can only be performed by a special exception to the proposed Technical Specification or by permitting us to use Cycle 2 data (if Cycle 2 data correlates sufficiently to new Rod Position Indication data to be acquired during Cycle 3 startup) to satisfy the accuracy requirements of the Technical Specifications while new data is being acquired.

I will appreciate your prompt review and comments on this information and I am prepared to discuss this matter with you or others of the NRC staff at your convenience. We will promptly make another submittal on the docket which addresses the concerns of the Staff related to the remaining Technical Specification changes submitted by our February 23, 1982 letter.

Very truly yours,

J. D. Sieber

J. D. Sieber, Manager
Nuclear Safety & Licensing
Department

Enclosures

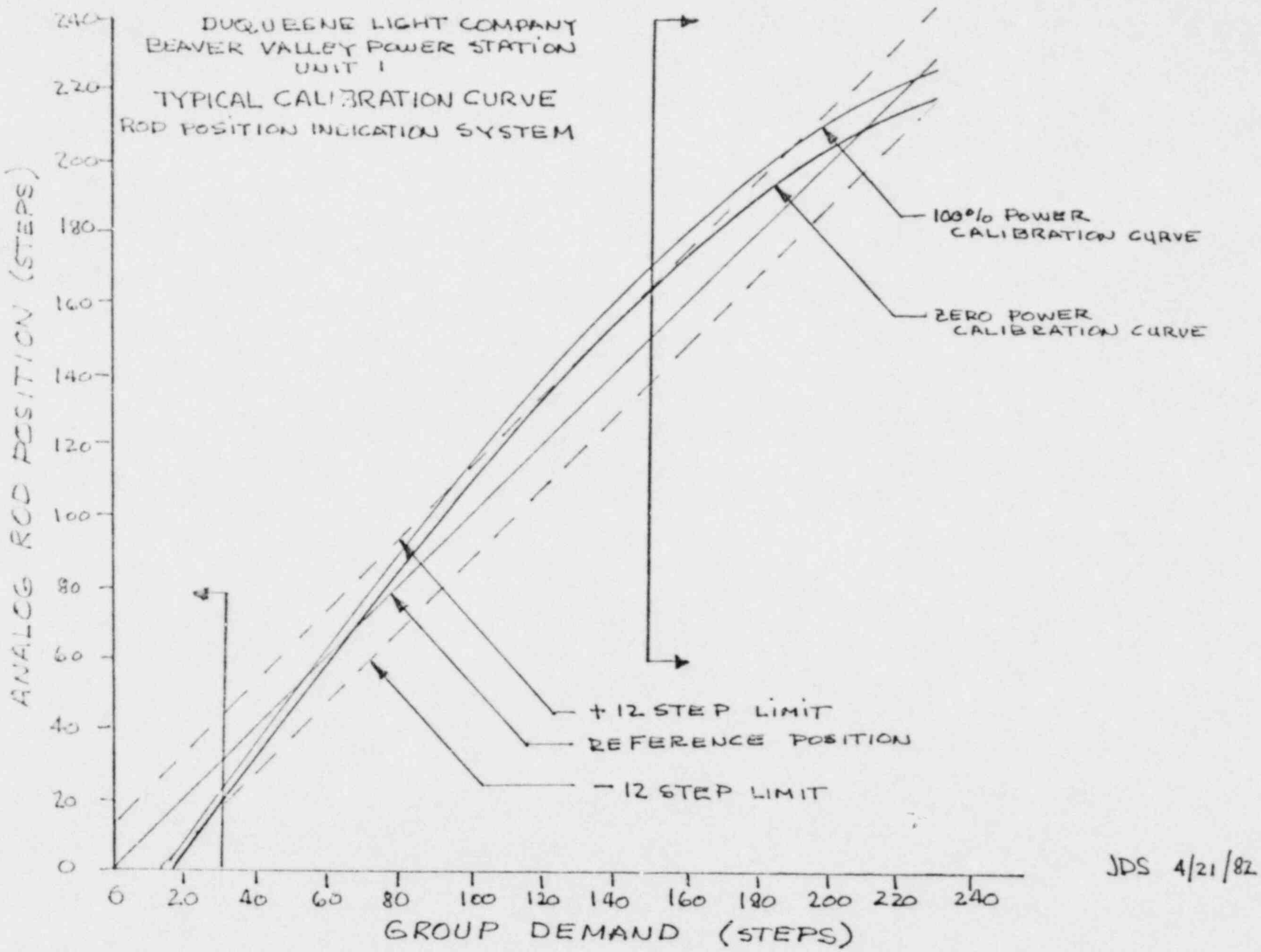
cc: Mr. D. L. Wigginton
BVPS Unit #1 Licensing Project Manager

Mr. D. A. Beckman
BVPS Unit #1 Resident Inspector

Ms. M. Chatterton

USNRC Document Management Branch

FIGURE 1



DUQUESNE LIGHT COMPANY
BEAVER VALLEY POWER STATION
UNIT 1
TYPICAL CALIBRATION CURVE
ROD POSITION INDICATION SYSTEM
ANALOG ROD POSITION (STEPS)
GROUP DEMAND (STEPS)
0
20
40
60
80
100
120
140
160
180
200
220
240
100% POWER CALIBRATION CURVE
ZERO POWER CALIBRATION CURVE
+12 STEP LIMIT
REFERENCE POSITION
−12 STEP LIMIT
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FIGURE 2

DUQUESNE LIGHT COMPANY

BEAVER VALLEY POWER STATION - UNIT 1

TYPICAL CALIBRATION CURVE

ROD POSITION INDICATION SYSTEM

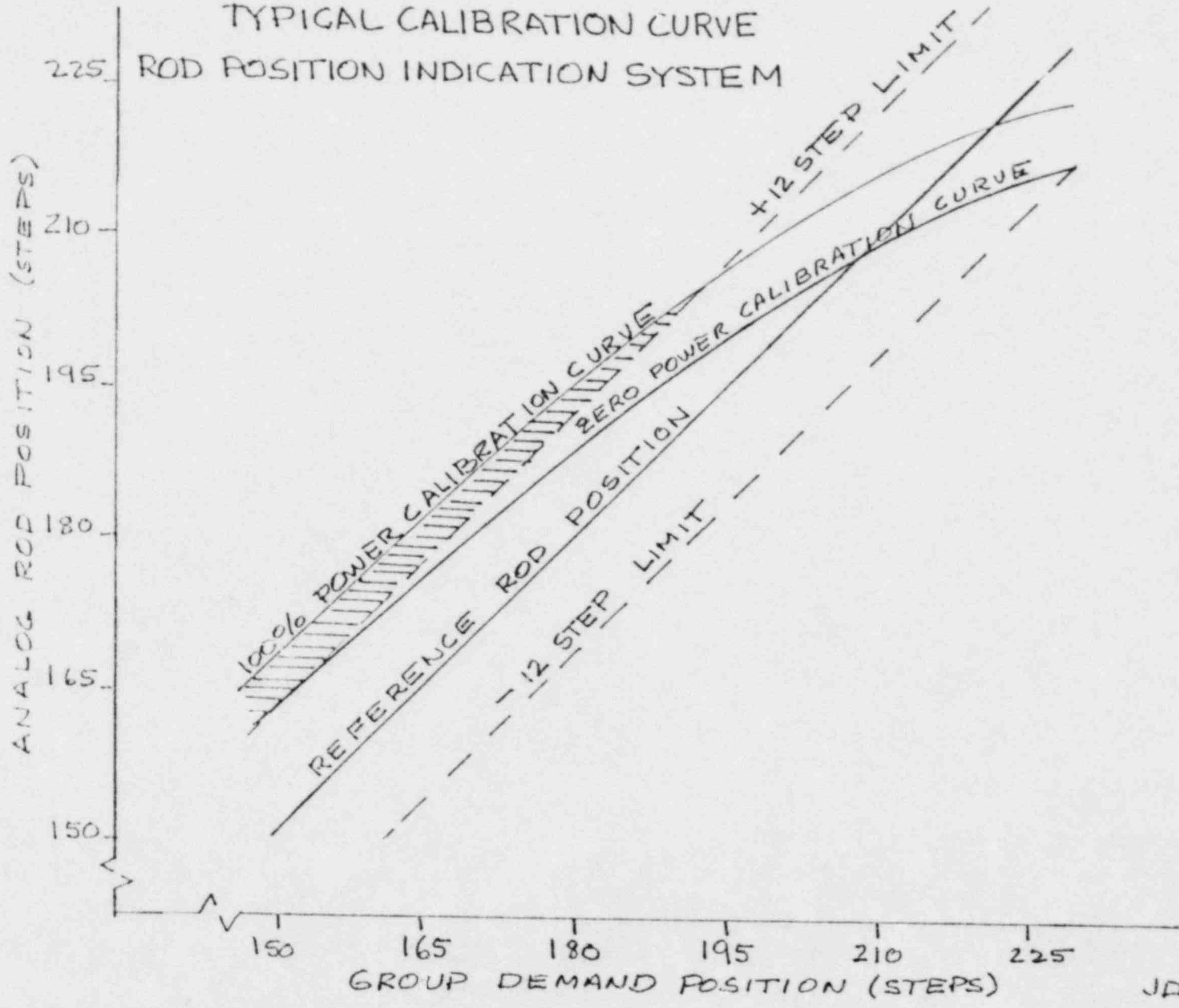

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FIGURE 3

BEAVER VALLEY POWER STATION
ROD MISALIGNMENT FΔH

VS.

POWER

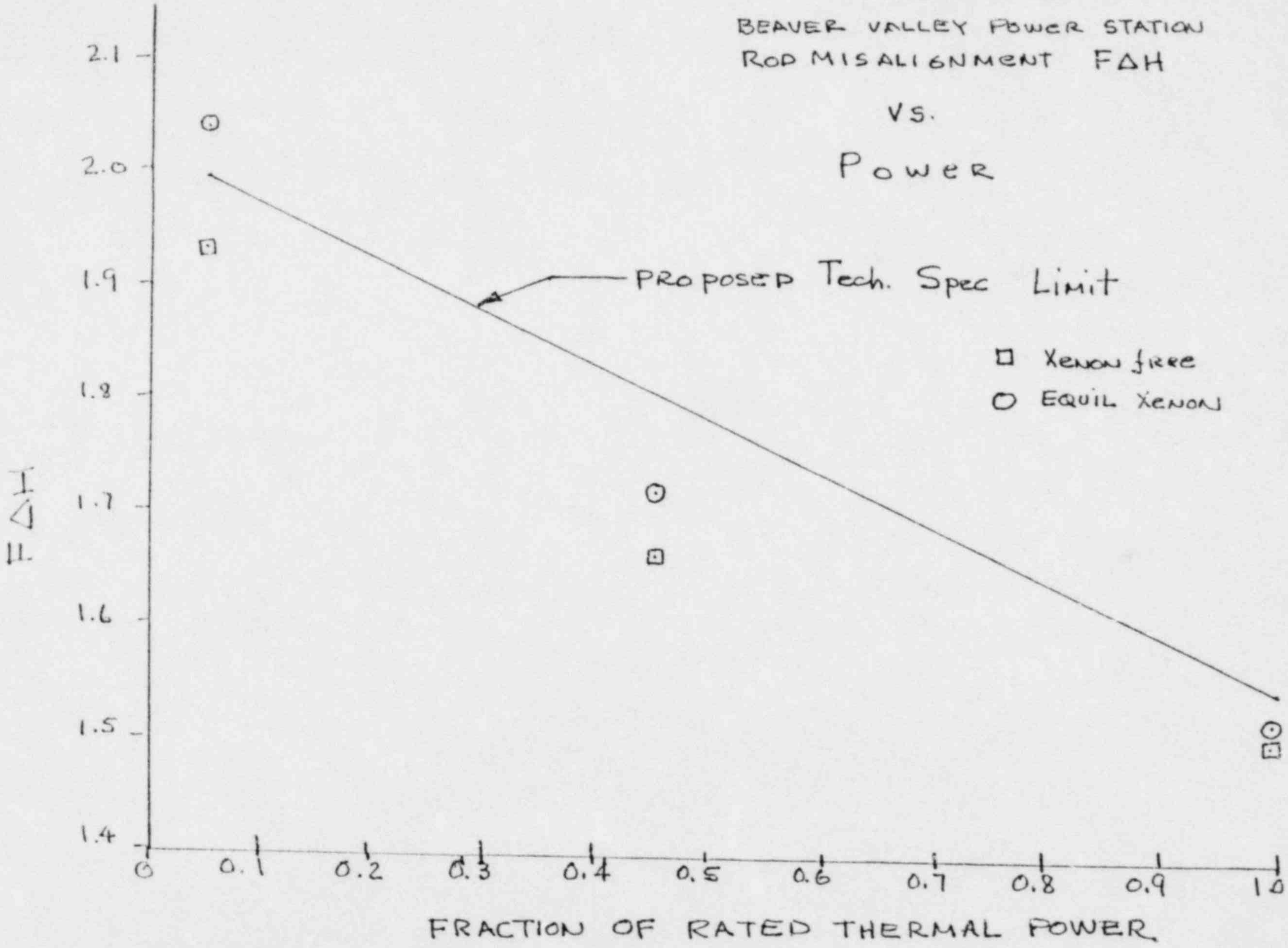

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FIGURE 4
BEAVER VALLEY POWER STATION
Fxy(Z) vs. Core Height
Hot Full Power
Rods into Insertion Limits

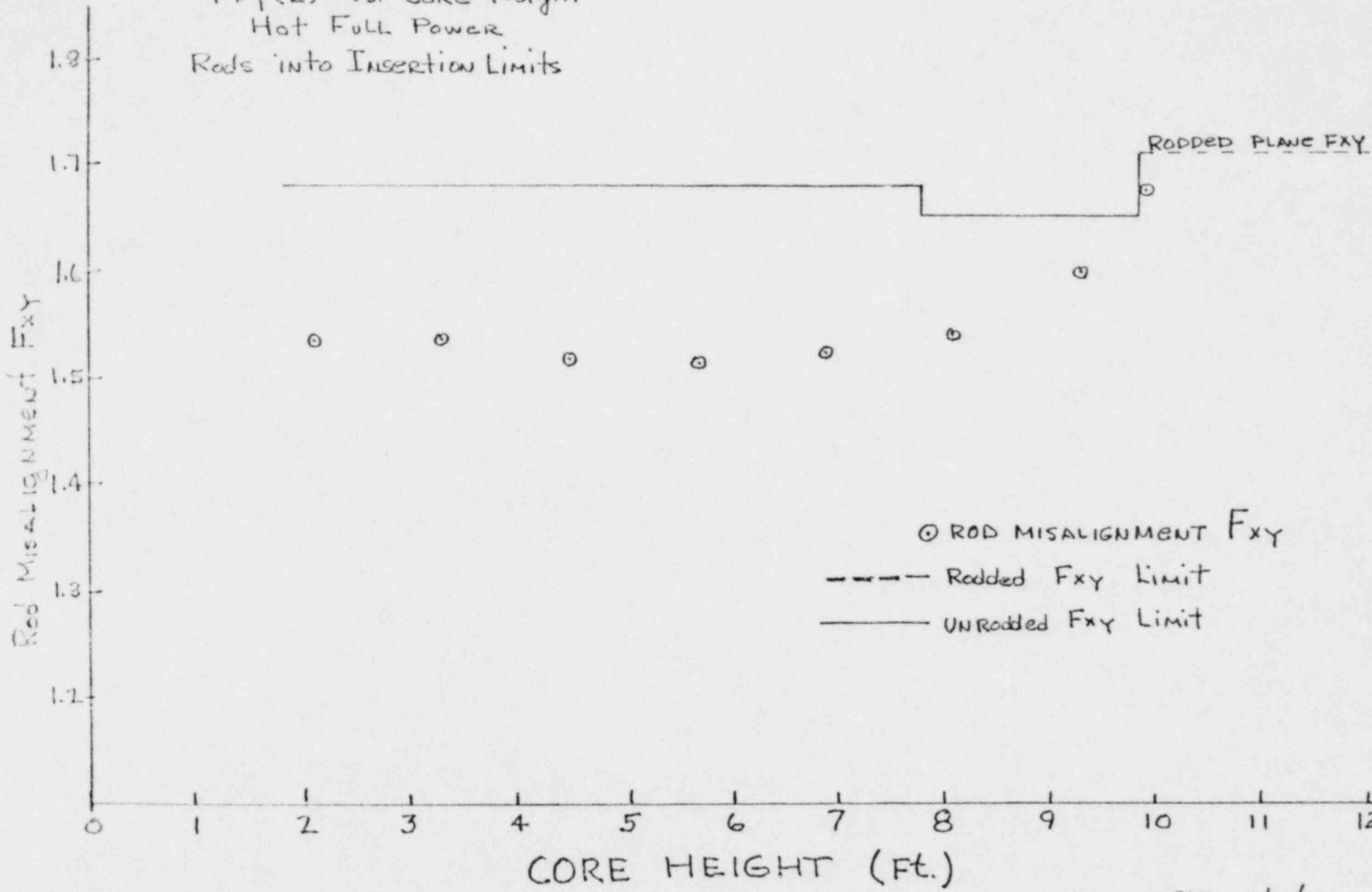

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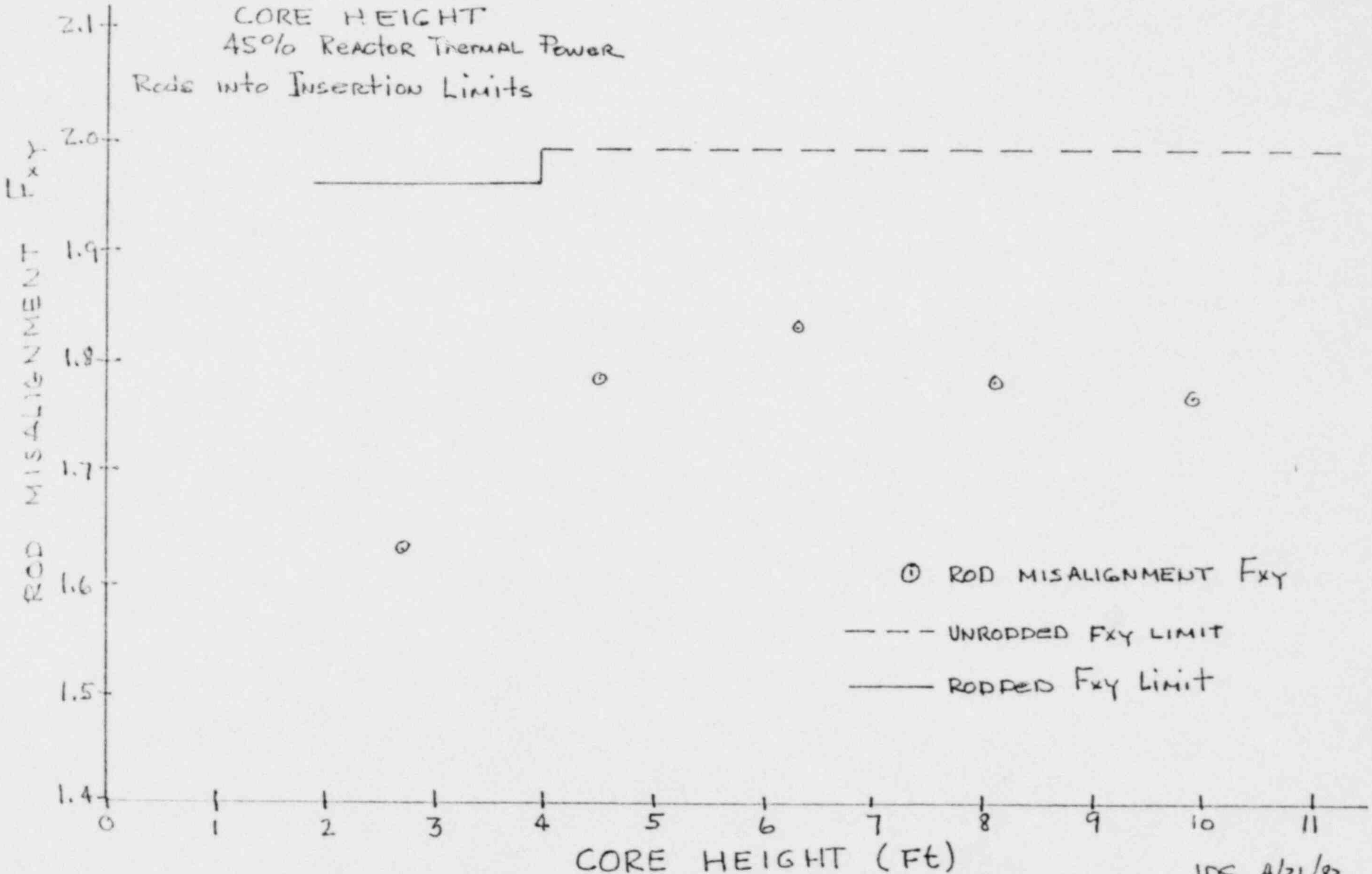
FIGURE 5

BEAVER VALLEY POWER STATION
ROD MISALIGNMENT Fxy
VS.
CORE HEIGHT
45% Reactor Thermal Power
Rods into Insertion Limits



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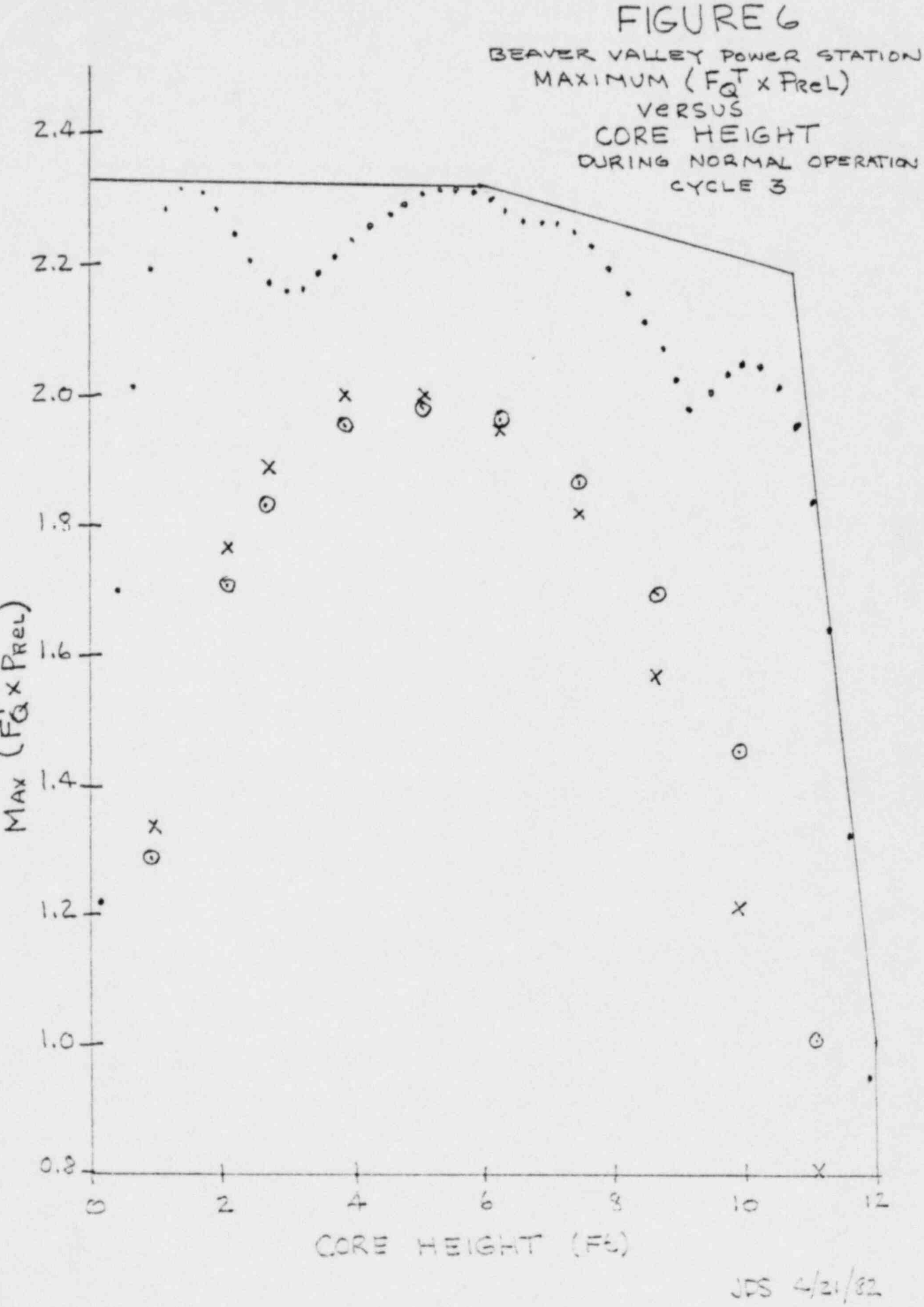
FIGURE 6
BEAVER VALLEY POWER STATION
MAXIMUM ($F_Q^T \times P_{REL}$)
VERSUS
CORE HEIGHT
DURING NORMAL OPERATION
CYCLE 3
Max ($F_Q^T \times P_{REL}$)
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0
2
4
6
8
10
12
CORE HEIGHT (Ft)
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REFERENCE POSITION

1.36
Analog Rod Position Indication System REFERENCE POSITION is defined as:

a. For all Shutdown Banks and Control Banks A and B, the group demand counter indicated position between 0 and 30 steps withdrawn inclusive and between 200 and 228 steps withdrawn inclusive.

b. For Control Banks C and D, the group demand counter indicated position between 0 and 30 steps withdrawn inclusive and between 150 and 228 steps withdrawn inclusive. For the withdrawal range of 31 to 149 steps inclusive, the REFERENCE POSITION shall be the individual rod calibration curve noting indicated analog rod position vs indicated group demand counter position.