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# PALISADES POWER DISTRIBUTION CONTROL PROCEDURES

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EXXON NUCLEAR COMPANY, Inc.

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# PALISADES POWER DISTRIBUTION CONTROL PROCEDURES

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## 1.0 INTRODUCTION

The two phase development of a PDC-II(1,2,3) type power distribution control procedure for the Palisades reactor has been completed. Phase I of the analysis demonstrated the applicability of a PDC-II type procedure for Palisades.(4) For completeness the Phase I report is duplicated in Appendix A. Phase II, reported herein, provides a procedure for the implementation of a plant specific version of PDC-II for Palisades. Phase II also demonstrates the validity of the Palisades calculational model.

The second phase of the evaluation of a power distribution control procedure for Palisades has been completed. The procedure developed specifically for Palisades is derived from the current PDC-II procedure.(1,2,3) Implementation of this procedure will allow full power operation for up to one month after the incore detector system becomes inoperable. Currently power must be reduced to 50% two hours after the incore monitoring system fails.

Protection of the power peaking limits is verified by evaluating the latest measured power distribution in conjunction with the expected variation in power peaking as determined by the PDC-II methodology and comparing to the Technical Specification limits on the power distribution. The variation in power peaking is controlled by limiting the change in axial offset measured by the excore detectors. In this way, the reactor can be operated exclusively on the excore detectors for an additional month after the last full core power map, used in establishing the target axial offset, was taken.

## 2.0 SUMMARY

A power distribution control procedure, based exclusively on monitoring by the excore detectors, has been developed for Palisades. This Palisades specific procedure is derived from the Exxon Nuclear Company (ENC) PDC-II methodology and will allow full power operation for a period of about one month subsequent to a full core power map. Analysis of non-equilibrium conditions has shown that the PDC-II type procedure will assure that power peaking will be maintained within the specified power peaking limits for Palisades. The Palisades Phase II analysis has shown that the model accurately predicts the change in power peaking for axial offsets beyond the range of expected operation.

The PDC-II procedure developed for Palisades is expected to be implemented only when the incore detector system is inoperable. In the event of a failure of the incore detector system, this procedure can be implemented without any interruption in power operation. The incore detector power peaking ($F_{(z)}$) alarm could be replaced by an alarm on the excore axial offset output; e.g., an alarm which would be activated when the axial offset drifts outside the allowable operating band. If the axial offset has been within the band prescribed by the Technical Specifications for the last 24 hours and the latest measured power distribution is within the prescribed limits, no change in power level will be required.

## 3.0 POWER DISTRIBUTION CONTROL FOR PALISADES

The power distribution control procedure described in this report enables the Palisades nuclear plant staff to manage the core power distribution without the incore monitoring system such that Technical Specification limits on $F_Q^T$ are not violated during normal operation. Limits on MDNBR are also protected during steady state, load follow, and anticipated transients. The procedure provides uninterrupted operation at full power for the Palisades in the event the incore detector system is not available. The PDC-II type procedure will provide up to one month of operation with the incore detectors inoperable as compared to only two hours currently allowed by the Technical Specifications.

This report provides the method for predicting the maximum $F_Q^T$ (z) distribution anticipated during operation under the PDC-II procedure, taking into account the incore measured equilibrium power distribution. A comparison of this maximum $F_Q^T$ (z) distribution with the Technical Specification limit curve determines whether the Technical Specification limit can be protected. If such protection can be confirmed, the excore monitored axial offset limits will protect the Technical Specification $F_Q^T$ limits. The maximum possible variation in $F_Q^T$ (z) that can occur while operating under the PDC-II procedures forms the bounding variation referred to as V (z). V (z) is the means by which the maximum anticipated $F_Q^T$ (z) is predicted.

Power distribution is controlled by keeping the axial offset within a prescribed band. The band is centered on the axial offset of the measured equilibrium power distribution, the target axial offset, and the width of the band is determined by the power level at which the reactor is operating. Application of these criteria is described in the following sections.

## 3.1 ESTABLISHING THE TARGET AXIAL OFFSET

The PDC-II methodology and resulting guidelines protect the core power distribution limits in the absence of incore measurements. Protection is accomplished through control of the axial offset, measured with the excore detectors, with respect to a target axial offset. Core axial offset is defined as:

$$AO = \frac{P_T - P_B}{P_T + P_B}$$

where

$P_T$ = Power in the top half of the core

$P_B$ = Power in the bottom half of the core

The target axial offset is established by measuring the core power shape at near equilibrium conditions with the incore detector system. Excore detectors are separately calibrated to reproduce the incore measured axial offset. Operation within PDC-II guidelines then allows axial power distribution changes within a band referred to as $AO_{TB}$. The axial offset target band is defined as:

$$AO_{TB} = \frac{\pm 5\%}{P/APL}$$

where:

P = Operating reactor power (MWth)

APL = Maximum Power (MWth) allowed under the axial power distribution constraints.

This band is shown graphically in Figure 3.1.

Below a relative power (P/APL) of 0.9, the axial offset is allowed to deviate from the target band for one hour out of each twenty-four consecutive hours, provided that the measured axial offset remains within a broader, but specified, axial offset band shown in Figure 3.2. If this requirement is violated, the core relative power must be reduced below 0.5 of the APL where no restrictions on AO are imposed. Above a relative power (P/APL) of 0.9, the measured AO must remain within the allowed target band at all times.

The target axial offset ($AO_T$) must correspond directly to an incore measured power shape. This power shape will be used to verify that operation under the power distribution control procedures will protect the plant $F_Q$ limits. The target axial offset is to be established after attaining a power level at which the reactor is expected to operate. This will ensure that the power distribution accurately represents the reactor conditions if the incore detectors are not available. The target axial offset should be determined after achieving equilibrium conditions for sustained operation.

As previously discussed, the target axial offset is tied explicitly to the core power distribution. The ±5% band about a target axial offset will protect the Technical Specification limits with sufficient margin in the power peaking to satisfy the procedure constraints. This feature permits the plant operator to alter the core power configuration and re-establish a target axial offset in an attempt to satisfy the criteria on measured power distributions. This of course can only be done when the incores are operable as a measured power distribution must be available which corresponds to $AO_T'$. From a long term operating standpoint it is not practical to establish a target axial offset for which the ±5% band cannot be maintained for sustained operation. Plant operators should establish a target axial offset consistent with the anticipated operating requirements. Generally, normal operation of Palisades will result in target axial offsets and associated power distributions which will satisfy the criteria on measured power distributions.

The schedule for establishing a target axial offset should be written into procedures instead of the Technical Specifications. This schedule should represent the maximum interval between measurements. The target axial offset should be evaluated for every measurement taken at equilibrium conditions. Extended operation, in the event that the incore instrumentation fails can be maximized by keeping the target axial offset and associated power distribution current.

## 3.2 VERIFYING THE POWER PEAKING PROTECTION

Prediction of the maximum anticipated $F_Q^T$ is made possible by controlling the power distribution such that it does not increase more than the factor V (z). This is accomplished by maintaining the core axial offset within the band prescribed in Section 3.1. The value of the V (z) factor is determined from analysis of plant operation during which the axial offset is maintained within the band during various operating conditions. The V (z) factor is multiplied by the measured power distribution with measurement uncertaintities included. The resulting power distribution is compared to the Technical Specifications to determine whether the Technical Specification limits are protected by the procedure. Procedures for this analysis are:

(1) An $F_Q^T\ (z)_{eq}$ distribution is determined along with an associated axial offset, denoted as the target axial offset ($AO_T$), at equilibrium power and xenon. The $F_Q^T\ (z)_{eq}$ distribution is the measured $F_Q^N\ (z)$ distribution multiplied by the measurement uncertainty factor of 1.10 and the engineering uncertainty factor of 1.03.

(2) The $F_Q^T\ (z)_{eq}$ distribution is multiplied by the V (z) factor, shown in Figure 3.3, to obtain the maximum anticipated $F_Q^T\ (z)_{max}$ which is compared to the Technical Specification limit, $F_Q^T\ (z)_{TS}$. If $F_Q^T\ (z)_{max}$ does not exceed the $F_Q^T\ (z)_{TS}$ limit, then operation may continue in the absence of incores.

If $F_Q^T(z)_{max}$ exceeds the $F_Q^T(z)_{TS}$ reactor core power must be reduced, in the absence of incores, to a power level equal to the minimum value of the ratio $(F_Q^T(z)_{TS}/F_Q^T(z)_{max})$.

(3) The maximum allowed power level (APL) is determined to be the minimum value of the ratio $(F_Q^T(z)_{TS}/F_Q^T(z)_{max})$ times the rated power. For case where the ratio is greater than one (1.0) the APL shall be the rated power.

### 3.3 ADDITIONAL PROTECTION FEATURES

The PDC-II criteria also includes a provision to account for any degradation in power peaking margin resulting from "upburn". The term "upburn" is used to describe the phenomenon in which the peak radial power increases with exposure rather than diminishes as is usually observed. The phrase "with exposure" is significant because "upburn" identifies a specific phenomenon and should not be confused with observed changes in peak power resulting from actions such as control rod movement or power level changes. Utilization of burnable poison is one recognized mechanism for producing "upburn". The integrated peak pin power, $F_r^{\Delta H}$, is used for monitoring upburn. When the target axial offset is established, the core power distribution obtained from incore measurements is compared to the distribution associated with the immediately previous target axial offset. As previously described the intent of the Technical Specification with regard to "upburn" is to provide protection with PDC-II in the event the power peak is increasing with exposure. The requirement that maps, to establish the target axial offset, be used to monitor for "upburn" provides a means to identify such an increase. If the $F_r^{\Delta H}$ is observed to increase between these maps, a provision for possible upburn during the period of operation without detectors must be made. The provision is to apply to the measured $F_Q$ an addicional 2% uncertainty above the previously specified uncertainties.

Another phenomenon that may be responsible for an increase in the peak radial power with increasing exposure is a change in the azimuthal power tilt. This can be monitored by the excore detectors. The integrated peak pin power, $F_r^{\Delta H}$, incorporates any azimuthal tilt at the time the power distribution is measured. During operation when the incore detector system is not available the azimuthal power tilt must be limited to protect the technical specifications limit for $F_r^{\Delta H}$ and $F_Q$. Any significant change in the azimuthal tilt would be indicated by the excore detectors. Azimuthal tilt, as measured by the excore detectors, shall not exceed 3% while operating under the guidelines of the power distribution control procedures.

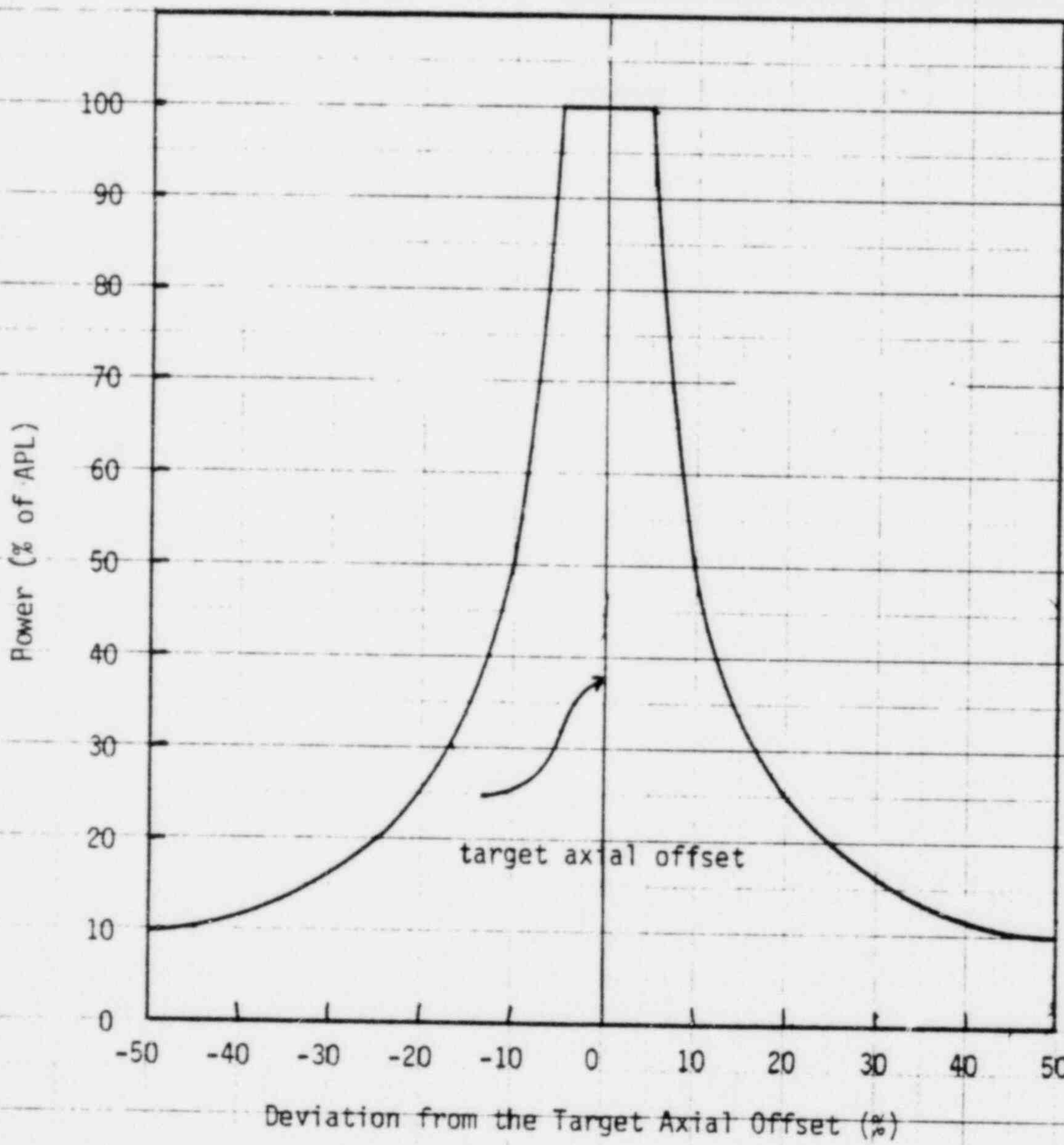


Figure 3.1 Palisades Target Axial Offset Band for Acceptable Operation

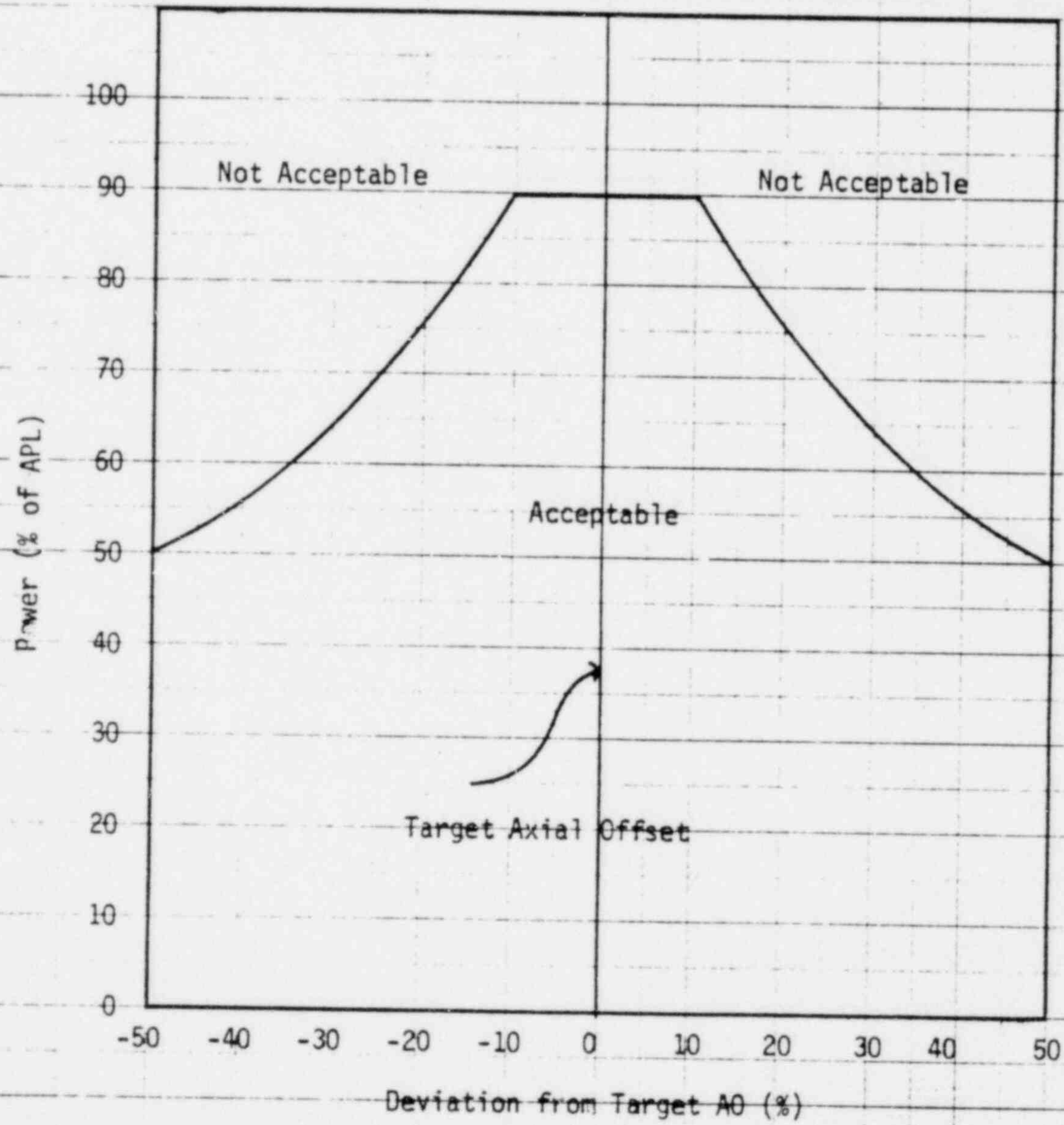


Figure 3.2 Palisades Acceptable Operation for One Hour Outside of Target Band

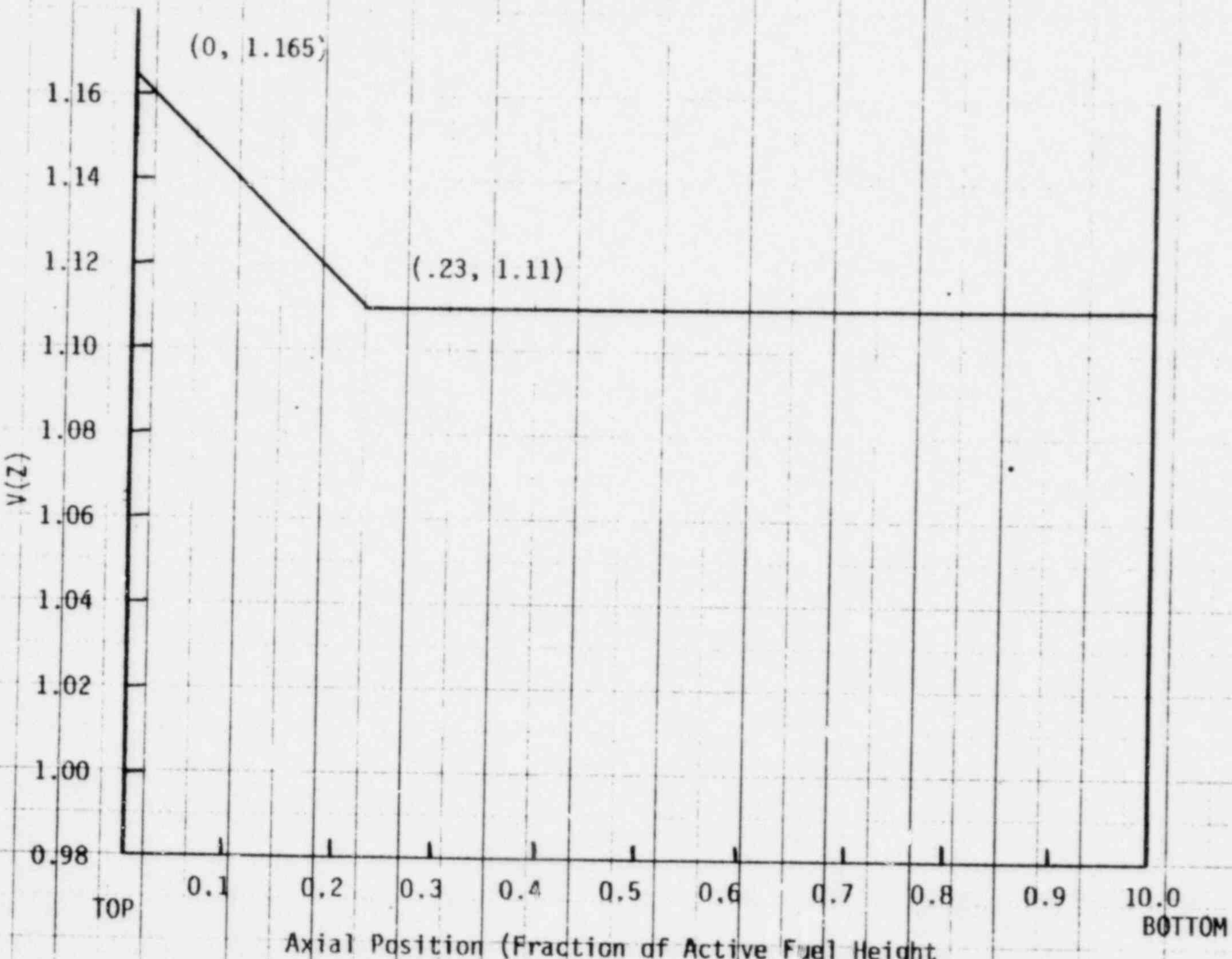


Figure 3.3 Palisades Axial Variation Bounding Condition

## 4.0 VERIFICATION OF THE POWER DISTRIBUTION CONTROL PROCEDURES FOR PALISADES

A 1D XTG model was developed for the Palisades Cycle 4 and simulations of various non-equilibrium situations were conducted. Load follow simulation cases investigated are described in Table 4.1. These cases were determined to be most limiting in the generic PDC-II analysis. The sensitive core parameters in the PDC-II model for Palisades were set equal to the parameters used in the generic PDC-II model as shown in Table 5.1. This resulted in a more conservative model since the simulation with the generic parameters is more sensitive to perturbation and the axial offsets encountered are more extreme than with Palisades specific parameters.

An analysis with the Palisades specific parameters demonstrated that during load follow conditions the reactor would not reach the bounding axial offset limits of the PDC-II procedures. Critical parameters used to increase the axial offset swings were the Doppler broadening coefficient and the moderator scattering cross-section. By increasing the Doppler broadening coefficient and reducing the moderator scattering cross-section the axial offset swings were increased. This allowed the simulation to reach the upper and lower axial offset limits of the PDC-II guidelines. During normal operation including conditions such as load follow, the Palisades reactor should not approach the axial offset limits of the PDC-II guidelines.

Calculations with the Palisades specific model showed that the change in power peaking fell below the upper bound of the maximum change in the linear heat generation rate established for the generic PDC-II reactor. Variation in power peaking was generally below 8% at the beginning of the cycle but increased to 10% near the end of the cycle. Analyses in Phase 1 showed peaking variation as high as 13% near the top of the core. Calculations for both BOC and EOC are shown in Figures 4.1 and 4.2. This analysis indicates that the PDC-II procedure, when used in Palisades, will provide adequate protection for the limits on linear heat generation rate.

Table 4.1 Reactor Operating Conditions Analyzed with the Palisades 1D Model

| Exposure (MWD/MT) | Target Axial Offset | Description of Operation |
| --- | --- | --- |
| 500 | 0.0 | Operation such that the axial offset is maintained within the target band (±5% AO target) |
| 500 | 0.0 | Operation such that at full power the axial offset is maintained at the positive limit and at half power the axial offset is maintained at the negative limit (+ (full)/- (half)) |
| 8500 | -2.5 | ±5% AO target |
| 8500 | -2.5 | +(full)/-(half) |

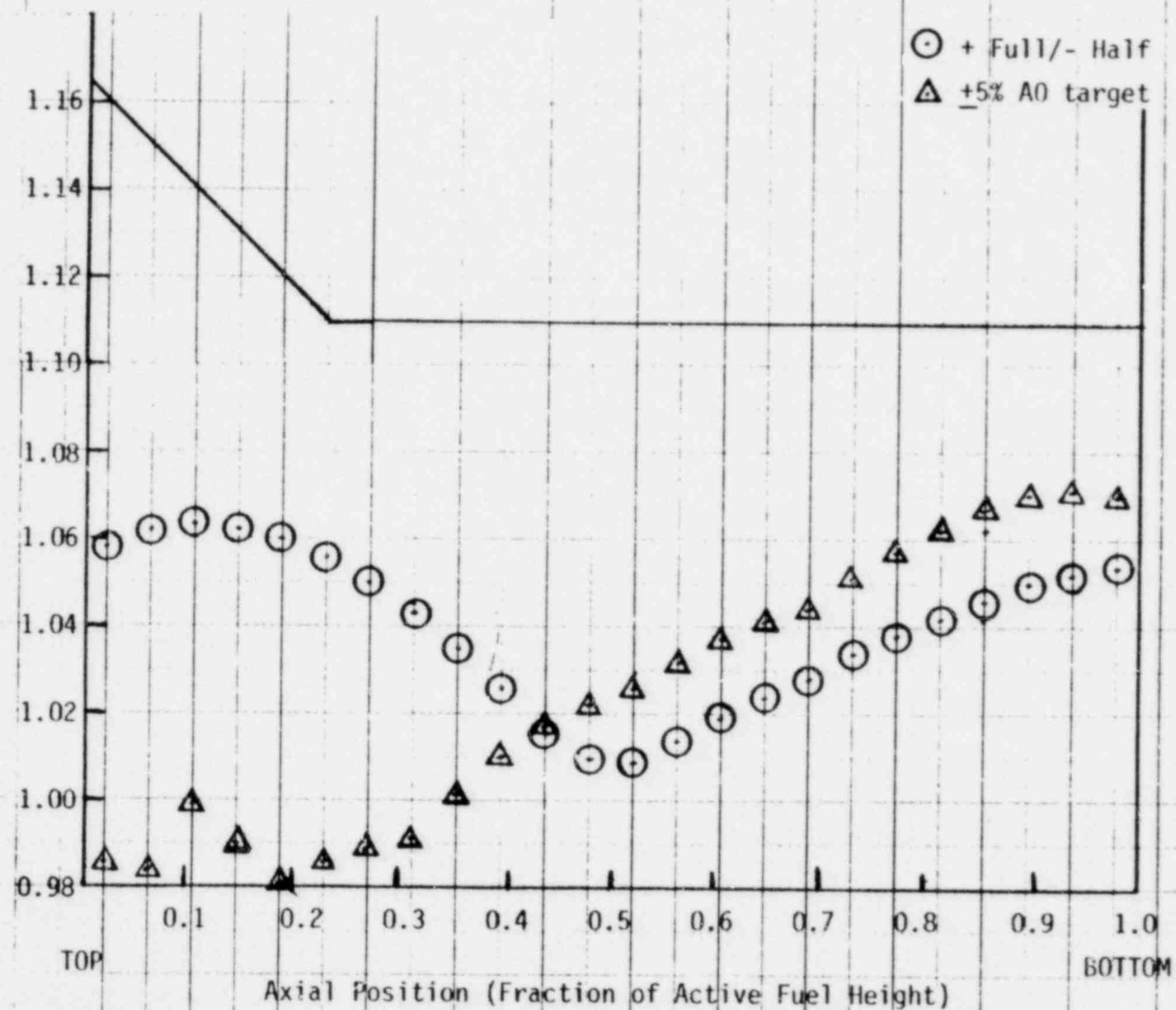


Figure 4.1 Palisades Variation in Local Peaking at 500 MWD/MT

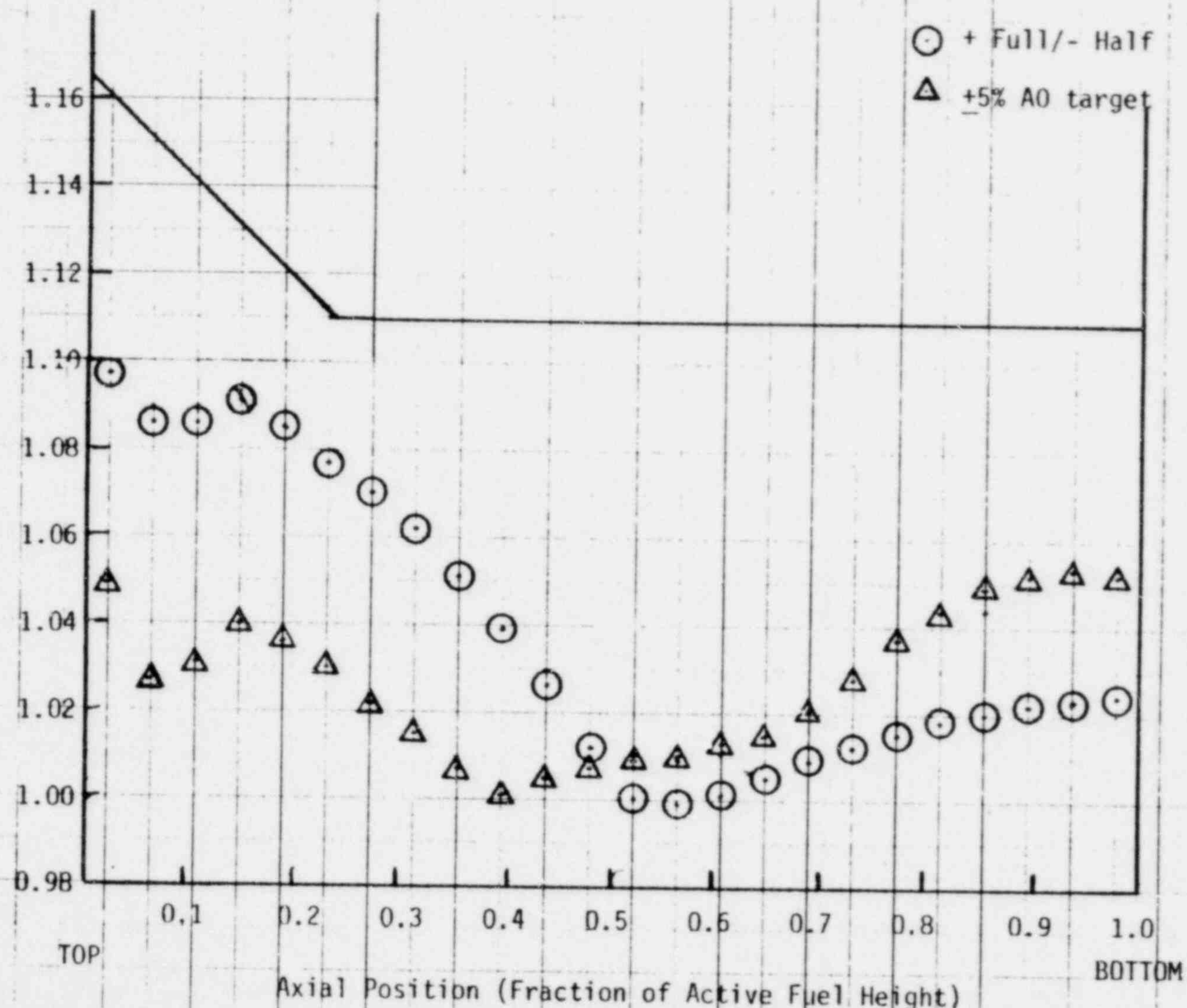


Figure 4.2 Palisades Variation in Local Peaking at 8500 MWD/MT

## 5.0 METHOD AND MODEL VERIFICATION

The power distribution control methodology described in References 1, 2, and 3 utilized the XTG[5] computer code in a one-dimensional configuration. The results obtained with the one-dimensional model have been tested against standard ENC methods[6,7,8] and operating data from the Ft. Calhoun, D. C. Cook #1 and Palisades reactors. Thermal hydraulics and Doppler feedback effects are accounted for in the model.

### 5.1 PALISADES CYCLE 2 XENON OSCILLATION

Near the end of the second operating cycle of the Palisades core a significant xenon oscillation was observed. The measured axial offset oscillated between +20% and -20%. The incore monitoring system was used to measure the power distribution throughout the oscillation. INCA power maps were evaluated at the peak axial offset for both the positive and negative swings. These maps were used to demonstrate the adequacy of the one-dimensional XTG model in calculating the variation in the axial power distribution for large axial offsets.

A 1D XTG model was developed for Cycle 2 and comparisons were made with measured data. Comparisons of the variation from the equilibrium power distribution before the oscillation for power distributions at plus and minus 20% axial offsets are shown in Figures 5.1 and 5.2. The calculated variation in power distribution compares well with the measured in both cases. The maximum difference is 3% for the 25% swing in axial offset and 2% for the 14% swing.

The accurate representation of the variation in power distributions at high axial offsets (outside the typical operating range for PWR's) in addition to the large data base the model has been tested against in the operating range, adequately demonstrates that the model accurately calculates the variation in axial power distributions for various axial offsets.

5.2 INPUT PARAMETERS FOR THE PDC-II ANALYSIS

In the Palisades specific PDC-II analysis several key core parameters were set equal to the values used in the generic PDC-II analysis. This was done in order to force the reactor simulation to calculate power distributions for the bounding axial offsets. The use of these generic core parameters in the Palisades analysis increases the confidence that the Palisades core can be protected by the PDC-II procedure. A comparison of some of the key parameters for Palisades and the generic reactor model is shown in Table 5.1.

Basic XTG input parameters such as fuel cross-section sets, exposure distributions, and extrapolation lengths were those specifically developed for the Palisades core. By using these parameters along with the generic ones, which increased the core sensitivity to perturbation, the model applies conservatively to Palisades and ensures that the Palisades reactor can be protected by following the PDC-II Guidelines.

Table 5.1 Key Parameters for the Generic Reactor and Palisades

| | Generic PDC-II PWR | Palisades PWR |
|---|---|---|
| Rated Power | 3,250 MWt | *2,530 MWt |
| Power Density | 100 kw/liter | *79.7 kw/liter |
| Acitve Fuel Length | 12 ft. | *11 ft. |
| Coolant Flow Rate | $1.43 \times 10^8$ lb/hr | *$1.269 \times 10^8$ lb/hr |
| Inlet Temperature | $545^oF$ | *$532.5^oF$ |
| Single Control Bank Worth | 1.0 %ρ | *0.45 %ρ |
| Doppler Broadening Coefficient | *0.0059 | 0.0035 |
| Control Rod Insertion Limit | 50% at Full Power | *25% at Full Power |
| Xenon Absorption Cross Section (MND) | *$3.10 \times 10^6$ barns | $2.80 \times 10^6$ barns |
| Moderator Scattering Cross Section | *1.5 barns | 1.6 barns |

* Denotes parameters used in the PDC-II analysis for Palisades.

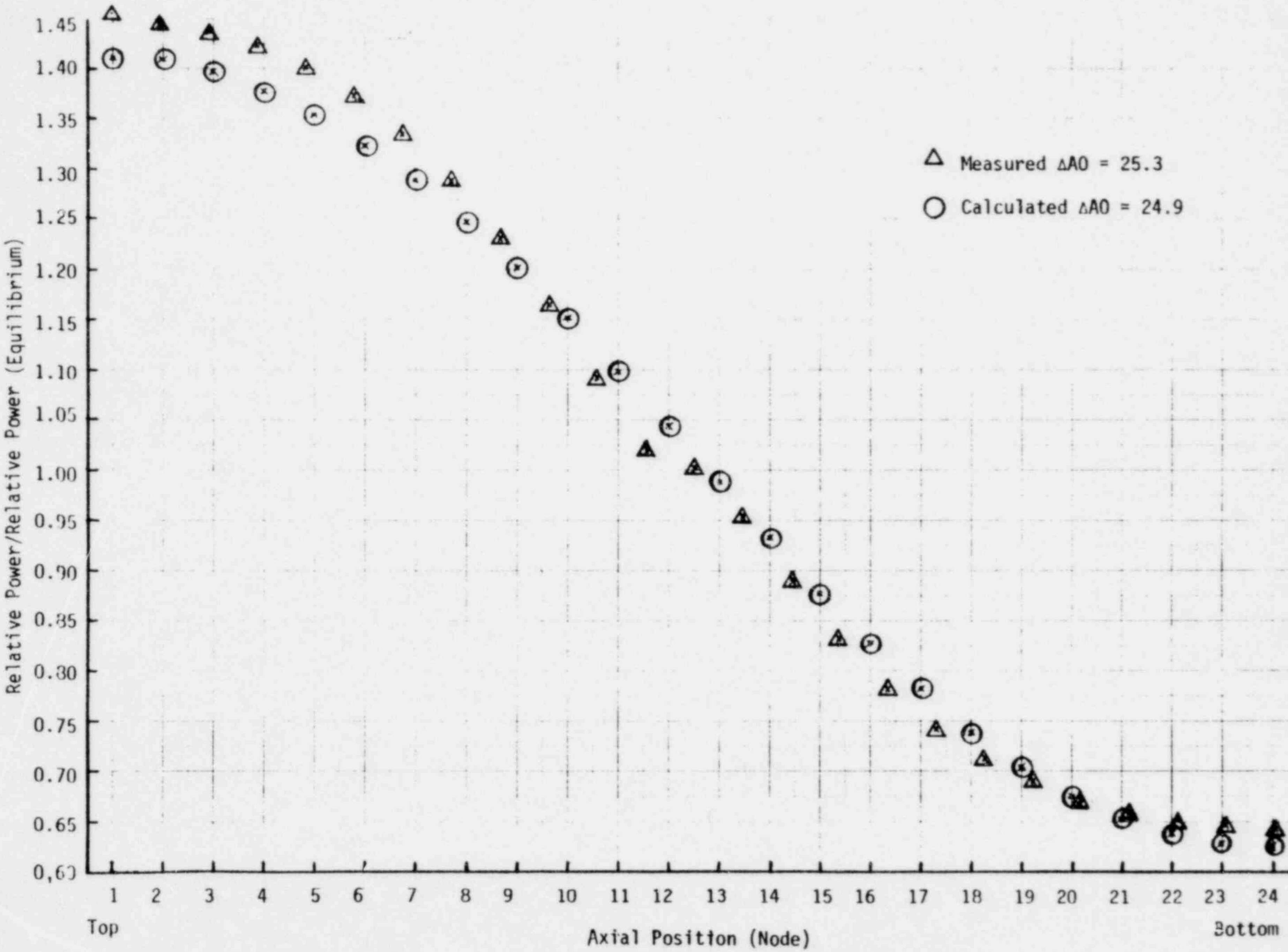


Figure 5.1 Palisades Axial Power Variation Comparison

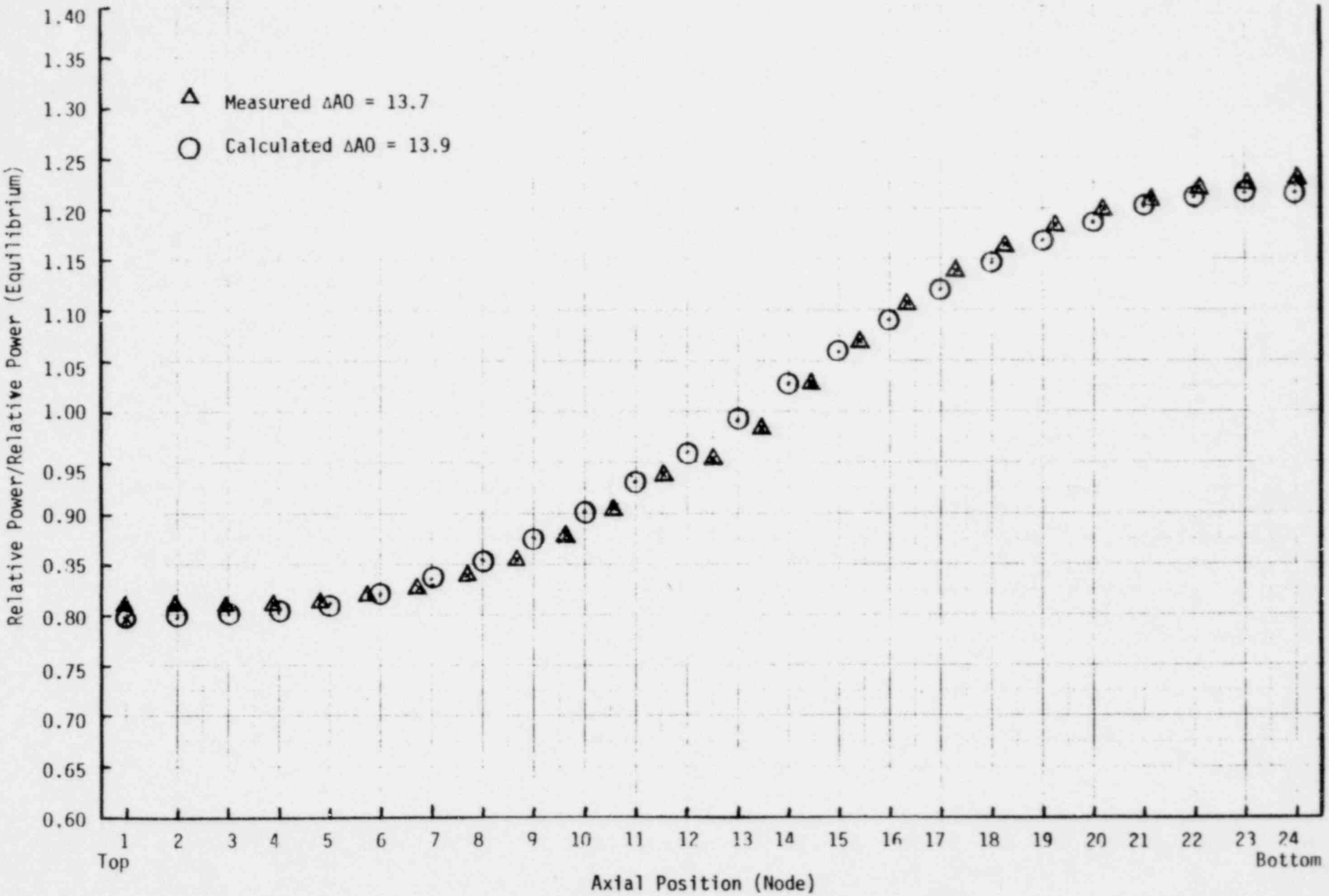


Figure 5.2 Palisades Axial Power Variation Comparison

## 6.0 REFERENCES

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5) XN-CC-28, Revision 5, "XTG - A Two Group Three-Dimensional Reactor Simulator Utilizing Coarse Mesh Spacing and Users Manual", Exxon Nuclear Company, R. B. Stout, July 1979.

6) XN-75-27, "Exxon Nuclear Neutronic Design Methods for Pressurized Water Reactors", Exxon Nuclear Company, F. B. Skogen, June 1975.

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8) Supplement 2 to XN-75-27, December 1977.

# APPENDIX A

## EVALUATION OF PDC PROCEDURES FOR IMPLEMENTATION IN THE PALISADES REACTOR

## 1.0 INTRODUCTION AND SUMMARY

A preliminary evaluation (Phase I) of operating the Palisades Reactor within the Exxon Nuclear Company developed power distribution (PDC-II control procedures has been completed. The implementation of a power distribution control procedure such as PDC-II in Palisades provides a means by which the reactor can be operated exclusively on excore detectors for a certain length of time in the event that the incore detectors fail. Power distribution control using PDC-II provides a separate system for ensuring margins to the safety limits such as LOCA (Loss of Coolant Accident) and MDNBR (Minimum Departure from Nucleate Boiling Ratio). The details of the ENC Power distribution control methodology can be found in Reference 3, PDC-I, and in References 4 and 5, PDC-II. Briefly, the PDC-I methodology protects a PWR generic $F_Q$-limit of 2.32 while PDC-II, which is keyed to the actual measured power distributions at the plant, will protect a variable (in magnitude) $F_Q$ limit. The latter is accomplished by quantifying the variation in the core power distribution during anticipated load follow operations and combining this function with the measured distribution to establish the maximum anticipated power shape or conversely the lowest limit that can be protected.

The Phase I investigation indicates that the PDC-II methodology, briefly discussed above and in References 3, 4, and 5, can be incorporated into the Palisades reactor control procedures. The PDC-II system, which depends only on excore instrumentation for normal operations and incore power maps for calibration, will benefit the Palisades reactor control system if implemented. The PDC-II procedure will allow operation of the Palisades reactor for a certain length of time after the failure of the incore detector system. This length of time will depend on how well the excore detectors will remain calibrated. In some cases the recalibration interval has been as long as four (4) months. For Palisades this parameter must be defined. Currently the plant is allowed to operate only two hours at 100% power after the loss of the incore detectors.

A plant specific PDC-II model for Palisades has been developed and compared to the generic ENC PDC-II reactor model. The Palisades model using conservative core input parameters from the generic model produce variations in LHGR results which are bounded by the generic PDC-II limits.

Based on these variational results in conjunction with anticipated Palisades equilibrium power distributions it is anticipated that the power distributions allowed by the PDC-II procedures will be bounded by those used in previous safety analyses.[10]

A preliminary outline of the procedures for implementation of PDC-II in Palisades has been included. In Phase II of this work a complete set of operating procedures will be issued. In addition, verification of measured and anticipated Palisades power distributions with regard to PDC-II will be conducted. The Phase II work will be aimed at incorporating PDC-II procedures into the Palisades Technical Specifications and the completion of all tasks required to obtain NRC approval for use of the procedures at the plant.

## 2.0 METHODS

The power distribution control methodology described in References 3, 4, and 5 utilized the computer code XTG[6] in a one-dimensional configuration. The results of the one-dimensional model were tested against standard ENC methods[7,8,9] and operating data from the Ft. Calhoun and D. C. Cook reactors. Thermal-Hydraulic and Doppler feedback effects are accounted for in the model.

Reactor power distributions can be bounded by the PDC-II procedure described in References 3, 4, and 5. The PDC-II operating guidelines proposed by ENC maintains the core power distribution within limits prescribed by Plant Technical Specifications through the use of excore detectors. The total peaking factor, $F_Q$, is protected by controlling the axial power distribution and maintaining the difference in the Axial Offset, (the difference in the power in the top half and the power in the bottom half over total power) as indicated on the excore detectors, to within $\pm 5\%$ of a target axial offset as determined by the last incore calibration. The significant feature of PDC-II is that it is viewed as controlling the variation in the axial power distribution rather than controlling the axial power distribution itself. The PDC-II procedural control of the variation of the axial power distribution ensures margins to the reactor safety limits without being operationally unduly restrictive.

In the Palisades analysis Cycles 1, 2, and 3 were analytically depleted in a three-dimensional quarter core model and normalized to measured data. The Cycle 3 model was then collapsed to a one-dimensional axial model for comparison to the generic PDC-II model. Only cases found to be most limiting with PDC were run with Palisades data and compared to the generic PDC-II results.

## 3.0 EVALUATION OF PDC-II CONTROL FOR PALISADES

Three areas have been investigated to determine if PDC-II can be utilized to control the power distribution in Palisades. The first area of investigation was to determine if the Palisades power distribution behaves and responds similarly to the reactor model used in the generic analyses performed in support of PDC-II. The second area of investigation was to determine if PDC-II procedures protect the MDNBR limits as specified in the Technical Specifications for Palisades. The third area was to determine if PDC-II would protect against exceeding the peak to average assembly power ratio limit ($F_r$) described in the Technical Specifications for Palisades. The means for showing that the Palisades reactor is similar to the generic PWR is discussed in Section 3.1. The work in this area concentrated on showing that the variations in the Palisades power distributions fell below the bounding limits of the generic reactor, and that the parameter selection of the Palisades PDC-II XTG models is conservative. The protection of the MDNBR limits for Palisades, discussed in Section 3.2, depends in part on the ability to ensure against exceeding the $F_r$ limit. The method to ensure against exceeding the $F_r$ limit is discussed in Section 3.3.

### 3.1 COMPARISON OF PALISADES TO THE GENERIC PDC-II REACTOR

Comparison of the generic PDC-II reactor to the Palisades reactor was conducted by comparing the results of the PDC-II generic model to the results obtained with the PDC-II model developed specifically for Palisades. The load follow simulation cases investigated are described in Table 3.1. These cases were determined to be the most limiting in the generic PDC-II analyses. In all cases the sensitive core parameters in the PDC-II model for Palisades were set equal to parameters from the generic PDC-II model and determined to be conservative. In addition the axial peaking factors, as a function of control rod insertion and axial position, from the generic PDC-II analysis were used for the Palisades reactor. These parameters in Palisades are as much as 7% lower than those used in the generic PDC-II analysis. The use of generic core parameters in the Palisades analysis increases the confidence that the results are bounded by the PDC-II limits. Table 3.2 shows a comparison of some key parameters for Palisades and the generic reactor. If this model is determined to be unduly conservative, the calculational model will be modified to correspond more specifically to Palisades.

Preliminary power peaking calculations with the Palisades PDC-II model, with conservatisms, was determined to fall below the upper bound of the maximum change in the linear heat generation rate peaking factor ($F_Q$) for the generic PDC-II reactor, see Figure 3.1. From this analysis the PDC-II procedure, when used in Palisades, will provide adequate protection for $F_Q(Z)$ limits.

## 3.2 PROTECTION OF MDNBR LIMITS

The PDC-II procedure ensures that MDNBR limits are not exceeded by showing that reactor operation does not exceed the limits set forth in the Technical Specifications. Reference 10 shows that at 115% power using peak pin and peak assembly limits, with a 6% maldistribution of flow that MDNBR was above the limit of 1.30. The transient results, reported in Reference 10, also indicate an MDNBR of greater than the 1.30 limits.

Analysis of the plant transients indicates that operation under PDC-II would yield MDNBR values greater than or equal to those calculated in Reference 10. In the transient analysis the input values for $F_r$, $F_z$ and $F_q^t$ are all greater than or equal to the peaking values anticipated by operation under the PDC-II procedure. The PDC-II procedure ensures that MDNBR limits are not exceeded by maintaining core peaking factors below operating limits.

### 3.3 PROTECTION OF $F_r$ LIMITS USING EXCORE DETECTORS

The PDC-II method does not directly ensure that the $F_r$ limit is not exceeded. By imposing a quadrant tilt limit using the excore detectors, however, it is possible to ensure an $F_r$ limit. If the excore quadrant tilt is calibrated with an incore measurement and a maximum quadrant tilt limit is imposed, the reactor should be allowed to continue operation with no real restrictions imposed under normal operating conditions. The restrictive tilt limit is needed to protect the core against any transient or abnormal operating condition which may cause radial power increases accompanied with only minimal changes in the axial power distribution, i.e., dropped rod.

Table 3.1 Reactor Operating Conditions Analyzed with the Palisades 1D Model

| Exposure MWD/MT | Target* Axial Offset | Description of Operation |
|---|---|---|
| 7,500 | -2.6 | Operated such that the axial offset is maintained within the target band. (+/-$AO_{TB}$) |
| 7,500 | -2.6 | Operated such that at full power the axial offset is maintained at the positive limit and at half power the axial offset is maintained at the negative limit. [+AO(full)/-AO(half)] |

Table 3.2 Plant Characteristics

| | Generic PDC-II PWR | Palisades PWR |
|---|---|---|
| Power | 3,250 MWt | 2,350 MWt |
| Power Density | 100 kw/liter | 79.7 kw/liter |
| Active Fuel Length | 12 ft. | 11 ft. |
| Coolant Flow Rate | $1.43\times10^{8}$ lb/hr | $1.269\times10^{8}$ lb/hr |
| Inlet Temperature | 545$^{o}$F | 537.5$^{o}$F |
| Single Control Bank Worth | 1.0 %$\rho$ | 0.45 %$\rho$ |
| Doppler Broadening Coefficient | 0.0059 | 0.00585 |
| Control Rod Insertion Limit | 50% at Full Power | 25% at Full Power |

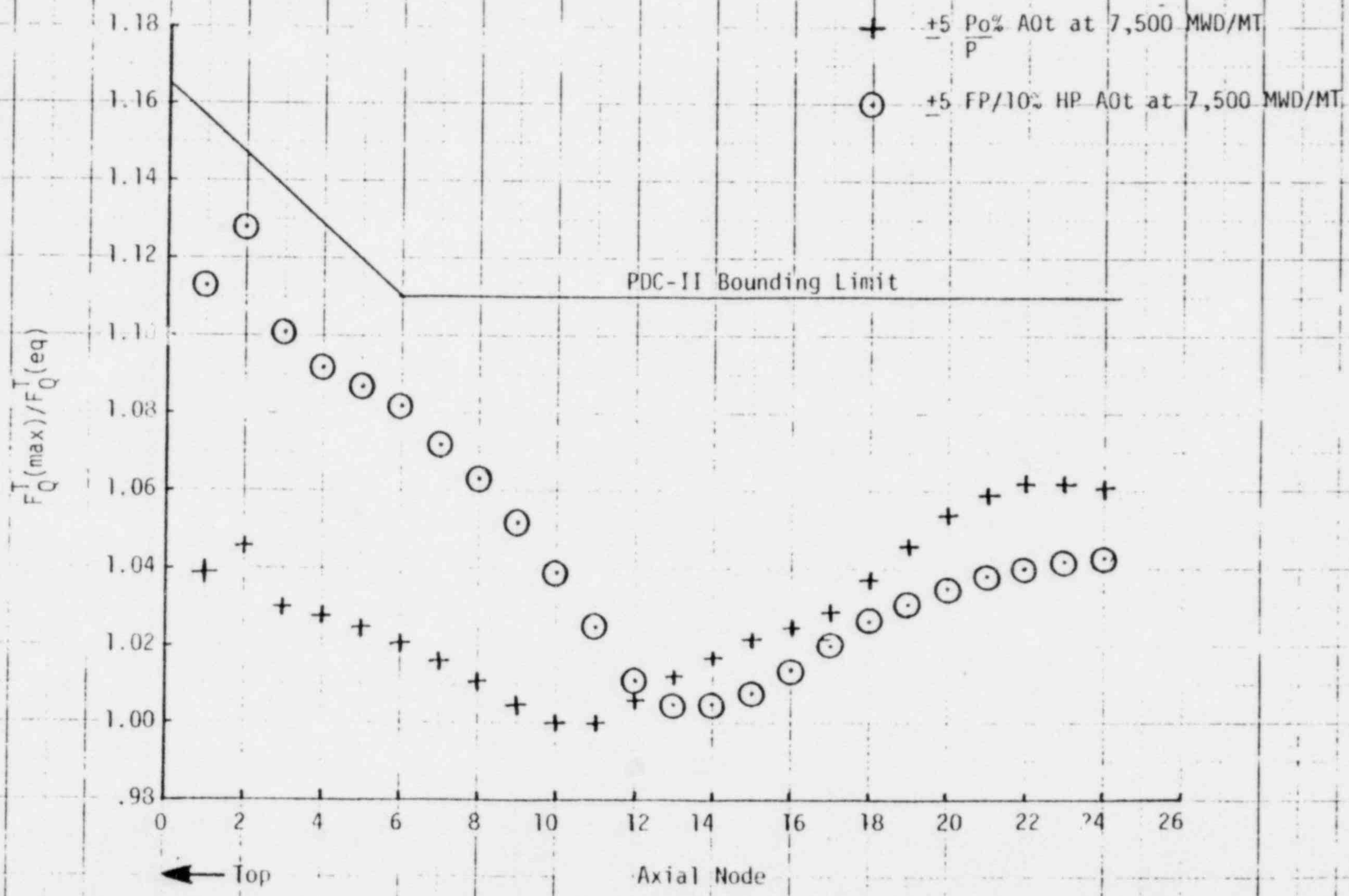


Figure 3.1 Variation from an Equilibrium Power Distribution-Comparison of Palisades Model vs. Generic PDC-II Limit

## 4.0 IMPLEMENTATION OF THE PDC-II PROCEDURES IN PALISADES

Implementing the PDC-II procedure in Palisades will impose tighter operating controls than do the incore detector and control system procedures presently in use. The PDC-II procedure bounds operation using excore detectors. PDC-II, being more restrictive, will require that it be in operation at all times to ensure that the condition of the core (Xenon distribution, Power Distribution, etc.) is within PDC-II limits in the event that the incore monitoring system is inoperative. The PDC-II procedure is based on maintaining the reactor axial offset within specific bounds to ensure that $F_Q(Z)$ and MDNBR limits are not exceeded.

The following is a brief description of procedures which will be required to implement PDC-II in Palisades:

- Quadrant Power Tilt with excore detectors. This procedure is needed to ensure $F_r$ limits when the plant is being operated exclusively on the excore detectors. Included in the procedure will be a new set of limits for Quadrant Power Tilt and an excore detector calibration procedure for Quadrant Power Tilt.
- Power Operation using the excore detector power ratio alarms - This procedure will incorporate axial offset limits on the core which are required to confrom to PDC-II procedures using the excore detectors. Included in these procedures will be operating guidelines and calibration procedure for excore detectors.

## 5.0 PHASE II WORK

There are several additional objectives to be achieved in the Phase II of the PDC-II procedure implementation for the Palisades reactor. The first will be to compare the Palisades PDC-II model to operating data dealing with xenon oscillations. This will calibrate the Palisades PDC-II model to operating data. The second will be to do a more detailed analysis of accident stiuations while operating under PDC-II limits to assure that MDNBR limits in Palisades are not violated. The third objective is to prepare a complete set of procedures for implementing PDC-II in Palisades with the intent of achieving on NRC operating license.

## 6.0 REFERENCES


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3. J.S. Holm F.B. Skogen, "Exxon Nuclear Power Distribution Control For Pressurized Water Reactors", XN-76-40, Exxon Nuclear Company, September, 1976.

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5. Supplement 1 to Reference 4, June, 1979.

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8. Supplement 1 to Reference 7, September 1976.

9. Supplement 2 to Reference 7, December, 1977.

10. R.H. Kelly, "Analysis of Axial Power Distribution Limits For The Palisades Reactor at 2530 $MW_e$", XN-NF-78-16, Exxon Nuclear Company, June, 1978.

III. Conclusion

Based on the foregoing, both the Palisades Plant Review Committee and the Safety and Audit Review Board have reviewed these changes and find them acceptable.

CONSUMERS POWER COMPANY

By R B DeWitt

R B DeWitt, Vice President
Nuclear Operations

Sworn and subscribed to before me this 21st day of July 1981.

Helen I Dempski

Helen I Dempski, Notary Public
Jackson County, Michigan
My commission expires December 14, 1983