Westinghouse Electric Company
Nuclear Services
P.O. Box 355
Pittsburgh, Pennsylvania 15230-0355
USA

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Direct tel: (412) 374-5036
Direct fax: (412) 374-4011
e-mail: galem1js@westinghouse.com

Attention: Chief, Information Management Branch
Division of Program Management
Policy Development and Analysis Staff

Our ref: CAW-02-1535

June 27, 2002

APPLICATION FOR WITHHOLDING PROPRIETARY
INFORMATION FROM PUBLIC DISCLOSURE

Subject: WCAP-15902-P, Rev. 0, Entitled "Conditional Extension of the Rod Misalignment Technical Specification for Indian Point Unit 2" (Proprietary)

The proprietary information for which withholding is being requested in the above-referenced report is further identified in Affidavit CAW-02-1535 signed by the owner of the proprietary information, Westinghouse Electric Company LLC. The affidavit, which accompanies this letter, sets forth the basis on which the information may be withheld from public disclosure by the Commission and addresses with specificity the considerations listed in paragraph (b)(4) of 10 CFR Section 2.790 of the Commission's regulations.

Accordingly, this letter authorizes the utilization of the accompanying Affidavit by the Westinghouse Owners Group.

Correspondence with respect to the proprietary aspects of the application for withholding or the Westinghouse affidavit should reference this letter, CAW-02-1535 and should be addressed to the undersigned.

Very truly yours,

J. S. Galembush, Acting Manager
Regulatory and Licensing Engineering

Enclosure

T007

**AFFIDAVIT**

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared John S. Galembush, who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Westinghouse Electric Company, LLC ("Westinghouse"), and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief:

John S. Galembush, Acting Manager
Regulatory and Licensing Engineering

Sworn to and subscribed
before me this 27th day
of June, 2002

Notary Public

Notarial Seal
Kay E. Gongaware, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires Feb. 7, 2005
Member, Pennsylvania Association of Notaries

KAY E. GONGAWARE
COMMONWEALTH OF PENNSYLVANIA
NOTARY PUBLIC

(1) I am Acting Manager, Regulatory and Licensing Engineering, in the Nuclear Services, of the Westinghouse Electric Company, LLC ("Westinghouse") and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rulemaking proceedings, and am authorized to apply for its withholding on behalf of Westinghouse Electric Company, LLC.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.790 of the Commission's regulations and in conjunction with the Westinghouse application for withholding accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by the Westinghouse Electric Company, LLC in designating information as a trade secret, privileged or as confidential commercial or financial information.

(4) Pursuant to the provisions of paragraph (b)(4) of Section 2.790 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse.

(ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitutes Westinghouse policy and provides the rational basis required.

Under that system, information is held in confidence if it falls in one or more of the following areas of potential competitive advantage:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.) the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

There are sound policy reasons behind the Westinghouse system which include the following:

(a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.

(b) It is information which is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

(c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition of those countries.

(f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

(iii) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.790, it is to be received in confidence by the Commission.

(iv) The information sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method to the best of our knowledge.

(v) The proprietary information sought to be withheld in this submittal is that which is appropriately marked in WCAP-15902-P, "Conditional Extension of the Rod Misalignment Technical Specification for Indian Point Unit 2," for information in support of Indian Point Unit 2 Technical Specifications licensing amendment change transmitted to Entergy Nuclear Operations Inc. via Westinghouse Letter CAC-02-120, dated June 27, 2002 for submittal to the Commission. The proprietary information was provided by Westinghouse Electric Company, LLC.

This information is part of that which will enable Westinghouse to:

(a) Assist the customers in the licensing and NRC approval of the Technical Specification changes associated with this program.

Further this information has substantial commercial value as follows:

(a) Westinghouse plans to sell the use of similar information to its customers for the purpose of extending the Rod Misalignment Technical Specification.

(b) Westinghouse can sell support and defense of the technology to its customers in the licensing process.

Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar calculation, evaluation and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent and experience, would have to be expended for development of analytical techniques and data in support of this program.

Further the deponent sayeth not.

**COPYRIGHT NOTICE**

## PROPRIETARY INFORMATION NOTICE

Transmitted herewith are proprietary and/or non-proprietary versions of documents furnished to the NRC in connection with requests for generic and/or plant-specific review and approval.

In order to conform to the requirements of 10 CFR 2.790 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary version is contained within brackets, and where the proprietary information has been deleted in the non-proprietary version, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the affidavit accompanying this transmittal pursuant to 10 CFR 2.790(b)(1).

Westinghouse Non-Proprietary Class 3

WCAP-15902-NP
Revision 0

June 2002

# Conditional Extension of the Rod Misalignment Technical Specification for Indian Point Unit 2

Westinghouse

WESTINGHOUSE NON-PROPRIETARY CLASS 3

WCAP-15902-NP

# Conditional Extension of the Rod Misalignment Technical Specification for Indian Point Unit 2

June, 2002

R. J. Fetterman

Verified:________________
F. F. Cortazar

Approved:________________
E. J. Piplica, Manager
Core Analysis C

Westinghouse Electric Company LLC
Nuclear Fuel
4350 Northern Pike
Monroeville, Pennsylvania 15146-2886

## ABSTRACT

This report proposes modifying the Technical Specification for allowable rod misalignment from the current ±12 steps indicated to a value up to a maximum of ±18 steps indicated, depending upon the minimum available peaking factor margin. Such a Technical Specifications change is sought to minimize disruptions to normal plant operations due to frequent and erroneous indications of rod misalignment from the Analog Rod Position Indicator (ARPI).

The required margins to the hot rod and hot spot peaking factor ($F_{\Delta H}$ and $F_Q$) limits will be determined by examining the changes in these peaking factors between similar cases with misalignments of ±12 and ±18 steps indicated. These resulting required margins will be determined such that they are cycle independent for Indian Point 2. It will also be shown that plant safety will not be compromised by this Technical Specifications change.

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## ACKNOWLEDGEMENTS

The author gratefully acknowledges the following individuals for their contributions to the completion of this report: F. F. Cortazar and C. R. Tuley.

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## LIST OF FIGURES

# 1 INTRODUCTION

The current Westinghouse licensing basis supports an indicated rod misalignment of ±12 steps for any rod(s) within a bank from the bank demand position. As the analog rod position indication system (ARPI) has an uncertainty of 12 steps, the actual misalignment may be as large as ±24 steps. In most cases, these indicated misalignments are false readings caused by fluctuations in the temperature of the control rod drive shafts. For example, such fluctuations can occur after rod control cluster assemblies (RCCAs) are withdrawn from the core during startup. However, when an indication of a misalignment does occur, false or otherwise, the reactor operator must take corrective action per the Technical Specifications.

Increasing the maximum allowable indicated misalignment to ±18 steps (actual misalignment of ±30 steps) for core powers above 85% rated thermal power (RTP) and ±24 steps (actual misalignment of ±36 steps) for core powers less than or equal to 85% rated thermal power (RTP) will provide relief to the aforementioned conditions of false misalignment indications from the ARPI. For real misalignments, these misalignment increases generally yield small but acceptable increases in the hot rod and hot spot peaking factors, $F_{\Delta H}$ and $F_Q$. This report will briefly review the feasible single failures of the rod control system that could yield misalignments of single and multiple rods. These feasible single failures will then form the basis for the cases analyzed and documented in this report to support the increase in the misalignment permitted by the Technical Specifications.

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# 2 DESCRIPTION OF ROD CONTROL SYSTEM FAILURES

To determine the misalignment cases to be analyzed for this Technical Specification change, an evaluation of the rod control system was performed, drawing from the Failure Mode and Effects Analysis (FMEA) documented in Reference 1. This evaluation considered single failures within the rod control system logic cabinets, power cabinets and the control rod drive mechanisms (CRDMs). This evaluation also considered the impacts of the revised current order timing previously documented in Reference 2.

This evaluation has determined that a single failure of the rod control system can result in six categories of failure mechanisms within the system:

A. [

]$^{a,c}$.

B. [

]$^{a,c}$.

C. [

]$^{a,c}$.

D. [

]$^{a,c}$.

E. [

]a,c.

F. [

]a,c.

# 3 ANALYSES SUPPORTING NORMAL OPERATION

For the remainder of this report, the failure mechanisms discussed in Section 2 will be referred to by the letter they are listed as; i.e. failures A through F. When analyzing these failure mechanisms for peaking factor impacts, the following cabinet configurations must be considered:

1. 1AC: groups CA1, CC1, SA1
2. 2AC: groups CA2, CC2, SA2
3. 1BD: groups CB1, CD1, SB1
4. 2BD: groups CB2, CD2, SB2
5. SCD: groups SC, SD

The above configurations are also illustrated in Figure 3.1. The group nomenclature used to describe the power cabinets is defined as follows: the first letter (C or S) refers to a control or shutdown bank; the second letter (A, B, C or D) refers to the bank; the number (1 or 2) refers to the group number. For example, power cabinet 1AC controls group CA1, which is group 1 of control bank A. Power cabinet 2BD controls group SB2, which is group 2 of shutdown bank B. Note that the Indian Point 2 plant does not have a shutdown bank E (SE), which would be the third group of rods in power cabinet SCD.

[

]$^{a,c}$.

## 3.1 ANALYSIS METHODOLOGY

The failure mechanism categories described in Section 2 will be analyzed using the USNRC-approved PHOENIX-P/ANC core design system documented in References 3 and 4. For each failure analyzed, calculations are performed for misalignments of ±24 steps plus additional misalignments and compared to the corresponding non-misaligned reference case.

The $F_{\Delta H}$ and $F_Q$ for these cases are calculated and compared [

]$^{a,c}$.

## 3.2 CORE MODELS USED FOR ANALYSIS

To perform the analysis of the possible rod misalignments, two different ANC models of the Indian Point 2 core were used. The first model represents the planned design for 24 month cycle operation. The second model represents an 18 month transition cycle. These two models are summarized in Table 3.1 below:

**Table 3.1 Design Models Used in Rod Misalignment Analyses**

| Design Parameter | Current Cycle | Future Cycle |
|---|---|---|
| Cycle Length (End of Full Power Capability, EFPD) | 660 | [ ]a,c |
| No. of Feed Assemblies | 88 | [ ]a,c |
| No. Feeds Under Lead Bank (No. @ w/o U235) | 8 @ 4.95 | [ ]a,c |
| Feed Enrichments (No. @ w/o U235) | 32 @ 4.60<br>8 @ 4.80<br>48 @ 4.95 | [ ]a,c |
| Axial Blankets (w/o U235) | 8, 6" 2.6 w/o Annular<br>80, 8" 3.2 w/o Annular | [ ]a,c |
| Burnable Absorbers (No. / Type / Length) | 848 IFBA, 120" centered<br>7664 IFBA, 128" centered<br>112 WABA, 132" centered<br>1040 WABA, 120" centered | [ ]a,c |
| $F_{\Delta H}$ Limit | 1.70 | [ ]a,c |
| $F_Q$ Limit | 2.50 | [ ]a,c |

## 3.3 MISALIGNMENT CASES ANALYZED

For the failure mechanism categories listed in Section 2, several distinct subsets of cases are analyzed in ANC. These cases are considered at [

]a,c. Some cases are also examined at other cycle burnups, although these cases were found to generally yield less limiting increases in peaking factors from an increase in the rod misalignment. Most of the calculations are performed assuming the reference condition as hot full power (HFP) [

]a,c; the Indian Point 2 RILs are illustrated in Figure 3.2. Several of these cases are repeated at other reference rod conditions above the RILs, and at part power conditions such as 85% and 50% rated thermal power. The subsets of cases analyzed are summarized below:

1. [

]a,c.

2. [

]a,c.

3. [

]a,c.

4. [

]a,c.

5. [

]a,c.

6. [

]a,c.

7. [

]a,c.

8. [

]a,c.

The basic analysis approach used in this report proposes dividing the rod misalignment Technical Specification into two modes of surveillance: operation at core powers greater than 85% rated thermal power (RTP); operation at core powers less than or equal to 85% RTP.

For the first mode of surveillance, the specific HFP cases analyzed for an additional 6 steps of misalignment are summarized in Table 3.3. The failure mechanisms listed in Table 3.3 are described in Section 2. Several of the limiting 6 step additional misalignment cases were repeated with only 3 steps of additional misalignment (±27 steps total) as listed in Table 3.4. The performance of the 3 step misalignment cases provide completeness and verify the bounding nature of the evaluation process utilized in this report. Results from these two tables are summarized in Table 3.2.

For the second mode of surveillance, additional cases were performed at part power conditions as listed in Tables 3.5 through 3.7 for additional misalignments of 6, 9 and 12 steps (30, 33 and 36 steps total). The results of the 12 additional step cases in Table 3.7 are used to determine an acceptable rod misalignment limit for core powers less than or equal to 85% RTP. The performance of the 6 and 9 step misalignment part-power cases provide completeness and verify the bounding nature of the evaluation process utilized in this report. Results from these three tables are also summarized in Table 3.2.

## 3.4 ANALYSIS RESULTS, POWER > 85% RTP

A complete description of all cases analyzed is presented in Tables 3.3 through 3.7. A summary of all cases analyzed and the limiting results to support the rod misalignment Technical Specifications change is given in Table 3.2. This data is presented as the change in the peak $F_{\Delta H}$ and $F_Q$ for an increase in the rod misalignment beyond the current licensing basis of ±12 steps indicated (±24 steps actual).

Note that with the current $F_{\Delta H}$ and $F_Q$ Technical Specifications, margins to the limits generally increase as power level decreases:

$$F_{\Delta H}^{LIMIT} = F_{\Delta H}^{HFP}[1 + 0.3(1 - P)] \quad (1)$$

$$F_Q^{LIMIT} = \frac{F_Q^{HFP}}{P}, P > 0.5 \quad (2)$$

Then, since $F_{\Delta H}$ and $F_Q$ margins are usually a minimum at HFP, the amount of margin required to allow the permissible indicated misalignment to be increased from ±12 to ±18 steps will be determined based on the HFP data for the additional ±6 step misalignments from Table 3.3 and summarized in Table 3.2.

For all HFP ±6 step misalignment cases, the 95/95 increases in $F_{\Delta H}$ and $F_Q$ are [ ]$^{a,c}$ and [ ]$^{a,c}$ respectively, and the maximum increases in $F_{\Delta H}$ and $F_Q$ are [ ]$^{a,c}$ and [ ]$^{a,c}$ respectively. These results can be conservatively bounded by required $F_{\Delta H}$ and $F_Q$ margins of [ ]$^{a,c}$ and [ ]$^{a,c}$, respectively, for increased rod misalignment of ±6 steps. Note that these required margins are an increase of [ ]$^{a,c}$ and [ ]$^{a,c}$ respectively over the 95/95 values and an increase of [ ]$^{a,c}$ and [ ]$^{a,c}$ respectively over the observed maximum values for all HFP ±6 step cases.

Examining the ±3 step misalignments from Table 3.4, and summarized in Table 3.2, the 95/95 increases in $F_{\Delta H}$ and $F_Q$ are [ ]$^{a,c}$ and [ ]$^{a,c}$ respectively, and the maximum increases in $F_{\Delta H}$ and $F_Q$ are [ ]$^{a,c}$ and [ ]$^{a,c}$ respectively. These results can be conservatively bounded by required $F_{\Delta H}$ and $F_Q$ margins of [ ]$^{a,c}$ and [ ]$^{a,c}$ respectively. Note that these required margins are an increase of [ ]$^{a,c}$ and [ ]$^{a,c}$ respectively over the 95/95 values and an increase of [ ]$^{a,c}$ and [ ]$^{a,c}$ respectively over the observed maximum values for all ±3 step cases. The analysis approach of the ±3 step cases is also conservative in that most of the cases analyzed [ ]$^{a,c}$ were chosen based on which cases provided limiting results in the ±6 step analysis. [ ]$^{a,c}$.

Therefore, the proposed $F_{\Delta H}$ and $F_Q$ margins for an additional 3 steps of misalignment are half of the limits proposed for an additional 6 steps. This would suggest that margin required for an increase in the permissible misalignment for core powers greater than 85% RTP can then be specified as a linear function of the available peaking factor margin, with the misalignment increase being determined from the minimum of the available $F_{\Delta H}$ or $F_Q$ margin. The proposed rod misalignment limit for core powers greater than 85% RTP is illustrated in Figure 3.3.

## 3.5 ANALYSIS RESULTS, POWER ≤ 85% RTP

The ±6, ±9 and ±12 additional step part-power misalignment cases are listed in Table 3.5 through 3.7 respectively, and summarized in Table 3.2. The 95/95 increases in the ±6, ±9 and ±12 additional step $F_{\Delta H}$ and $F_Q$ are [ ]$^{a,c}$ and [ ]$^{a,c}$, [ ]$^{a,c}$ and [ ]$^{a,c}$, and [ ]$^{a,c}$ and [ ]$^{a,c}$ respectively. The ±6 additional step part-power 95/95 $F_{\Delta H}$ and $F_Q$ increases are only [ ]$^{a,c}$ and [ ]$^{a,c}$, respectively, larger than the HFP-only ±6 additional step increases. However, by 85% power, the Technical Specification $F_{\Delta H}$ and $F_Q$ limits have increased by 4.5% and 17%, respectively, as defined in Equations 1 and 2. [ ]$^{a,c}$, the proposed rod misalignment Technical Specification limit of ±18 steps indicated for core powers above 85% RTP can be increased for core powers less than or equal to 85% RTP. At 85% RTP, the peaking factor limit increases of 4.5% in $F_{\Delta H}$ and 17% in $F_Q$ [ ]$^{a,c}$ in $F_Q$ due to the additional ±12 additional steps of rod misalignment. The analysis approach of the part-power misalignment cases is also conservative in that most of the cases analyzed [ ]a,c were chosen based on which cases provided limiting results in the ±6 step analysis. [

]a,c. Therefore, the proposed allowable indicated misalignment is ±24 steps for core powers of 85% RTP or less.

## 3.6 PROPOSED TECHNICAL SPECIFICATION CHANGES

A graphic representation of the proposed Technical Specification for core powers greater than 85% RTP discussed in Section 3.4 is shown in Figure 3.3. The amount of available margin must be determined at least once every 30 EFPD during normal incore flux map surveillance. For Indian Point 2, the amount of $F_Q$ margin will be based on the $F_Q$ surveillance methodology (Reference 6), which accounts for any transient and burnup effects on the measured steady-state $F_Q$. The required peaking factors margins for additional misalignments at core powers above 85% RTP are also summarized below:

| **Indicated Misalignment ( Steps)** | **Additional Misalignment ( Steps)** | **Required Margin** | |
|---|---|---|---|
| | | **$F_{\Delta H}$** | **$F_Q$** |
| 12 | 0 | [ ]a,c | [ ]a,c |
| 13 | 1 | [ ]a,c | [ ]a,c |
| 14 | 2 | [ ]a,c | [ ]a,c |
| 15 | 3 | [ ]a,c | [ ]a,c |
| 16 | 4 | [ ]a,c | [ ]a,c |
| 17 | 5 | [ ]a,c | [ ]a,c |
| 18 | 6 | [ ]a,c | [ ]a,c |

For core powers of 85% RTP or less, as discussed in Section 3.5, the allowable indicated rod misalignment will be ±24 steps. At this amount of misalignment, the increase in the peaking factors relative to the current limit of ±12 steps is [ ]a,c as defined in Equations 1 and 2 of Section 3.4.

**Figure 3.1 Indian Point 2 Control and Shutdown Rod Configuration By Subgroup and Power Cabinet**

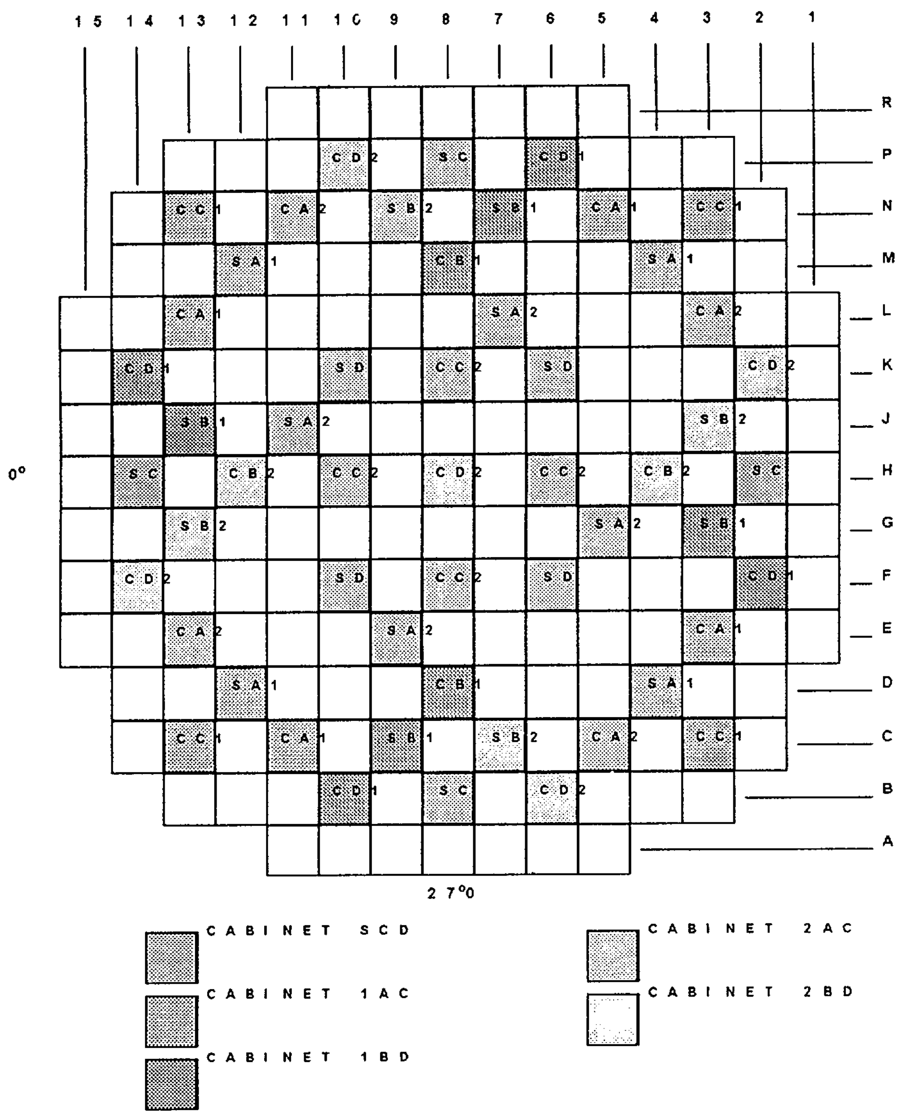

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**Figure 3.2 Indian Point 2 Control Rod Insertion Limits**

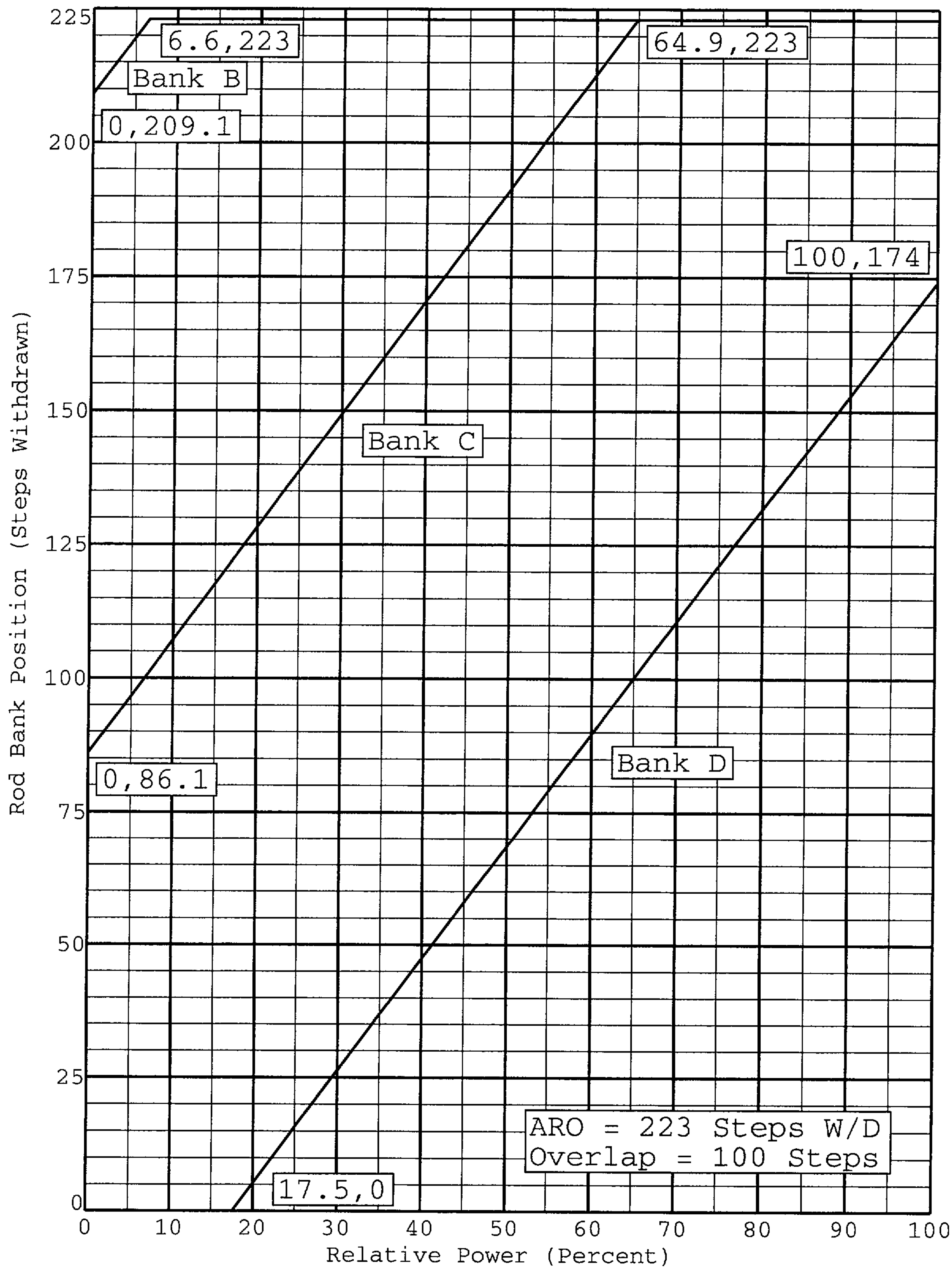

**Figure 3.3 Permissible Increase in Rod Misalignment Vs. Available $F_{\Delta H}$ and $F_Q$ Margin**

a,c

## Table 3.2 Summary of Misalignment Cases Analyzed; Change in Peak $F_{\Delta H}$ and $F_Q$ for Increased Misalignment Beyond ±12 Steps Indicated

| Power, Indicated Misalignment, No. Points, Summary Table No. | Peak | Distribution Function | Mean ($\bar{x}$), % | Std. Dev. ($\sigma$), % | 95/95 Value, % | Max. % (Case No.) |
|---|---|---|---|---|---|---|
| HFP ±18 [ ]a,c Table 3.3 | $F_{\Delta H}$ | Extreme Value | [ ]a,c | [ ]a,c | [ ]a,c | [ ]a,c |
| | $F_Q$ | Beta | [ ]a,c | [ ]a,c | [ ]a,c | [ ]a,c |
| All Powers ±15 [ ]a,c Table 3.4 | $F_{\Delta H}$ | Weibell | [ ]a,c | [ ]a,c | [ ]a,c | [ ]a,c |
| | $F_Q$ | Beta | [ ]a,c | [ ]a,c | [ ]a,c | [ ]a,c |
| Part Power ±18 [ ]a,c Table 3.5 | $F_{\Delta H}$ | Beta | [ ]a,c | [ ]a,c | [ ]a,c | [ ]a,c |
| | $F_Q$ | Weibell | [ ]a,c | [ ]a,c | [ ]a,c | [ ]a,c |
| Part Power ±21 [ ]a,c Table 3.6 | $F_{\Delta H}$ | Beta | [ ]a,c | [ ]a,c | [ ]a,c | [ ]a,c |
| | $F_Q$ | Weibell | [ ]a,c | [ ]a,c | [ ]a,c | [ ]a,c |
| Part Power ±24 [ ]a,c Table 3.7 | $F_{\Delta H}$ | Beta | [ ]a,c | [ ]a,c | [ ]a,c | [ ]a,c |
| | $F_Q$ | Weibell | [ ]a,c | [ ]a,c | [ ]a,c | [ ]a,c |

**Table 3.3 Summary of 18 Step Indicated Hot Full Power Rod Misalignment Cases Analyzed (Sheet 1 of 16)**

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rod(s) Misaligned | Peaking Factor % Increase for Additional 6 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 1 | BOL | HFP | Current | A | D at 174 | | | |
| 2 | BOL | HFP | Current | D | D at 174 | | | |
| 3 | BOL | HFP | Current | A | D at 186 | | | |
| 4 | BOL | HFP | Current | D | D at 186 | | | |
| 5 | BOL | HFP | Current | A | D at 198 | | | |
| 6 | BOL | HFP | Current | A | D at 210 | | | |
| 7 | BOL | HFP | Current | A | D at 174 | | | |
| 8 | BOL | HFP | Current | D | D at 174 | | | |
| 9 | BOL | HFP | Future | A | D at 174 | | | |
| 10 | BOL | HFP | Future | D | D at 174 | | | |
| 11 | BOL | HFP | Future | A | D at 186 | | | |
| 12 | BOL | HFP | Future | D | D at 186 | | | |

a,c

## Table 3.3 Summary of 18 Step Indicated Hot Full Power Rod Misalignment Cases Analyzed (Sheet 2 of 16)

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rod(s) Misaligned | Peaking Factor % Increase for Additional 6 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 13 | BOL | HFP | Future | A | D at 198 | | | |
| 14 | BOL | HFP | Future | A | D at 210 | | | |
| 15 | BOL | HFP | Future | A | D at 174 | | | |
| 16 | BOL | HFP | Future | D | D at 174 | | | |
| 17 | MOL | HFP | Current | A | D at 174 | | | |
| 18 | MOL | HFP | Current | D | D at 174 | | | |
| 19 | MOL | HFP | Current | A | D at 174 | | | |
| 20 | MOL | HFP | Current | D | D at 174 | | | |
| 21 | MOL | HFP | Future | A | D at 174 | | | |
| 22 | MOL | HFP | Future | D | D at 174 | | | |
| 23 | MOL | HFP | Future | A | D at 174 | | | |
| 24 | MOL | HFP | Future | D | D at 174 | | | |

a,c

**Table 3.3 Summary of 18 Step Indicated Hot Full Power Rod Misalignment Cases Analyzed (Sheet 3 of 16)**

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rod(s) Misaligned | Peaking Factor % Increase for Additional 6 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 25 | EOL | HFP | Current | A | D at 174 | | | a,c |
| 26 | EOL | HFP | Current | D | D at 174 | | | |
| 27 | EOL | HFP | Current | A | D at 186 | | | |
| 28 | EOL | HFP | Current | D | D at 186 | | | |
| 29 | EOL | HFP | Current | A | D at 198 | | | |
| 30 | EOL | HFP | Current | A | D at 210 | | | |
| 31 | EOL | HFP | Future | A | D at 174 | | | |
| 32 | EOL | HFP | Future | D | D at 174 | | | |
| 33 | EOL | HFP | Future | A | D at 186 | | | |
| 34 | EOL | HFP | Future | D | D at 186 | | | |
| 35 | EOL | HFP | Future | A | D at 198 | | | |
| 36 | EOL | HFP | Future | A | D at 210 | | | |

## Table 3.3 Summary of 18 Step Indicated Hot Full Power Rod Misalignment Cases Analyzed (Sheet 4 of 16)

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rod(s) Misaligned | Peaking Factor % Increase for Additional 6 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 37 | BOL | HFP | Current | A | D at 174 | | | a,c |
| 38 | BOL | HFP | Current | D | D at 174 | | | |
| 39 | BOL | HFP | Current | A | D at 174 | | | |
| 40 | BOL | HFP | Current | D | D at 174 | | | |
| 41 | BOL | HFP | Current | A | D at 174 | | | |
| 42 | BOL | HFP | Current | D | D at 174 | | | |
| 43 | BOL | HFP | Future | A | D at 174 | | | |
| 44 | BOL | HFP | Future | D | D at 174 | | | |
| 45 | BOL | HFP | Future | A | D at 174 | | | |
| 46 | BOL | HFP | Future | D | D at 174 | | | |
| 47 | BOL | HFP | Future | A | D at 174 | | | |
| 48 | BOL | HFP | Future | D | D at 174 | | | |

**Table 3.3 Summary of 18 Step Indicated Hot Full Power Rod Misalignment Cases Analyzed (Sheet 5 of 16)**

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rod(s) Misaligned | Peaking Factor % Increase for Additional 6 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 49 | MOL | HFP | Current | A | D at 174 | | | a,c |
| 50 | MOL | HFP | Current | D | D at 174 | | | |
| 51 | MOL | HFP | Current | A | D at 174 | | | |
| 52 | MOL | HFP | Current | D | D at 174 | | | |
| 53 | MOL | HFP | Future | A | D at 174 | | | |
| 54 | MOL | HFP | Future | D | D at 174 | | | |
| 55 | MOL | HFP | Future | A | D at 174 | | | |
| 56 | MOL | HFP | Future | D | D at 174 | | | |
| 57 | EOL | HFP | Current | A | D at 174 | | | |
| 58 | EOL | HFP | Current | D | D at 174 | | | |
| 59 | EOL | HFP | Current | A | D at 174 | | | |
| 60 | EOL | HFP | Current | D | D at 174 | | | |

**Table 3.3 Summary of 18 Step Indicated Hot Full Power Rod Misalignment Cases Analyzed (Sheet 6 of 16)**

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rod(s) Misaligned | Peaking Factor % Increase for Additional 6 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 61 | EOL | HFP | Current | A | D at 174 | | | a,c |
| 62 | EOL | HFP | Current | D | D at 174 | | | |
| 63 | EOL | HFP | Current | A | D at 198 | | | |
| 64 | EOL | HFP | Current | A | D at 198 | | | |
| 65 | EOL | HFP | Future | A | D at 174 | | | |
| 66 | EOL | HFP | Future | D | D at 174 | | | |
| 67 | EOL | HFP | Future | A | D at 174 | | | |
| 68 | EOL | HFP | Future | D | D at 174 | | | |
| 69 | EOL | HFP | Future | A | D at 174 | | | |
| 70 | EOL | HFP | Future | D | D at 174 | | | |
| 71 | EOL | HFP | Future | A | D at 198 | | | |
| 72 | EOL | HFP | Future | A | D at 198 | | | |

**Table 3.3 Summary of 18 Step Indicated Hot Full Power Rod Misalignment Cases Analyzed (Sheet 7 of 16)**

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rod(s) Misaligned | Peaking Factor % Increase for Additional 6 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 73 | BOL | HFP | Current | A | D at 174 | | | a,c |
| 74 | BOL | HFP | Current | D | D at 174 | | | |
| 75 | BOL | HFP | Current | A | D at 174 | | | |
| 76 | BOL | HFP | Current | D | D at 174 | | | |
| 77 | BOL | HFP | Future | A | D at 174 | | | |
| 78 | BOL | HFP | Future | D | D at 174 | | | |
| 79 | BOL | HFP | Future | A | D at 174 | | | |
| 80 | BOL | HFP | Future | D | D at 174 | | | |
| 81 | EOL | HFP | Current | A | D at 174 | | | |
| 82 | EOL | HFP | Current | D | D at 174 | | | |
| 83 | EOL | HFP | Current | A | D at 174 | | | |
| 84 | EOL | HFP | Current | D | D at 174 | | | |

## Table 3.3 Summary of 18 Step Indicated Hot Full Power Rod Misalignment Cases Analyzed (Sheet 8 of 16)

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rod(s) Misaligned | Peaking Factor % Increase for Additional 6 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 85 | EOL | HFP | Current | A | D at 174 | | | a,c |
| 86 | EOL | HFP | Current | D | D at 174 | | | |
| 87 | EOL | HFP | Current | A | D at 174 | | | |
| 88 | EOL | HFP | Current | D | D at 174 | | | |
| 89 | EOL | HFP | Future | A | D at 174 | | | |
| 90 | EOL | HFP | Future | D | D at 174 | | | |
| 91 | EOL | HFP | Future | A | D at 174 | | | |
| 92 | EOL | HFP | Future | D | D at 174 | | | |
| 93 | EOL | HFP | Future | A | D at 174 | | | |
| 94 | EOL | HFP | Future | D | D at 174 | | | |
| 95 | EOL | HFP | Future | A | D at 174 | | | |

**Table 3.3 Summary of 18 Step Indicated Hot Full Power Rod Misalignment Cases Analyzed (Sheet 9 of 16)**

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rod(s) Misaligned | Peaking Factor % Increase for Additional 6 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 96 | EOL | HFP | Future | D | D at 174 | | | a,c |
| 97 | BOL | HFP | Current | A | D at 174 | | | |
| 98 | BOL | HFP | Current | A | D at 174 | | | |
| 99 | BOL | HFP | Current | A | D at 223 (ARO) | | | |
| 100 | BOL | HFP | Current | A | D at 174 | | | |
| 101 | BOL | HFP | Current | A | D at 223 (ARO) | | | |
| 102 | BOL | HFP | Current | A | D at 174 | | | |
| 103 | BOL | HFP | Current | A | D at 223 (ARO) | | | |
| 104 | BOL | HFP | Future | A | D at 174 | | | |

**Table 3.3 Summary of 18 Step Indicated Hot Full Power Rod Misalignment Cases Analyzed (Sheet 10 of 16)**

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rod(s) Misaligned | Peaking Factor % Increase for Additional 6 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 105 | BOL | HFP | Future | A | D at 174 | | | a,c |
| 106 | BOL | HFP | Future | A | D at 223 (ARO) | | | |
| 107 | BOL | HFP | Future | A | D at 174 | | | |
| 108 | BOL | HFP | Future | A | D at 223 (ARO) | | | |
| 109 | BOL | HFP | Future | A | D at 174 | | | |
| 110 | BOL | HFP | Future | A | D at 223 (ARO) | | | |
| 111 | MOL | HFP | Current | A | D at 174 | | | |
| 112 | MOL | HFP | Current | A | D at 174 | | | |
| 113 | MOL | HFP | Current | A | D at 223 (ARO) | | | |

**Table 3.3 Summary of 18 Step Indicated Hot Full Power Rod Misalignment Cases Analyzed (Sheet 11 of 16)**

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rod(s) Misaligned | Peaking Factor % Increase for Additional 6 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 114 | MOL | HFP | Future | A | D at 174 | | | a,c |
| 115 | MOL | HFP | Future | A | D at 174 | | | |
| 116 | MOL | HFP | Future | A | D at 223 (ARO) | | | |
| 117 | EOL | HFP | Current | A | D at 174 | | | |
| 118 | EOL | HFP | Current | A | D at 174 | | | |
| 119 | EOL | HFP | Current | A | D at 223 (ARO) | | | |
| 120 | EOL | HFP | Current | A | D at 174 | | | |
| 121 | EOL | HFP | Current | A | D at 174 | | | |
| 122 | EOL | HFP | Current | A | D at 174 | | | |
| 123 | EOL | HFP | Current | A | D at 174 | | | |

Table 3.3 Summary of 18 Step Indicated Hot Full Power Rod Misalignment Cases Analyzed (Sheet 12 of 16)

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rod(s) Misaligned | Peaking Factor % Increase for Additional 6 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 124 | EOL | HFP | Current | A | D at 174 | | | a,c |
| 125 | EOL | HFP | Current | A | D at 174 | | | |
| 126 | EOL | HFP | Current | A | D at 174 | | | |
| 127 | EOL | HFP | Current | A | D at 174 | | | |
| 128 | EOL | HFP | Future | A | D at 174 | | | |
| 129 | EOL | HFP | Future | A | D at 174 | | | |
| 130 | EOL | HFP | Future | A | D at 223 (ARO) | | | |
| 131 | EOL | HFP | Future | A | D at 174 | | | |
| 132 | EOL | HFP | Future | A | D at 174 | | | |
| 133 | EOL | HFP | Future | A | D at 174 | | | |
| 134 | EOL | HFP | Future | A | D at 174 | | | |

**Table 3.3 Summary of 18 Step Indicated Hot Full Power Rod Misalignment Cases Analyzed (Sheet 13 of 16)**

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rod(s) Misaligned | Peaking Factor % Increase for Additional 6 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 135 | EOL | HFP | Future | A | D at 174 | | | a,c |
| 136 | EOL | HFP | Future | AB | D at 174 | | | |
| 137 | EOL | HFP | Future | A | D at 174 | | | |
| 138 | EOL | HFP | Future | A | D at 174 | | | |
| 139 | BOL | HFP | Current | B | D at 174 | | | |
| 140 | BOL | HFP | Current | B | D at 174 | | | |
| 141 | BOL | HFP | Current | B | D at 174 | | | |
| 142 | BOL | HFP | Current | B | D at 174 | | | |
| 143 | BOL | HFP | Future | B | D at 174 | | | |
| 144 | BOL | HFP | Future | B | D at 174 | | | |
| 145 | BOL | HFP | Future | B | D at 174 | | | |
| 146 | BOL | HFP | Future | B | D at 174 | | | |

Table 3.3 Summary of 18 Step Indicated Hot Full Power Rod Misalignment Cases Analyzed (Sheet 14 of 16)

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rod(s) Misaligned | Peaking Factor % Increase for Additional 6 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 147 | EOL | HFP | Current | B | D at 174 | | | a,c |
| 148 | EOL | HFP | Current | B | D at 174 | | | |
| 149 | EOL | HFP | Future | B | D at 174 | | | |
| 150 | EOL | HFP | Future | B | D at 174 | | | |
| 151 | BOL | HFP | Current | C | D at 174 | | | |
| 152 | BOL | HFP | Future | C | D at 174 | | | |
| 153 | EOL | HFP | Current | C | D at 174 | | | |
| 154 | EOL | HFP | Future | C | D at 174 | | | |
| 155 | BOL | HFP | Current | E | D at 174 | | | |
| 156 | BOL | HFP | Current | E | D at 186 | | | |
| 157 | BOL | HFP | Future | E | D at 174 | | | |

**Table 3.3 Summary of 18 Step Indicated Hot Full Power Rod Misalignment Cases Analyzed (Sheet 15 of 16)**

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rod(s) Misaligned | Peaking Factor % Increase for Additional 6 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 158 | BOL | HFP | Future | E | D at 186 | | | a,c |
| 159 | EOL | HFP | Current | E | D at 174 | | | |
| 160 | EOL | HFP | Current | E | D at 174 | | | |
| 161 | EOL | HFP | Current | E | D at 174 | | | |
| 162 | EOL | HFP | Future | E | D at 174 | | | |
| 163 | EOL | HFP | Future | E | D at 174 | | | |
| 164 | EOL | HFP | Future | E | D at 174 | | | |
| 165 | BOL | HFP | Current | F | D at 174 | | | |
| 166 | BOL | HFP | Future | F | D at 174 | | | |

## Table 3.3 Summary of 18 Step Indicated Hot Full Power Rod Misalignment Cases Analyzed (Sheet 16 of 16)

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| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rod(s) Misaligned | Peaking Factor % Increase for Additional 6 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 167 | EOL | HFP | Current | F | D at 174 | | | |
| 168 | EOL | HFP | Future | F | D at 174 | | | |
| (*) | Signifies that plots of peaking factors and increases due to additional steps of misalignment are included in the Appendix of this report. | | | | | | | |

## Table 3.4 Summary of 15 Step Indicated Rod Misalignment Cases Analyzed (Sheet 1 of 7)

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rods Misaligned | Peaking Factor % Increase for Additional 3 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 169 | BOL | HFP | Current | A | D at 174 | | | a,c |
| 170 | BOL | HFP | Current | D | D at 174 | | | |
| 171 | BOL | HFP | Future | A | D at 174 | | | |
| 172 | BOL | HFP | Future | D | D at 174 | | | |
| 173 | EOL | HFP | Current | D | D at 174 | | | |
| 174 | EOL | HFP | Current | A | D at 186 | | | |
| 175 | EOL | HFP | Current | D | D at 186 | | | |
| 176 | EOL | HFP | Future | D | D at 174 | | | |
| 177 | EOL | HFP | Future | A | D at 186 | | | |
| 178 | EOL | HFP | Future | D | D at 186 | | | |
| 179 | BOL | HFP | Current | A | D at 174 | | | |
| 180 | BOL | HFP | Current | D | D at 174 | | | |

**Table 3.4 Summary of 15 Step Indicated Rod Misalignment Cases Analyzed (Sheet 2 of 7)**

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rods Misaligned | Peaking Factor % Increase for Additional 3 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 181 | BOL | HFP | Future | A | D at 174 | | | |
| 182 | BOL | HFP | Future | D | D at 174 | | | |
| 183 | EOL | HFP | Current | A | D at 174 | | | |
| 184 | EOL | HFP | Current | D | D at 174 | | | |
| 185 | EOL | HFP | Future | A | D at 174 | | | |
| 186 | EOL | HFP | Future | D | D at 174 | | | |
| 187 | BOL | HFP | Current | A | D at 174 | | | |
| 188 | BOL | HFP | Current | D | D at 174 | | | |
| 189 | BOL | HFP | Future | A | D at 174 | | | |
| 190 | BOL | HFP | Future | D | D at 174 | | | |
| 191 | EOL | HFP | Current | A | D at 174 | | | |
| 192 | EOL | HFP | Current | D | D at 174 | | | |

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**Table 3.4 Summary of 15 Step Indicated Rod Misalignment Cases Analyzed (Sheet 3 of 7)**

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rods Misaligned | Peaking Factor % Increase for Additional 3 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 193 | EOL | HFP | Future | A | D at 174 | | | a,c |
| 194 | EOL | HFP | Future | D | D at 174 | | | |
| 195 | BOL | HFP | Current | A | D at 174 | | | |
| 196 | BOL | HFP | Current | A | D at 174 | | | |
| 197 | BOL | HFP | Current | A | D at 223 (ARO) | | | |
| 198 | BOL | HFP | Current | A | D at 174 | | | |
| 199 | BOL | HFP | Current | A | D at 174 | | | |
| 200 | BOL | HFP | Current | A | D at 223 (ARO) | | | |
| 201 | BOL | HFP | Future | A | D at 174 | | | |

Table 3.4 Summary of 15 Step Indicated Rod Misalignment Cases Analyzed (Sheet 4 of 7)

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rods Misaligned | Peaking Factor % Increase for Additional 3 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 202 | BOL | HFP | Future | A | D at 174 | | | a,c |
| 203 | BOL | HFP | Future | A | D at 223 (ARO) | | | |
| 204 | BOL | HFP | Future | A | D at 174 | | | |
| 205 | BOL | HFP | Future | A | D at 174 | | | |
| 206 | BOL | HFP | Future | A | D at 223 (ARO) | | | |
| 207 | MOL | HFP | Current | A | D at 174 | | | |
| 208 | MOL | HFP | Current | A | D at 223 (ARO) | | | |
| 209 | MOL | HFP | Future | A | D at 174 | | | |
| 210 | MOL | HFP | Future | A | D at 223 (ARO) | | | |

**Table 3.4 Summary of 15 Step Indicated Rod Misalignment Cases Analyzed (Sheet 5 of 7)**

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rods Misaligned | Peaking Factor % Increase for Additional 3 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 211 | EOL | HFP | Current | A | D at 174 | | | a,c |
| 212 | EOL | HFP | Current | A | D at 174 | | | |
| 213 | EOL | HFP | Current | A | D at 223 (ARO) | | | |
| 214 | EOL | HFP | Current | A | D at 174 | | | |
| 215 | EOL | HFP | Current | A | D at 174 | | | |
| 216 | EOL | HFP | Current | A | D at 174 | | | |
| 217 | EOL | HFP | Current | A | D at 174 | | | |
| 218 | EOL | HFP | Current | A | D at 174 | | | |
| 219 | EOL | HFP | Current | A | D at 174 | | | |
| 220 | EOL | HFP | Future | A | D at 174 | | | |

**Table 3.4 Summary of 15 Step Indicated Rod Misalignment Cases Analyzed (Sheet 6 of 7)**

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rods Misaligned | Peaking Factor % Increase for Additional 3 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 221 | EOL | HFP | Future | A | D at 174 | [ | | ] a,c |
| 222 | EOL | HFP | Future | A | D at 223 (ARO) | | | |
| 223 | EOL | HFP | Future | A | D at 174 | | | |
| 224 | EOL | HFP | Future | A | D at 174 | | | |
| 225 | EOL | HFP | Future | A | D at 174 | | | |
| 226 | EOL | HFP | Future | A | D at 174 | | | |
| 227 | EOL | HFP | Future | A | D at 174 | | | |
| 228 | EOL | HFP | Future | A | D at 174 | | | |
| 229 | EOL | HFP | Current | C | D at 174 | | | |
| 230 | EOL | HFP | Future | C | D at 174 | | | |
| 231 | BOL | HFP | Current | E | D at 186 | [ | | ] |

**Table 3.4 Summary of 15 Step Indicated Rod Misalignment Cases Analyzed (Sheet 7 of 7)**

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rods Misaligned | Peaking Factor % Increase for Additional 3 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 232 | BOL | HFP | Future | E | D at 186 | | | a,c |
| 233 | BOL | HFP | Current | F | D at 174 | | | |
| 234 | BOL | HFP | Current | F | D at 174 | | | |

**Table 3.5 Summary of 18 Step Indicated Part-Power Rod Misalignment Cases Analyzed (Sheet 1 of 6)**

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rods Misaligned | Peaking Factor % Increase for Additional 6 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 235 | BOL | 85 | Current | A | D at 174 | | | a,c |
| 236 | BOL | 85 | Current | A | D at 142 | | | |
| 237 | BOL | 50 | Current | A | D at 174 | | | |
| 238 | BOL | 50 | Current | A | D at 68,<br>C at 191 | | | |
| 239 | BOL | 50 | Current | A | D at 223<br>(ARO) | | | |
| 240 | BOL | 85 | Current | A | D at 223<br>(ARO) | | | |
| 241 | BOL | 85 | Future | A | D at 174 | | | |
| 242 | BOL | 85 | Future | A | D at 142 | | | |

**Table 3.5 Summary of 18 Step Indicated Part-Power Rod Misalignment Cases Analyzed (Sheet 2 of 6)**

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rods Misaligned | Peaking Factor % Increase for Additional 6 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 243 | BOL | 50 | Future | A | D at 174 | | | a,c |
| 244 | BOL | 50 | Future | A | D at 68,<br>C at 191 | | | |
| 245 | BOL | 50 | Future | A | D at 223<br>(ARO) | | | |
| 246 | BOL | 85 | Future | A | D at 223<br>(ARO) | | | |
| 247 | MOL | 85 | Current | A | D at 174 | | | |
| 248 | MOL | 85 | Current | A | D at 142 | | | |
| 249 | MOL | 85 | Current | A | D at 223<br>(ARO) | | | |
| 250 | MOL | 85 | Future | A | D at 174 | | | |

Table 3.5 Summary of 18 Step Indicated Part-Power Rod Misalignment Cases Analyzed (Sheet 3 of 6)

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rods Misaligned | Peaking Factor % Increase for Additional 6 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 251 | MOL | 85 | Future | A | D at 142 | | | |
| 252 | MOL | 85 | Future | A | D at 223 (ARO) | | | |
| 253 | EOL | 85 | Current | A | D at 174 | | | |
| 254 | EOL | 85 | Current | A | D at 142 | | | |
| 255 | EOL | 50 | Current | A | D at 174 | | | |
| 256 | EOL | 50 | Current | A | D at 68, C at 191 | | | |
| 257 | EOL | 50 | Current | A | D at 223 (ARO) | | | |
| 258 | EOL | 85 | Current | A | D at 223 (ARO) | | | |

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## Table 3.5 Summary of 18 Step Indicated Part-Power Rod Misalignment Cases Analyzed (Sheet 4 of 6)

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rods Misaligned | Peaking Factor % Increase for Additional 6 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 259 | EOL | 85 | Current | A | D at 174 | | | a,c |
| 260 | EOL | 85 | Current | A | D at 174 | | | |
| 261 | EOL | 85 | Current | A | D at 174 | | | |
| 262 | EOL | 85 | Current | A | D at 142 | | | |
| 263 | EOL | 85 | Current | A | D at 174 | | | |
| 264 | EOL | 85 | Current | A | D at 142 | | | |
| 265 | EOL | 50 | Current | A | D at 174 | | | |
| 266 | EOL | 50 | Current | A | D at 68,<br>C at 191 | | | |
| 267 | EOL | 85 | Current | C | D at 142 | | | |
| 268 | EOL | 85 | Current | C | D at 174 | | | |

**Table 3.5 Summary of 18 Step Indicated Part-Power Rod Misalignment Cases Analyzed (Sheet 5 of 6)**

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rods Misaligned | Peaking Factor % Increase for Additional 6 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 269 | EOL | 85 | Future | A | D at 174 | | | |
| 270 | EOL | 85 | Future | A | D at 142 | | | |
| 271 | EOL | 50 | Future | A | D at 174 | | | |
| 272 | EOL | 50 | Future | A | D at 68, C at 191 | | | |
| 273 | EOL | 50 | Future | A | D at 223 (ARO) | | | |
| 274 | EOL | 85 | Future | A | D at 223 (ARO) | | | |
| 275 | EOL | 85 | Future | A | D at 174 | | | |
| 276 | EOL | 85 | Future | A | D at 174 | | | |

a,c

## Table 3.5 Summary of 18 Step Indicated Part-Power Rod Misalignment Cases Analyzed (Sheet 6 of 6)

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rods Misaligned | Peaking Factor % Increase for Additional 6 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 277 | EOL | 85 | Future | A | D at 174 | | | a,c |
| 278 | EOL | 85 | Future | A | D at 142 | | | |
| 279 | EOL | 85 | Future | A | D at 174 | | | |
| 280 | EOL | 85 | Future | A | D at 142 | | | |
| 281 | EOL | 50 | Future | A | D at 174 | | | |
| 282 | EOL | 50 | Future | A | D at 68, C at 191 | | | |
| 283 | EOL | 85 | Future | C | D at 142 | | | |
| 284 | EOL | 85 | Future | C | D at 174 | | | |

**Table 3.6 Summary of 21 Step Indicated Part-Power Rod Misalignment Cases Analyzed (Sheet 1 of 6)**

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rods Misaligned | Peaking Factor % Increase for Additional 9 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 285 | BOL | 85 | Current | A | D at 174 | | | a,c |
| 286 | BOL | 85 | Current | A | D at 142 | | | |
| 287 | BOL | 50 | Current | A | D at 174 | | | |
| 288 | BOL | 50 | Current | A | D at 68, C at 191 | | | |
| 289 | BOL | 50 | Current | A | D at 223 (ARO) | | | |
| 290 | BOL | 85 | Current | A | D at 223 (ARO) | | | |
| 291 | BOL | 85 | Future | A | D at 174 | | | |
| 292 | BOL | 85 | Future | A | D at 142 | | | |

**Table 3.6 Summary of 21 Step Indicated Part-Power Rod Misalignment Cases Analyzed (Sheet 2 of 6)**

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rods Misaligned | Peaking Factor % Increase for Additional 9 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 293 | BOL | 50 | Future | A | D at 174 | [ | | ] a,c |
| 294 | BOL | 50 | Future | A | D at 68, C at 191 | | | |
| 295 | BOL | 50 | Future | A | D at 223 (ARO) | | | |
| 296 | BOL | 85 | Future | A | D at 223 (ARO) | | | |
| 297 | MOL | 85 | Current | A | D at 174 | | | |
| 298 | MOL | 85 | Current | A | D at 142 | | | |
| 299 | MOL | 85 | Current | A | D at 223 (ARO) | | | |
| 300 | MOL | 85 | Future | A | D at 174 | | | |

**Table 3.6 Summary of 21 Step Indicated Part-Power Rod Misalignment Cases Analyzed (Sheet 3 of 6)**

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rods Misaligned | Peaking Factor % Increase for Additional 9 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 301 | MOL | 85 | Future | A | D at 142 | | | |
| 302 | MOL | 85 | Future | A | D at 223 (ARO) | | | |
| 303 | EOL | 85 | Current | A | D at 174 | | | |
| 304 | EOL | 85 | Current | A | D at 142 | | | |
| 305 | EOL | 50 | Current | A | D at 174 | | | |
| 306 | EOL | 50 | Current | A | D at 68, C at 191 | | | |
| 307 | EOL | 50 | Current | A | D at 223 (ARO) | | | |
| 308 | EOL | 85 | Current | A | D at 223 (ARO) | | | |

a,c

**Table 3.6 Summary of 21 Step Indicated Part-Power Rod Misalignment Cases Analyzed (Sheet 4 of 6)**

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rods Misaligned | Peaking Factor % Increase for Additional 9 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 309 | EOL | 85 | Current | A | D at 174 | [ | | ] a,c |
| 310 | EOL | 85 | Current | A | D at 174 | | | |
| 311 | EOL | 85 | Current | A | D at 174 | | | |
| 312 | EOL | 85 | Current | A | D at 142 | | | |
| 313 | EOL | 85 | Current | A | D at 174 | | | |
| 314 | EOL | 85 | Current | A | D at 142 | | | |
| 315 | EOL | 50 | Current | A | D at 174 | | | |
| 316 | EOL | 50 | Current | A | D at 68,<br>C at 191 | | | |
| 317 | EOL | 85 | Current | C | D at 142 | | | |
| 318 | EOL | 85 | Current | C | D at 174 | | | ] |

Table 3.6 **Summary of 21 Step Indicated Part-Power Rod Misalignment Cases Analyzed (Sheet 5 of 6)**

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rods Misaligned | Peaking Factor % Increase for Additional 9 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 319 | EOL | 85 | Future | A | D at 174 | | | a,c |
| 320 | EOL | 85 | Future | A | D at 142 | | | |
| 321 | EOL | 50 | Future | A | D at 174 | | | |
| 322 | EOL | 50 | Future | A | D at 68, C at 191 | | | |
| 323 | EOL | 50 | Future | A | D at 223 (ARO) | | | |
| 324 | EOL | 85 | Future | A | D at 223 (ARO) | | | |
| 325 | EOL | 85 | Future | A | D at 174 | | | |
| 326 | EOL | 85 | Future | A | D at 174 | | | |

## Table 3.6 Summary of 21 Step Indicated Part-Power Rod Misalignment Cases Analyzed (Sheet 6 of 6)

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rods Misaligned | Peaking Factor % Increase for Additional 9 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 327 | EOL | 85 | Future | A | D at 174 | | | a,c |
| 328 | EOL | 85 | Future | A | D at 142 | | | |
| 329 | EOL | 85 | Future | A | D at 174 | | | |
| 330 | EOL | 85 | Future | A | D at 142 | | | |
| 331 | EOL | 50 | Future | A | D at 174 | | | |
| 332 | EOL | 50 | Future | A | D at 68,<br>C at 191 | | | |
| 333 | EOL | 85 | Future | C | D at 142 | | | |
| 334 | EOL | 85 | Future | C | D at 174 | | | |

**Table 3.7 Summary of 24 Step Indicated Part-Power Rod Misalignment Cases Analyzed (Sheet 1 of 6)**

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rods Misaligned | Peaking Factor % Increase for Additional 12 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 335 | BOL | 85 | Current | A | D at 174 | | | a,c |
| 336 | BOL | 85 | Current | A | D at 142 | | | |
| 337 | BOL | 50 | Current | A | D at 174 | | | |
| 338 | BOL | 50 | Current | A | D at 68, C at 191 | | | |
| 339 | BOL | 50 | Current | A | D at 223 (ARO) | | | |
| 340 | BOL | 85 | Current | A | D at 223 (ARO) | | | |
| 341 | BOL | 85 | Future | A | D at 174 | | | |
| 342 | BOL | 85 | Future | A | D at 142 | | | |

Table 3.7 Summary of 24 Step Indicated Part-Power Rod Misalignment Cases Analyzed (Sheet 2 of 6)

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rods Misaligned | Peaking Factor % Increase for Additional 12 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 343 | BOL | 50 | Future | A | D at 174 | [ | | ] a,c |
| 344 | BOL | 50 | Future | A | D at 68, C at 191 | | | |
| 345 | BOL | 50 | Future | A | D at 223 (ARO) | | | |
| 346 | BOL | 85 | Future | A | D at 223 (ARO) | | | |
| 347 | MOL | 85 | Current | A | D at 174 | | | |
| 348 | MOL | 85 | Current | A | D at 142 | | | |
| 349 | MOL | 85 | Current | A | D at 223 (ARO) | | | |
| 350 | MOL | 85 | Future | A | D at 174 | | | |

**Table 3.7 Summary of 24 Step Indicated Part-Power Rod Misalignment Cases Analyzed (Sheet 3 of 6)**

a,c

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rods Misaligned | Peaking Factor % Increase for Additional 12 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 351 | MOL | 85 | Future | A | D at 142 | | | |
| 352 | MOL | 85 | Future | A | D at 223 (ARO) | | | |
| 353 | EOL | 85 | Current | A | D at 174 | | | |
| 354 | EOL | 85 | Current | A | D at 142 | | | |
| 355 | EOL | 50 | Current | A | D at 174 | | | |
| 356 | EOL | 50 | Current | A | D at 68, C at 191 | | | |
| 357 | EOL | 50 | Current | A | D at 223 (ARO) | | | |
| 358 | EOL | 85 | Current | A | D at 223 (ARO) | | | |

Table 3.7 Summary of 24 Step Indicated Part-Power Rod Misalignment Cases Analyzed (Sheet 4 of 6)

a,c

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rods Misaligned | Peaking Factor % Increase for Additional 12 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 359 | EOL | 85 | Current | A | D at 174 | | | |
| 360 | EOL | 85 | Current | A | D at 174 | | | |
| 361 | EOL | 85 | Current | A | D at 174 | | | |
| 362 | EOL | 85 | Current | A | D at 142 | | | |
| 363 | EOL | 85 | Current | A | D at 174 | | | |
| 364 | EOL | 85 | Current | A | D at 142 | | | |
| 365 | EOL | 50 | Current | A | D at 174 | | | |
| 366 | EOL | 50 | Current | A | D at 68, C at 191 | | | |
| 367 | EOL | 85 | Current | C | D at 142 | | | |
| 368 | EOL | 85 | Current | C | D at 174 | | | |

## Table 3.7 Summary of 24 Step Indicated Part-Power Rod Misalignment Cases Analyzed (Sheet 5 of 6)

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rods Misaligned | Peaking Factor % Increase for Additional 12 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 369 | EOL | 85 | Future | A | D at 174 | | | a,c |
| 370 | EOL | 85 | Future | A | D at 142 | | | |
| 371 | EOL | 50 | Future | A | D at 174 | | | |
| 372 | EOL | 50 | Future | A | D at 68, C at 191 | | | |
| 373 | EOL | 50 | Future | A | D at 223 (ARO) | | | |
| 374 | EOL | 85 | Future | A | D at 223 (ARO) | | | |
| 375 | EOL | 85 | Future | A | D at 174 | | | |
| 376 | EOL | 85 | Future | A | D at 142 | | | |

**Table 3.7 Summary of 24 Step Indicated Part-Power Rod Misalignment Cases Analyzed (Sheet 6 of 6)**

| Case No. | Burnup | Power | Cycle | Failure Mechanism | Reference Bank Position | Rods Misaligned | Peaking Factor % Increase for Additional 12 Steps | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | $F_{\Delta H}$ | $F_Q$ |
| 377 | EOL | 85 | Future | A | D at 174 | | | a,c |
| 378 | EOL | 85 | Future | A | D at 142 | | | |
| 379 | EOL | 85 | Future | A | D at 174 | | | |
| 380 | EOL | 85 | Future | A | D at 142 | | | |
| 381 | EOL | 50 | Future | A | D at 174 | | | |
| 382 | EOL | 50 | Future | A | D at 68, C at 191 | | | |
| 383 | EOL | 85 | Future | C | D at 142 | | | |
| 384 | EOL | 85 | Future | C | D at 174 | | | |

(*) Signifies that plots of peaking factors and increases due to additional steps of misalignment are included in the Appendix of this report.

# 4 SAFETY ANALYSIS IMPACTS

Section 3 discussed the effects of increased misalignment on the normal operation peaking factors. This section will address the effects on safety analysis inputs used for the reload safety evaluation (Reference 7).

An increase in rod misalignment does not have a significant impact on any of the [ ]$^{a,c}$. An increase in the rod misalignment also will not adversely effect the [ ]$^{a,c}$ or data generated for the evaluation of [ ]$^{a,c}$.

Many of the Condition II transients, such as rod out of position, dropped rod and single rod withdrawal are based on the motion of a control rod or control bank. These are considered fully misaligned rod transients caused by a single failure of the rod control system. Recall from Section 3.0 that a key assumption of the analysis documented in this report is that rod misalignments resulting from a [ ]$^{a,c}$ need be considered, consistent with the current Westinghouse licensing basis. Series of [ ]$^{a,c}$ do not need to be considered. Therefore, one does not need to assume a rod misalignment from the [ ]$^{a,c}$ as a precondition to one of the above mentioned Condition II rod misalignment transients; such an assumption would be beyond the [ ]$^{a,c}$. As such, the proposed changes to the rod misalignment Tech Spec do not have an adverse impact on the safety analysis inputs for these accidents, or the DNB analysis results.

Another possible impact of the increase in the rod misalignment is an increase in the rod insertion allowance (RIA), the worth of the rods at their insertion limits or RILs. The RIA has a direct impact on the available trip reactivity and the shutdown margin (SDM) assumed in several transient analyses including steamline break. The maximum increase in the RIA, and hence largest reduction in the trip worth and SDM, would be due to an entire bank being misaligned in deeper than the RIL, consistent with failure category C described in Section 3.3. However, the available trip worth and SDM also assume that the core is subcritical with an N-1 rod configuration, where the highest individual worth rod is stuck out of the core, consistent with failure category D. As stated above, rod misalignments resulting from a [ ]$^{a,c}$. Therefore, for the trip reactivity and SDM one does not need to assume an increase in the RIA due to [ ]$^{a,c}$. In addition, the reduction in available SDM due to the WSR is much greater than the worth that would be lost due to an increase in the RIA. As such, the proposed changes to the rod misalignment Tech Spec do not have an adverse impact on the available trip worth or SDM.

Safety analyses inputs that would be affected by an increase in the allowable misalignment are the rod ejection $F_Q$, the ejected rod worth $\Delta\rho_{EJ}$, and the available trip worth following a rod ejection.

The rod ejection parameters can be affected by an increased rod misalignment of the RIL rods at HZP prior to the ejection. Misalignments of individual rods, bank groups and entire banks were considered to determine the limiting effects on $F_Q$ and $\Delta\rho_{EJ}$. Calculations were also performed for both cycles described in Section 2, assuming an additional 12 steps of rod misalignment at the HZP RIL. Results of these calculations show maximum increases of [ ]$^{a,c}$ in $F_Q$ and [ ]$^{a,c}$ in $\Delta\rho_{EJ}$ for the current cycle and [ ]$^{a,c}$ in $F_Q$ and [ ]$^{a,c}$ in $\Delta\rho_{EJ}$ for the future cycle. Note that these values are very similar for the two cycles, indicating that the results are reasonably independent of the cycle design. Then for application of this Technical Specification change, [ ]$^{a,c}$.

The safety analysis of the rod ejection transient also assumes a certain amount of available trip worth following the rod ejection. Since the ejected rod is assumed to damage a neighboring RCCA drive housing, the trip worth for this transient is defined as the change in core reactivity between the HZP, RIL condition and the HZP, all rods inserted (ARI) minus the ejected rod and the neighboring rod. For this part of the rod ejection transient, the limiting misalignment will be the [ ]$^{a,c}$. Inserting [ ]$^{a,c}$. Then for application of this Technical Specification, the trip worth available following a rod ejection calculated as part of the reload safety evaluation [ ]$^{a,c}$. The [ ]$^{a,c}$ pcm is approximately [ ]$^{a,c}$ than the maximum calculated value for either cycle.

# 5 CONCLUSIONS

An extension of the allowable indicated rod misalignment of ±12 steps to ±18 steps may be permitted for core powers above 85% RTP as long as it is demonstrated that sufficient peaking factor margin is available. To increase the allowable indicated misalignment by 6 steps for operation above 85% of rated thermal power, [ ]a,c $F_Q$ margin and [ ]a,c $F_{\Delta H}$ margin must be available. The amount of required margin is also linearly dependent upon the amount of additional misalignment desired, as shown in Figure 3.3 and summarized below:

| **Indicated Misalignment ( Steps)** | **Additional Misalignment ( Steps)** | **Required Margin** | |
|---|---|---|---|
| | | $F_{\Delta H}$ | $F_Q$ |
| 12 | 0 | [ ]a,c | [ ]a,c |
| 13 | 1 | [ ]a,c | [ ]a,c |
| 14 | 2 | [ ]a,c | [ ]a,c |
| 15 | 3 | [ ]a,c | [ ]a,c |
| 16 | 4 | [ ]a,c | [ ]a,c |
| 17 | 5 | [ ]a,c | [ ]a,c |
| 18 | 6 | [ ]a,c | [ ]a,c |

Indicated misalignments of up to 24 steps are also permitted for all powers of 85% RTP or less.

The analysis documented in this report has been performed such that the above mentioned excess peaking factor margin required for additional indicated rod misalignment is [ ]a,c.

The analysis documented in this report is conservative and appropriate based on the following assumptions on rod insertion:

- The rod insertion limits (RILs) shown in Figure 3.2 determine the maximum bank demand position as a function of core power;
- The all rods out (ARO) demand position can be as deep as [ ]a,c, which corresponds to the top of the active fuel stack for the Indian Point 2 Cycle 15 feed fuel assemblies.

The results of this report are also conservative and appropriate for any future change in the RILs that would reduce the maximum allowable rod insertion and for any ARO position above [ ]a,c. Any future change to the RILs or the ARO position that would permit deeper rod insertion would also require an evaluation of the results of this report.

As part of the reload specific safety evaluation, design calculations will include the following additional conservatisms to bound the maximum increases in rod misalignment any time during the cycle:

- [ ]a,c
- [ ]a,c
- [ ]a,c

# 6 REFERENCES


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4. Liu, Y. S., et. al., *ANC: A Westinghouse Advanced Nodal Computer Code*, WCAP-10965-P-A (Westinghouse Proprietary), December 1985.

5. Morita, T. et. al., *Topical Report - Power Distribution Control and Load Following Procedures*, WCAP-8385 (Westinghouse Proprietary), September 1974.

6. Miller, R. W. et. al., *Relaxation of Constant Axial Offset Control - FQ Surveillance Technical Specification*, WCAP-10216-P-A, Revision 1, February 1994.

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# A APPENDIX

This section provides some additional detail to the cases highlighted in Tables 3.3 and 3.7. These cases yielded the limiting increase in $F_{\Delta H}$, $F_Q$ or both. The following figures provide the misaligned peaking factors compared to the reference non-misaligned case, and the percent differences relative to 24 steps of total misalignment (±12 steps indicated). Data in these figures are provided as a function of axial offset, covering the maximum expected range for Indian Point 2. The data summarized in Tables 3.3 through 3.7 represents the maximum points from these figures.

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**Figure A.1: Case 99; BOL HFP Current Cycle $F_Q$ Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.2: Case 99; BOL HFP Current Cycle $F_Q$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

[ ]a,c

**Figure A.3: Case 106; BOL HFP Future Cycle $F_{\Delta H}$ Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.4: Case 106; BOL HFP Future Cycle $F_{\Delta H}$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.5: Case 116; MOL HFP Future Cycle $F_{\Delta H}$ Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.6: Case 116; MOL HFP Future Cycle $F_{\Delta H}$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.7: Case 116; MOL HFP Future Cycle $F_Q$ Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.8: Case 116; MOL HFP Future Cycle $F_Q$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.9: Case 117; EOL HFP Current Cycle $F_Q$ Versus Axial Offset, Control Bank D at 174 and Cabinet 2AC Misaligned In Except for Rod C-05**

a,c

**Figure A.10: Case 117; EOL HFP Current Cycle $F_Q$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Bank D at 174 and Cabinet 2AC Misaligned In Except for Rod C-05**

a,c

**Figure A.11: Case 118; EOL HFP Current Cycle $F_Q$ Versus Axial Offset, Control Bank D at 174 and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

Figure A.12: Case 118; EOL HFP Current Cycle $F_Q$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Bank D at 174 and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05

a,c

**Figure A.13: Case 119; EOL HFP Current Cycle $F_{\Delta H}$ Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

Figure A.14: Case 119; EOL HFP Current Cycle $F_{\Delta H}$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05

a,c

**Figure A.15: Case 124; EOL HFP Current Cycle $F_Q$ Versus Axial Offset, Control Bank D at 174 and Cabinet 2AC Misaligned In**

[ ]a,c

**Figure A.16: Case 124; EOL HFP Current Cycle $F_Q$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Bank D at 174 and Cabinet 2AC Misaligned In**

a,c

**Figure A.17: Case 128; EOL HFP Future $F_Q$ Versus Axial Offset, Control Bank D at 174 and Cabinet 2AC Misaligned In Except for Rod C-05**

a,c

**Figure A.18: Case 128; EOL HFP Future Cycle $F_Q$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Bank D at 174 and Cabinet 2AC Misaligned In Except for Rod C-05**

a,c

**Figure A.19: Case 129; EOL HFP Future Cycle $F_{\Delta H}$ Versus Axial Offset, Control Bank D at 174 and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.20: Case 129; EOL HFP Future Cycle $F_{\Delta H}$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Bank D at 174 and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.21: Case 129; EOL HFP Future Cycle $F_Q$ Versus Axial Offset, Control Bank D at 174 and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.22: Case 129; EOL HFP Future Cycle $F_Q$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Bank D at 174 and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.23: Case 130; EOL HFP Future Cycle $F_{\Delta H}$ Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.24: Case 130; EOL HFP Future Cycle $F_{\Delta H}$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.25: Case 339; BOL 50% RTP Current Cycle $F_Q$ Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.26: Case 339; BOL 50% RTP Current Cycle $F_Q$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.27: Case 345; BOL 50% RTP Future Cycle $F_{\Delta H}$ Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.28: Case 345; BOL 50% RTP Future Cycle $F_{\Delta H}$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.29: Case 345; BOL 50% RTP Future Cycle $F_Q$ Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.30: Case 345; BOL 50% RTP Future Cycle $F_Q$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.31: Case 351; MOL 85% RTP Future Cycle $F_{\Delta H}$ Versus Axial Offset, Control Bank D at 142 and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.32: Case 351; MOL 85% RTP Future Cycle $F_{\Delta H}$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Bank D at 142 and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.33: Case 357; EOL 50% RTP Current Cycle $F_{\Delta H}$ Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.34: Case 357; EOL 50% RTP Current Cycle $F_{\Delta H}$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.35: Case 357; EOL 50% RTP Current Cycle $F_Q$ Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.36: Case 357; EOL 50% RTP Current Cycle $F_Q$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.37: Case 370; EOL 85% RTP Future Cycle $F_{\Delta H}$ Versus Axial Offset, Control Bank D at 142 and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.38: Case 370; EOL 85% RTP Future Cycle $F_{\Delta H}$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Bank D at 142 and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.39: Case 371; EOL 50% RTP Future Cycle $F_{\Delta H}$ Versus Axial Offset, Control Bank D at 174 and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.40: Case 371; EOL 50% RTP Future Cycle $F_{\Delta H}$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Bank D at 174 and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.41: Case 371; EOL 50% RTP Future Cycle $F_Q$ Versus Axial Offset, Control Bank D at 174 and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.42: Case 371; EOL 50% RTP Future Cycle $F_Q$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Bank D at 174 and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.43: Case 372; EOL 50% RTP Future Cycle $F_{\Delta H}$ Versus Axial Offset, Control Banks D/C at 68/191 and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.44: Case 372; EOL 50% RTP Future Cycle $F_{\Delta H}$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Banks D/C at 68/191 and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

Figure A.45: Case 372; EOL 50% RTP Future Cycle $F_Q$ Versus Axial Offset, Control Bank D/C at 68/191 and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05

a,c

**Figure A.46: Case 372; EOL 50% RTP Future Cycle $F_Q$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Bank D/C at 68/191 and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.47: Case 373; EOL 50% RTP Future Cycle $F_{\Delta H}$ Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

Figure A.48: Case 373; EOL 50% RTP Future Cycle $F_{\Delta H}$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05

[ ]a,c

Figure A.49: Case 373; EOL 50% RTP Future Cycle $F_Q$ Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05

a,c

**Figure A.50: Case 373; EOL 50% RTP Future Cycle $F_Q$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Bank D at 223 (ARO) and Cabinet 2AC Misaligned In Except for Rods C-05 and G-05**

a,c

**Figure A.51: Case 376; EOL 85% RTP Future Cycle $F_Q$ Versus Axial Offset, Control Bank D at 142 and Cabinet 2AC Misaligned In Except for Rods C-05**

a,c

**Figure A.52: Case 376; EOL 85% RTP Future Cycle $F_Q$ Difference Relative to 12 Step Indicated Misalignment Versus Axial Offset, Control Bank D at 142 and Cabinet 2AC Misaligned In Except for Rod C-05**

a,c