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APPLICATION OF THE "REGIONAL EXCLUSION WITH FLOW-BIASED APRM NEUTRON FLUX SCRAM" STABILITY SOLUTION (OPTION I-D) TO THE MONTICELLO NUCLEAR POWER PLANT

Licensing Topical Report

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TABLE OF CONTENTS

Section	Title	Page
	LIST OF TABLES	iv
	LIST OF FIGURES	v
	ABSTRACT	vi
1	INTRODUCTION	1-1
1.1	Historical Perspective	1-1
1.2	BWR Owners' Group Response	1-2
1.3	Option I-D Solution	1-2
1.4	Applicability of Option I-D to Monticello	1-4
2	SUMMARY AND CONCLUSIONS	2-1
3	APPLICATION OF BWROG STABILITY LONG-TERM SOLUTION REGIONAL EXCLUSION METHODOLOGY	3-1
3.1	Void Coefficient	3-1
3.2	Thermal-hydraulic Data	3-1
3.3	Hot-channel Axial Power Distribution	3-1
3.4	Average-channel Axial Power Distribution	3-2
3.5	Radial Power Distribution	3-3
3.6	Pellet-clad Gap Conductance	3-3
3.7	Miscellaneous Input Values	3-3
4	REGIONAL EXCLUSION RESULTS	4-1
5	APPLICATION OF BWROG STABILITY LONG-TERM SOLUTION DETECTION AND SUPPRESSION METHODOLOGY	5-1
5.1	Core-wide Mode Oscillations	5-1
5.1.1	Initial Conditions	5-1
5.1.2	Oscillation Contours	5-1
5.1.3	Oscillation Growth Rate	5-2
5.1.4	Trip System Definition	5-3
5.1.5	LPRM Failures	5-3
5.1.6	Change in MCPR with Flow Reduction	5-3
5.1.7	CPR Performance	5-4

TABLE OF CONTENTS (cont'd)

Section Title Page

5.2 Regional Mode Oscillations 5-5
- 5.2.1 Initial Conditions 5-5
- 5.2.2 Oscillation Contours 5-5
- 5.2.3 Oscillation Growth Rate 5-5
- 5.2.4 Trip System Definition 5-5
- 5.2.5 LPRM Failures 5-6
- 5.2.6 Change in MCPR with Flow Reduction 5-6
- 5.2.7 CPR Performance 5-6

6 DETECTION AND SUPPRESSION RESULTS 6-1

7 REFERENCES 7-1

LIST OF TABLES

Table	Title	Page
4-1	Base Points in Operating Map	4-2
4-2	Coordinates of Exclusion Region Boundary	4-3
5-1	67B Scram Times	5-2
5-2	LPRM Failure Statistics	5-3
5-3	MCPR Increase with Flow Reduction Statistics	5-3
6-1	FMCPR Values for Both Modes of Oscillation	6-1

LIST OF FIGURES

Figure	Title	Page
1-1	Typical Exclusion Region in Operating Map	1-3
2-1	Monticello Exclusion Region (Cycle 15)	2-1
3-1	Hot-channel Axial Power Profiles	3-2
3-2	Average-channel Axial Power Profiles	3-3
4-1	Probe Points in Operating Map	4-1
4-2	Coordinates of Probe Points in Stability Criterion Map	4-3
4-3	Monticello Exclusion Region (Cycle 15)	4-5
5-1	CPR Performance Curve for Core-wide Mode Oscillations	5-4
5-2	CPR Performance Curve for Regional Mode Oscillations	5-7

ABSTRACT

This report demonstrates the application of the "Regional Exclusion with Flow-Biased APRM Neutron Flux Scram" Stability Solution (Option I-D) of the "BWR Owners' Group Stability Long-term Solutions Licensing Methodology" to Cycle 15 of the Monticello Nuclear Power Plant. Compliance with General Design Criterion 12 is met and protection of the fuel Safety Limit Minimum Critical Power Ratio is demonstrated with conservative methodology for Core-Wide Mode oscillations with high statistical confidence for the high power, low flow corner of the exclusion region with the Flow-biased APRM Neutron Flux Scram System. Nominal statistical confidence levels show protection throughout the exclusion region. An Exclusion Region is presented for the plant which identifies plant conditions that may lead to an instability and it is shown that the large single-phase pressure drops induced by the relatively small inlet orifices of Monticello will create a preference for Core-wide Mode oscillations should the plant maneuver into the conditions susceptible to oscillations. The analysis concludes that Regional Mode oscillations are not anticipated to occur for Monticello.

1 INTRODUCTION

This report demonstrates the application of the "Regional Exclusion with Flow-Biased APRM Neutron Flux Scram" Stability Solution (Option I-D) to the Monticello Nuclear Power Plant as prescribed by the "BWR Owners' Group Long-term Stability Solutions Licensing Methodology" [1]. The protection of the Safety Limit Minimum Critical Power Ratio (SLMCPR) afforded by the Flow-biased Average Power Range Monitor (APRM) Neutron Flux Scram is demonstrated for the preferred mode of coupled thermal-hydraulic/neutronic oscillations for Monticello, i.e., Core-wide Mode. For Regional Mode oscillations, protection of the SLMCPR is calculated commensurate with expected frequency of occurrence of such oscillations. This solution creates an "Exclusion Region" in the plant operating map wherein oscillatory power behavior is conservatively predicted and which is avoided during plant operations.

1.1 Historical Perspective

Protection against power oscillations that might lead to fuel damage has always been required by General Design Criterion 12 [2], which requires that such oscillations either not be possible or be reliably detected and suppressed. In the past, this requirement was met by showing that oscillations are not possible by calculating Core and Channel Decay Ratios as a part of reload licensing analyses. Such results notwithstanding, guidance was provided to BWR operators as early as 1982 in the form of a GE Service Information Letter [3] on the detection and suppression of hypothetical power oscillations at low-flow and high-power conditions.

With the advent of 8X8 fuel designs and more aggressive operating strategies to improve operational flexibility and fuel utilization (e.g., extended load lines, feedwater heaters out-of-service, etc.), stability margins decreased such that instabilities could no longer be demonstrated to be impossible; therefore, in 1982 and after, protection against power oscillations was ensured by providing plant operators with guidance on detecting and suppressing such oscillations [3,4]. In addition, analysis was performed to demonstrate that the occurrence of such oscillations did not challenge fuel thermal-mechanical limits [5,6]

Additional concerns about BWR stability were raised by the March 9, 1988, oscillation event at the LaSalle-2 plant, when investigations revealed that power oscillations could occur more rapidly than had been thought probable. Furthermore, new analyses predicted less margin to the MCPR limit than was previously shown [7]. This event led NRC to issue Bulletin 88-07 [8], which requires BWR owners to indicate how they would guard against such events in the future.

1.2 BWR Owners' Group Response

In response to NRC Bulletin 88-07, the BWR Owners' Group, in conjunction with GE, implemented a program to develop a long-term solution to the whole stability issue. The BWROG approach, as well as interim protective guidelines, was accepted by the NRC in Supplement 1 to the aforementioned Bulletin [9]. The BWROG efforts have culminated in the generation of the "BWR Owners' Group Long-term Stability Solutions Licensing Methodology," which outlines several solution options. Some of these involve the introduction of a new Reactor Protection System (RPS) trip function and may be applied to all BWR's, while others demonstrate the adequacy of existing hardware but are applicable to only a limited set of plants.

1.3 Option I-D Solution

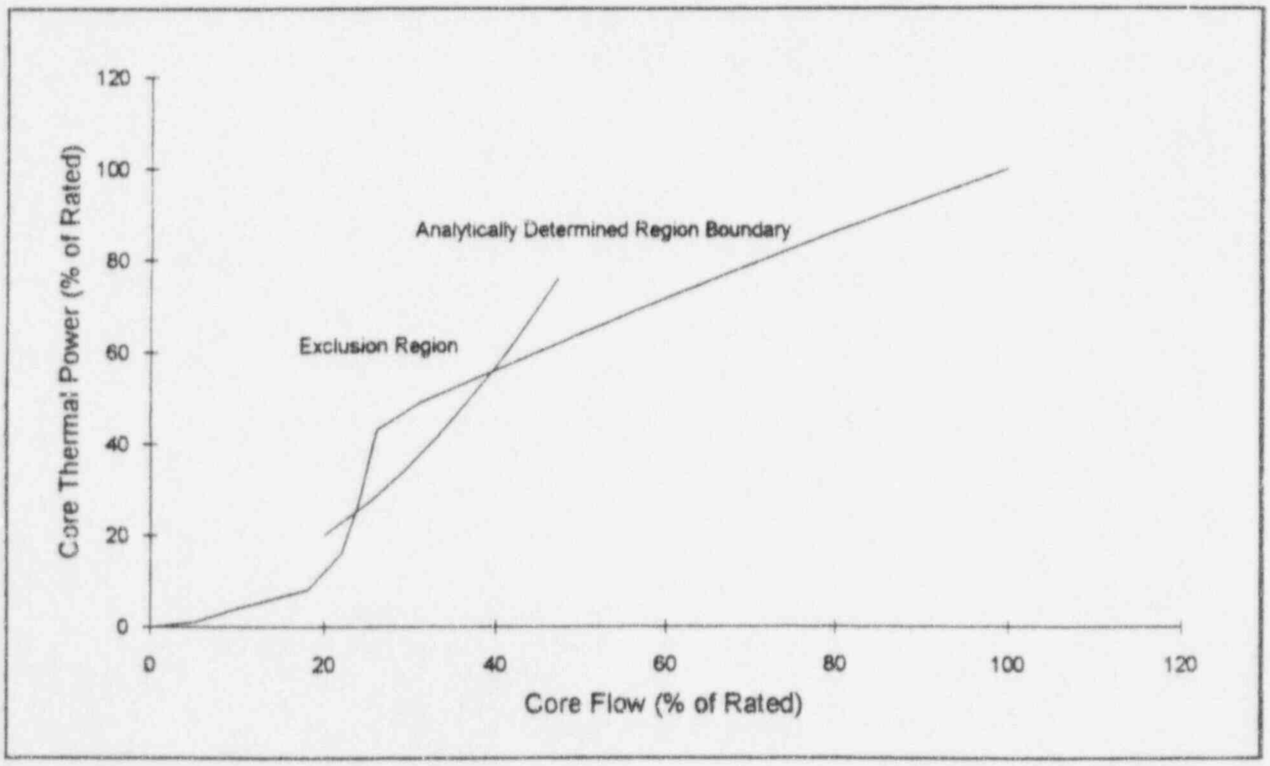
One of the solutions which demonstrates the adequacy of existing hardware is Option I-D, entitled, "Regional Exclusion with Flow-Biased APRM Neutron Flux Scram." This solution consists of two parts. The first is the creation of an Exclusion Region in the operating map for the plant (Figure 1-1). This is a region where conservative Decay Ratio calculations indicate that power oscillations are possible. If the plant should enter this region due to an operational transient, such as a Recirculation Pump trip, a Recirculation Pump runback, or, the Loss of Feedwater Heating or Inadvertent Control Rod Withdrawal at low flow, the operators are instructed to leave the region promptly or provide manual scram if oscillations occur. As a part of the generation of the Exclusion Region, the margin to Regional Mode oscillations is quantified using the methodology identified in Supplement 1 to NEDO-31960 [1]. As described therein (Section 5.0), there are unrealized conservatisms in the prediction of the already low likelihood of Regional Mode oscillations by neglecting the higher eigenvalue separation for the small core size of Monticello.

The second part of this solution is a demonstration that, even in the unlikely event of a power oscillation, an APRM Flow-Biased Flux Trip will detect and suppress the most probable mode power oscillations (Core-wide Mode) before the MCPR limit is reached. This demonstration uses the statistical methodology described in NEDO-31960 [1] (Section 6.0). It is conservatively applied for Core-wide Mode oscillations both in terms of the inputs and confidence levels used in the statistical methodology. In addition, a similar demonstration is made for Regional Mode oscillations, but with best estimate nominal values selected as inputs to the analysis and nominal confidence levels, even though such oscillations are not predicted to occur (Figure 4-2).

While the Exclusion Region and MCPR analysis are the most prominent parts of the Option I-D solution, they should not be regarded, in and of themselves, as the complete solution. Rather, they are part of a hierarchy of barriers that provide a high degree of assurance that fuel thermal limits cannot be approached. The barriers that must be scaled before fuel limits can be approached may be summarized as:

- Occurrence of a transient that brings the plant into the Exclusion Region (e.g., pump trip, pump runback, Inadvertent Control Rod withdrawal or Loss of Feedwater Heating during startup)
- Failure to leave the Exclusion Region either by increasing flow or decreasing power (It has been observed that an appreciable time lapse occurs before the system stabilizes at the new operating point and that oscillations require some time to evolve. There is adequate time for the operators to maneuver the plant out of the Exclusion Region or to scram the plant upon recognition of an oscillation.)
- Development of oscillatory power behavior for which a RPS trip does not occur before fuel thermal limits are exceeded

Figure 1-1
Typical Exclusion Region in Operating Map



1.4 Applicability of Option I-D to Monticello

Integral to the Option I-D approach is the assertion that Regional Mode oscillations have a low probability of occurrence. One feature of Monticello that assists in protecting against the occurrence of Regional Mode oscillations is that there are large single-phase channel pressure losses when compared to other BWR's. Such losses, in the absence of other changes in core hydraulic characteristics, are known to be stabilizing. When comparing various plant designs, differences in single phase pressure losses are mostly attributable to the fuel inlet orifices; thus, plants, such as Monticello, which have relatively small inlet orifice diameters, are expected to be more stable than those with large inlet orifice diameters (the inlet orifice diameter for Monticello is 2.15 inches as compared to 2.43 inches for most other BWR 4's and 5's).

A second feature is that the core is relatively "small." Since the phenomenon underlying the neutronic portion of Regional Mode oscillations is the excitation of the higher harmonics modes of the fundamental (i.e., critical) flux shape, the occurrence of Region Mode oscillations requires the insertion of sufficient reactivity to overcome the inherent sub-critical multiplication of those modes (i.e., "eigenvalue separation"). The eigenvalue separation has been found to be strongly dependent on the size of the core, with smaller cores (e.g., 484 bundles) having markedly greater separation than larger cores (e.g., 764 bundles). The assertion for a small core such as Monticello with 484 bundles is that a Core-wide Mode oscillation will be excited long before an azimuthal (Regional Mode) oscillation, and the APRM Flow Biased Flux Scram will suppress the oscillations before a thermal limit is reached (the MCPR limit is the most sensitive thermal limit for oscillations). Nevertheless, the current analysis conservatively neglects eigenvalue separation and relies wholly on the larger hydraulic losses of the inlet orifices to demonstrate a preference for the Core-wide Mode of oscillation.

A third feature in the application of Option I-D is that Monticello has a relatively low power density (~40 kW/l) when compared to the other plants (~49-51 kW/l) that are implementing the Option I-D solution. A lower power density translates into a lower absolute power to flow ratio in the core at the same relative state point on the power/flow operating map and provides additional stability margin.

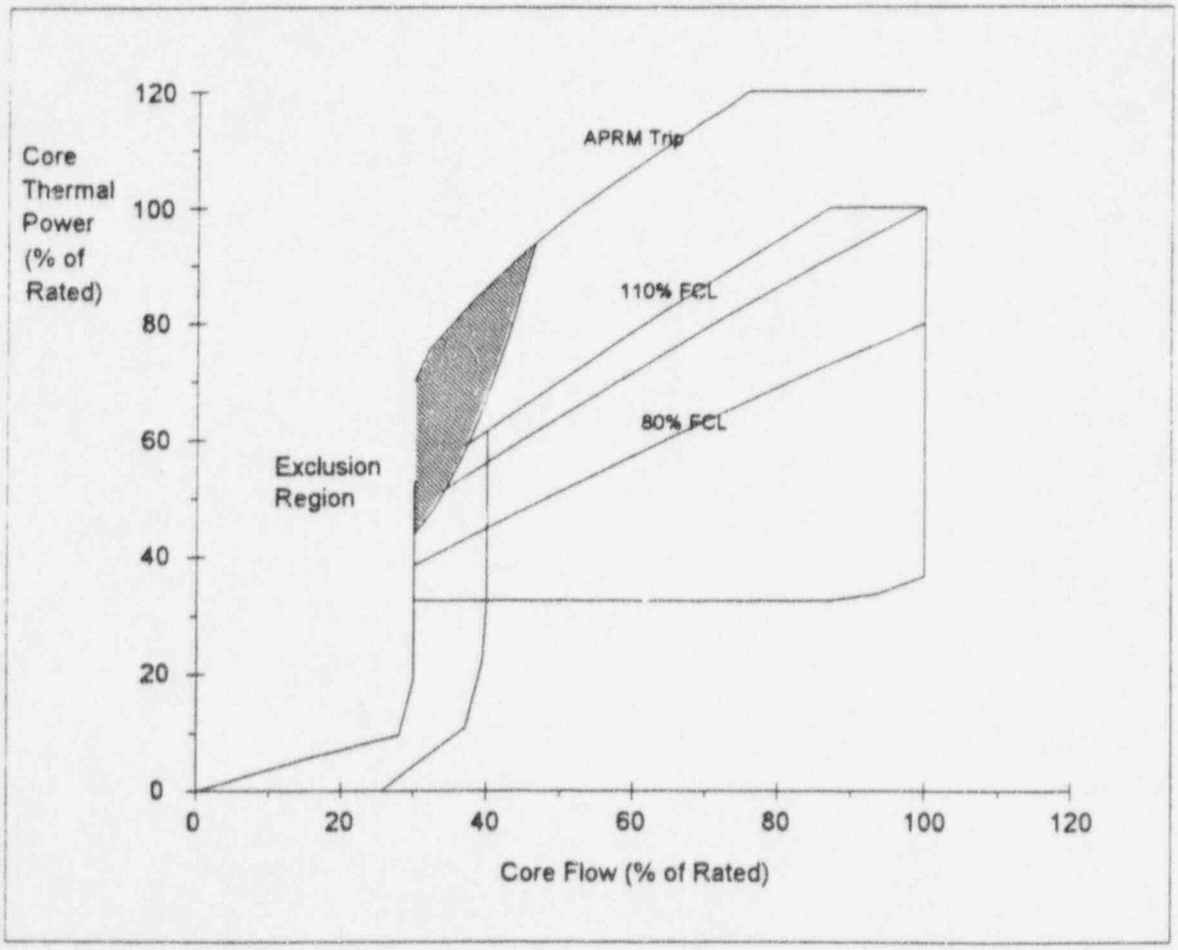
A fourth feature in the application of Option I-D is that Monticello has an unfiltered APRM Flow Biased Flux Scram instead of a Simulated Thermal Power Monitor (STPM). The APRM neutron flux signal provides an instantaneous response to an oscillation rather than the slower fuel thermal response associated with a STPM.

2 SUMMARY AND CONCLUSIONS

Compliance with General Design Criterion 12 is met with the Regional Exclusion with Flow-biased APRM Neutron Flux Scram Stability Solution (Option I-D) for Cycle 15 of the Monticello Nuclear Power Plant.

The Exclusion Region for Cycle 15 of Monticello is shown in Figure 2-1. The analysis shows that Core-wide Mode oscillations are the preferred mode for Monticello primarily due to the relatively small fuel inlet orifices.

Figure 2-1
Monticello Exclusion Region (Cycle 15)



The Safety Limit Minimum Critical Power Ratio (SLMCPR) is met for Core-wide Mode oscillations at the 105% Flow-control Line with high statistical confidence. Therefore, the Flow-Biased APRM Neutron Flux Scram provides protection of the fuel SLMCPR against the preferred mode of oscillation with high confidence for the high power, low flow corner of the exclusion region without impacting plant operating limits for Cycle 15.

The SLMCPR is not met for Regional Mode oscillations at the 120% Flow-control Line. Thus, the Flow-Biased APRM Neutron Flux Scram does not provide protection of the fuel SLMCPR against this mode of oscillation for the exclusion region. However, Regional Mode oscillations are not anticipated to occur for Monticello.

The analysis uses conservative inputs and assumptions so as to provide assurance that the results of this demonstration for Cycle 15 are conservative with respect to future reload cycles .

3 APPLICATION OF BWROG STABILITY LONG-TERM SOLUTION REGIONAL EXCLUSION METHODOLOGY

Section 3 describes the application of the BWROG Regional Exclusion Methodology for Monticello. This application is intended to define the power flow conditions to be avoided during normal operation. Also, the results of this analysis conservatively indicate that the Core-wide Mode is the preferred mode for Monticello. The analysis inputs described below for the demonstration application were developed for Cycle 15. Future operating cycle reload analysis will confirm the applicability of the power flow map Exclusion Region and preference for Core-wide Mode oscillations to the particular characteristics of the new fuel cycle.

The algorithm used to define the Exclusion Region is based on the FABLE/BYPSS methodology and the inputs to it are as described in Section 5.2 of the BWROG methodology report [1]. Input parameters that are dependent upon cycle specific parameters, such as fuel loading, are from Cycle 15 for Monticello. As such, the Exclusion Region is specific to Cycle 15 and its validity must be confirmed for each subsequent fuel reload.

3.1 Void Coefficient

The most negative point model void-feedback parameters (nuclear void coefficient and delayed neutron data) for Cycle 15 are used. Since this coefficient is the most negative value for the cycle, it does not correspond to the other inputs to the methodology (e.g., axial power distribution) but is conservative.

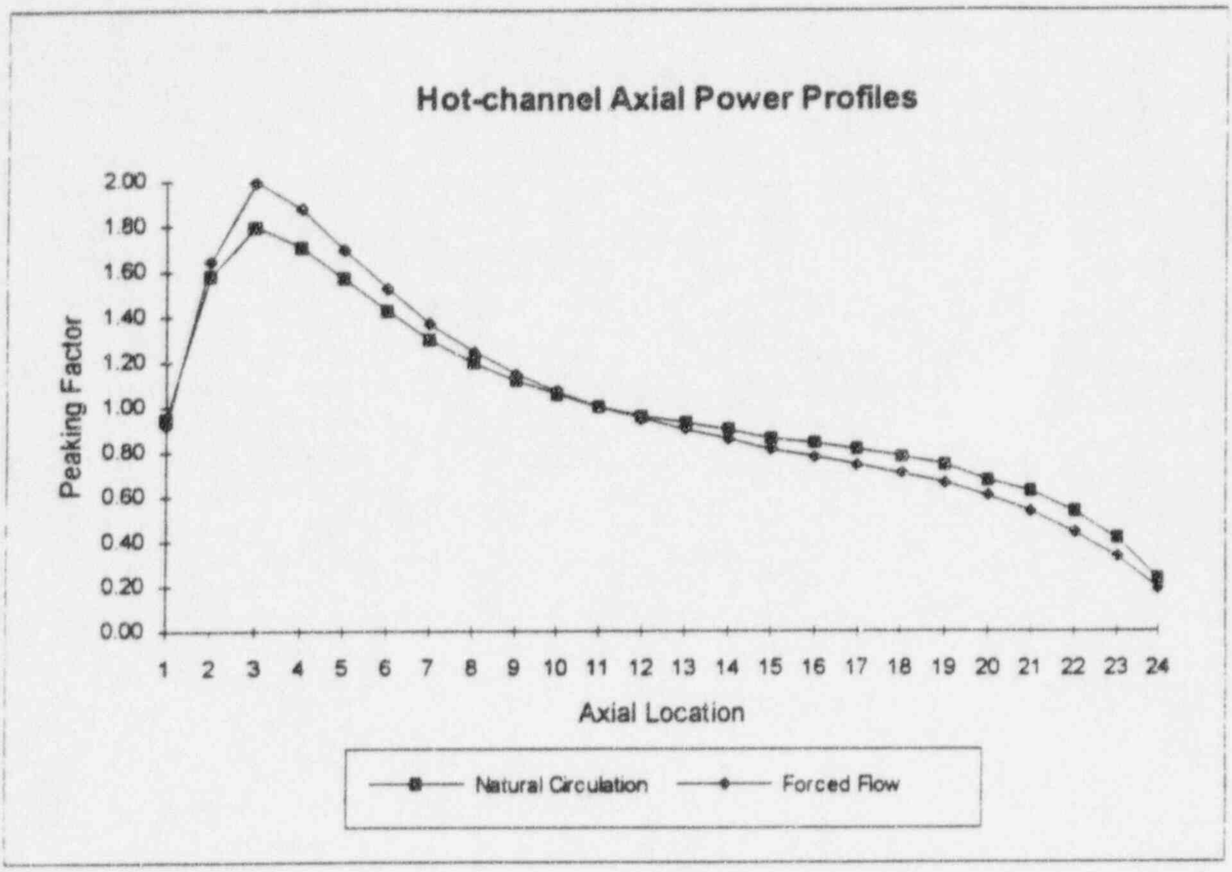
3.2 Thermal-hydraulic Data

Standard design values for Monticello, consistent with the FABLE/BYPSS qualification bases, are used in the analysis.

3.3 Hot-Channel Axial Power Distribution

Channel hydraulic stability is known to be strongly affected by the channel's axial power distribution. For the hot channels, the axial power distribution is fixed by the procedure to be peaked near the bottom of the channel, a distribution that is known to be less stable. These axial power distributions for both forced flow and natural circulation are shown in Figure 3-1. These axial profiles are consistent with those shown in Figure 5-5 of the BWROG Methods report [1]. Hot channels are identified for each hydraulic channel design in the Monticello core.

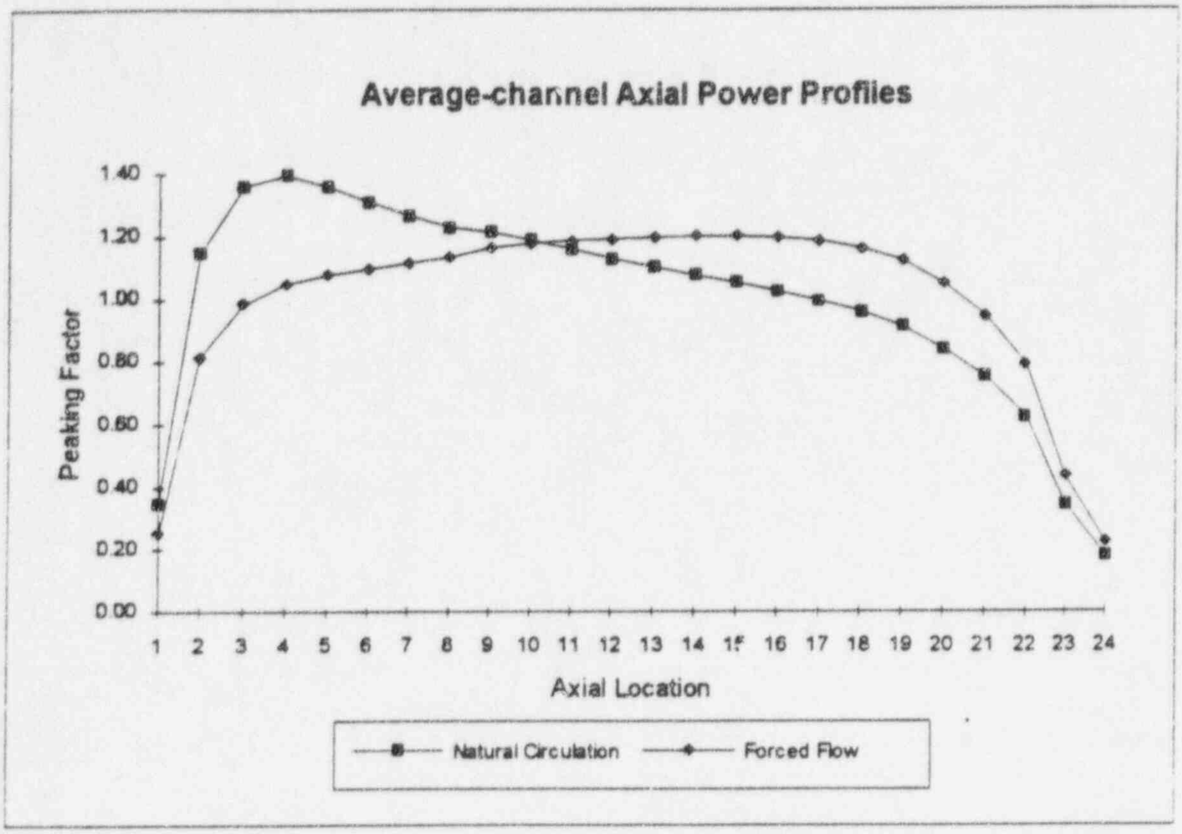
Figure 3-1



3.4 Average-Channel Axial Power Distribution

Core stability is known to be affected by the axial power distribution of the bulk of the channels in the core (all those other than the "hot channels"). In the absence of other changes, a relatively "flat" axial power distribution will be less stable than top-peaked or bottom-peaked distributions; therefore, for forced circulation conditions, the Haling End-of-Cycle 15 (EOC-15) full power and flow core-average axial power distribution is used (see Figure 3-2). For natural circulation conditions the power distribution moves strongly to the bottom of the core and use of a Haling profile characteristic of full power and flow would be too conservative; therefore, a core-average axial power distribution characteristic of Natural Circulation flow at the Haling EOC-15 exposure point is used. The axial power profile at the intersection of the rated Flow-control Line (FCL) and the Natural Circulation flow line is shown in Figure 3-2.

Figure 3-2



3.5 Radial Power Distribution

The radial peaking factors for the channel grouping used in the FABLE/BYPSS analyses are based on those obtained from the GE 3D BWR Simulator Code [10]. The values chosen are from the EOC-15 Haling exposure point.

3.6 Pellet-Clad Gap Conductance

Core average pellet-clad gap conductances were determined for each fuel design using the approved fuel licensing model consistent with the FABLE/BYPSS qualification bases.

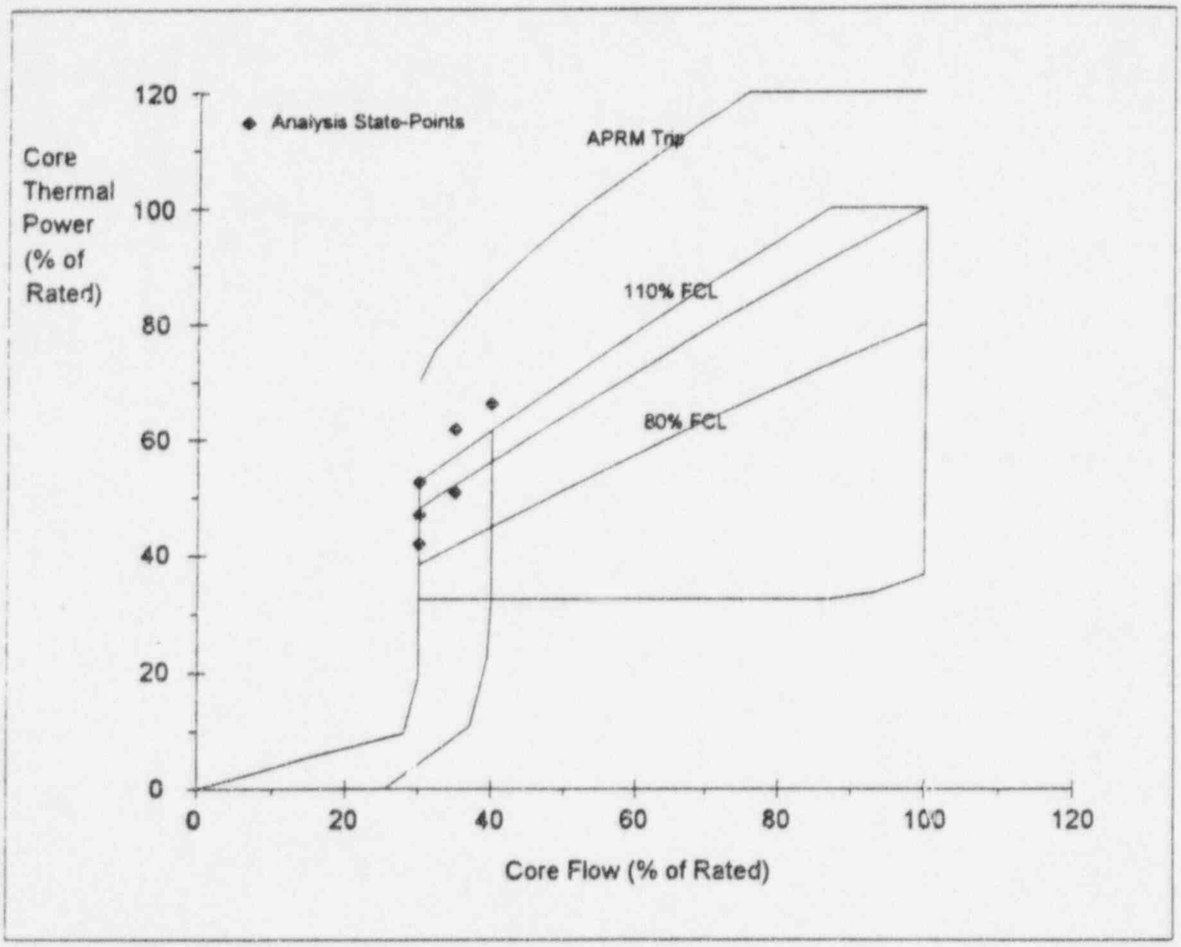
3.7 Miscellaneous Input Values

Other input values to the FABLE/BYPSS analyses, such as heat balance data, recirculation loop resistance, fuel physical parameters and material properties are standard design values for the Monticello plant. It is assumed that the nominal heat balance assumptions, such as the operation of all Feedwater Heaters, are valid for this model.

4 REGIONAL EXCLUSION RESULTS

Core and Channel Decay Ratios were calculated for several power flow combinations on the operating map (see Figure 4-1) using the inputs described in Section 3. The purpose of analyzing these combinations is to determine the Exclusion Region boundary on the power flow map and, using the generic BWROG Stability Criterion Map, establish the preferred mode of oscillation and the margin to the occurrence of Regional Mode oscillations for Monticello.

Figure 4-1
Probe Points on Operating Map



The points calculated are provided in Table 4-1. Points 1 and 2 are along the 120% Flow-control Line; Point 3 is at the same flow rate as point 2, but at a lower power level; Points 4 through 6 are along the natural circulation line with Point 5 being at the intersection of the 110% Flow-control Line and the natural circulation line. The core and channel decay ratio results of the analyzed points are tabulated in Table 4-1.

Table 4-1
Probe Points on Operating Map

Point Number	Power (%)	Flow (%)	Channel Hydraulic Decay Ratio	Core Decay Ratio	Symbol on Figure 4-2
1	66.8	40.0	0.348	0.788	■
2	62.3	35.0	0.437	0.993	■
3	51.0	35.0	0.312	0.753	◆
4	47.2	30.0	0.375	0.914	◆
5	52.4	30.0	0.461	1.054	×
6	42.2	30.0	0.311	0.744	×

The points shown in Figure 4-1 and provided in Table 4-1 are plotted on the Stability Criterion Map in Figure 4-2. The plotting symbols have been provided in Table 4-1 for clarification. The lines which connect the appropriate state points in Figure 4-2 are used to determine the power and flow conditions at which the stability map criterion are exactly met. The coordinates of the intersections with the stability map criterion lines are given in Table 4-2.

Figure 4-2
Coordinates of Probe Points on Stability Criterion Map

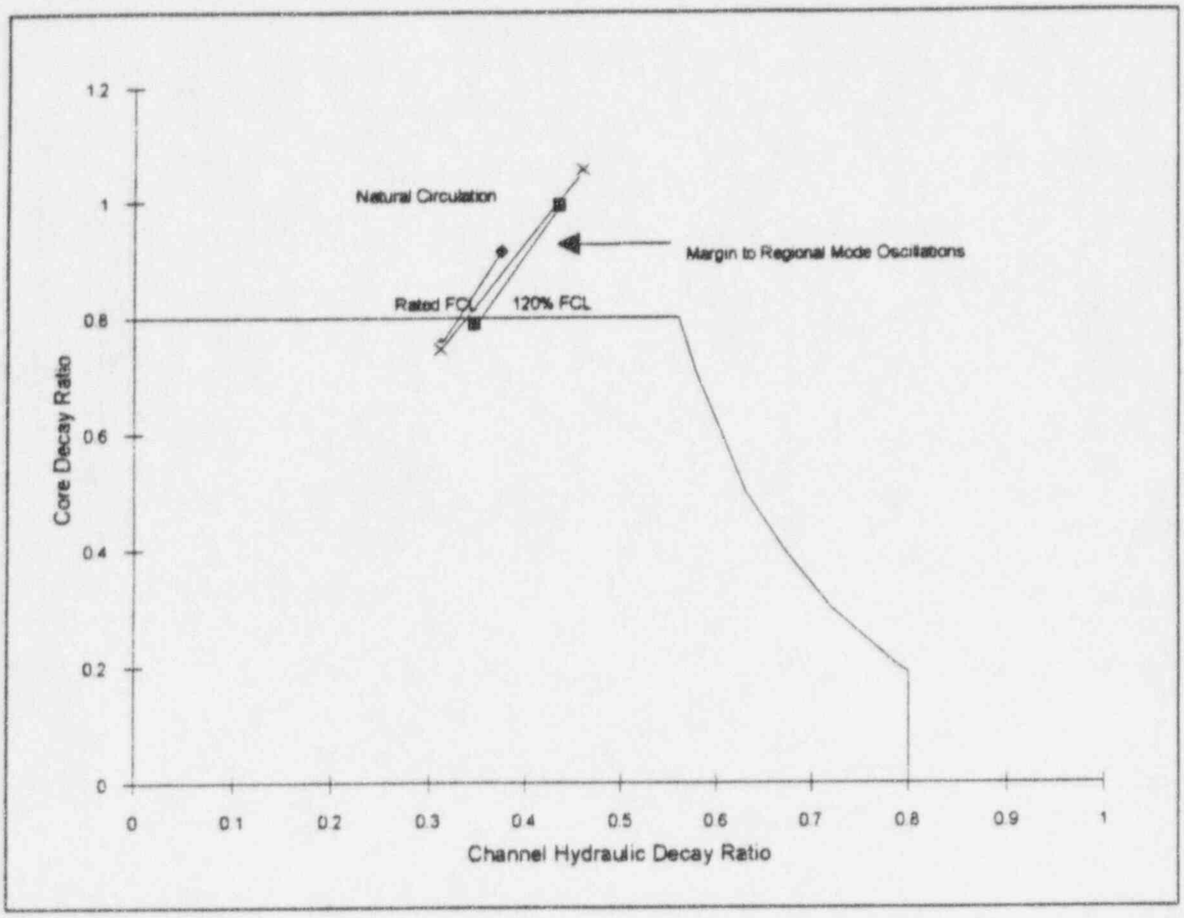


Table 4-2
Coordinates of Exclusion Region Boundary

Flow (%)	Power (%)
30.00	43.85
33.54	49.89
39.71	66.54

The coordinates of the probe points on the Stability Criterion Map, Figure 4-2, provide further evidence that Regional Mode oscillations are not probable for Monticello. It was shown in the stability solutions licensing methodology report [1] that the probability of Regional Mode oscillations becomes progressively smaller as Channel Hydraulic Decay Ratio is decreased, and Regional Mode oscillations have not been observed for Channel Hydraulic Decay Ratios less than 0.6. The largest Channel Hydraulic Decay Ratio conservatively predicted by the methodology for Monticello in 0.46 and occurs at the intersection of the natural circulation flow line and the extended operating domain flow control line: at the high-power/low-flow corner of the Exclusion Region (point 5). Regional Mode oscillations are not anticipated anywhere on the operating map for Monticello because of relatively low Channel Hydraulic Decay Ratios.

The points identified in Table 4-2 were then used to determine the location of the Exclusion Region boundary, which is shown in Figure 4-3. The actual Exclusion Region boundary for Monticello is specified as a least-squares fit to the values tabulated in Table 4-2. The equation for the boundary is as follows:

$$\text{Power} = 95.4410 - 4.78522\ (\text{Flow}) + 0.102181\ (\text{Flow})^2$$

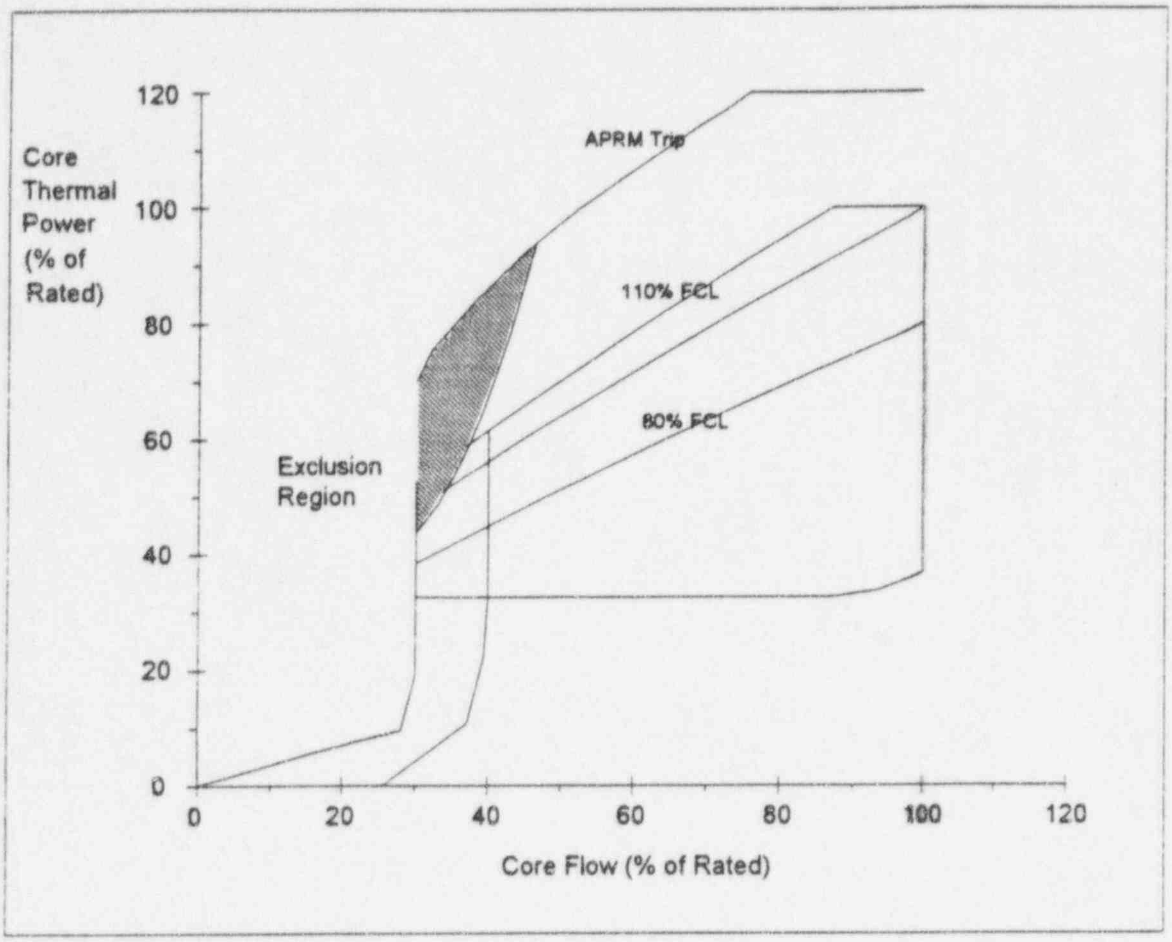
where,

Flow = core flow as percent of rated
Power = core thermal power as percent of rated

and the range of validity of the fit is:

$$30.0 < \text{Flow} < 39.7$$

Figure 4-3
Monticello Exclusion Region (Cycle 15)



5 APPLICATION OF BWROG STABILITY LONG-TERM SOLUTION DETECTION AND SUPPRESSION METHODOLOGY

Section 5 describes the application of the BWROG Detection and Suppression Methodology for Monticello This application is intended to demonstrate the protection for the SLMCPR provided by the Flow-Biased APRM Neutron Flux Scram System to Core-wide and Regional Mode oscillations.

The algorithm used to determine the margin to the SLMCPR is that described in Section 6.2 of the BWROG methodology report [1]. The analysis inputs described below for the demonstration application were developed for Cycle 15. Future operating cycle reload analysis will confirm the applicability of the Detection and Suppression results to the particular characteristics of the new fuel cycle.

Inputs to the methodology are different depending on the mode of oscillation. Because of this, the specific input for both Core-wide Mode and Regional Mode oscillations will be reviewed.

5.1 Core-Wide Mode Oscillations

Inputs to the Detection and Suppression methodology for Core-wide Mode oscillations are chosen to reflect the assumption that this is the expected mode of oscillation for Monticello. Correspondingly, statistical results at a high confidence level are reported.

5.1.1 Initial Conditions

Consistent with the BWROG generic methodology identified in Reference 1, 95% of the initiating transients are assumed to start at full-power conditions, while the remaining five percent start at minimum forced flow along the 105% Flow-control Line. For both starting points, the MCPR is assumed to be on the limits specified in the Cycle 15 Core Operating Limits Report (COLR). The limiting MCPR at full power conditions is 1.35 and at minimum forced flow is 1.59. Nominal statistical confidence level results are also shown for the rated Flow-control Line.

5.1.2 Oscillation Contours

The oscillation contour is the relative distribution of oscillation magnitudes within the core and is used in the methodology in the simulation of the LPRM signals that are used to confirm the detect/suppress system setpoints. The oscillation contour for Core-wide Mode oscillations is assumed to be the Fundamental Mode power shape and representative values for a 484 bundle core are used.

5.1.3 Oscillation Growth Rate

A range of oscillation growth rates is used that reflects both those observed in actual instabilities and from models of hypothetical instabilities. The effect of noise on the signals is also included. It is assumed that the reactor trip is effective in suppressing oscillations after the first oscillation peak following the reactor trip level being exceeded. In previous analyses (i.e., Appendix A of the BWROG methodology report), the trip was assumed to be effective only after the second oscillation peak after the trip level is exceeded. However, it is more realistic to assume that the trip is effective after the first peak as described below.

The maximum frequency for Density Wave Oscillations is approximately 0.7 Hz, which corresponds to a period of about 1.4 seconds. It may be assumed that the oscillation will be suppressed when the Control Rods are inserted approximately one-third of the way into the core. This is because the peak axial power induced by the oscillation occurs at or below this axial location. The minimum time to the second peak is twice the minimum period or 2.8 seconds.

The design basis Scram Times for Monticello are shown in Table 5-1. (Actual Scram Times are demonstrated to be faster than those shown in this table.) The average time to an insertion fraction of 0.33 is 1.377 seconds by interpolation in Table 5-1. Therefore, there is a margin of 1.423 seconds (2.8 - 1.377) to the second peak and use of the first peak overshoot is acceptable.

Table 5-1
67B Design Basis Scram Times

Insertion Fraction	Average Scram Time (seconds)
0.00	0.200
0.05	0.375
0.20	0.900
0.50	2.000
0.90	3.500

5.1.4 Trip System Definition

A trip system definition consistent with the Monticello Flow-biased APRM Neutron Flux Trip System was used for this analysis. Consistent with the probability of this mode of oscillation, the failure of the highest reading APRM channel is assumed in the analysis for Core-wide Mode oscillations. The trip equation is defined as:

$$\text{Power}(\%) = 0.66 * \text{Flow}(\%) + 70(\%)$$

5.1.5 LPRM Failures

A random distribution of failed and bypassed LPRM's was assumed for this analysis. These values are shown in Table 5-2. They are consistent with those obtained for the BWR fleet.

Table 5-2
LPRM Failure Statistics

Point in Cycle	Failure Fraction (%)
BOC	6
MOC	8
EOC	9

5.1.6 Change in MCPR with Flow Reduction

This term is used to compute the change in MCPR due to the initiating event (flow reduction) and prior to the inception of oscillations. The statistics used to evaluate the increase in MCPR with flow reduction are shown in Table 5-3. These values are different from those shown in Table 6-5 of the BWROG Methodology report [1] and represent a more comprehensive survey of the BWR fleet.

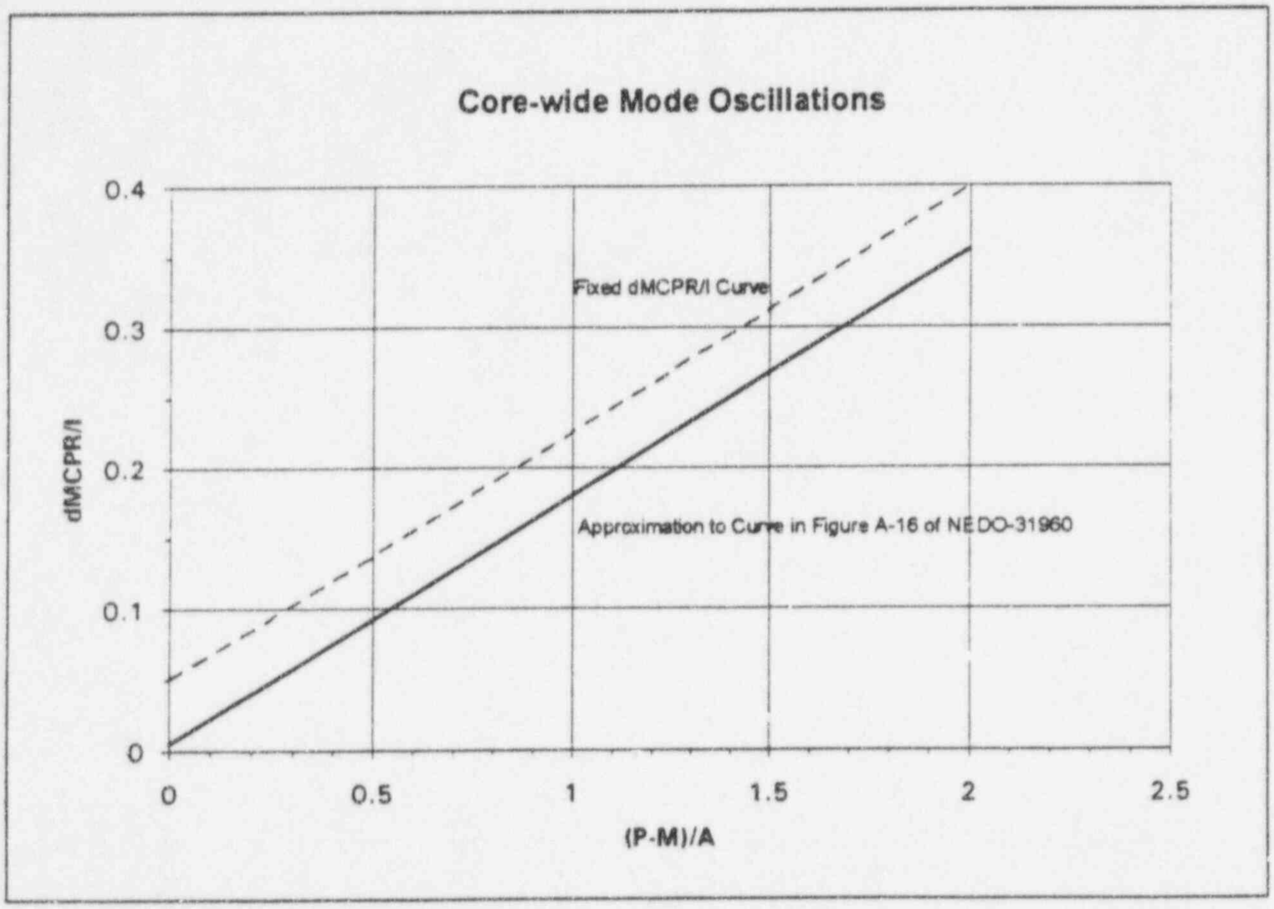
Table 5-3
MCPR Increase with Flow Reduction Statistics

Parameter	**Value**
Mean (ΔMCPR)	0.0041
Standard Deviation	0.0013
Number of Samples	40

5.1.7 CPR Performance

The change in the Minimum Critical Power Ratio (MCPR) with oscillation magnitude is a "fixed" curve based on detailed analyses of coupled thermal-hydraulic/neutronic oscillations [1]. Since the expected mode of oscillations for Monticello is Core Wide, a "fixed" curve is selected that shows large margin to the majority of the existing fully coupled results (see Figure 5-1). This selection is consistent with the objective of obtaining a statistically high-confidence result.

Figure 5-1
CPR Performance Curve for Core-wide Mode Oscillations



dMCPR/I = change in MCPR due to oscillation relative to the initial MCPR
(P-M)/A = peak minus minimum over average oscillation magnitude

5.2 Regional Mode Oscillations

Inputs to the Detection and Suppression Methodology for Regional Mode oscillations are chosen to reflect the unlikely potential for this mode to occur for Monticello as shown by the results of the Regional Exclusion analysis in Section 4. The relatively small fuel inlet orifice diameters and small core size create a preference for Core-wide Mode oscillations over the entire operating map as discussed in Section 4. Correspondingly, statistical results at an expected confidence level are reported for Regional Mode oscillations.

5.2.1 Initial Conditions

In accordance with the BWROG generic methodology, 95% of the initiating transients are assumed to start at full power conditions, while the remaining five percent start at minimum forced flow along the rated Flow-control Line. Initial MCPR values are chosen that are representative of those obtained during actual operation. The representative MCPR at full power conditions is 1.50 and at minimum forced flow is 2.09.

5.2.2 Oscillation Contours

The oscillation contours for Regional Mode oscillations are assumed to be the First Azimuthal Mode power shape and representative values for a 484 bundle core are used. The contours are computed with the GE 3D BWR Simulator and are consistent with plant data for this oscillation mode.

5.2.3 Oscillation Growth Rate

Since this mode of oscillation is not anticipated, its occurrence would result in slowly growing, low-magnitude limit cycle oscillations that would exhibit essentially no power overshoot after the trip signal is obtained, therefore a zero growth rate is assumed.

5.2.4 Trip System Definition

A trip system definition consistent with the Monticello Flow-biased APRM Neutron Flux Trip System is used for this analysis. No channel failures are assumed. The trip equation is given in Section 5.1.4.

5.2.5 LPRM Failures

A random distribution of failed and bypassed LPRM's was assumed for this analysis that is the same as that used for Core-wide Mode oscillations (see Table 5-2).

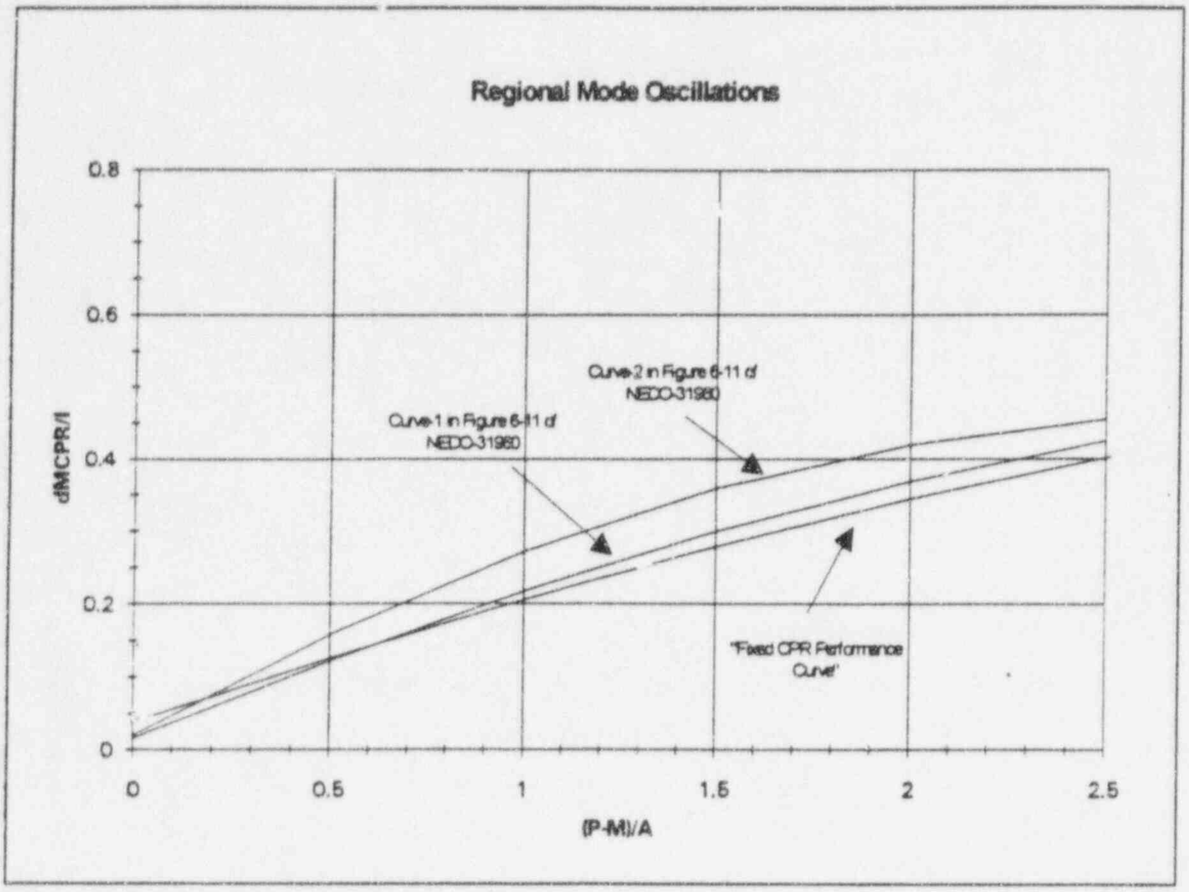
5.2.6 Change in MCPR with Flow Reduction

The MCPR change statistics with flow reduction are the same as those used for Core-wide Mode oscillations (Table 5-3).

5.2.7 CPR Performance

The change in the Minimum Critical Power Ratio (MCPR) with oscillation magnitude is a "fixed" curve based on detailed analyses of coupled thermal-hydraulic/neutronic oscillations [1]. Since this mode of oscillation is not expected, a "fixed" curve is selected that is representative of the more challenging fully coupled results (see Figure 5-2).

Figure 5-2
CPR Performance Curve for Regional Mode Oscillations



dMCPR/I = change in MCPR due to oscillation relative to the initial MCPR
(P-M)/A = peak minus minimum over average oscillation magnitude

6 DETECTION AND SUPPRESSION RESULTS

The Detection and Suppression Methodology application to Monticello described in Section 5, herein, was used to calculate the Oscillation-induced, Final MCPR (FMCPR) values for both Core-wide Mode and Regional Mode oscillations. Both were analyzed for initiating transients that result in oscillations starting at equilibrated conditions at the intersection of the Natural Circulation Line and the identified Flow-control Line that yielded a FMCPR that met the SLMCPR. The highest Flow-control Line analyzed was 120%. The initiating transient in the methodology is a dual Recirculation Pump trip. The FMCPR values resulting from both modes of oscillation are shown in Table 6-1.

Table 6-1
FMCPR Values for Both Modes of Oscillation

Mode of Oscillation	FMCPR	Corresponding Flow-control Line
Core Wide (high confidence)	1.09	105%
Core Wide (nominal confidence)	1.29	100%
Regional (nominal confidence)	0.87	120%

The SLMCPR is met for Core-wide Mode oscillations at the 105% Flow-control Line with high statistical confidence. Therefore, the Flow-Biased APRM Neutron Flux Scram provides protection of the fuel SLMCPR against the preferred mode of oscillation with high confidence for the high power, low flow corner of the exclusion region without impacting plant operating limits for Cycle 15. Nominal statistical confidence level results show large margin to the SLMCPR at the rated Flow-control Line and thus protection is available throughout the exclusion region. In addition, note that raising the Operating Limit MCPR (OLMCPR) also raises the FMCPR.

The SLMCPR is not met for Regional Mode oscillations at the 120% Flow-control Line. Thus, the Flow-Biased APRM Neutron Flux scram does not provide protection of the fuel SLMCPR against this mode of oscillation for the exclusion region. However, as was described in Section 4 of this report, Regional Mode oscillations are unlikely to occur for Monticello.

7 REFERENCES

1. "BWR Owners' Group Long-Term Stability Solutions Licensing Methodology," NEDO-31960, June 1991, and NEDO-31960 Supplement 1, March 1992.

2. 10 CFR 50, Appendix A.

3. GE Service Information Letter, SIL-380, Revision 0, August 11, 1982.

4. GE Service Information Letter, SIL-380, Revision 1, February 10, 1984.

5. NEDE-22277-P, "Compliance of the General Electric Boiling Water Reactor Fuel Designs to Stability Licensing Criteria," December, 1982.

6. NEDE-22277-P-1, "Compliance of the General Electric Boiling Water Reactor Fuel Designs to Stability Licensing Criteria," October, 1984.

7. NEDO-31708, "Fuel Thermal Margin during Core Thermal Hydraulic Oscillations in a Boiling Water Reactor," June, 1989.

8. NRC Bulletin No. 88-07, "Power Oscillations in Boiling Water Reactors," June 15, 1988.

9. NRC Bulletin No. 88-07, Supplement 1, "Power Oscillations in Boiling Water Reactors," December 30, 1988.

10. NEDO-30130-A, "Steady State Nuclear Methods," April, 1985.

11. NEDE-31917P, "GE11 Compliance with Amendment 22 of NEDE-24011-P-A (GESTAR II)," April, 1991.