

October 23, 2019

L-PI-19-043
TS 5.6.5.d

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

Prairie Island Nuclear Generating Plant Unit 2
Docket No. 50-306
Renewed Facility Operating License No. DPR-60

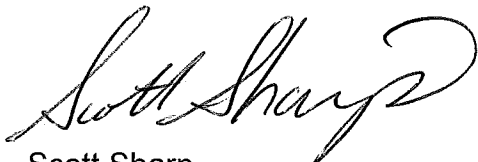
Core Operating Limits Report (COLR) for Prairie Island Nuclear Generating Plant (PINGP)
Unit 2, Cycle 31, Revision 0

Pursuant to the requirements of Technical Specification 5.6.5.d, Northern States Power Company, a Minnesota Corporation (NSPM), doing business as Xcel Energy, hereby submits the COLR for the PINGP Unit 2, Cycle 31, Revision 0. The COLR provides the cycle-specific values of the limits established using NRC approved methodologies such that the applicable limits of the plant safety analysis are met.

The COLR for PINGP Unit 2 Cycle 31, Revision 0, is provided in Enclosure 1.

Summary of Commitments

This letter contains no new commitments and no revisions to existing commitments.



Scott Sharp
Site Vice President, Prairie Island Nuclear Generating Plant
Northern States Power Company – Minnesota

Enclosure

cc: Administrator, Region III, USNRC
Project Manager, Prairie Island, USNRC
Resident Inspector, Prairie Island, USNRC
State of Minnesota

ENCLOSURE 1

**PRAIRIE ISLAND NUCLEAR GENERATING PLANT
CORE OPERATING LIMITS REPORT
UNIT 2 – CYCLE 31
REVISION 0**

PRAIRIE ISLAND NUCLEAR GENERATING PLANT

Core Operating Limits Report

Record of Revision

Unit	Cycle	Revision No.	Approval Date	Remarks
2	13	0	3/22/90	Original Unit 2 Core Operating Limits Report, distributed with Technical Specification Revision 92.
1	14	0	3/22/90	Original Unit 1 Core Operating Limits Report, distributed with Technical Specification Revision 92.
		1	7/27/90	Incorporated expanded V(z) curves.
		2	9/27/90	Clarified rod insertion limit curve applicability.
		3	2/11/91	Incorporated revised F_Q of 2.45 as a result of NRC approval of Westinghouse Topical Report WCAP-10924-P-A, Volume 1, Addendum 4, October 1990.
2	14	0	-	Not used.
		1	9/27/90	Updated to Unit 2 Cycle 14, incorporated expanded V(z) curves and clarified rod insertion limit curve applicability.
		2	2/11/91	Incorporated revised F_Q of 2.45 as a result of NRC approval of Westinghouse Topical Report WCAP-10924-P-A, Volume 1, Addendum 4, October 1990.
1	15	0	6/25/91	Updated to Unit 1 Cycle 15.
2	15	0	3/9/92	Updated to Unit 2 Cycle 15 and clarified labeling of Figure 4. Clarified the actions to be taken if the nuclear enthalpy rise hot channel factor exceeds the Technical Specification limit.
1	16	0	12/28/92	Updated to Unit 1 Cycle 16, removed V(z) curves and replaced them with list of bounding V(z) values for three ranges of exposures.
2	16	0	12/8/93	Updated to Unit 2 Cycle 16. Removed the multiple V(z) curves and replaced them with a single figure with bounding V(z) curves for four ranges of exposures. Incorporated additional discussion related to V(z) and K(z).

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Unit	Cycle	Revision No.	Approval Date	Remarks
2	16	1	11/3/94	The table containing the bounding V(z) values and Figure 2 updated to incorporate revised bounding V(z) values for the exposure range of 14-21.5 GWD/MTU. Figures 3 through 6 re-formatted.
1	17	0	6/17/94	Updated to Unit 1 Cycle 17. Removed the list of bounding V(z) values and replaced it with multiple V(z) curves. Incorporated additional discussion related to V(z) and K(z).
2	17	0	6/2/95	Updated to Unit 2 Cycle 17. Incorporated Table 1 and expanded Figure 2 with updated bounding V(z) values.
1	18	0	2/7/96	Updated to Unit 1 Cycle 18. Incorporated revised $F_{\Delta H}$ limit of 1.77. Incorporated Table 1 and updated Figure 2 with revised bounding V(z) values.
2	18	0	2/27/97	Updated to Unit 2 Cycle 18. Revised $F_{\Delta H}$ limit to 1.77. Updated Table 1 and Figures 2a through 2e with revised bounding V(z) values. Incorporated new Figures 2f and 2g with additional bounding V(z) values.
1	19	0	9/25/97	Updated to Unit 1 Cycle 19. Updated Table 1 and Figures 2a through 2f with revised bounding V(z) values.
2	19	0	12/17/98	Updated to Unit 2 Cycle 19. Updated Table 1 and Figures 2a through 2d with revised bounding V(z) values. Deleted Figures 2e, 2f and 2g.
1	20	0	5/13/99	Updated to Unit 1 Cycle 20. Updated Table 1 and Figures 2a through 2f with revised bounding V(z) values.
		1	8/4/00	Technical Specification Amendment 151: Relocate shutdown margin (SDM) requirements from Tech Specs and incorporate additional SDM requirements for Modes 3-6 from revised analysis of Uncontrolled Dilution event.

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Unit	Cycle	Revision No.	Approval Date	Remarks
2	20	0	5/31/00	Updated to Unit 2 Cycle 20. Updated Table 1 and Figures 2a through 2d with revised bounding V(z) values. Added new Table 2 and Figures 2e, 2f and 2g with additional bounding V(z) values. Added references to Tables 1 and 2 and to Figures 2e, 2f and 2g to discussion of heat flux hot channel factor limits. Added discussion clarifying applicability of axial flux difference limits when using Tables 1 and 2 and Figures 2a through 2g. Added discussion of two tier V(z) curve presented in Table 2 and Figure 2g.
		1	8/4/00	Technical Specification Amendment 142: Relocate shutdown margin (SDM) requirements from Tech Specs and incorporate additional SDM requirements for Modes 3-6 from revised analysis of Uncontrolled Dilution event.
1	20	2	9/1/00	Revised to change axial flux difference target band.
1	21	0	1/31/01	Updated to support refueling activities associated with Unit 1 Cycle 21. Revision 0 of the Unit 1 Cycle 21 COLR had to be issued prior to confirming the applicability of the LOCA analysis. Therefore, Revision 0 of the Unit 1 Cycle 21 COLR does not contain all of the operating limits necessary to support operation of Unit 1 Cycle 21.
1	21	1	2/19/01	Updated to Unit 1 Cycle 21. Updated Tables 1 and 2 and Figures 2a through 2f with revised bounding V(z) values.
1	21	2	10/02/02	Revised to support License Amendment 158 changes, including revision of all references to TS, revision of F_Q symbols, addition of Table 4, ITC limits, DNB limits and refueling boron concentrations.
2	21	0	2/06/02	Updated to Unit 2 Cycle 21.

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Unit	Cycle	Revision No.	Approval Date	Remarks
2	21	1	10/02/02	Revised to support License Amendment 149 changes, including revision of all references to TS, revision of F_Q symbols, addition of Table 4, ITC limits, DNB limits and refueling boron concentrations. Also revised to include an additional V(z) curve to give greater F_Q margin between 13.0 and 16.0 GWd/MTU.
1	22	0	11/25/02	Updated to Unit 1 Cycle 22. Updated Tables 1 and 2 and Figures 2a through 2f with revised bounding V(z) values. Incorporated new Figure 2g with additional bounding V(z) values. Updated Table 3 with revised minimum shutdown margin limits. Deleted and revised text to eliminate duplication with the Technical Specifications and the Bases.
2	22	0	9/19/03	Updated to Unit 2 Cycle 22. Updated Tables 1 and 2. A reduced number of exposure ranges were calculated in Table 1, therefore new Figures 2a through 2e with revised bounding V(z) values replaced Figures 2a through 2f. New Figure 2f replaced Figure 2g for the 2 tier band bounding V(z) values. Updated Table 3 with revised minimum shutdown margin limits. Deleted and revised text to eliminate duplication with the Technical Specifications and the Bases.
1	22	1	7/6/04	Revision to incorporate Westinghouse Safety Analysis Transition per LA 162/153. Revision 1 contains transitional values for the OP/OT ΔT Trip setpoints that will be used while the physical changes are implemented.
2	22	1	7/6/04	Revision to incorporate Westinghouse Safety Analysis transition per LA 162/153. Revision 1 contains transitional values for the OP/OT ΔT Trip setpoints that will be used while the physical changes are implemented.
2	22	2	7/12/04	Revised F_Q limit from 2.4 to 2.5. Removed OP and OT delta-T setpoints based on NMC methodology and replaced with Westinghouse developed setpoints.

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Record of Revision

Unit	Cycle	Revision No.	Approval Date	Remarks
1	22	2	7/16/04	Revised Fq limit from 2.4 to 2.5. Removed OP and OT delta-T setpoints based on NMC methodology and replaced with Westinghouse developed setpoints.
1	23	0	10/20/04	Updated to Unit 1 Cycle 23.
2	23	0	-	Not used due to core redesign.
2	23	1	5/19/05	Updated to Unit 2 Cycle 23 and to support redesign of Unit 2 Cycle 23 core.
1	23	1	7/11/05	Revised ITC upper limit from < 0 pcm/ $^{\circ}$ F for power levels $> 70\%$ RTP to less than a line that slopes linearly from 0 pcm/ $^{\circ}$ F at 70% RTP to -2.9 pcm/ $^{\circ}$ F at 100% RTP. Revised the title of Figure 3 to reference T.S. 3.1.4 Condition B and revised the title of Figure 4 to reference T.S. 3.1.4 Condition A. Added references 24 and 25 to include the 50.59 screenings written to issue revision 1.
1	24	0	5/10/06	Updated to Unit 1 Cycle 24.
1	24	1	8/7/06	Updated Table 3 to reflect the correct $F_q^w(z)$ penalty factors.
2	24	0	11/26/06	Updated to Unit 2 Cycle 24 Modes 5 and 6.
2	24	1	12/6/06	Updated to Unit 2 Cycle 24 for Modes 1-6.
2	24	2	9/4/07	Revised to support LA-179/169. Revised reference 24 to include the revision number (revision 0) and the correct date of the report (January 2005). Revised references 6a, 6b, 6c, and 8 to say 'Deleted.' These references referred to the old LBLOCA methodology and model.
1	24	2	2/11/08	Updated Table 1 to reflect correct Shutdown Margin Requirements and added Figures 6A through 6H.

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Record of Revision

Unit	Cycle	Revision No.	Approval Date	Remarks
2	24	3	2/11/08	Updated Table 1 to reflect correct Shutdown Margin Requirements and added Figures 6A through 6H.
1	25	0	2/24/08	Updated to Unit 1 Cycle 25
1	25	1	5/28/08	Updated Table 2 to reflect the correct W(z) at a burnup of 150 MWd/MTU and a core height of 6.20 feet
2	25	0	9/26/08	Updated for Unit 2 Cycle 25
1	26	0	9/24/09	Updated for Unit 1 Cycle 26
2	26	0	5/3/10	Updated for Unit 2 Cycle 26
2	26	1	5/17/10	Updated to include part power W(z) factors
1	26	1	9/2/10	Updated for second set of W(z) factors
2	26	2	9/30/10	Updated for Measurement Uncertainty Recapture power uprate to 1677 MWth and for a second set of W(z) factors
1	26	2	9/30/10	Updated for Measurement Uncertainty Recapture power uprate to 1677 MWth
1	26	3	12/17/10	Updated SDM in Table 1 for Mode 2 to say 1.9.
1	27	0	5/5/11	Updated for Unit 1 Cycle 27
1	27	1	6/2/11	Updated for Unit 1 Cycle 27 Modes 1 through 6
2	27	0	3/28/12	Updated for Unit 2 Cycle 27
1	28	0	11/29/12	Updated for Unit 1 Cycle 28

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Record of Revision

Unit	Cycle	Revision No.	Approval Date	Remarks
2	28	0	11/23/13	Updated for Unit 2 Cycle 28
1	29	0	10/23/14	Updated for Unit 1 Cycle 29
2	29	0	11/05/15	Updated for Unit 2 Cycle 29
1	30	0	10/25/16	Updated for Unit 1 Cycle 30
2	30	0	10/24/17	Updated for Unit 2 Cycle 30
1	31	0	09/06/18	Updated for Unit 1 Cycle 31
2	31	0	10/14/19	Updated for Unit 2 Cycle 31

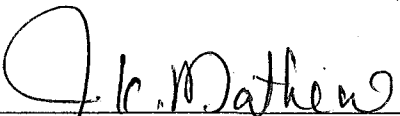
Core Operating Limits Report
Unit 2, Cycle 31
Revision 0

PRAIRIE ISLAND NUCLEAR GENERATING PLANT

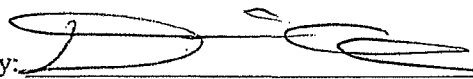
CORE OPERATING LIMITS REPORT

UNIT 2 - CYCLE 31


REVISION 0

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Note: This report is not part of the Technical Specifications

This report is referenced in the Technical Specifications

PRAIRIE ISLAND NUCLEAR GENERATING PLANT**CORE OPERATING LIMITS REPORT****UNIT 2 – CYCLE 31****REVISION 0**

This report provides the values of the limits for Unit 2 Cycle 31 as required by Technical Specification 5.6.5. These values have been established using NRC approved methodology and are established such that all applicable limits of the plant safety analysis are met. The Technical Specifications affected by this report are listed below:

1. 2.1.1 Reactor Core Safety Limits
2. 3.1.1 Shutdown Margin Requirements
3. 3.1.3 Isothermal Temperature Coefficient (ITC)
4. 3.1.5 Shutdown Bank Insertion Limits
5. 3.1.6 Control Bank Insertion Limits
6. 3.1.8 Physics Tests Exceptions - MODE 2
7. 3.2.1 Heat Flux Hot Channel Factor ($F_Q(z)$)
8. 3.2.2 Nuclear Enthalpy Rise Hot Channel Factor (F_{AH}^N)
9. 3.2.3 Axial Flux Difference (AFD)
10. 3.3.1 Reactor Trip System (RTS) Instrumentation
Overtemperature ΔT and Overpower ΔT Parameter Values for Technical Specification Table 3.3.1-1 (Note 1 and Note 2)
11. 3.4.1 RCS Pressure, Temperature, and Flow - Departure from Nucleate Boiling (DNB) Limits
12. 3.9.1 Refueling Boron Concentration

1. 2.1.1 Reactor Core Safety Limits

Reactor Core Safety Limits are shown in Figure 1.

Reference Technical Specification 2.1.1.

2. 3.1.1 Shutdown Margin Requirements

Minimum Shutdown Margin requirements are shown in Table 1.

Reference Technical Specification 3.1.1.

3. 3.1.3 Isothermal Temperature Coefficient (ITC)

ITC Upper limit:

- a. < 5 pcm/ $^{\circ}$ F for power levels $< 70\%$ RTP; and
- b. a line which slopes linearly from
 - i. 0 pcm/ $^{\circ}$ F at a power level = 70% RTP to
 - ii. -1.5 pcm/ $^{\circ}$ F at a power level = 100% RTP

ITC Lower limit:

- a. -43.15 pcm/ $^{\circ}$ F

Reference Technical Specification 3.1.3.

4. 3.1.5 Shutdown Bank Insertion Limits

The shutdown rods shall be fully withdrawn.

Reference Technical Specification 3.1.5.

5. 3.1.6 Control Bank Insertion Limits

The control rod banks shall be limited in physical insertion as shown in Figures 2, 3, and 4.

The control rod banks withdrawal sequence shall be Bank A, Bank B, Bank C, and finally Bank D.

The control rod banks shall be withdrawn maintaining 128 step tip-to-tip distance.

Reference Technical Specification 3.1.6.

6. 3.1.8 Physics Tests Exceptions - MODE 2

Minimum Shutdown Margin requirements during physics testing are shown in Table 1.

Reference Technical Specification 3.1.8.

7. 3.2.1 Heat Flux Hot Channel Factor ($F_Q(Z)$)

The Heat Flux Hot Channel Factor shall be within the following limits:

$$CFQ = 2.50$$

$K(Z)$ is a constant value = 1.0 at all elevations.

The HFP $W(Z)$ values are provided in Table 2 and Table 4.

The $W(Z)$ values in Table 2 and Table 4 are applicable to Figure 5.

The data in Tables 2 and 4 should be used independently; cross interpolation or extrapolation between $W(Z)$ sets is prohibited.

The Part Power $W(Z)$ values for $75\% \leq P < 85\%$ and Part Power $W(Z)$ values for $85 \leq P < 95\%$ are provided in Table 6.

The $W(Z)$ values in Table 6 are applicable to Figure 5.

The $F_Q^W(Z)$ Penalty Factors associated with Figure 5 and Table 2 are provided in Table 3.

The $F_Q^W(Z)$ Penalty Factors associated with Figure 5 and Table 4 are provided in Table 5.

The $W(Z)$ values in Table 4 are based on a steady-state model with perturbed Axial Flux Difference (AFD) that simulates a Delta-Axial-Offset (D-AO) of -4% for the entire cycle. D-AO is defined as the measured Axial Offset (AO) less the predicted AO from Table 2. The ranges of applicability for the Table 2 and 4 $W(z)$ values are defined below:

1. Table 2 values should be used when D-AO is in the range of $\pm 3\%$ of the Table 2 supplied AO.
2. Table 4 values should be used when D-AO is more negative than -3% and more positive than -7% of the Table 2 supplied AO.

The HFP $W(Z)$ values are generated assuming that they will be used for full power surveillance. Part power $W(Z)$ values are only required to be used when the part power surveillance is performed using the moveable incore detector system. When a part power surveillance is performed from BOC through 150 MWd/MTU and at a power level specified for Table 6, the $W(Z)$ values provided in Table 6 should be used. When a part power surveillance is performed after 150 MWd/MTU, or at a power level other than those specified for Table 6, the HFP $W(Z)$ values in Table 2 or Table 4 should be used.

$W(Z)$ values should be multiplied by the factor $1/P$, when $P > 0.5$. When $P \leq 0.5$, the $W(Z)$ values should be multiplied by the factor $1/(0.5)$, or 2.0. This is consistent with the adjustment in the $F_Q(Z)$ limit at part power conditions.

Reference Technical Specification 3.2.1.

8. 3.2.2 Nuclear Enthalpy Rise Hot Channel Factor ($F_{\Delta H}^N$)

The Nuclear Enthalpy Rise Hot Channel Factor shall be within the following limits:

$$F_{\Delta H} \leq 1.77 \times [1 + 0.3(1 - P)]$$

where: P is the fraction of RATED THERMAL POWER at which the core is operating.

Reference Technical Specification 3.2.2.

9. 3.2.3 Axial Flux Difference (AFD)

The indicated axial flux difference shall be maintained within the allowed operational space defined by Figure 5.

Reference Technical Specification 3.2.3.

10. 3.3.1 Reactor Trip System (RTS) Instrumentation

Overtemperature ΔT and Overpower ΔT Parameter Values for Technical Specification
Table 3.3.1-1 (Note 1 and Note 2):

Overtemperature ΔT Setpoint

Overtemperature ΔT setpoint parameter values:

ΔT_0	=	Indicated ΔT at RATED THERMAL POWER, %
T	=	Average temperature, °F
T'	=	560.0 °F
P	=	Pressurizer Pressure, psig
P'	=	2235 psig
K_1	\leq	1.17
K_2	=	0.014 /°F
K_3	=	0.00100 /psi
τ_1	=	30 seconds
τ_2	=	4 seconds
$f(\Delta I)$	=	A function of the indicated difference between top and bottom detectors of the power range nuclear ion chambers. Selected gains are based on measured instrument response during plant startup tests, where q_t and q_b are the percent power in the top and bottom halves of the core respectively, and $q_t + q_b$ is total core power in percent of RATED THERMAL POWER, such that
(a)		For $q_t - q_b$ within -13, +8 % $f(\Delta I) = 0$
(b)		For each percent that the magnitude of $q_t - q_b$ exceeds +8% the ΔT trip setpoint shall be automatically reduced by an equivalent of 1.73 % of RATED THERMAL POWER.
(c)		For each percent that the magnitude of $q_t - q_b$ exceeds -13 % the ΔT trip setpoint shall be automatically reduced by an equivalent of 3.846 % of RATED THERMAL POWER.

Overpower ΔT Setpoint

Overpower ΔT setpoint parameter values:

ΔT_0	=	Indicated ΔT at RATED THERMAL POWER, %
T	=	Average temperature, °F
T'	=	560.0 °F
K_4	\leq	1.11
K_5	=	0.0275/°F for increasing T ; 0 for decreasing T
K_6	=	0.002/°F for $T > T'$; 0 for $T \leq T'$
τ_3	=	10 seconds

Reference Technical Specification 3.3.1.

11. 3.4.1 RCS Pressure, Temperature, and Flow - Departure from Nucleate Boiling (DNB) Limits

The DNB Limits are:

Pressurizer pressure limit = 2190 psia

RCS average temperature limit = 564°F

RCS total flow rate limit = 178,000 gpm

Reference Technical Specification 3.4.1.

12. 3.9.1 Refueling Boron Concentration.

The boron concentration of the reactor coolant system and the refueling cavity shall be sufficient to ensure that the more restrictive of the following conditions is met:

- a) $K_{\text{eff}} \leq 0.95$
- b) 2000 ppm
- c) The Shutdown Margin specified in Table 1

Reference Technical Specification 3.9.1.

REFERENCES
(NRC Approved Methodologies for COLR Parameters)

1. NSPNAD-8101-A, "Qualification of Reactor Physics Methods for Application to Prairie Island," Revision 2, October 2000.
2. NSPNAD-8102-PA, "Prairie Island Nuclear Power Plant Reload Safety Evaluation Methods for Application to PI Units," Revision 7, July 1999.
3. NSPNAD-97002-PA, "Northern States Power Company's "Steam Line Break Methodology," Revision 1, October 2000.
4. WCAP-9272-P-A, "Westinghouse Reload Safety Evaluation Methodology," July, 1985.
- 5.a WCAP-10054-P-A, "Westinghouse Small Break ECCS Evaluation Model using the NOTRUMP Code," August, 1985.
- 5.b WCAP-10054-P-A, "Westinghouse Small Break ECCS Evaluation Model using the NOTRUMP Code," Addendum 2 Revision 1, July 1997.
6. WCAP-16045-P-A Addendum 1-A, "Qualification of the NEXUS Nuclear Data Methodology," August 2007.
7. WCAP-10924-P-A, Volume 1, Revision 1, and Volume 2, Revision 2, "Westinghouse Large Break LOCA Best Estimate Methodology," September 2005.
8. XN-NF-77-57-(A), XN-NF-77-57, Supplement 1 (A), "Exxon Nuclear Power Distribution Control for Pressurized Water Reactors Phase II," May 1981.
9. WCAP-13677-P-A, "10 CFR 50.46 Evaluation Model Report: W-COBRA/TRAC 2-Loop Upper Plenum Injection Model Update to Support ZIRLO™ Cladding Options," February 1994.
10. NSPNAD-93003-A, "Prairie Island Units 1 and 2 Transient Power Distribution Methodology," Revision 0, April 1993.
11. NAD-PI-003, "Prairie Island Nuclear Power Plant Required Shutdown Margin During Physics Tests," Revision 0, January 2001.
12. NAD-PI-004, "Prairie Island Nuclear Power Plant $F_Q^w(Z)$ Penalty With Increasing $[F_Q^c(Z) / K(Z)]$ Trend," Revision 0, January 2001.
13. WCAP-10216-P-A, Revision 1A, "Relaxation of Constant Axial Offset Control/ FQ Surveillance Technical Specification," February 1994.

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14. WCAP-8745-P-A, "Design Bases for the Thermal Overpower ΔT and Thermal Overtemperature ΔT Trip Functions," September 1986.
15. WCAP-11397-P-A, "Revised Thermal Design Procedure," April 1989.
16. WCAP-14483-A, "Generic Methodology for Expanded Core Operating Limits Report," January 1999.
17. WCAP-7588 Rev. 1-A, "An Evaluation of the Rod Ejection Accident in Westinghouse Pressurized Water Reactors Using Spatial Kinetics Methods," January 1975.
18. WCAP-7908-A, "FACTRAN – A FORTRAN IV Code for Thermal Transients in a UO₂ Fuel Rod," December 1989.
19. WCAP-7907-P-A, "LOFTRAN Code Description," April 1984.
20. WCAP-7979-P-A, "TWINKLE – A Multidimensional Neutron Kinetics Computer Code," January 1975.
21. WCAP-10965-P-A, "ANC: A Westinghouse Advanced Nodal Computer Code," September 1986.
22. WCAP-11394-P-A, "Methodology for the Analysis of the Dropped Rod Event," January 1990.
23. WCAP-16045-P-A, "Qualification of the Two-Dimensional Transport Code PARAGON," August 2004.
24. WCAP-12910 Rev. 1-A, "Pressurizer Safety Valve Set Pressure Shift," May 1993.
25. WCAP-14565-P-A, "VIPRE-01 Modeling and Qualification for Pressurized Water Reactor Non-LOCA Thermal-Hydraulic Safety Analysis," October 1999.
26. WCAP-14882-P-A, "RETRAN-02 Modeling and Qualification for Westinghouse Pressurized Water Reactor Non-LOCA Safety Analyses," April 1999.
27. WCAP-16009-P-A, "Realistic Large-Break LOCA Evaluation Methodology Using the Automated Statistical Treatment Of Uncertainty Method (ASTRUM)," Revision 0, January 2005.
28. Caldon, Inc. Engineering Report-80P, "Improving Thermal Power Accuracy and Plant Safety While Increasing Operating Power Level Using the LEFM \sqrt{t} ™ System," Revision 0, March 1997.
29. Caldon, Inc. Engineering Report-157P, "Supplement to Topical Report ER-80P: Basis for a Power Uprate With the LEFM \sqrt{t} ™ Check or CheckPlus™ System," Revision 5, October 2001.
30. WCAP-12610-P-A, "VANTAGE+ Fuel Assembly Reference Core Report," April 1995.

31. WCAP-12610-P-A and CENPD-404-P-A, Addendum 1-A, "**Optimized ZIRLO™**," July 2006.
32. Design Equivalent Change 601000001607 Rev.0 "2R31 Core Reload IFBA/GAD"

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Table 1

Minimum Required Shutdown Margin, % $\Delta\rho$

Number of Charging Pumps Running**			
Mode 1*			
	0-1 Pump	2 Pumps	3 Pumps
0 - 25000 MWd/MTU	-	-	-

Mode 2*			
	0-1 Pump	2 Pumps	3 Pumps
0 - 25000 MWd/MTU	1.7	1.7	1.7

Physics Testing in Mode 2			
	0-1 Pump	2 Pumps	3 Pumps
0 - 25000 MWd/MTU	0.5	0.5	0.5

Mode 3	$T_{ave} \geq 520^{\circ}\text{F}$ (Most Reactive Rod Out)		
	0-1 Pump	2 Pumps	3 Pumps
0 - 25000 MWd/MTU	2.0	2.0	2.0

Mode 3	$350^{\circ}\text{F} \leq T_{ave} < 520^{\circ}\text{F}$ (Most Reactive Rod Out)		
	0-1 Pump	2 Pumps	3 Pumps
0 MWd/MTU	2.0	2.0	2.0
3500 MWd/MTU	2.0	2.0	2.0
6000 MWd/MTU	2.0	2.0	2.0
11000 MWd/MTU	2.0	2.0	2.0
16000 MWd/MTU	2.0	2.0	2.0
25000 MWd/MTU	2.0	2.0	2.0

Operational Mode Definitions, as per TS Table 1.1-1.

* For Mode 1 and Mode 2 with $K_{eff} \geq 1.0$, the minimum shutdown margin requirements are provided by the Rod Insertion Limits.

** Charging pump(s) in service only pertains to steady state operations. It does not include transitory operations. For example, operations such as starting a second charging pump in order to secure the operating pump would fall under the one pump in service column.

Note: Linear interpolation between burnup steps is allowed. Extrapolation is not allowed.

Table 1, Continued

Minimum Required Shutdown Margin, % $\Delta\rho$

Number of Charging Pumps Running**			
Mode 4	200°F < T _{ave} < 350°F (Most Reactive Rod Out)		
	0-1 Pump	2 Pumps	3 Pumps
0 MWd/MTU	2.0	3.5	5.5
3500 MWd/MTU	2.0	4.0	6.0
6000 MWd/MTU	2.0	4.0	6.0
11000 MWd/MTU	2.0	3.5	5.5
16000 MWd/MTU	2.0	3.0	4.5
25000 MWd/MTU	2.0	2.0	2.5

Mode 5	68°F ≤ T _{ave} ≤ 200°F (Most Reactive Rod Out)		
	0-1 Pump	2 Pumps	3 Pumps
0 MWd/MTU***	2.0	4.0	6.5
3500 MWd/MTU	2.0	4.5	6.5
6000 MWd/MTU	2.0	4.5	6.5
11000 MWd/MTU	2.0	4.0	6.0
16000 MWd/MTU	2.0	3.5	5.5
25000 MWd/MTU	2.0	2.0	3.0

Operational Mode Definitions, as per TS Table 1.1-1.

** Charging pump(s) in service only pertains to steady state operations. It does not include transitory operations. For example, operations such as starting a second charging pump in order to secure the operating pump would fall under the one pump in service column.

*** These values are also applicable for the Unit 2 Cycle 30 end of cycle.

Note: Linear interpolation between burnup steps is allowed. Extrapolation is not allowed.

Table 1, Continued

Minimum Required Shutdown Margin, % Δp

Number of Charging Pumps Running**			
Mode 6	68°F ≤ T _{ave} < 200°F (ARI)		
	0-1 Pump	2 Pumps	3 Pumps
0 MWd/MTU***	5.129	5.129	6.5
3500 MWd/MTU	5.129	5.129	6.5
6000 MWd/MTU	5.129	5.129	6.5
11000 MWd/MTU	5.129	5.129	6.0
16000 MWd/MTU	5.129	5.129	5.129
25000 MWd/MTU	5.129	5.129	5.129

Mode 6	68°F ≤ T _{ave} < 200°F (ARO)		
	0-1 Pump	2 Pumps	3 Pumps
0 MWd/MTU***	5.129	5.129	8.0
3500 MWd/MTU	5.129	5.129	8.5
6000 MWd/MTU	5.129	5.129	8.5
11000 MWd/MTU	5.129	5.129	8.0
16000 MWd/MTU	5.129	5.129	7.0
25000 MWd/MTU	5.129	5.129	5.129

Operational Mode Definitions, as per TS Table 1.1-1.

** Charging pump(s) in service only pertains to steady state operations. It does not include transitory operations. For example, operations such as starting a second charging pump in order to secure the operating pump would fall under the one pump in service column.

*** These values are also applicable for the Unit 2 Cycle 30 end of cycle.

Note: Linear interpolation between burnup steps is allowed. Extrapolation is not allowed.

Table 2 - W(z) Values associated with Figure 5(Top 10% and Bottom 8% excluded)*

	Height	BU [MWd/MTU]										
		[ft]	150	1000	2000	3000	3500	4000	5000	7000	8000	9000
			AO = 0.08%	AO = 0.29%	AO = 0.33%	AO = 0.15%	AO = -0.04%	AO = -0.20%	AO = -0.60%	AO = -1.38%	AO = -1.70%	AO = -1.95%
[BOTTOM] 1	0.00	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
2	0.20	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
3	0.40	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
4	0.60	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
5	0.80	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
6	1.00	1.2163	1.2385	1.2493	1.2510	1.2450	1.2447	1.2336	1.2297	1.2135	1.2189	
7	1.20	1.2089	1.2309	1.2412	1.2424	1.2365	1.2363	1.2254	1.2217	1.2060	1.2112	
8	1.40	1.2008	1.2219	1.2316	1.2322	1.2263	1.2263	1.2155	1.2119	1.1968	1.2018	
9	1.60	1.1935	1.2118	1.2207	1.2210	1.2151	1.2147	1.2043	1.2007	1.1862	1.1911	
10	1.80	1.1866	1.2009	1.2090	1.2092	1.2034	1.2021	1.1926	1.1886	1.1748	1.1796	
11	2.00	1.1788	1.1892	1.1964	1.1964	1.1908	1.1885	1.1806	1.1755	1.1626	1.1674	
12	2.20	1.1710	1.1775	1.1837	1.1836	1.1782	1.1747	1.1683	1.1623	1.1502	1.1550	
13	2.40	1.1630	1.1659	1.1712	1.1708	1.1655	1.1612	1.1591	1.1488	1.1376	1.1423	
14	2.60	1.1553	1.1550	1.1596	1.1597	1.1553	1.1503	1.1510	1.1353	1.1248	1.1295	
15	2.80	1.1472	1.1434	1.1496	1.1501	1.1486	1.1403	1.1425	1.1231	1.1138	1.1180	
16	3.00	1.1401	1.1341	1.1420	1.1422	1.1433	1.1315	1.1349	1.1154	1.1074	1.1108	
17	3.20	1.1349	1.1308	1.1364	1.1363	1.1372	1.1269	1.1291	1.1130	1.1051	1.1090	
18	3.40	1.1290	1.1294	1.1307	1.1300	1.1308	1.1255	1.1226	1.1097	1.1021	1.1064	
19	3.60	1.1238	1.1277	1.1279	1.1270	1.1250	1.1240	1.1176	1.1056	1.0983	1.1040	
20	3.80	1.1207	1.1254	1.1258	1.1253	1.1214	1.1218	1.1149	1.1032	1.0959	1.1026	
21	4.00	1.1186	1.1226	1.1227	1.1223	1.1193	1.1192	1.1128	1.1022	1.0947	1.1018	
22	4.20	1.1155	1.1191	1.1191	1.1188	1.1161	1.1159	1.1100	1.1004	1.0934	1.1007	
23	4.40	1.1121	1.1153	1.1151	1.1150	1.1126	1.1123	1.1069	1.0984	1.0935	1.0994	
24	4.60	1.1085	1.1112	1.1109	1.1109	1.1088	1.1084	1.1034	1.0958	1.0931	1.0974	
25	4.80	1.1050	1.1071	1.1063	1.1066	1.1048	1.1043	1.0998	1.0941	1.0923	1.0950	
26	5.00	1.1001	1.1020	1.1022	1.1018	1.1003	1.0995	1.0953	1.0922	1.0920	1.0929	
27	5.20	1.0974	1.0980	1.0983	1.0967	1.0954	1.0951	1.0925	1.0913	1.0921	1.0925	
28	5.40	1.1001	1.0978	1.0958	1.0936	1.0925	1.0936	1.0924	1.0920	1.0930	1.0936	
29	5.60	1.1020	1.1006	1.0985	1.0962	1.0954	1.0953	1.0948	1.0935	1.0949	1.0944	
30	5.80	1.1048	1.1049	1.1023	1.1000	1.0995	1.0986	1.0978	1.0974	1.0983	1.0983	
31	6.00	1.1090	1.1093	1.1065	1.1042	1.1040	1.1031	1.1021	1.1025	1.1022	1.1032	
32	6.20	1.1133	1.1133	1.1103	1.1081	1.1084	1.1075	1.1071	1.1071	1.1056	1.1074	
33	6.40	1.1171	1.1165	1.1135	1.1115	1.1121	1.1113	1.1117	1.1113	1.1098	1.1113	
34	6.61	1.1206	1.1195	1.1164	1.1145	1.1155	1.1147	1.1160	1.1151	1.1169	1.1157	
35	6.81	1.1232	1.1221	1.1183	1.1165	1.1179	1.1171	1.1191	1.1188	1.1227	1.1201	
36	7.01	1.1260	1.1255	1.1207	1.1192	1.1208	1.1201	1.1228	1.1229	1.1277	1.1240	
37	7.21	1.1293	1.1288	1.1236	1.1222	1.1242	1.1235	1.1270	1.1267	1.1324	1.1271	
38	7.41	1.1327	1.1313	1.1263	1.1250	1.1273	1.1267	1.1310	1.1310	1.1369	1.1319	
39	7.61	1.1355	1.1334	1.1285	1.1273	1.1300	1.1295	1.1346	1.1369	1.1407	1.1393	
40	7.81	1.1371	1.1344	1.1297	1.1288	1.1318	1.1313	1.1371	1.1423	1.1434	1.1456	
41	8.01	1.1379	1.1340	1.1296	1.1289	1.1321	1.1316	1.1388	1.1470	1.1468	1.1510	
42	8.21	1.1370	1.1346	1.1305	1.1301	1.1338	1.1337	1.1389	1.1507	1.1518	1.1555	
43	8.41	1.1359	1.1377	1.1342	1.1341	1.1381	1.1384	1.1389	1.1541	1.1573	1.1588	
44	8.61	1.1357	1.1420	1.1389	1.1390	1.1434	1.1434	1.1401	1.1584	1.1614	1.1608	
45	8.81	1.1363	1.1458	1.1432	1.1438	1.1480	1.1483	1.1425	1.1634	1.1649	1.1618	
46	9.01	1.1429	1.1494	1.1489	1.1517	1.1509	1.1563	1.1499	1.1682	1.1711	1.1655	
47	9.21	1.1525	1.1515	1.1529	1.1583	1.1538	1.1632	1.1612	1.1780	1.1767	1.1748	
48	9.41	1.1610	1.1567	1.1613	1.1686	1.1616	1.1731	1.1729	1.1878	1.1855	1.1850	
49	9.61	1.1705	1.1678	1.1724	1.1811	1.1729	1.1847	1.1827	1.1987	1.1958	1.1931	
50	9.81	1.1838	1.1826	1.1836	1.1938	1.1848	1.1965	1.1923	1.2116	1.2056	1.2011	
51	10.01	1.1976	1.1974	1.1996	1.2119	1.1992	1.2126	1.2044	1.2207	1.2182	1.2115	
52	10.21	1.2114	1.2122	1.2156	1.2294	1.2157	1.2271	1.2160	1.2317	1.2287	1.2211	
53	10.41	1.2195	1.2214	1.2288	1.2461	1.2301	1.2430	1.2298	1.2389	1.2387	1.2320	
54	10.61	1.2288	1.2304	1.2395	1.2627	1.2440	1.2607	1.2482	1.2453	1.2482	1.2454	
55	10.81	1.2421	1.2416	1.2473	1.2684	1.2569	1.2714	1.2665	1.2525	1.2508	1.2553	
56	11.01	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
57	11.21	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
58	11.41	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
59	11.61	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
60	11.81	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
[TOP] 61	12.01	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	

* Linear extrapolation based on a line between 19,000 MWD/MTU and 22,000 MWD/MTU is adequate for addressing burnups beyond 22,000 MWD/MTU.

**Table 2 (cont.) - W(z) Values associated with Figure 5
(Top 10% and Bottom 8% excluded)***

[BOTTOM]	Height [ft]	BU [MWd/MTU]									
		10000	10500	11000	12000	14000	15000	16000	17000	19000	22000
		AO = -2.10%	AO = -2.10%	AO = -2.04%	AO = -1.79%	AO = -1.13%	AO = -0.94%	AO = -0.91%	AO = -0.96%	AO = -1.18%	AO = -1.48%
1	0.00	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	0.20	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	0.40	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	0.60	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	0.80	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.00	1.2087	1.2010	1.2140	1.2017	1.2053	1.1956	1.1968	1.2128	1.1881	1.1984
7	1.20	1.2014	1.1937	1.2067	1.1947	1.1988	1.1893	1.1906	1.2062	1.1817	1.1910
8	1.40	1.1924	1.1849	1.1976	1.1861	1.1910	1.1816	1.1832	1.1983	1.1740	1.1825
9	1.60	1.1823	1.1749	1.1874	1.1763	1.1821	1.1729	1.1749	1.1896	1.1657	1.1734
10	1.80	1.1714	1.1642	1.1764	1.1660	1.1727	1.1640	1.1665	1.1806	1.1574	1.1645
11	2.00	1.1599	1.1530	1.1648	1.1551	1.1630	1.1547	1.1578	1.1715	1.1491	1.1558
12	2.20	1.1482	1.1415	1.1530	1.1440	1.1530	1.1451	1.1490	1.1620	1.1405	1.1467
13	2.40	1.1361	1.1297	1.1407	1.1323	1.1422	1.1346	1.1390	1.1515	1.1308	1.1362
14	2.60	1.1240	1.1177	1.1280	1.1201	1.1309	1.1237	1.1299	1.1405	1.1206	1.1251
15	2.80	1.1133	1.1075	1.1177	1.1106	1.1213	1.1143	1.1207	1.1302	1.1112	1.1149
16	3.00	1.1069	1.1018	1.1120	1.1056	1.1155	1.1088	1.1143	1.1215	1.1066	1.1103
17	3.20	1.1051	1.1003	1.1093	1.1031	1.1129	1.1070	1.1139	1.1153	1.1065	1.1109
18	3.40	1.1027	1.0983	1.1059	1.1000	1.1095	1.1059	1.1132	1.1108	1.1091	1.1113
19	3.60	1.1010	1.0980	1.1025	1.0979	1.1083	1.1058	1.1138	1.1108	1.1116	1.1107
20	3.80	1.1006	1.0988	1.1007	1.0973	1.1078	1.1072	1.1149	1.1126	1.1137	1.1123
21	4.00	1.1004	1.0991	1.1000	1.0968	1.1068	1.1106	1.1154	1.1139	1.1156	1.1179
22	4.20	1.0998	1.0992	1.0987	1.0962	1.1056	1.1137	1.1157	1.1149	1.1171	1.1226
23	4.40	1.0988	1.0990	1.0970	1.0972	1.1042	1.1163	1.1156	1.1154	1.1180	1.1267
24	4.60	1.0972	1.0979	1.0963	1.0974	1.1035	1.1174	1.1140	1.1146	1.1171	1.1287
25	4.80	1.0951	1.0965	1.0954	1.0971	1.1024	1.1178	1.1139	1.1131	1.1171	1.1295
26	5.00	1.0937	1.0946	1.0939	1.0962	1.1009	1.1178	1.1147	1.1113	1.1173	1.1298
27	5.20	1.0931	1.0933	1.0931	1.0959	1.1002	1.1171	1.1151	1.1089	1.1170	1.1298
28	5.40	1.0929	1.0932	1.0935	1.0972	1.1010	1.1161	1.1150	1.1066	1.1160	1.1289
29	5.60	1.0941	1.0949	1.0957	1.0981	1.1018	1.1154	1.1153	1.1074	1.1145	1.1275
30	5.80	1.0969	1.0984	1.0997	1.1005	1.1054	1.1153	1.1159	1.1128	1.1168	1.1315
31	6.00	1.1012	1.1020	1.1039	1.1044	1.1115	1.1179	1.1188	1.1193	1.1237	1.1416
32	6.20	1.1070	1.1052	1.1076	1.1098	1.1179	1.1247	1.1234	1.1267	1.1331	1.1529
33	6.40	1.1138	1.1096	1.1118	1.1163	1.1237	1.1311	1.1295	1.1383	1.1437	1.1635
34	6.61	1.1202	1.1168	1.1171	1.1223	1.1300	1.1369	1.1396	1.1490	1.1535	1.1734
35	6.81	1.1252	1.1222	1.1207	1.1263	1.1386	1.1407	1.1476	1.1573	1.1608	1.1803
36	7.01	1.1292	1.1293	1.1261	1.1339	1.1467	1.1431	1.1544	1.1644	1.1668	1.1856
37	7.21	1.1335	1.1381	1.1339	1.1425	1.1538	1.1479	1.1605	1.1707	1.1720	1.1901
38	7.41	1.1396	1.1469	1.1422	1.1497	1.1601	1.1544	1.1655	1.1758	1.1761	1.1933
39	7.61	1.1475	1.1547	1.1497	1.1561	1.1653	1.1593	1.1693	1.1797	1.1788	1.1950
40	7.81	1.1540	1.1615	1.1564	1.1613	1.1691	1.1631	1.1717	1.1820	1.1800	1.1949
41	8.01	1.1596	1.1672	1.1620	1.1654	1.1716	1.1656	1.1725	1.1827	1.1794	1.1929
42	8.21	1.1641	1.1718	1.1666	1.1682	1.1726	1.1669	1.1720	1.1819	1.1774	1.1889
43	8.41	1.1673	1.1751	1.1702	1.1696	1.1720	1.1666	1.1694	1.1789	1.1728	1.1835
44	8.61	1.1692	1.1770	1.1724	1.1694	1.1699	1.1654	1.1657	1.1748	1.1681	1.1802
45	8.81	1.1701	1.1777	1.1737	1.1681	1.1674	1.1656	1.1645	1.1722	1.1690	1.1809
46	9.01	1.1721	1.1798	1.1778	1.1684	1.1676	1.1670	1.1630	1.1665	1.1661	1.1773
47	9.21	1.1800	1.1875	1.1818	1.1742	1.1711	1.1668	1.1648	1.1641	1.1662	1.1761
48	9.41	1.1881	1.1954	1.1889	1.1802	1.1746	1.1687	1.1666	1.1619	1.1672	1.1749
49	9.61	1.1970	1.2040	1.1973	1.1868	1.1790	1.1721	1.1686	1.1605	1.1676	1.1734
50	9.81	1.2079	1.2147	1.2052	1.1955	1.1851	1.1749	1.1725	1.1616	1.1681	1.1735
51	10.01	1.2163	1.2227	1.2162	1.2016	1.1886	1.1809	1.1759	1.1660	1.1726	1.1775
52	10.21	1.2255	1.2331	1.2250	1.2086	1.1935	1.1837	1.1829	1.1668	1.1795	1.1841
53	10.41	1.2329	1.2423	1.2350	1.2144	1.1963	1.1866	1.1904	1.1731	1.1863	1.1908
54	10.61	1.2411	1.2478	1.2427	1.2214	1.1997	1.1912	1.1980	1.1870	1.1938	1.1983
55	10.81	1.2494	1.2469	1.2421	1.2284	1.2004	1.1945	1.2037	1.1962	1.1995	1.2045
56	11.01	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
57	11.21	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
58	11.41	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
59	11.61	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
60	11.81	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
[TOP] 61	12.01	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

* Linear extrapolation based on a line between 19,000 MWd/MTU and 22,000 MWd/MTU is adequate for addressing burnups beyond 22,000 MWd/MTU.

Table 3 **$F_Q^w(Z)$ Penalty Factor associated with Figure 5 and Table 2****

Cycle Burnup (MWD/MTU)	$F_Q(z)$ Penalty Factor
0	1.0200
1695	1.0200
1867	1.0203
2039	1.0210
2210	1.0200
10109	1.0200
10280	1.0216
10452	1.0216
10624	1.0200
25000	1.0200

**Linear interpolation is adequate for intermediate cycle burnups.

Table 4 –Negative Delta AO W(z) Values associated with Figure 5 (Top 10% and Bottom 8% excluded)*

[BOTTOM]	Height		BU [MWd/MTU]								
	[ft]		150	1000	2000	3000	3500	4000	5000	7000	9000
			AO = -3.91%	AO = -3.70%	AO = -3.68%	AO = -3.85%	AO = -4.04%	AO = -4.20%	AO = -4.59%	AO = -5.38%	AO = -5.70%
1	0.00		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	0.20		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	0.40		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	0.60		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	0.80		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.00		1.1790	1.1799	1.1911	1.1940	1.1887	1.1921	1.1861	1.1595	1.1415
7	1.20		1.1720	1.1724	1.1834	1.1862	1.1810	1.1843	1.1785	1.1526	1.1350
8	1.40		1.1637	1.1635	1.1742	1.1770	1.1718	1.1749	1.1694	1.1442	1.1272
9	1.60		1.1544	1.1535	1.1637	1.1664	1.1614	1.1642	1.1589	1.1347	1.1182
10	1.80		1.1444	1.1427	1.1524	1.1549	1.1500	1.1526	1.1477	1.1246	1.1087
11	2.00		1.1338	1.1312	1.1403	1.1427	1.1379	1.1403	1.1357	1.1141	1.0988
12	2.20		1.1232	1.1197	1.1282	1.1304	1.1258	1.1278	1.1237	1.1034	1.0889
13	2.40		1.1127	1.1082	1.1161	1.1180	1.1136	1.1153	1.1115	1.0926	1.0787
14	2.60		1.1026	1.0970	1.1044	1.1061	1.1018	1.1033	1.0998	1.0821	1.0685
15	2.80		1.0928	1.0867	1.0927	1.0941	1.0900	1.0912	1.0882	1.0723	1.0605
16	3.00		1.0868	1.0815	1.0855	1.0863	1.0825	1.0835	1.0811	1.0673	1.0576
17	3.20		1.0868	1.0809	1.0853	1.0859	1.0823	1.0831	1.0809	1.0674	1.0579
18	3.40		1.0859	1.0813	1.0839	1.0845	1.0811	1.0818	1.0796	1.0678	1.0581
19	3.60		1.0845	1.0823	1.0836	1.0833	1.0793	1.0800	1.0777	1.0707	1.0598
20	3.80		1.0834	1.0834	1.0839	1.0835	1.0789	1.0799	1.0774	1.0745	1.0633
21	4.00		1.0835	1.0843	1.0846	1.0842	1.0801	1.0811	1.0789	1.0776	1.0666
22	4.20		1.0854	1.0862	1.0860	1.0844	1.0814	1.0825	1.0806	1.0804	1.0699
23	4.40		1.0879	1.0882	1.0878	1.0860	1.0835	1.0847	1.0830	1.0831	1.0744
24	4.60		1.0901	1.0898	1.0891	1.0873	1.0851	1.0863	1.0848	1.0849	1.0784
25	4.80		1.0919	1.0909	1.0902	1.0883	1.0863	1.0876	1.0864	1.0865	1.0819
26	5.00		1.0933	1.0926	1.0907	1.0888	1.0877	1.0884	1.0873	1.0875	1.0851
27	5.20		1.0949	1.0950	1.0912	1.0893	1.0898	1.0892	1.0886	1.0888	1.0880
28	5.40		1.0975	1.0971	1.0931	1.0911	1.0921	1.0912	1.0907	1.0912	1.0906
29	5.60		1.1001	1.0990	1.0963	1.0942	1.0938	1.0946	1.0926	1.0935	1.0929
30	5.80		1.1050	1.1034	1.1009	1.0987	1.0982	1.0994	1.0974	1.0971	1.0965
31	6.00		1.1104	1.1085	1.1056	1.1035	1.1034	1.1045	1.1030	1.1023	1.1006
32	6.20		1.1148	1.1125	1.1095	1.1073	1.1078	1.1089	1.1077	1.1076	1.1059
33	6.40		1.1188	1.1160	1.1129	1.1110	1.1117	1.1128	1.1121	1.1125	1.1133
34	6.61		1.1230	1.1193	1.1175	1.1177	1.1153	1.1165	1.1162	1.1183	1.1202
35	6.81		1.1278	1.1225	1.1236	1.1240	1.1191	1.1191	1.1204	1.1238	1.1258
36	7.01		1.1322	1.1264	1.1296	1.1298	1.1232	1.1226	1.1250	1.1288	1.1305
37	7.21		1.1359	1.1299	1.1347	1.1350	1.1270	1.1263	1.1291	1.1334	1.1363
38	7.41		1.1400	1.1338	1.1403	1.1406	1.1311	1.1305	1.1337	1.1404	1.1445
39	7.61		1.1456	1.1392	1.1473	1.1475	1.1368	1.1364	1.1406	1.1505	1.1543
40	7.81		1.1524	1.1458	1.1539	1.1541	1.1437	1.1435	1.1495	1.1594	1.1631
41	8.01		1.1599	1.1523	1.1599	1.1601	1.1514	1.1513	1.1579	1.1675	1.1710
42	8.21		1.1667	1.1577	1.1650	1.1652	1.1590	1.1590	1.1656	1.1749	1.1782
43	8.41		1.1722	1.1637	1.1691	1.1693	1.1656	1.1657	1.1720	1.1810	1.1841
44	8.61		1.1775	1.1716	1.1721	1.1724	1.1721	1.1723	1.1779	1.1866	1.1895
45	8.81		1.1860	1.1805	1.1769	1.1771	1.1820	1.1820	1.1875	1.1952	1.1976
46	9.01		1.1982	1.1932	1.1901	1.1905	1.1961	1.1959	1.2014	1.2073	1.2088
47	9.21		1.2103	1.2061	1.2037	1.2050	1.2102	1.2100	1.2153	1.2200	1.2204
48	9.41		1.2214	1.2180	1.2172	1.2207	1.2240	1.2258	1.2309	1.2347	1.2343
49	9.61		1.2304	1.2281	1.2316	1.2373	1.2383	1.2426	1.2478	1.2506	1.2494
50	9.81		1.2391	1.2385	1.2458	1.2529	1.2533	1.2583	1.2635	1.2653	1.2633
51	10.01		1.2516	1.2543	1.2592	1.2678	1.2673	1.2733	1.2785	1.2793	1.2764
52	10.21		1.2635	1.2700	1.2711	1.2820	1.2797	1.2876	1.2928	1.2925	1.2888
53	10.41		1.2773	1.2834	1.2842	1.2926	1.2937	1.2983	1.3036	1.3027	1.2982
54	10.61		1.2957	1.2993	1.3029	1.3072	1.3130	1.3128	1.3177	1.3153	1.3102
55	10.81		1.3116	1.3151	1.3206	1.3249	1.3313	1.3304	1.3348	1.3299	1.3240
56	11.01		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
57	11.21		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
58	11.41		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
59	11.61		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
60	11.81		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
61	12.01		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

* Linear extrapolation based on a line between 19,000 MWD/MTU and 22,000 MWD/MTU is adequate for addressing burnups beyond 22,000 MWD/MTU.

**Table 4 (cont.) – Negative Delta AO W(z) Values associated with Figure 5
(Top 10% and Bottom 8% excluded)***

[BOTTOM]	Height [ft]	BU [MWd/MTU]									
		10000	10500	11000	12000	14000	15000	16000	17000	19000	22000
		AO = -6.09%	AO = -6.10%	AO = -6.04%	AO = -5.79%	AO = -5.13%	AO = -4.95%	AO = -4.92%	AO = -4.96%	AO = -5.18%	AO = -5.48%
1	0.00	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	0.20	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	0.40	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	0.60	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	0.80	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.00	1.1410	1.1250	1.1241	1.1243	1.1347	1.1168	1.1320	1.1200	1.1211	1.1159
7	1.20	1.1347	1.1194	1.1185	1.1189	1.1297	1.1125	1.1274	1.1156	1.1166	1.1110
8	1.40	1.1270	1.1126	1.1116	1.1122	1.1236	1.1072	1.1216	1.1101	1.1113	1.1053
9	1.60	1.1184	1.1049	1.1039	1.1046	1.1169	1.1014	1.1153	1.1043	1.1057	1.0995
10	1.80	1.1093	1.0969	1.0959	1.0968	1.1100	1.0957	1.1090	1.0986	1.1006	1.0943
11	2.00	1.1000	1.0887	1.0878	1.0889	1.1031	1.0901	1.1028	1.0930	1.0958	1.0897
12	2.20	1.0906	1.0805	1.0796	1.0808	1.0960	1.0843	1.0964	1.0874	1.0910	1.0849
13	2.40	1.0808	1.0720	1.0711	1.0722	1.0882	1.0778	1.0890	1.0807	1.0851	1.0788
14	2.60	1.0711	1.0634	1.0624	1.0634	1.0805	1.0711	1.0816	1.0737	1.0789	1.0725
15	2.80	1.0631	1.0565	1.0555	1.0566	1.0724	1.0653	1.0738	1.0671	1.0730	1.0660
16	3.00	1.0596	1.0538	1.0529	1.0539	1.0677	1.0623	1.0681	1.0622	1.0680	1.0622
17	3.20	1.0597	1.0543	1.0535	1.0538	1.0675	1.0620	1.0672	1.0615	1.0657	1.0623
18	3.40	1.0617	1.0570	1.0565	1.0556	1.0677	1.0655	1.0675	1.0660	1.0662	1.0658
19	3.60	1.0657	1.0615	1.0612	1.0596	1.0678	1.0703	1.0677	1.0711	1.0666	1.0687
20	3.80	1.0701	1.0664	1.0662	1.0643	1.0680	1.0753	1.0698	1.0758	1.0694	1.0742
21	4.00	1.0741	1.0709	1.0709	1.0685	1.0693	1.0803	1.0758	1.0807	1.0768	1.0831
22	4.20	1.0779	1.0753	1.0754	1.0727	1.0741	1.0853	1.0812	1.0855	1.0834	1.0921
23	4.40	1.0815	1.0794	1.0797	1.0767	1.0786	1.0900	1.0865	1.0900	1.0897	1.1005
24	4.60	1.0841	1.0825	1.0829	1.0794	1.0835	1.0934	1.0904	1.0931	1.0944	1.1069
25	4.80	1.0862	1.0852	1.0857	1.0829	1.0880	1.0962	1.0935	1.0952	1.0980	1.1120
26	5.00	1.0881	1.0875	1.0882	1.0867	1.0921	1.0986	1.0965	1.0980	1.1021	1.1169
27	5.20	1.0896	1.0896	1.0903	1.0901	1.0959	1.1007	1.0990	1.1011	1.1068	1.1211
28	5.40	1.0909	1.0913	1.0922	1.0932	1.0994	1.1023	1.1013	1.1041	1.1110	1.1249
29	5.60	1.0925	1.0934	1.0942	1.0963	1.1031	1.1043	1.1056	1.1084	1.1153	1.1314
30	5.80	1.0968	1.0982	1.0975	1.1007	1.1071	1.1097	1.1127	1.1171	1.1271	1.1458
31	6.00	1.1017	1.1037	1.1026	1.1048	1.1142	1.1196	1.1253	1.1298	1.1410	1.1622
32	6.20	1.1060	1.1085	1.1086	1.1113	1.1257	1.1329	1.1414	1.1439	1.1532	1.1767
33	6.40	1.1113	1.1143	1.1159	1.1242	1.1395	1.1476	1.1566	1.1571	1.1652	1.1910
34	6.61	1.1200	1.1234	1.1273	1.1398	1.1528	1.1616	1.1713	1.1698	1.1764	1.2044
35	6.81	1.1313	1.1354	1.1396	1.1534	1.1637	1.1731	1.1833	1.1798	1.1847	1.2142
36	7.01	1.1422	1.1468	1.1510	1.1660	1.1734	1.1835	1.1941	1.1884	1.1917	1.2223
37	7.21	1.1530	1.1582	1.1625	1.1780	1.1832	1.1930	1.2039	1.1971	1.1985	1.2303
38	7.41	1.1639	1.1696	1.1740	1.1889	1.1928	1.2012	1.2124	1.2053	1.2048	1.2375
39	7.61	1.1741	1.1803	1.1848	1.1988	1.2011	1.2080	1.2194	1.2120	1.2095	1.2428
40	7.81	1.1833	1.1900	1.1944	1.2073	1.2080	1.2133	1.2247	1.2172	1.2126	1.2463
41	8.01	1.1914	1.1987	1.2030	1.2144	1.2135	1.2168	1.2282	1.2208	1.2142	1.2478
42	8.21	1.1986	1.2062	1.2103	1.2200	1.2175	1.2188	1.2299	1.2224	1.2133	1.2473
43	8.41	1.2042	1.2124	1.2163	1.2238	1.2195	1.2181	1.2295	1.2231	1.2128	1.2447
44	8.61	1.2089	1.2171	1.2207	1.2258	1.2205	1.2167	1.2287	1.2250	1.2156	1.2407
45	8.81	1.2168	1.2209	1.2242	1.2264	1.2240	1.2192	1.2286	1.2281	1.2188	1.2371
46	9.01	1.2275	1.2255	1.2286	1.2281	1.2268	1.2184	1.2246	1.2275	1.2179	1.2329
47	9.21	1.2386	1.2290	1.2323	1.2344	1.2273	1.2212	1.2237	1.2244	1.2173	1.2312
48	9.41	1.2488	1.2394	1.2390	1.2405	1.2303	1.2255	1.2227	1.2239	1.2164	1.2299
49	9.61	1.2573	1.2548	1.2467	1.2467	1.2343	1.2272	1.2216	1.2247	1.2138	1.2271
50	9.81	1.2650	1.2688	1.2537	1.2553	1.2375	1.2290	1.2222	1.2269	1.2125	1.2262
51	10.01	1.2751	1.2825	1.2637	1.2638	1.2436	1.2363	1.2237	1.2315	1.2168	1.2323
52	10.21	1.2881	1.2957	1.2717	1.2746	1.2470	1.2444	1.2258	1.2357	1.2218	1.2389
53	10.41	1.3007	1.3078	1.2790	1.2851	1.2493	1.2517	1.2272	1.2375	1.2263	1.2447
54	10.61	1.3127	1.3196	1.2892	1.2953	1.2563	1.2594	1.2326	1.2425	1.2319	1.2516
55	10.81	1.3215	1.3282	1.2986	1.3026	1.2651	1.2648	1.2403	1.2500	1.2358	1.2570
56	11.01	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
57	11.21	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
58	11.41	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
59	11.61	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
60	11.81	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
[TOP] 61	12.01	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

* Linear extrapolation based on a line between 19,000 MWd/MTU and 22,000 MWd/MTU is adequate for addressing burnups beyond 22,000 MWd/MTU.

Table 5
Negative Delta AO $F_Q^W(Z)$ Penalty Factor associated with Figure 5 and Table 4**

Cycle Burnup (MWD/MTU)	FQ(z) Penalty Factor
0	1.0200
1352	1.0200
1524	1.0219
1695	1.0233
1867	1.0235
2039	1.0225
2210	1.0208
2382	1.0200
25000	1.0200

**Linear interpolation is adequate for intermediate cycle burnups.

Table 6 - W(z) Values Associated with Figure 5 for Part Power Surveillances*
(Top 10% and Bottom 8% excluded)

	Height [ft]	Part Power W(z) Functions (% of Hot Full Power)	
		80 [†]	90 ^{††}
		D-Bank @ 197 Steps [‡]	D-Bank @ 206 Steps [‡]
		HFP AO = 0.13%	HFP AO = 0.13%
[BOTTOM]			
1	0.00	1.0000	1.0000
2	0.20	1.0000	1.0000
3	0.40	1.0000	1.0000
4	0.60	1.0000	1.0000
5	0.80	1.0000	1.0000
6	1.00	1.2293	1.2163
7	1.20	1.2200	1.2081
8	1.40	1.2099	1.1992
9	1.60	1.2015	1.1927
10	1.80	1.1937	1.1858
11	2.00	1.1858	1.1788
12	2.20	1.1751	1.1710
13	2.40	1.1667	1.1637
14	2.60	1.1582	1.1560
15	2.80	1.1486	1.1479
16	3.00	1.1408	1.1415
17	3.20	1.1349	1.1363
18	3.40	1.1270	1.1304
19	3.60	1.1211	1.1252
20	3.80	1.1167	1.1220
21	4.00	1.1133	1.1199
22	4.20	1.1096	1.1168
23	4.40	1.1036	1.1128
24	4.60	1.0994	1.1092
25	4.80	1.0961	1.1063
26	5.00	1.0906	1.1020
27	5.20	1.0867	1.0987
28	5.40	1.0894	1.1020
29	5.60	1.0900	1.1039
30	5.80	1.0922	1.1067

* W(z) values only valid for core average burnups ≤ 150 MWd/MTU

[†] 80% of full power W(z) values are applicable for powers $75\% \leq P < 85\%$

^{††} 90% of full power W(z) values are applicable for powers $85\% \leq P < 95\%$

[‡] Rod insertion is given as a target value. Use control rods as necessary to control to target AO

Table 6 (cont.) - W(z) Values Associated with Figure 5 for Part Power Surveillances*
(Top 10% and Bottom 8% excluded)

	Height [ft]	Part Power W(z) Functions (% of Hot Full Power)	
		80 [†]	90 ^{††}
		D-Bank @ 197 Steps [‡]	D-Bank @ 206 Steps [‡]
		HFP AO = 0.13%	HFP AO = 0.13%
31	6.00	1.0958	1.1116
32	6.20	1.0994	1.1159
33	6.40	1.1030	1.1203
34	6.61	1.1052	1.1234
35	6.81	1.1083	1.1265
36	7.01	1.1119	1.1299
37	7.21	1.1158	1.1339
38	7.41	1.1191	1.1373
39	7.61	1.1231	1.1415
40	7.81	1.1247	1.1431
41	8.01	1.1267	1.1446
42	8.21	1.1271	1.1444
43	8.41	1.1266	1.1440
44	8.61	1.1276	1.1439
45	8.81	1.1289	1.1446
46	9.01	1.1380	1.1527
47	9.21	1.1504	1.1638
48	9.41	1.1610	1.1732
49	9.61	1.1734	1.1844
50	9.81	1.1892	1.1983
51	10.01	1.2037	1.2122
52	10.21	1.2208	1.2272
53	10.41	1.2305	1.2346
54	10.61	1.2413	1.2447
55	10.81	1.2556	1.2573
56	11.01	1.0000	1.0000
57	11.21	1.0000	1.0000
58	11.41	1.0000	1.0000
59	11.61	1.0000	1.0000
60	11.81	1.0000	1.0000
[TOP] 61	12.01	1.0000	1.0000

* W(z) values only valid for core average burnups ≤ 150 MWd/MTU

[†] 80% of full power W(z) values are applicable for powers $75\% \leq P < 85\%$

^{††} 90% of full power W(z) values are applicable for powers $85\% \leq P < 95\%$

[‡] Rod insertion is given as a target value. Use control rods as necessary to control to target AO

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Figure 1

Reactor Core Safety Limits

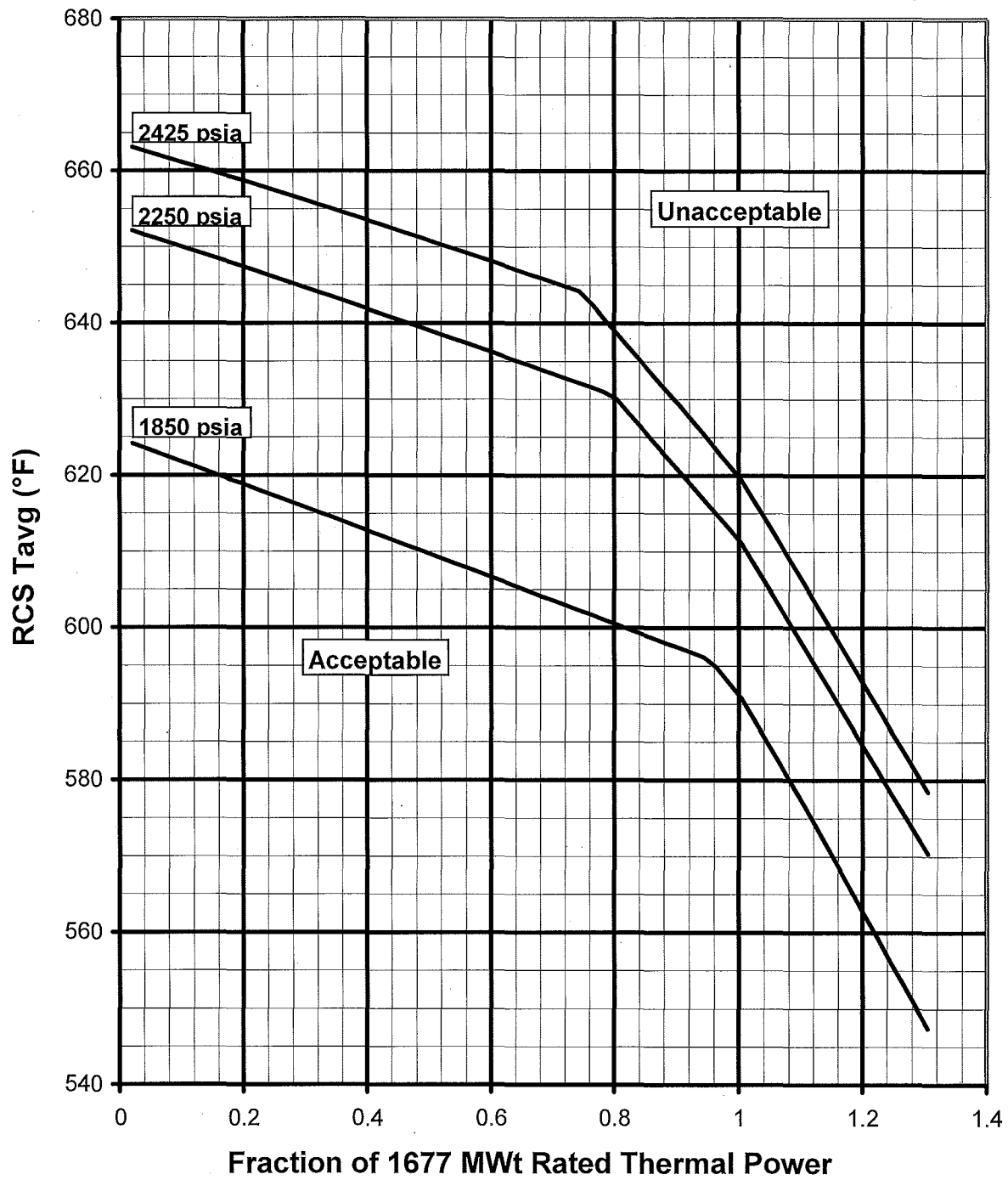
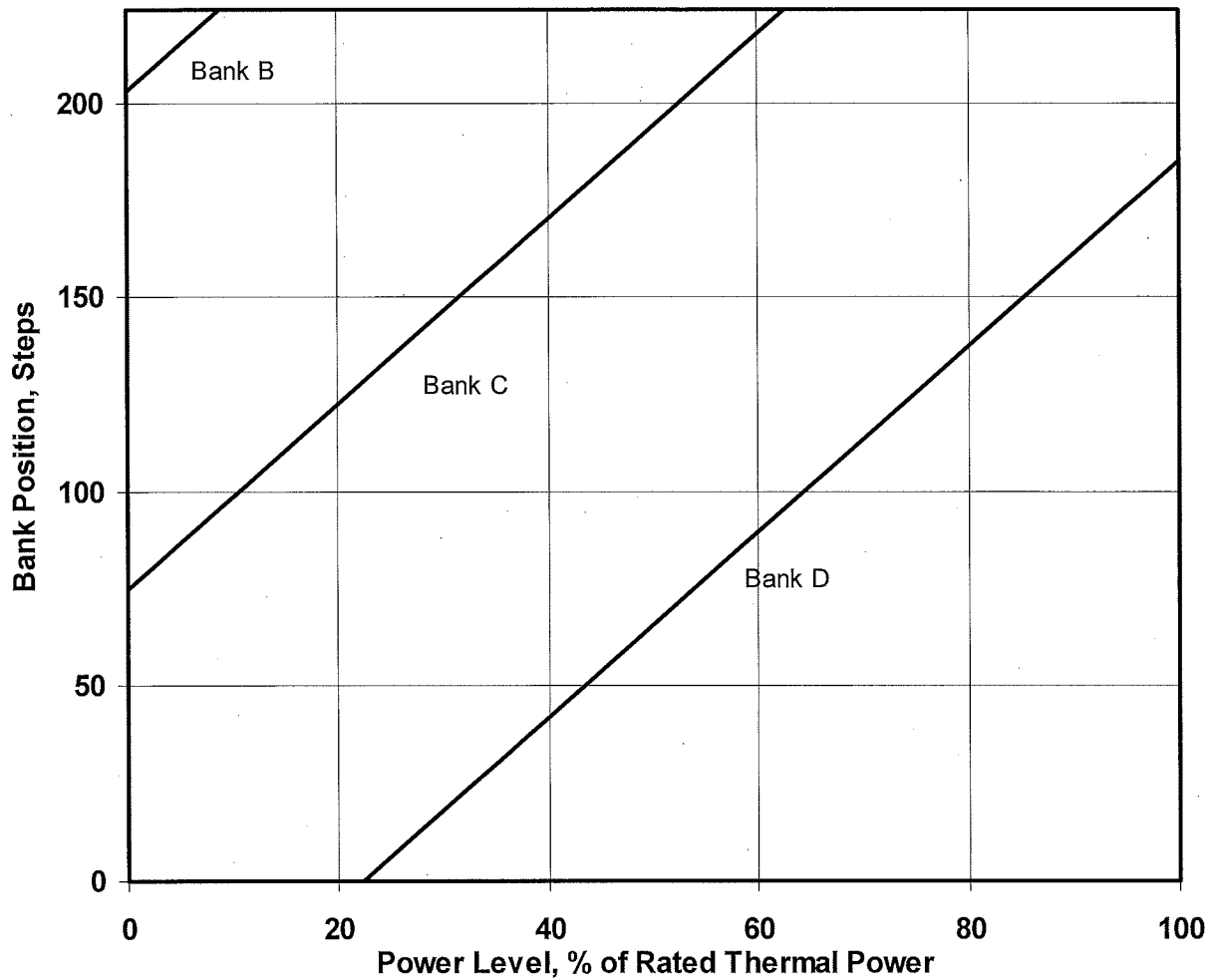


Figure 2
Rod Insertion Limit, 128 Step Tip-to-Tip

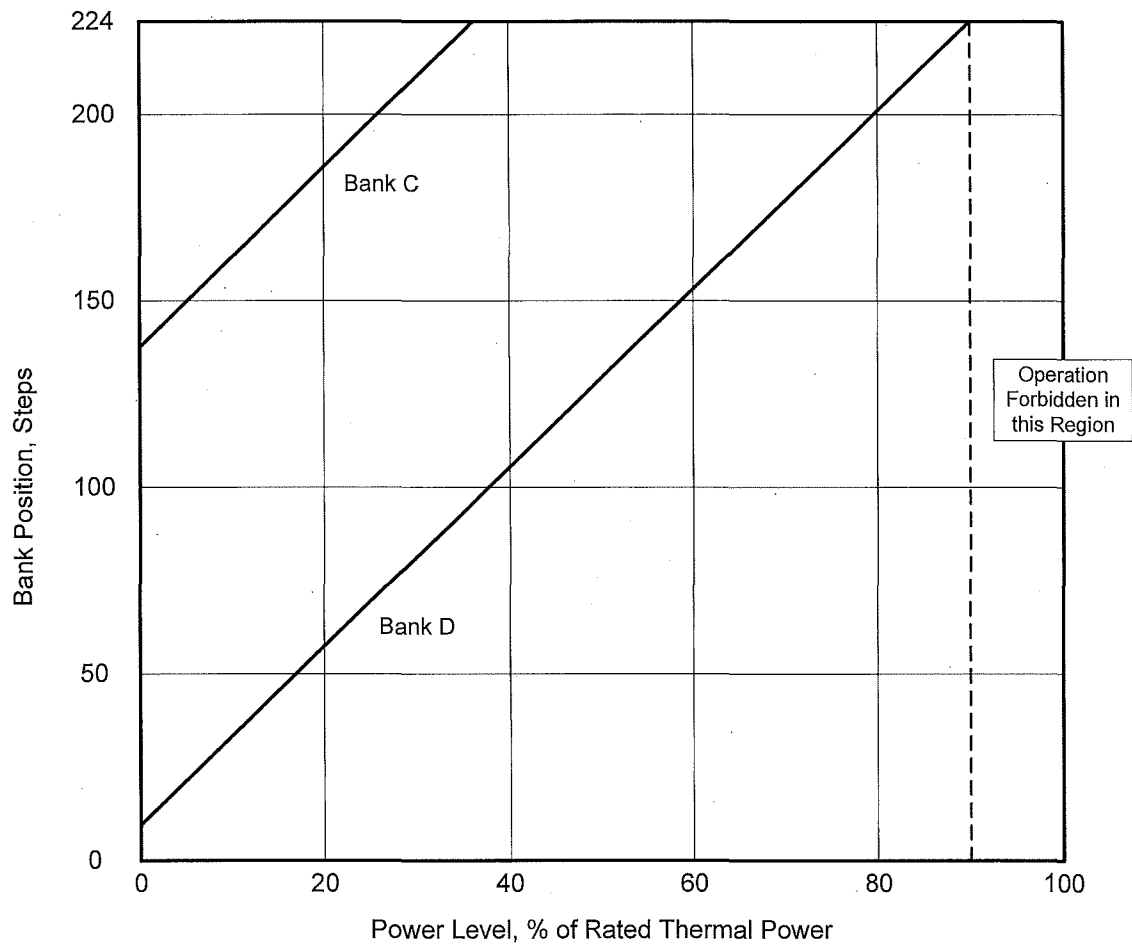


Bank Positions Given By:

- Bank D = $(150 / 63) * (P - 100) + 185$
- Bank C = $(150 / 63) * (P - 100) + 185 + 128$
- Bank B = $(150 / 63) * (P - 100) + 185 + 128 + 128$

NOTE: The top of the active fuel height corresponds to 224 steps.

Figure 3
Rod Insertion Limit, 128 Step Tip-to-Tip, One Bottomed Rod
(Technical Specification 3.1.4, Condition B)

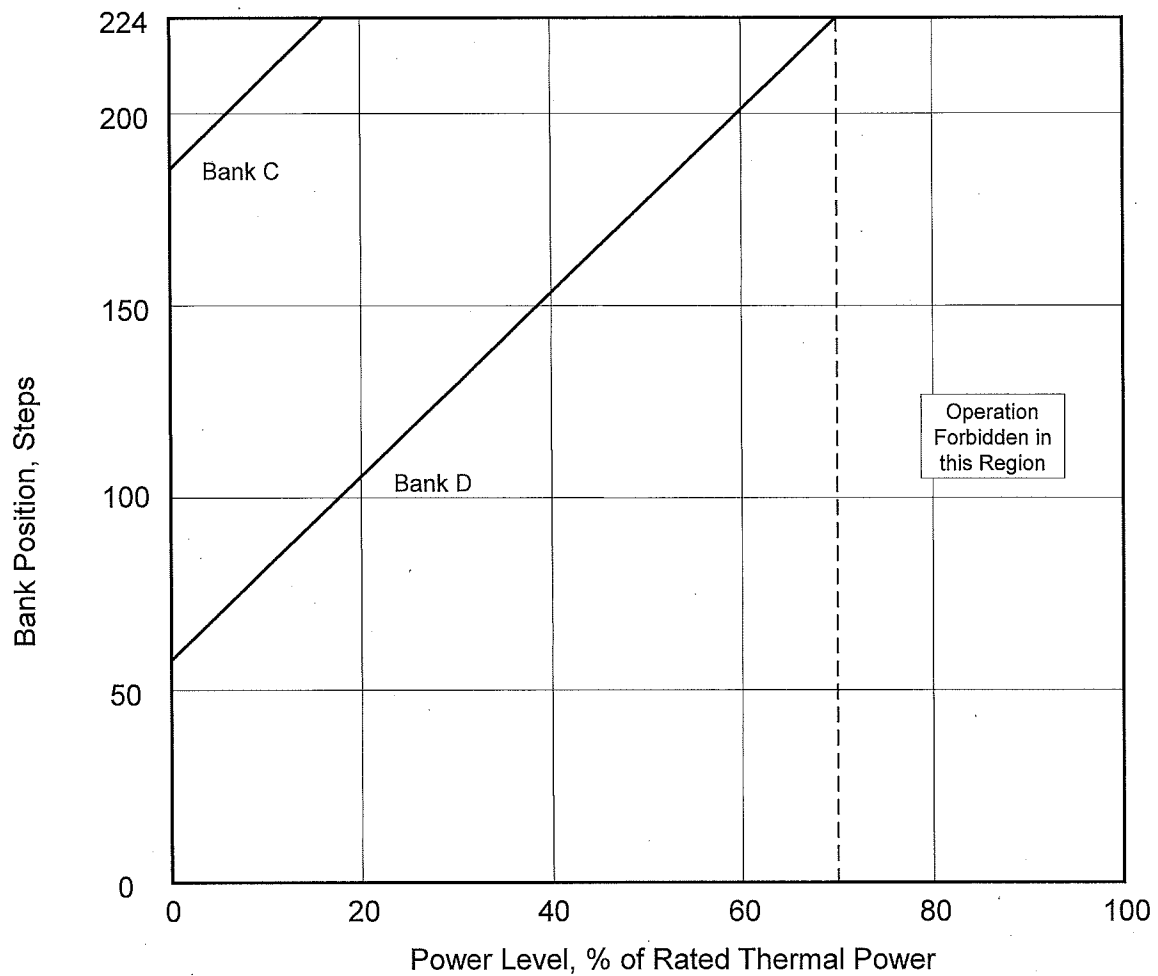


Bank Positions Given By:

- Bank D = $(150 / 63) * (P - 90) + 224$
- Bank C = $(150 / 63) * (P - 90) + 224 + 128$

NOTE: The top of the active fuel height corresponds to 224 steps.

Figure 4
Rod Insertion Limit, 128 Step Tip-to-Tip, One Inoperable Rod
(Technical Specification 3.1.4, Condition A)



Bank Positions Given By:

- Bank D = $(150 / 63) * (P - 70) + 224$
- Bank C = $(150 / 63) * (P - 70) + 224 + 128$

NOTE: The top of the active fuel height corresponds to 224 steps.

Figure 5
Flux Difference Operating Envelope associated with Table 2, Table 4, and Table 6

