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U S Nuclear Regulatory Commission
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Prairie Island Nuclear Generating Plant Unit 2
Docket 50-306
Renewed License No. DPR-60

Core Operating Limits Report (COLR) for Prairie Island Nuclear Generating Plant (PINGP) Unit 2, Cycle 27, Revision 0

Pursuant to the requirements of Technical Specification 5.6.5.d, Northern States Power Company, a Minnesota corporation, doing business as Xcel Energy (hereafter "NSPM"), submits the COLR for the PINGP Unit 2, Cycle 27, 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 27, Revision 0, is provided in Enclosure 1.

Summary of Commitments

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

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Enclosure

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ENCLOSURE 1

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
CORE OPERATING LIMITS REPORT
UNIT 2 – CYCLE 27
REVISION 0

Record of Revision (6 pages)

Unit 2 – Cycle 27, Revision 0 (24 pages)

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).

PRAIRIE ISLAND NUCLEAR GENERATING PLANT

Core Operating Limits Report

Record of Revision

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.

PRAIRIE ISLAND NUCLEAR GENERATING PLANT

Core Operating Limits Report

Record of Revision

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.

Record of Revision

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 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.

PRAIRIE ISLAND NUCLEAR GENERATING PLANT

Core Operating Limits Report

Record of Revision

Unit	Cycle	Revision No.	Approval Date	Remarks
1	22	2	7/16/04	Revised Fq limit form 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/°F for power levels > 70% RTP to less than a line that slopes linearly from 0 pcm/°F at 70% RTP to -2.9 pcm/°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.

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

PRAIRIE ISLAND NUCLEAR GENERATING PLANT

CORE OPERATING LIMITS REPORT

UNIT 2 - CYCLE 27

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 27
REVISION 0

This report provides the values of the limits for Unit 2 Cycle 27 as required by Technical Specification 5.6.5. These values have been established using NRC approved methodologies and are established such that all applicable limits of the safety analysis are met. The Technical Specifications affected by this report are listed below:

1. 2.1.1 Reactor Core SLs
2. 3.1.1 Shutdown Margin (SDM)
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 $\left(F_{\Delta H}^{N}\right)$
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 Boron Concentration

1. <u>2.1.1 Reactor Core Safety Limits</u>

The Reactor Core Safety Limits are shown in Figure 1.

Reference Technical Specification 2.1.1.

2. <u>3.1.1 Shutdown Margin Requirements</u>

The Minimum Shutdown Margin requirements are shown in Table 1.

Reference Technical Specification 3.1.1.

3. 3.1.3 Isothermal Temperature Coefficient (ITC)

The ITC Upper limit is:

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

The ITC Lower limit is:

a. -43.15 pcm/°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 a 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 are only applicable to Figure 5.

The W(Z) values in Table 4 are only applicable to Figure 6.

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%≤P<85% and Part Power W(Z) values for 85%≤P<95% are provided in Table 6. The W(Z) values in Table 6 are only applicable to Figure 5.

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

The $F^W_Q(Z)$ Penalty Factors associated with Figure 6 and Table 4 are provided in Table 5.

The Axial Flux Difference (AFD) Band in Figure 6 is more restrictive that the AFD Band in Figure 5. Prior to switching from Figure 6 to Figure 5, $F^W_Q(Z)$ must be confirmed to meet Technical Specification requirements by one of the following methods:

1. Confirm $F^W_Q(Z)$ meets the Technical Specification Limit with the Table 2 W(Z) values for the most recent surveillance performed.
2. Perform a new surveillance and confirm $F^W_Q(Z)$ meets the Technical Specification Limit with the Table 2 W(Z) values.

The HFP W(Z) values are generated assuming that they will be used for full power surveillance. 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 is ≤ 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 10 provides the basis for multiple sets of W(Z) curves.

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:

$F_{\Delta H} \leq 1.77 \times [1 + 0.3(1- P)]$ for all 422V+ type fuel assemblies, and

$F_{\Delta H} \leq 1.66 \times [1 + 0.3(1- P)]$ for all OFA type fuel assemblies

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 or the more restrictive operational space as defined by Figure 6.

Both Figures 5 and 6 can be used any time during the cycle.

Prior to switching to the more restrictive AFD envelope (Figure 6), it should be confirmed that the plant is within the specified AFD envelope.

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

The Overtemperature ΔT setpoint parameter values are:

ΔT_0	=	Indicated ΔT at RATED THERMAL POWER (%), °F
T	=	Average temperature, °F
T′	=	560.0 °F
P	=	Pressurizer Pressure, psig
P′	=	2235 psig
K_1	≤	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

The Overpower ΔT setpoint parameter values are:

ΔT_0	=	Indicated ΔT at RATED THERMAL POWER (%), °F
T	=	Average temperature, °F
T′	=	560.0 °F
K_4	≤	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

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) $K_{eff} \leq 0.95$
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. Not used.

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 $F^W_Q(Z)$ Penalty With Increasing [$F^C_Q(Z)$ / 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 UO_2 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-11596-P-A, "Qualification of the PHOENIX-P/ANC Nuclear Design System for Pressurized Water Reactor Cores," June 1988.

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 √™ 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 √™ 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 & CENPD-404-P-A, Addendum 1-A, "**Optimized ZIRLO™**," July 2006.

32. 50.59 Evaluation 1094, Revision 0 "Unit 2 Cycle 27 Core Reload Modification."

Table 1

Minimum Required Shutdown Margin, %Δρ

	Number of Charging Pumps Running**		
Mode 1*			
	0-1 Pump	**2 Pumps**	**3 Pumps**
0 – 21000 MWd/MTU	-	-	-
Mode 2*			
	0-1 Pump	**2 Pumps**	**3 Pumps**
0 – 21000 MWd/MTU	1.9	1.9	1.9
Physics Testing in Mode 2			
	0-1 Pump	**2 Pumps**	**3 Pumps**
0 – 21000 MWd/MTU	0.5	0.5	0.5
Mode 3	**$T_{ave} \geq 520$ °F (Most Reactive Rod Out)**		
	0-1 Pump	**2 Pumps**	**3 Pumps**
0 – 21000 MWd/MTU	2.0	2.0	2.0
Mode 3	**350 °F ≤ T_{ave} < 520°F (Most Reactive Rod Out)**		
	0-1 Pump	**2 Pumps**	**3 Pumps**
0 MWd/MTU	2.0	2.0	2.5
13000 MWd/MTU	2.0	2.0	2.0
21000 MWd/MTU	2.0	2.0	2.0
Mode 4	**200 °F < T_{ave} < 350°F (Most Reactive Rod Out)**		
	0-1 Pump	**2 Pumps**	**3 Pumps**
0 MWd/MTU	2.0	4.0	6.0
13000 MWd/MTU	2.0	2.5	4.0
21000 MWd/MTU	2.0	2.0	2.5

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

Table 1, Continued

Minimum Required Shutdown Margin, %Δρ

	Number of Charging Pumps Running**		
Mode 5	**68°F ≤ T_{ave} ≤ 200°F (Most Reactive Rod Out)**		
	0-1 Pump	**2 Pumps**	**3 Pumps**
0 MWd/MTU* **	2.5	4.5	7.0
13000 MWd/MTU	2.0	3.0	4.5
21000 MWd/MTU	2.0	2.0	3.0

Mode 6	**68°F ≤ T_{ave} < 200°F (ARI)**		
	0-1 Pump	**2 Pumps**	**3 Pumps**
0 MWd/MTU* **	5.129	5.129	7.0
13000 MWd/MTU	5.129	5.129	5.129
21000 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	5.5	8.5
13000 MWd/MTU	5.129	5.129	6.5
21000 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 26 end of cycle.

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

	Height [ft]	BU [MWd/MTU]						
		150	6000	9000	12000	14000	16000	19000
		AO = -2.63	AO = -3.56	AO = -4.73	AO = -5.41	AO = -2.49	AO = 0.41	AO = 0.66
[BOTTOM] 1	0.00	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
3	0.40	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
5	0.80	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.00	1.2216	1.1966	1.1553	1.1500	1.1867	1.2520	1.2461
7	1.20	1.2126	1.1885	1.1484	1.1429	1.1789	1.2432	1.2368
8	1.40	1.2019	1.1790	1.1404	1.1348	1.1699	1.2333	1.2264
9	1.60	1.1902	1.1686	1.1318	1.1263	1.1603	1.2227	1.2157
10	1.80	1.1776	1.1576	1.1229	1.1174	1.1503	1.2115	1.2046
11	2.00	1.1644	1.1460	1.1136	1.1083	1.1398	1.1998	1.1932
12	2.20	1.1509	1.1341	1.1043	1.0992	1.1293	1.1877	1.1815
13	2.40	1.1372	1.1222	1.0951	1.0902	1.1182	1.1753	1.1696
14	2.60	1.1236	1.1103	1.0860	1.0813	1.1076	1.1626	1.1575
15	2.80	1.1100	1.0981	1.0767	1.0725	1.1037	1.1496	1.1449
16	3.00	1.0986	1.0898	1.0729	1.0662	1.1035	1.1378	1.1352
17	3.20	1.0960	1.0879	1.0732	1.0649	1.1038	1.1323	1.1330
18	3.40	1.0979	1.0890	1.0786	1.0667	1.1034	1.1318	1.1358
19	3.60	1.0992	1.0928	1.0830	1.0677	1.1027	1.1296	1.1369
20	3.80	1.1002	1.0960	1.0870	1.0709	1.1027	1.1296	1.1409
21	4.00	1.1009	1.0987	1.0905	1.0767	1.1038	1.1306	1.1457
22	4.20	1.1011	1.1010	1.0935	1.0831	1.1062	1.1312	1.1494
23	4.40	1.1008	1.1026	1.0959	1.0886	1.1089	1.1310	1.1522
24	4.60	1.1001	1.1038	1.0978	1.0936	1.1108	1.1310	1.1539
25	4.80	1.0991	1.1044	1.0993	1.0979	1.1120	1.1320	1.1545
26	5.00	1.0973	1.1042	1.1018	1.1017	1.1126	1.1328	1.1541
27	5.20	1.0969	1.1044	1.1045	1.1049	1.1127	1.1325	1.1528
28	5.40	1.0980	1.1061	1.1068	1.1077	1.1133	1.1314	1.1505
29	5.60	1.1011	1.1096	1.1110	1.1104	1.1159	1.1313	1.1504
30	5.80	1.1059	1.1150	1.1172	1.1142	1.1224	1.1374	1.1581
31	6.00	1.1120	1.1209	1.1235	1.1220	1.1316	1.1471	1.1681
32	6.20	1.1182	1.1289	1.1291	1.1320	1.1412	1.1560	1.1758
33	6.40	1.1236	1.1397	1.1348	1.1405	1.1498	1.1639	1.1828
34	6.60	1.1285	1.1493	1.1420	1.1497	1.1575	1.1707	1.1885
35	6.80	1.1328	1.1581	1.1501	1.1625	1.1642	1.1764	1.1927
36	7.00	1.1380	1.1658	1.1608	1.1758	1.1702	1.1808	1.1960
37	7.20	1.1433	1.1728	1.1725	1.1875	1.1769	1.1837	1.1984

* **Linear extrapolation based on a line between 16,000 MWD/MTU and 19,000 MWD/MTU is adequate for addressing burnups beyond 19,000 MWD/MTU.**

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

	Height [ft]	BU [MWd/MTU]						
		150	6000	9000	12000	14000	16000	19000
		AO = -2.63	AO = -3.56	AO = -4.73	AO = -5.41	AO = -2.49	AO = 0.41	AO = 0.66
38	7.40	1.1480	1.1792	1.1827	1.1982	1.1845	1.1852	1.1995
39	7.60	1.1543	1.1846	1.1918	1.2075	1.1905	1.1850	1.1989
40	7.80	1.1610	1.1890	1.1995	1.2153	1.1948	1.1831	1.1963
41	8.00	1.1668	1.1942	1.2056	1.2213	1.1976	1.1793	1.1918
42	8.20	1.1716	1.1994	1.2101	1.2256	1.1985	1.1739	1.1852
43	8.40	1.1753	1.2025	1.2128	1.2277	1.1975	1.1663	1.1769
44	8.60	1.1778	1.2040	1.2134	1.2275	1.1942	1.1562	1.1695
45	8.80	1.1802	1.2034	1.2131	1.2279	1.1918	1.1526	1.1636
46	9.00	1.1860	1.2047	1.2143	1.2302	1.1915	1.1511	1.1574
47	9.20	1.1943	1.2118	1.2198	1.2349	1.1929	1.1477	1.1475
48	9.40	1.2032	1.2221	1.2280	1.2413	1.1949	1.1455	1.1372
49	9.60	1.2190	1.2307	1.2348	1.2464	1.1953	1.1455	1.1391
50	9.80	1.2342	1.2424	1.2452	1.2535	1.2003	1.1493	1.1426
51	10.00	1.2493	1.2516	1.2538	1.2621	1.2081	1.1541	1.1445
52	10.20	1.2644	1.2576	1.2591	1.2697	1.2139	1.1578	1.1461
53	10.40	1.2762	1.2691	1.2682	1.2770	1.2194	1.1609	1.1481
54	10.60	1.2885	1.2747	1.2786	1.2881	1.2304	1.1655	1.1551
55	10.80	1.2926	1.2799	1.2859	1.2952	1.2410	1.1774	1.1611
56	11.00	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
57	11.20	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
58	11.40	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
59	11.60	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
60	11.80	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
[TOP] 61	12.00	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

* **Linear extrapolation based on a line between 16,000 MWD/MTU and 19,000 MWD/MTU is adequate for addressing burnups beyond 19,000 MWD/MTU.**

Table 3

$F^W_Q(Z)$ Penalty Factor associated with Figure 5 and Table 2

Cycle Burnup (MWD/MTU)	$F^W_Q(z)$ Penalty Factor
0	1.0200
14465	1.0200
14606	1.0206
14746	1.0226
14886	1.0239
15027	1.0230
15167	1.0222
15308	1.0210
15448	1.0200
21000	1.0200

Linear interpolation is adequate for intermediate cycle burnups.

Table 4 - W(z) Values associated with Figure 6 (Top 10% and Bottom 8% excluded)*

	Height [ft]	BU [MWd/MTU]						
		150	6000	9000	12000	14000	16000	19000
		AO = -2.63	AO = -3.56	AO = -4.73	AO = -5.41	AO = -2.49	AO = 0.41	AO = 0.66
[BOTTOM] 1	0.00	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
3	0.40	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
5	0.80	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.00	1.1622	1.1259	1.1316	1.0910	1.1396	1.1882	1.2066
7	1.20	1.1549	1.1202	1.1251	1.0853	1.1334	1.1806	1.1981
8	1.40	1.1462	1.1134	1.1175	1.0790	1.1264	1.1720	1.1885
9	1.60	1.1367	1.1061	1.1095	1.0725	1.1190	1.1628	1.1787
10	1.80	1.1265	1.0983	1.1010	1.0661	1.1113	1.1532	1.1685
11	2.00	1.1158	1.0904	1.0923	1.0597	1.1036	1.1432	1.1581
12	2.20	1.1052	1.0823	1.0835	1.0538	1.0958	1.1332	1.1473
13	2.40	1.0967	1.0742	1.0748	1.0482	1.0882	1.1255	1.1366
14	2.60	1.0915	1.0664	1.0663	1.0432	1.0807	1.1219	1.1256
15	2.80	1.0862	1.0589	1.0575	1.0389	1.0729	1.1181	1.1137
16	3.00	1.0805	1.0543	1.0545	1.0341	1.0709	1.1142	1.1097
17	3.20	1.0788	1.0558	1.0541	1.0358	1.0725	1.1130	1.1100
18	3.40	1.0793	1.0620	1.0556	1.0450	1.0779	1.1148	1.1153
19	3.60	1.0792	1.0686	1.0576	1.0525	1.0831	1.1165	1.1221
20	3.80	1.0811	1.0749	1.0638	1.0599	1.0880	1.1174	1.1283
21	4.00	1.0845	1.0807	1.0706	1.0669	1.0924	1.1208	1.1335
22	4.20	1.0879	1.0859	1.0763	1.0734	1.0961	1.1253	1.1380
23	4.40	1.0906	1.0907	1.0817	1.0795	1.0993	1.1284	1.1414
24	4.60	1.0929	1.0948	1.0864	1.0849	1.1017	1.1307	1.1438
25	4.80	1.0946	1.0984	1.0906	1.0898	1.1041	1.1320	1.1451
26	5.00	1.0959	1.1015	1.0959	1.0942	1.1073	1.1327	1.1455
27	5.20	1.0967	1.1039	1.1018	1.0992	1.1108	1.1325	1.1453
28	5.40	1.0980	1.1061	1.1067	1.1050	1.1133	1.1314	1.1456
29	5.60	1.1011	1.1096	1.1110	1.1102	1.1159	1.1313	1.1493
30	5.80	1.1059	1.1150	1.1171	1.1142	1.1223	1.1353	1.1581
31	6.00	1.1120	1.1209	1.1235	1.1220	1.1316	1.1416	1.1680
32	6.20	1.1182	1.1289	1.1291	1.1320	1.1412	1.1473	1.1758
33	6.40	1.1236	1.1397	1.1348	1.1405	1.1498	1.1520	1.1828
34	6.60	1.1285	1.1493	1.1420	1.1485	1.1575	1.1558	1.1884
35	6.80	1.1328	1.1581	1.1487	1.1555	1.1642	1.1584	1.1927
36	7.00	1.1380	1.1658	1.1538	1.1619	1.1699	1.1602	1.1957
37	7.20	1.1433	1.1728	1.1593	1.1696	1.1749	1.1614	1.1971

* **Linear extrapolation based on a line between 16,000 MWD/MTU and 19,000 MWD/MTU is adequate for addressing burnups beyond 19,000 MWD/MTU.**

Table 4 (cont.) - W(z) Values associated with Figure 6 (Top 10% and Bottom 8% excluded)*

	Height [ft]	BU [MWd/MTU]						
		150	6000	9000	12000	14000	16000	19000
		AO = -2.63	AO = -3.56	AO = -4.73	AO = -5.41	AO = -2.49	AO = 0.41	AO = 0.66
38	7.40	1.1479	1.1792	1.1668	1.1790	1.1793	1.1617	1.1967
39	7.60	1.1521	1.1846	1.1742	1.1868	1.1822	1.1605	1.1945
40	7.80	1.1553	1.1886	1.1805	1.1933	1.1835	1.1578	1.1903
41	8.00	1.1565	1.1909	1.1854	1.1983	1.1832	1.1535	1.1841
42	8.20	1.1581	1.1916	1.1887	1.2018	1.1812	1.1478	1.1759
43	8.40	1.1623	1.1905	1.1905	1.2034	1.1774	1.1404	1.1657
44	8.60	1.1654	1.1877	1.1906	1.2031	1.1715	1.1308	1.1542
45	8.80	1.1661	1.1819	1.1894	1.2032	1.1667	1.1262	1.1423
46	9.00	1.1689	1.1821	1.1907	1.2052	1.1663	1.1244	1.1280
47	9.20	1.1780	1.1871	1.1945	1.2085	1.1675	1.1207	1.1141
48	9.40	1.1916	1.1895	1.1960	1.2096	1.1664	1.1156	1.1082
49	9.60	1.2038	1.1988	1.2038	1.2155	1.1684	1.1130	1.1117
50	9.80	1.2192	1.2076	1.2115	1.2211	1.1700	1.1076	1.1165
51	10.00	1.2323	1.2161	1.2197	1.2271	1.1723	1.1063	1.1206
52	10.20	1.2423	1.2248	1.2283	1.2348	1.1749	1.1099	1.1250
53	10.40	1.2552	1.2323	1.2339	1.2427	1.1775	1.1127	1.1294
54	10.60	1.2636	1.2400	1.2401	1.2513	1.1886	1.1283	1.1337
55	10.80	1.2672	1.2415	1.2409	1.2565	1.2012	1.1462	1.1378
56	11.00	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
57	11.20	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
58	11.40	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
59	11.60	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
60	11.80	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
[TOP] 61	12.00	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

* **Linear extrapolation based on a line between 16,000 MWD/MTU and 19,000 MWD/MTU is adequate for addressing burnups beyond 19,000 MWD/MTU.**

Table 5
$F^W_Q(Z)$ Penalty Factor associated with Figure 6 and Table 4

Cycle Burnup (MWD/MTU)	$F^W_Q(z)$ Penalty Factor
0	1.0200
21000	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	Part Power W(z) Functions (% of Hot Full Power)	
		80†	90††
		D-Bank @ 188 Steps‡	D-Bank @ 200 Steps‡
	[ft]	HFP AO = -2.63	HFP AO = -2.63
[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	1.2535	1.2473
7	1.20	1.2416	1.2368
8	1.40	1.2283	1.2246
9	1.60	1.2142	1.2113
10	1.80	1.1992	1.1972
11	2.00	1.1836	1.1825
12	2.20	1.1671	1.1676
13	2.40	1.1505	1.1525
14	2.60	1.1341	1.1373
15	2.80	1.1181	1.1220
16	3.00	1.1042	1.1089
17	3.20	1.0991	1.1051
18	3.40	1.0985	1.1059
19	3.60	1.0974	1.1060
20	3.80	1.0959	1.1053
21	4.00	1.0942	1.1045
22	4.20	1.0920	1.1032
23	4.40	1.0893	1.1016
24	4.60	1.0863	1.0996
25	4.80	1.0828	1.0972
26	5.00	1.0786	1.0942
27	5.20	1.0760	1.0923
28	5.40	1.0751	1.0919
29	5.60	1.0762	1.0934
30	5.80	1.0787	1.0967

* W(z) values only valid for core average burnups $\leq$ 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	Part Power W(z) Functions (% of Hot Full Power)	
		80†	90††
		D-Bank @ 188 Steps‡	D-Bank @ 200 Steps‡
	[ft]	HFP AO = -2.63	HFP AO = -2.63
31	6.00	1.0825	1.1013
32	6.20	1.0866	1.1061
33	6.40	1.0901	1.1102
34	6.60	1.0934	1.1138
35	6.80	1.0961	1.1168
36	7.00	1.0998	1.1205
37	7.20	1.1038	1.1245
38	7.40	1.1086	1.1280
39	7.60	1.1167	1.1333
40	7.80	1.1255	1.1404
41	8.00	1.1339	1.1479
42	8.20	1.1416	1.1547
43	8.40	1.1487	1.1606
44	8.60	1.1551	1.1655
45	8.80	1.1619	1.1707
46	9.00	1.1731	1.1799
47	9.20	1.1872	1.1921
48	9.40	1.2022	1.2051
49	9.60	1.2246	1.2257
50	9.80	1.2464	1.2458
51	10.00	1.2683	1.2663
52	10.20	1.2900	1.2869
53	10.40	1.3078	1.3036
54	10.60	1.3261	1.3210
55	10.80	1.3354	1.3297
56	11.00	1.0000	1.0000
57	11.20	1.0000	1.0000
58	11.40	1.0000	1.0000
59	11.60	1.0000	1.0000
60	11.80	1.0000	1.0000
[TOP] 61	12.00	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% ≤ P < 85%.

†† 90% of full power W(z) values are applicable for powers 85% ≤ P < 95%.

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

Figure 1

Reactor Core Safety Limits

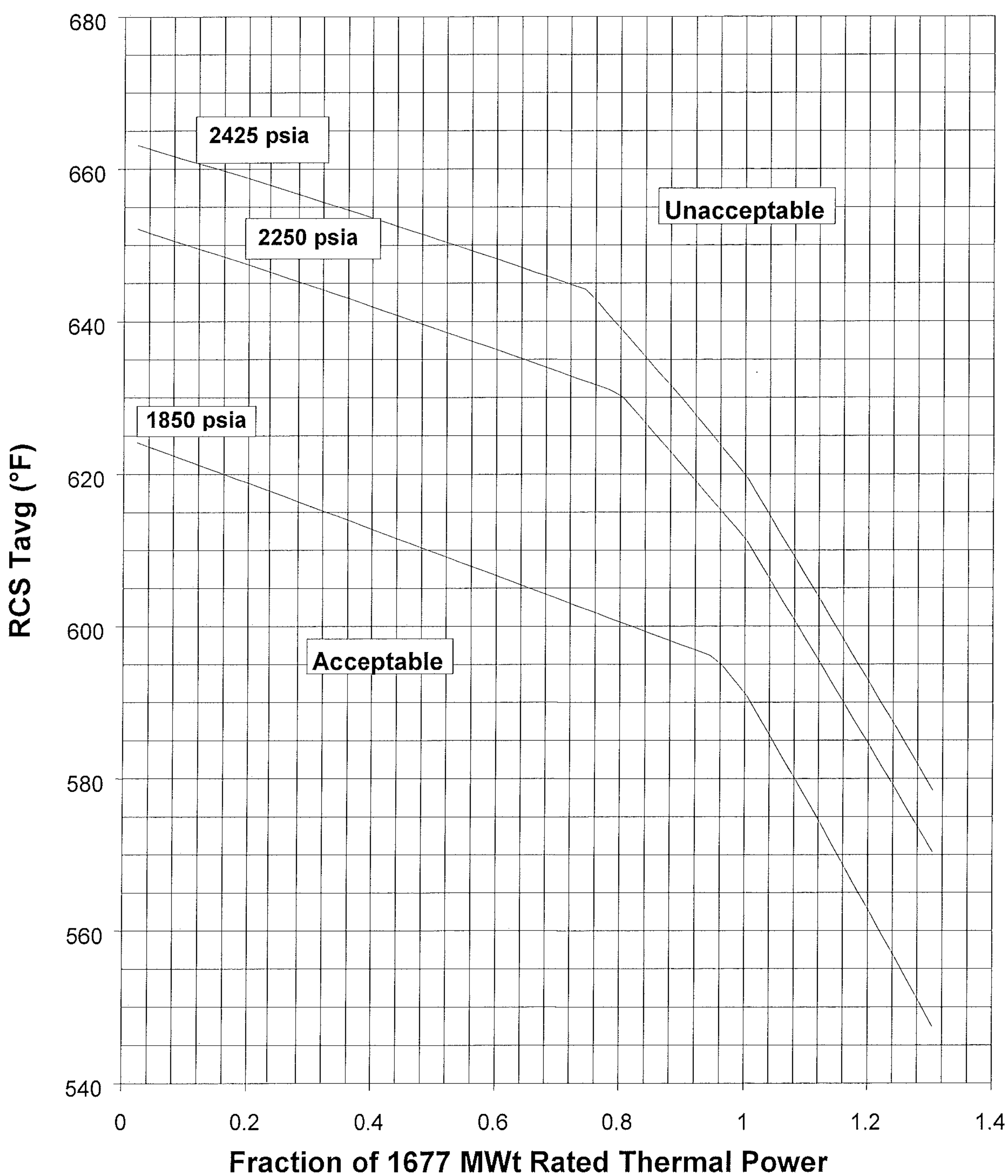
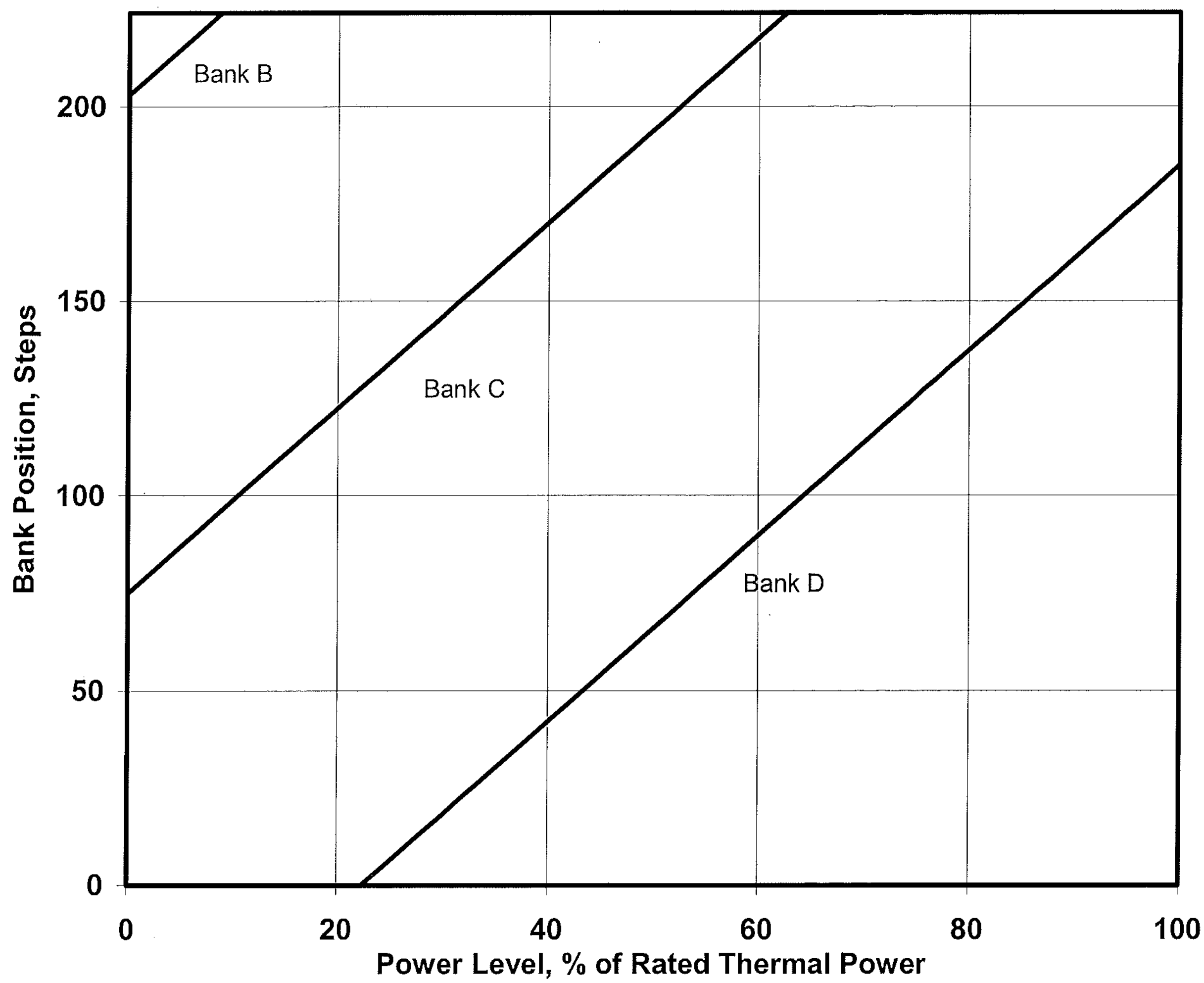


Figure 2
Rod Insertion Limit, 128 Step Tip-to-Tip

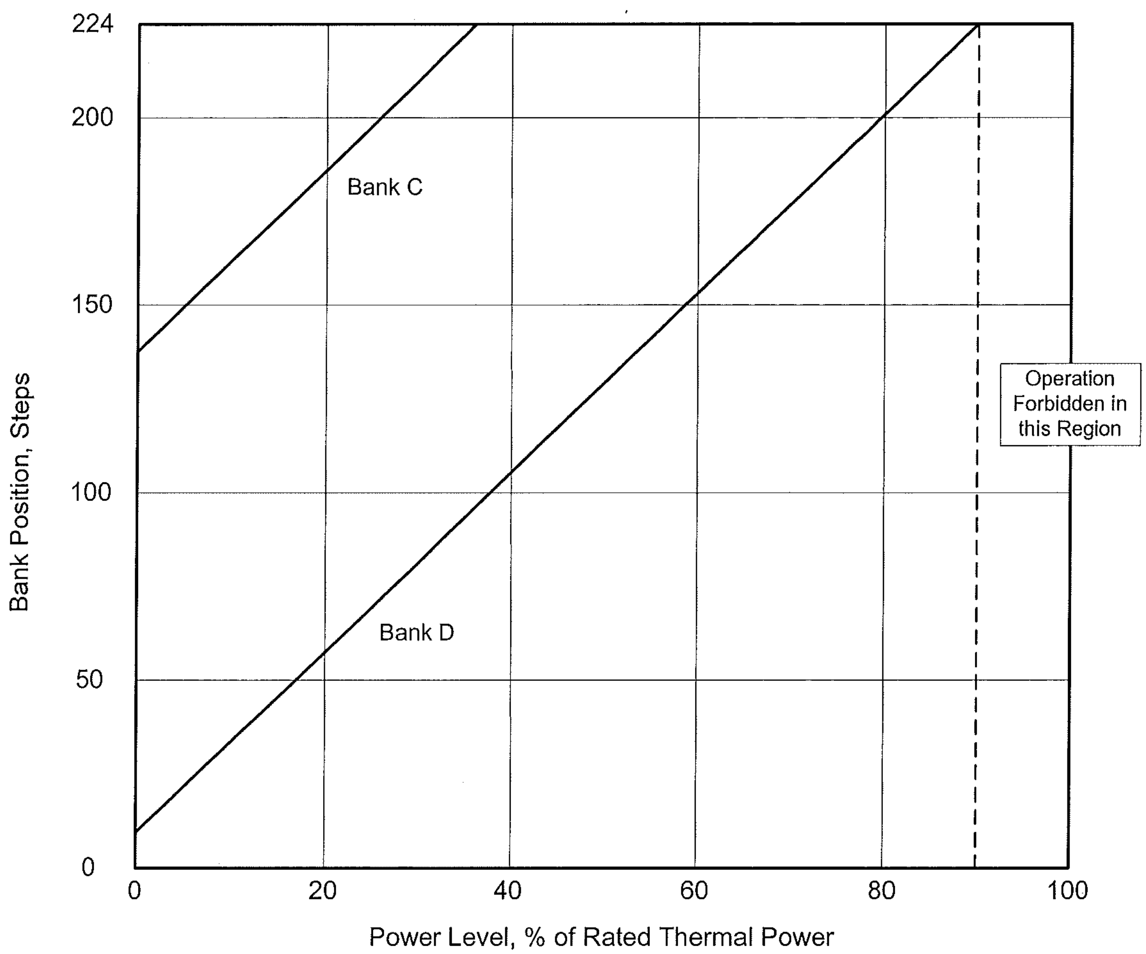


Bank Positions Given By:

- 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. The ARO parking position may be any position above 224 steps.

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

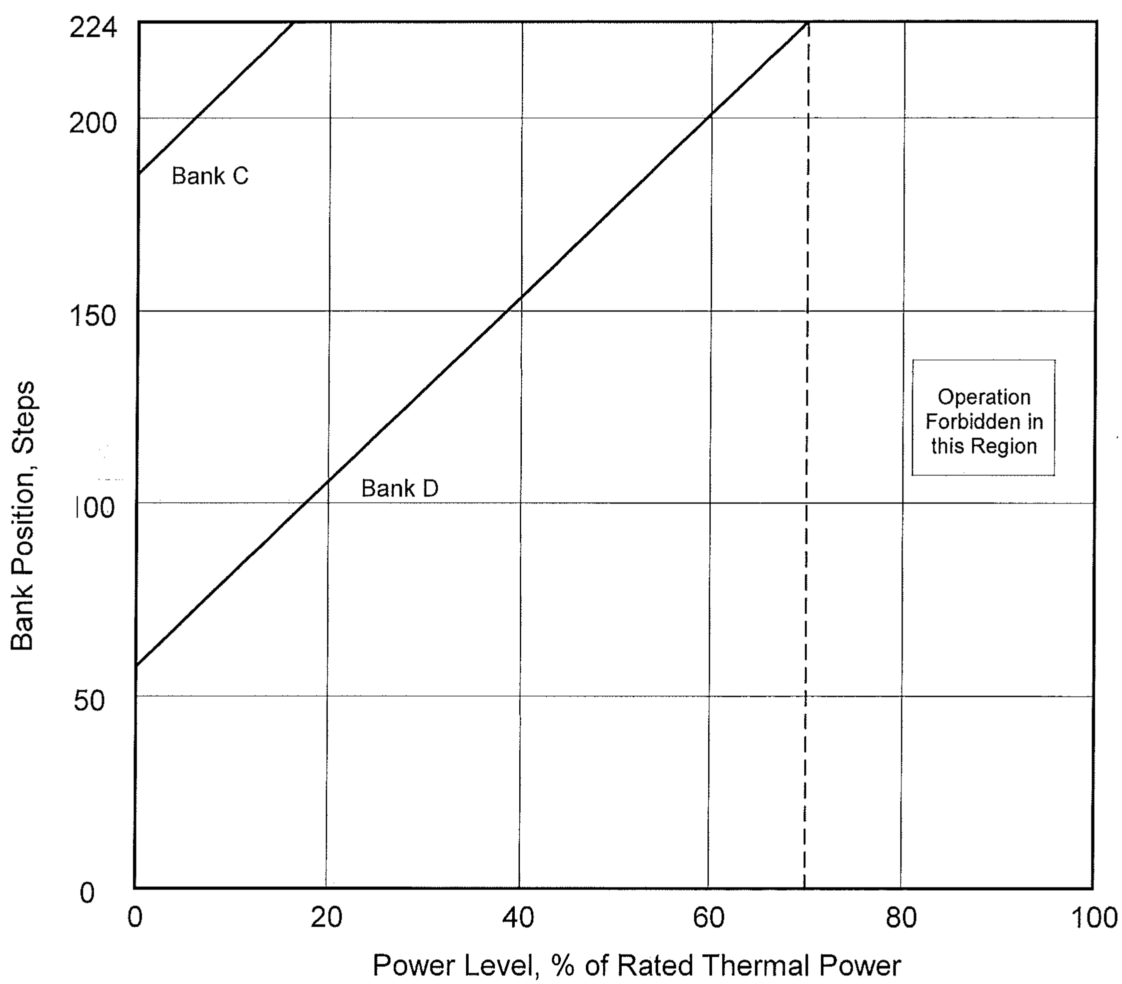


Bank Positions Given By:

- 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. The ARO parking position may be any position above 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. The ARO parking position may be any position above 224 steps.

Figure 5

Flux Difference Operating Envelope associated with Table 2 and Table 6

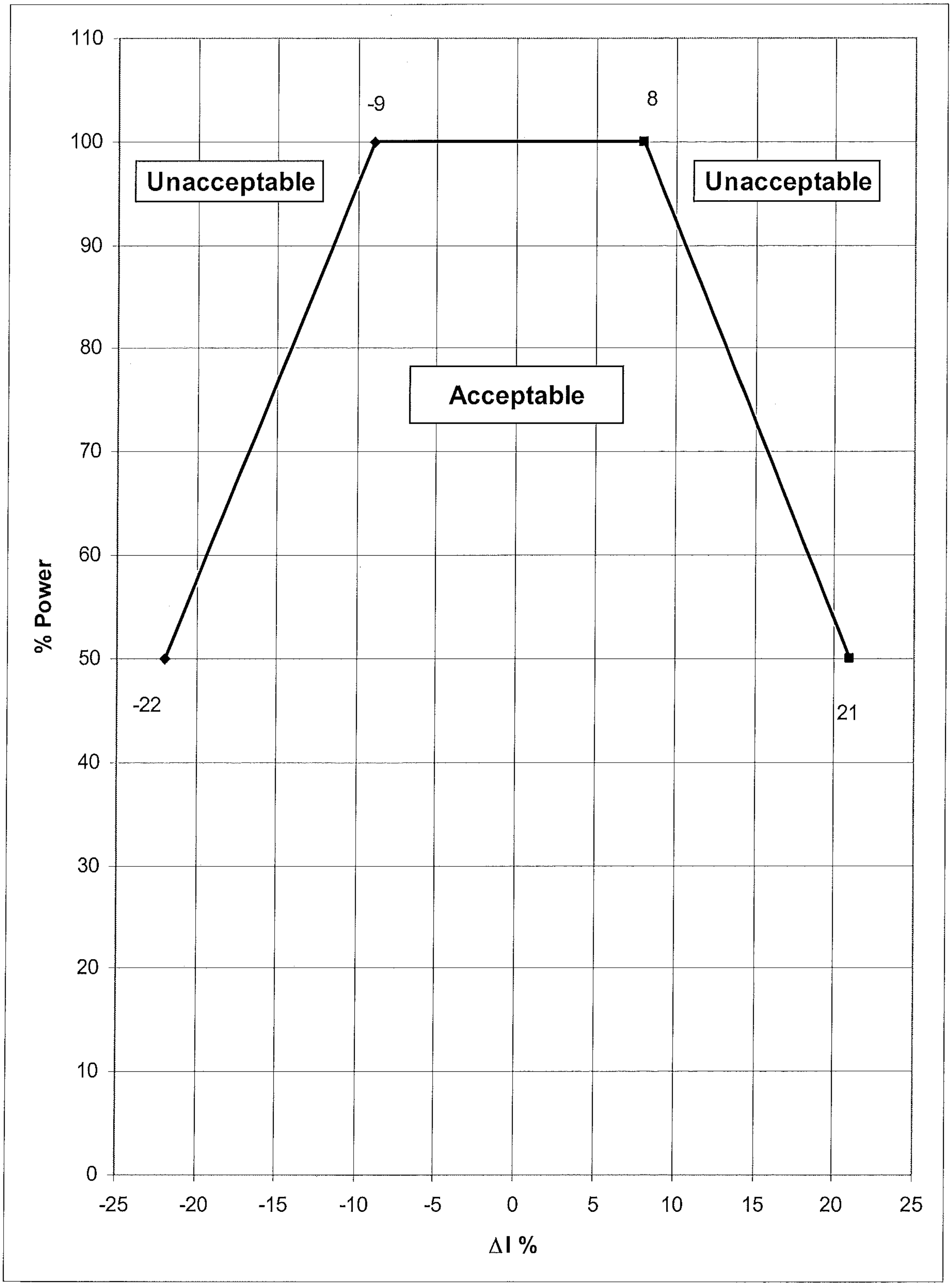


Figure 6
Flux Difference Operating Envelope associated with Table 4