Xcel Energy®

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L-PI-22-043
TS 5.6.5.d

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

Prairie Island Nuclear Generating Plant, Unit 1
Docket No. 50-282
Renewed Facility Operating License No. DPR-42

Core Operating Limits Report (COLR) for Prairie Island Nuclear Generating Plant (PINGP) Unit 1, Cycle 33, 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"), hereby submits the COLR for the PINGP Unit 1, Cycle 33, 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.

If you have any questions about this submittal, please contact Carrie Seipp, Senior Regulatory Engineer, at 612-330-5576.

Summary of Commitments

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

Harlan D. Hanson
Plant Manager, 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 1 – CYCLE 33
REVISION 0

35 pages follow

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).

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.

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.

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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
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
2	31	1	09/14/20	Updated to revise Table 2 and Table 3 due to Flexible Power Operation
1	32	0	09/21/20	Updated for Unit 1 Cycle 32
2	32	0	10/11/21	Updated for Unit 2 Cycle 32
2	32	1	10/25/21	Updated to clarify power value used in calculation of $F_Q^W(Z)$
1	33	0	10/13/22	Updated for Unit 1 Cycle 33

PRAIRIE ISLAND NUCLEAR GENERATING PLANT

CORE OPERATING LIMITS REPORT

UNIT 1 - CYCLE 33

REVISION 0

Reviewed By: *Reviewed per LDC 604000000633*
Darius Ahrar
Manager, Nuclear Analysis & Design

Approved By: *Reviewed per LDC 604000000633*
Mark Brossart
Manager, Engineering

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 1 – CYCLE 33
REVISION 0

This report provides the values of the limits for Unit 1 Cycle 33 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 $\left(F^N_{\Delta H}\right)$
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 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/°F for power levels < 70% RTP; and
b. a line which slopes linearly from
   i. 0 pcm/ºF at a power level = 70% RTP to
   ii. -1.5 pcm/ºF at a power level = 100% RTP

ITC Lower limit:

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 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:

$$F_Q^W(z) \leq \frac{CFQ}{P} * K(z) \quad for\ P > 0.5$$

$$F_Q^W(z) \leq \frac{CFQ}{0.5} * K(z) \quad for\ P \leq 0.5$$

$F_Q^W(z) = [F_{XY}(z)]_{Surv}^M * \frac{[T(z)]^{COLR}}{P} * A_{XY}(z) * [R_j]^{COLR} * 1.0815$ for $P > 0.5$

$F_Q^W(z) = [F_{XY}(z)]_{Surv}^M * \frac{[T(z)]^{COLR}}{0.5} * A_{XY}(z) * [R_j]^{COLR} * 1.0815$ for $P \leq 0.5$

$[F_{XY}(z)]_{Surv}^M$ is the measured planar radial peaking factor.

P is the ratio of thermal power at the time of surveillance to rated thermal power.

CFQ = 2.50

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

The T(Z) values are provided in Tables 2 and 4.

The T(Z) values in Table 2 are applicable to Figure 5, which represents "RAOC Operation Space #1 (ROS1).

The T(Z) values in Table 4 are applicable to Figure 6, which represents "RAOC Operating Space #2 (ROS2). Through Table 6, Table 4 is also associated with Figures 7 and 8.

The R_j Penalty Factors associated with Figure 5 and Table 2 (ROS1) are provided in Table 3.

The R_j Penalty Factors associated with Figure 6 and Table 4 (ROS2) are provided in Table 5. Through Table 6, Table 5 is also associated with Figures 7 and 8.

The $A_{XY}(Z)$ factors adjust the surveillance to the reference conditions assumed in generating the T(z) factors. $A_{XY}(Z)$ may be assumed to equal 1.0 or may be determined for specific surveillance conditions using the approved methods listed in TS 5.6.5.

Either ROS1 or ROS2 may be implemented at any time during Cycle 33.

If ROS1 is implemented and entering LCO 3.2.1 Condition B for $F^{W}_{Q}(Z)$ not within limits, EITHER take Action B.1.1 by implementing ROS2, OR take Action B.2.1 by using Table 6 to determine required THERMAL POWER and AFD limits based on Required $F^{W}_{Q}(Z)$ margin improvement available in ROS1.

If ROS2 is implemented and entering LCO 3.2.1 Condition B for $F^{W}_{Q}(Z)$ not within limits, take Action B.2.1 by using Table 6 to determine required THERMAL POWER and AFD limits based on Required $F^{W}_{Q}(Z)$ margin improvement available in ROS2.

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 either Figure 5, if ROS1 is implemented, or Figure 6 if ROS2 is implemented. If implementing TS 3.2.1 Required Action B.2.1. the AFD shall be maintained within the allowed spaced defined by Figure 7 or 8, as determined by Table 6 and the condition that led to the required action.

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	≤	1.17
K_2	=	0.014 /°F
K_3	=	0.00100 /psi
τ_1	=	30 seconds
τ_2	=	4 seconds
f(ΔI)	=	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(ΔI) = 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	≤	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 ≤ 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) $K_{eff} \leq 0.95$
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 $F^{W}_{Q}(Z)$ 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.

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

32. Design Equivalent Change 601000003539 Rev. 0 "1R33 Core Reload."

33. WCAP-17661-P-A, "Improved RAOC and CAOC FQ Surveillance Technical Specifications", February 2019.

Table 1
Minimum Required Shutdown Margin, %Δρ

Number of Charging Pumps Running**			
Mode 1*			
	0-1 Pump	**2 Pumps**	**3 Pumps**
0 - 24750 MWd/MTU	-	-	-

Mode 2*			
	0-1 Pump	**2 Pumps**	**3 Pumps**
0 - 24750 MWd/MTU	1.7	1.7	1.7

Physics Testing in Mode 2			
	0-1 Pump	**2 Pumps**	**3 Pumps**
0 - 24750 MWd/MTU	0.5	0.5	0.5

Mode 3	**T_{ave} ≥ 520°F (Most Reactive Rod Out)**		
	0-1 Pump	**2 Pumps**	**3 Pumps**
0 - 24750 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	2.0
3000 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
24750 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 Keff ≥ 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, %Δρ

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
3000 MWd/MTU	2.0	3.5	5.5
6000 MWd/MTU	2.0	3.5	5.5
11000 MWd/MTU	2.0	3.5	5.5
16000 MWd/MTU	2.0	3.0	4.5
24750 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	6.0
3000 MWd/MTU	2.0	4.0	6.5
6000 MWd/MTU	2.0	4.0	6.5
11000 MWd/MTU	2.0	4.0	6.0
16000 MWd/MTU	2.0	3.5	5.5
24750 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 1 Cycle 32 end of cycle.

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

Table 1, Continued

Minimum Required Shutdown Margin, %Δρ

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	6.0
3000 MWd/MTU	5.129	5.129	6.0
6000 MWd/MTU	5.129	5.129	6.0
11000 MWd/MTU	5.129	5.129	6.0
16000 MWd/MTU	5.129	5.129	5.129
24750 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
3000 MWd/MTU	5.129	5.129	8.0
6000 MWd/MTU	5.129	5.5	8.0
11000 MWd/MTU	5.129	5.129	8.0
16000 MWd/MTU	5.129	5.129	7.0
24750 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 1 Cycle 32 end of cycle.

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

Table 2 - T(z) Factors associated with Figure 5 (ROS1) (Top 10% and Bottom 8% excluded)*

	Height	BU [MWd/MTU]									
	[ft]	150	1000	2000	2500	3000	4000	5000	6000	7000	8000
[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	1.0981	1.0692	1.0290	1.0262	1.0024	1.0205	1.0238	1.0415	1.0478	1.0822
7	1.20	1.1430	1.1194	1.0838	1.0829	1.0598	1.0809	1.0857	1.1047	1.1111	1.1465
8	1.40	1.1738	1.1555	1.1245	1.1253	1.1029	1.1258	1.1313	1.1502	1.1557	1.1900
9	1.60	1.2040	1.1904	1.1638	1.1660	1.1443	1.1684	1.1740	1.1923	1.1964	1.2289
10	1.80	1.2140	1.2048	1.1825	1.1860	1.1654	1.1899	1.1955	1.2128	1.2153	1.2457
11	2.00	1.1825	1.1775	1.1602	1.1648	1.1460	1.1700	1.1757	1.1916	1.1931	1.2203
12	2.20	1.1468	1.1456	1.1372	1.1420	1.1252	1.1481	1.1534	1.1677	1.1703	1.1882
13	2.40	1.1768	1.1785	1.1725	1.1750	1.1621	1.1805	1.1878	1.1974	1.2020	1.2158
14	2.60	1.2243	1.2282	1.2280	1.2259	1.2222	1.2336	1.2416	1.2452	1.2520	1.2578
15	2.80	1.2387	1.2447	1.2510	1.2507	1.2526	1.2581	1.2632	1.2611	1.2703	1.2687
16	3.00	1.2292	1.2374	1.2495	1.2544	1.2561	1.2591	1.2609	1.2562	1.2643	1.2580
17	3.20	1.2259	1.2365	1.2494	1.2561	1.2582	1.2596	1.2602	1.2562	1.2607	1.2528
18	3.40	1.2306	1.2430	1.2576	1.2644	1.2667	1.2676	1.2670	1.2633	1.2632	1.2535
19	3.60	1.2433	1.2582	1.2738	1.2804	1.2826	1.2830	1.2809	1.2777	1.2710	1.2594
20	3.80	1.2583	1.2753	1.2917	1.2979	1.3000	1.2996	1.2962	1.2932	1.2811	1.2676
21	4.00	1.2532	1.2716	1.2884	1.2949	1.2971	1.2962	1.2918	1.2884	1.2733	1.2581
22	4.20	1.2121	1.2320	1.2483	1.2558	1.2581	1.2575	1.2530	1.2485	1.2336	1.2183
23	4.40	1.1729	1.1940	1.2109	1.2184	1.2210	1.2205	1.2159	1.2101	1.1953	1.1815
24	4.60	1.2039	1.2267	1.2443	1.2517	1.2541	1.2529	1.2470	1.2387	1.2223	1.2089
25	4.80	1.2519	1.2760	1.2941	1.3016	1.3038	1.3016	1.2942	1.2830	1.2658	1.2516
26	5.00	1.2684	1.2931	1.3112	1.3177	1.3199	1.3173	1.3090	1.2959	1.2802	1.2649
27	5.20	1.2600	1.2844	1.3028	1.3077	1.3099	1.3073	1.2990	1.2860	1.2714	1.2551
28	5.40	1.2524	1.2769	1.2964	1.3004	1.3025	1.2998	1.2922	1.2797	1.2643	1.2476
29	5.60	1.2536	1.2798	1.2997	1.3035	1.3056	1.3029	1.2945	1.2808	1.2658	1.2494
30	5.80	1.2641	1.2908	1.3107	1.3140	1.3161	1.3136	1.3048	1.2908	1.2761	1.2589
31	6.00	1.2789	1.3052	1.3247	1.3284	1.3304	1.3272	1.3185	1.3050	1.2907	1.2718
32	6.20	1.2717	1.2972	1.3163	1.3217	1.3238	1.3190	1.3108	1.2985	1.2855	1.2650
33	6.40	1.2283	1.2524	1.2707	1.2781	1.2805	1.2745	1.2677	1.2575	1.2465	1.2262
34	6.61	1.1886	1.2113	1.2291	1.2381	1.2407	1.2344	1.2289	1.2200	1.2110	1.1964
35	6.81	1.2224	1.2427	1.2638	1.2701	1.2728	1.2687	1.2633	1.2514	1.2431	1.2285
36	7.01	1.2713	1.2905	1.3139	1.3178	1.3191	1.3178	1.3124	1.2980	1.2903	1.2763
37	7.21	1.2862	1.3044	1.3289	1.3320	1.3324	1.3326	1.3278	1.3126	1.3062	1.2935
38	7.41	1.2752	1.2919	1.3173	1.3200	1.3208	1.3215	1.3180	1.3025	1.2982	1.2879
39	7.61	1.2655	1.2808	1.3066	1.3088	1.3098	1.3113	1.3094	1.2937	1.2918	1.2842
40	7.81	1.2651	1.2786	1.3054	1.3069	1.3082	1.3103	1.3092	1.2933	1.2932	1.2882
41	8.01	1.2702	1.2820	1.3100	1.3108	1.3122	1.3149	1.3150	1.2980	1.3004	1.2993
42	8.21	1.2796	1.2887	1.3150	1.3149	1.3166	1.3198	1.3211	1.3064	1.3082	1.3115
43	8.41	1.2689	1.2754	1.2960	1.2954	1.2974	1.3013	1.3039	1.2958	1.2935	1.3011
44	8.61	1.2217	1.2273	1.2407	1.2395	1.2419	1.2469	1.2512	1.2509	1.2456	1.2561
45	8.81	1.1795	1.1837	1.1912	1.1897	1.1924	1.1980	1.2035	1.2102	1.2049	1.2151
46	9.01	1.2087	1.2116	1.2168	1.2180	1.2205	1.2229	1.2258	1.2379	1.2306	1.2416
47	9.21	1.2491	1.2503	1.2539	1.2584	1.2604	1.2588	1.2612	1.2756	1.2719	1.2830
48	9.41	1.2577	1.2575	1.2566	1.2628	1.2644	1.2605	1.2659	1.2818	1.2802	1.2909
49	9.61	1.2415	1.2399	1.2345	1.2383	1.2398	1.2396	1.2479	1.2622	1.2611	1.2737
50	9.81	1.2235	1.2197	1.2125	1.2114	1.2133	1.2202	1.2289	1.2389	1.2391	1.2553
51	10.01	1.2151	1.2086	1.1988	1.1956	1.1975	1.2041	1.2132	1.2224	1.2192	1.2365
52	10.21	1.2099	1.1990	1.1860	1.1828	1.1841	1.1900	1.1993	1.2048	1.2040	1.2207
53	10.41	1.1999	1.1852	1.1689	1.1631	1.1638	1.1691	1.1782	1.1807	1.1835	1.1999
54	10.61	1.1562	1.1396	1.1204	1.1149	1.1149	1.1192	1.1279	1.1284	1.1342	1.1506
55	10.81	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
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 20,000 MWD/MTU and 22,000 MWD/MTU is adequate for addressing burnups beyond 22,000 MWD/MTU.**

Table 2 (cont.) - T(z) Factors associated with Figure 5 (ROS1) (Top 10% and Bottom 8% excluded)*

	Height	BU [MWd/MTU]									
	[ft]	9000	10000	11000	12000	13000	14000	16000	18000	20000	22000
[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	1.0989	1.1072	1.1418	1.1482	1.1743	1.2066	1.2282	1.2520	1.2726	1.2705
7	1.20	1.1631	1.1707	1.2054	1.2105	1.2354	1.2660	1.2823	1.3013	1.3172	1.3103
8	1.40	1.2052	1.2110	1.2436	1.2462	1.2681	1.2951	1.3044	1.3177	1.3283	1.3171
9	1.60	1.2421	1.2457	1.2756	1.2753	1.2936	1.3166	1.3194	1.3273	1.3333	1.3184
10	1.80	1.2570	1.2585	1.2853	1.2826	1.2977	1.3169	1.3147	1.3186	1.3214	1.3047
11	2.00	1.2299	1.2299	1.2532	1.2490	1.2612	1.2770	1.2722	1.2738	1.2754	1.2594
12	2.20	1.1959	1.1943	1.2138	1.2080	1.2173	1.2299	1.2231	1.2231	1.2242	1.2101
13	2.40	1.2211	1.2170	1.2327	1.2239	1.2296	1.2384	1.2283	1.2251	1.2245	1.2105
14	2.60	1.2608	1.2539	1.2656	1.2535	1.2558	1.2608	1.2485	1.2409	1.2389	1.2254
15	2.80	1.2693	1.2609	1.2698	1.2560	1.2548	1.2572	1.2423	1.2342	1.2311	1.2178
16	3.00	1.2563	1.2470	1.2535	1.2389	1.2345	1.2350	1.2186	1.2119	1.2092	1.1969
17	3.20	1.2496	1.2384	1.2417	1.2251	1.2191	1.2167	1.2025	1.1949	1.1944	1.1857
18	3.40	1.2489	1.2361	1.2355	1.2173	1.2117	1.2046	1.1927	1.1867	1.1855	1.1803
19	3.60	1.2538	1.2414	1.2362	1.2177	1.2132	1.2039	1.1921	1.1867	1.1837	1.1811
20	3.80	1.2628	1.2510	1.2409	1.2219	1.2173	1.2048	1.1932	1.1891	1.1828	1.1855
21	4.00	1.2546	1.2424	1.2305	1.2108	1.2056	1.1913	1.1809	1.1777	1.1712	1.1785
22	4.20	1.2144	1.2029	1.1898	1.1712	1.1664	1.1514	1.1432	1.1417	1.1402	1.1478
23	4.40	1.1760	1.1652	1.1510	1.1356	1.1291	1.1138	1.1074	1.1074	1.1114	1.1185
24	4.60	1.2002	1.1886	1.1735	1.1574	1.1477	1.1320	1.1249	1.1234	1.1309	1.1361
25	4.80	1.2394	1.2269	1.2104	1.1932	1.1800	1.1637	1.1571	1.1509	1.1621	1.1662
26	5.00	1.2508	1.2371	1.2217	1.2033	1.1875	1.1714	1.1670	1.1597	1.1717	1.1761
27	5.20	1.2409	1.2262	1.2124	1.1931	1.1759	1.1609	1.1578	1.1531	1.1630	1.1686
28	5.40	1.2328	1.2185	1.2039	1.1854	1.1672	1.1532	1.1486	1.1455	1.1540	1.1603
29	5.60	1.2331	1.2193	1.2053	1.1875	1.1681	1.1550	1.1476	1.1448	1.1530	1.1574
30	5.80	1.2424	1.2279	1.2146	1.1957	1.1761	1.1640	1.1530	1.1497	1.1570	1.1584
31	6.00	1.2563	1.2394	1.2274	1.2079	1.1909	1.1782	1.1664	1.1615	1.1658	1.1682
32	6.20	1.2512	1.2344	1.2224	1.2055	1.1920	1.1781	1.1686	1.1622	1.1658	1.1720
33	6.40	1.2147	1.2029	1.1878	1.1763	1.1651	1.1507	1.1440	1.1372	1.1462	1.1521
34	6.61	1.1845	1.1763	1.1596	1.1521	1.1432	1.1284	1.1243	1.1168	1.1301	1.1361
35	6.81	1.2151	1.2077	1.1890	1.1824	1.1745	1.1608	1.1539	1.1444	1.1602	1.1648
36	7.01	1.2611	1.2540	1.2353	1.2290	1.2194	1.2088	1.1959	1.1863	1.2022	1.2050
37	7.21	1.2773	1.2717	1.2570	1.2515	1.2384	1.2318	1.2155	1.2065	1.2211	1.2227
38	7.41	1.2722	1.2691	1.2586	1.2536	1.2390	1.2343	1.2177	1.2087	1.2214	1.2222
39	7.61	1.2696	1.2690	1.2588	1.2541	1.2401	1.2362	1.2191	1.2102	1.2208	1.2205
40	7.81	1.2742	1.2751	1.2659	1.2613	1.2487	1.2443	1.2265	1.2174	1.2253	1.2237
41	8.01	1.2856	1.2880	1.2799	1.2753	1.2644	1.2592	1.2404	1.2310	1.2356	1.2322
42	8.21	1.2970	1.3010	1.2941	1.2893	1.2804	1.2744	1.2548	1.2452	1.2462	1.2406
43	8.41	1.2865	1.2922	1.2871	1.2824	1.2762	1.2697	1.2502	1.2414	1.2388	1.2321
44	8.61	1.2421	1.2497	1.2472	1.2431	1.2406	1.2341	1.2168	1.2103	1.2051	1.1991
45	8.81	1.2017	1.2114	1.2114	1.2077	1.2104	1.2039	1.1903	1.1873	1.1804	1.1735
46	9.01	1.2291	1.2395	1.2424	1.2373	1.2420	1.2358	1.2226	1.2179	1.2082	1.1981
47	9.21	1.2736	1.2810	1.2842	1.2790	1.2853	1.2784	1.2684	1.2572	1.2469	1.2325
48	9.41	1.2867	1.2893	1.2935	1.2867	1.2954	1.2889	1.2884	1.2727	1.2605	1.2479
49	9.61	1.2720	1.2734	1.2786	1.2747	1.2843	1.2823	1.2860	1.2742	1.2582	1.2517
50	9.81	1.2536	1.2592	1.2631	1.2688	1.2764	1.2817	1.2819	1.2783	1.2580	1.2586
51	10.01	1.2401	1.2507	1.2543	1.2640	1.2718	1.2821	1.2861	1.2848	1.2684	1.2688
52	10.21	1.2273	1.2432	1.2463	1.2600	1.2676	1.2833	1.2928	1.2927	1.2815	1.2812
53	10.41	1.2078	1.2276	1.2288	1.2479	1.2543	1.2764	1.2923	1.2932	1.2885	1.2900
54	10.61	1.1605	1.1817	1.1831	1.2052	1.2113	1.2383	1.2610	1.2642	1.2680	1.2744
55	10.81	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
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 20,000 MWD/MTU and 22,000 MWD/MTU is adequate for addressing burnups beyond 22,000 MWD/MTU.**

Table 3: R_J Margin Decrease Factors associated with Figure 5 (ROS1) and Table 2

Cycle Burnup (MWD/MTU)	R_J Penalty Multiplier	Cycle Burnup (MWD/MTU)	R_J Penalty Multiplier	Cycle Burnup (MWD/MTU)	R_J Penalty Multiplier
150	1.017	7183	1.013	14216	1.002
322	1.017	7354	1.014	14387	1.001
493	1.016	7526	1.017	14559	1.000
665	1.015	7697	1.017	14730	1.000
836	1.013	7869	1.016	14902	1.000
1008	1.011	8041	1.014	15073	1.000
1179	1.009	8212	1.012	15245	1.000
1351	1.007	8384	1.010	15416	1.000
1522	1.006	8555	1.007	15588	1.000
1694	1.004	8727	1.006	15760	1.000
1865	1.002	8898	1.007	15931	1.000
2037	1.001	9070	1.008	16103	1.000
2208	1.001	9241	1.014	16274	1.000
2380	1.000	9413	1.015	16446	1.000
2551	1.000	9584	1.020	16617	1.000
2723	1.000	9756	1.022	16789	1.000
2895	1.000	9927	1.023	16960	1.000
3066	1.000	10099	1.023	17132	1.000
3238	1.000	10270	1.021	17303	1.000
3409	1.000	10442	1.018	17475	1.000
3581	1.000	10614	1.012	17646	1.000
3752	1.000	10785	1.011	17818	1.000
3924	1.000	10957	1.010	17989	1.000
4095	1.000	11128	1.011	18161	1.000
4267	1.004	11300	1.011	18333	1.000
4438	1.008	11471	1.012	18504	1.000
4610	1.012	11643	1.018	18676	1.000
4781	1.015	11814	1.019	18847	1.001
4953	1.017	11986	1.020	19019	1.000
5124	1.018	12157	1.022	19190	1.000
5296	1.017	12329	1.022	19362	1.000
5468	1.016	12500	1.020	19533	1.000
5639	1.014	12672	1.019	19705	1.000
5811	1.012	12843	1.018	19876	1.000
5982	1.010	13015	1.017	20048	1.000
6154	1.007	13187	1.015	20219	1.000
6325	1.006	13358	1.013	20391	1.000
6497	1.007	13530	1.008	20562	1.000
6668	1.008	13701	1.006		
6840	1.009	13873	1.004		
7011	1.011	14044	1.003		

Values may be interpolated to the surveillance cycle burnup. The R_j factor value for the last burnup step shall be used for all burnups greater than the last burnup step.

Table 4 – T(z) Factors associated with Figures 6, 7, and 8 (ROS2) (Top 10% and Bottom 8% excluded)*

	Height	BU [MWd/MTU]									
	[ft]	150	1000	2000	2500	3000	4000	5000	6000	7000	8000
[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	1.0614	1.0330	1.0086	0.9913	0.9884	0.9993	1.0022	1.0058	1.0336	1.0440
7	1.20	1.1054	1.0821	1.0627	1.0466	1.0452	1.0588	1.0631	1.0674	1.0964	1.1066
8	1.40	1.1359	1.1176	1.1031	1.0883	1.0879	1.1033	1.1082	1.1121	1.1405	1.1494
9	1.60	1.1659	1.1523	1.1422	1.1286	1.1290	1.1456	1.1507	1.1536	1.1809	1.1878
10	1.80	1.1766	1.1672	1.1613	1.1489	1.1501	1.1674	1.1725	1.1744	1.2000	1.2050
11	2.00	1.1472	1.1419	1.1402	1.1294	1.1312	1.1488	1.1539	1.1550	1.1782	1.1817
12	2.20	1.1137	1.1157	1.1178	1.1085	1.1107	1.1282	1.1331	1.1330	1.1534	1.1518
13	2.40	1.1442	1.1454	1.1505	1.1416	1.1438	1.1612	1.1652	1.1632	1.1808	1.1799
14	2.60	1.1916	1.1950	1.2026	1.1948	1.1986	1.2128	1.2155	1.2108	1.2258	1.2220
15	2.80	1.2078	1.2129	1.2225	1.2216	1.2253	1.2323	1.2339	1.2291	1.2402	1.2348
16	3.00	1.2010	1.2091	1.2203	1.2257	1.2277	1.2302	1.2309	1.2274	1.2333	1.2269
17	3.20	1.1996	1.2091	1.2220	1.2290	1.2311	1.2323	1.2322	1.2286	1.2319	1.2236
18	3.40	1.2064	1.2168	1.2315	1.2391	1.2414	1.2422	1.2404	1.2367	1.2356	1.2262
19	3.60	1.2230	1.2352	1.2500	1.2563	1.2587	1.2587	1.2560	1.2522	1.2459	1.2338
20	3.80	1.2419	1.2565	1.2718	1.2765	1.2787	1.2786	1.2751	1.2689	1.2585	1.2451
21	4.00	1.2400	1.2563	1.2731	1.2775	1.2795	1.2799	1.2754	1.2660	1.2537	1.2402
22	4.20	1.2022	1.2198	1.2374	1.2415	1.2438	1.2446	1.2400	1.2294	1.2169	1.2044
23	4.40	1.1660	1.1847	1.2062	1.2101	1.2126	1.2137	1.2059	1.1957	1.1827	1.1712
24	4.60	1.1994	1.2197	1.2389	1.2423	1.2447	1.2453	1.2393	1.2280	1.2138	1.2011
25	4.80	1.2495	1.2713	1.2914	1.2941	1.2963	1.2963	1.2888	1.2761	1.2603	1.2461
26	5.00	1.2672	1.2908	1.3105	1.3133	1.3154	1.3147	1.3064	1.2933	1.2772	1.2622
27	5.20	1.2584	1.2839	1.3029	1.3064	1.3085	1.3067	1.2982	1.2851	1.2705	1.2545
28	5.40	1.2506	1.2769	1.2964	1.3004	1.3025	1.2998	1.2912	1.2775	1.2643	1.2476
29	5.60	1.2532	1.2798	1.2997	1.3035	1.3056	1.3029	1.2943	1.2801	1.2658	1.2494
30	5.80	1.2641	1.2908	1.3107	1.3140	1.3160	1.3136	1.3049	1.2908	1.2761	1.2589
31	6.00	1.2783	1.3052	1.3247	1.3284	1.3304	1.3272	1.3185	1.3050	1.2907	1.2717
32	6.20	1.2707	1.2972	1.3162	1.3217	1.3238	1.3190	1.3108	1.2985	1.2855	1.2651
33	6.40	1.2268	1.2524	1.2707	1.2781	1.2805	1.2745	1.2677	1.2575	1.2465	1.2261
34	6.61	1.1867	1.2113	1.2287	1.2380	1.2406	1.2343	1.2280	1.2199	1.2110	1.1919
35	6.81	1.2201	1.2425	1.2588	1.2701	1.2727	1.2685	1.2577	1.2513	1.2430	1.2260
36	7.01	1.2684	1.2903	1.3046	1.3164	1.3188	1.3175	1.3027	1.2978	1.2900	1.2738
37	7.21	1.2828	1.3041	1.3170	1.3298	1.3323	1.3324	1.3157	1.3125	1.3061	1.2913
38	7.41	1.2716	1.2917	1.3035	1.3174	1.3200	1.3208	1.3038	1.3017	1.2973	1.2850
39	7.61	1.2616	1.2805	1.2910	1.3039	1.3066	1.3081	1.2931	1.2900	1.2876	1.2782
40	7.81	1.2608	1.2783	1.2875	1.2977	1.3004	1.3025	1.2909	1.2851	1.2854	1.2781
41	8.01	1.2661	1.2821	1.2898	1.2984	1.3011	1.3037	1.2942	1.2862	1.2885	1.2837
42	8.21	1.2721	1.2864	1.2925	1.2985	1.3012	1.3044	1.2991	1.2910	1.2913	1.2900
43	8.41	1.2548	1.2672	1.2718	1.2744	1.2769	1.2809	1.2824	1.2770	1.2728	1.2758
44	8.61	1.2028	1.2134	1.2171	1.2162	1.2184	1.2234	1.2309	1.2281	1.2230	1.2296
45	8.81	1.1585	1.1679	1.1703	1.1688	1.1714	1.1773	1.1835	1.1834	1.1784	1.1871
46	9.01	1.1836	1.1918	1.1926	1.1911	1.1938	1.1988	1.2048	1.2078	1.2006	1.2107
47	9.21	1.2254	1.2328	1.2316	1.2301	1.2328	1.2364	1.2426	1.2433	1.2403	1.2497
48	9.41	1.2337	1.2404	1.2370	1.2359	1.2387	1.2404	1.2470	1.2484	1.2485	1.2565
49	9.61	1.2176	1.2228	1.2172	1.2139	1.2161	1.2188	1.2257	1.2285	1.2289	1.2390
50	9.81	1.2030	1.2058	1.1977	1.1914	1.1916	1.1967	1.2036	1.2050	1.2060	1.2202
51	10.01	1.1917	1.1917	1.1810	1.1736	1.1729	1.1769	1.1832	1.1883	1.1888	1.2013
52	10.21	1.1871	1.1819	1.1682	1.1598	1.1574	1.1606	1.1661	1.1707	1.1725	1.1858
53	10.41	1.1742	1.1656	1.1487	1.1388	1.1377	1.1363	1.1405	1.1468	1.1508	1.1629
54	10.61	1.1279	1.1168	1.0978	1.0901	1.0905	1.0824	1.0870	1.0955	1.1026	1.1124
55	10.81	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
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 20,000 MWD/MTU and 22,000 MWD/MTU is adequate for addressing burnups beyond 22,000 MWD/MTU.**

Table 4 (cont.) – T(z) Factors associated with Figures 6, 7 and 8 (ROS2) (Top 10% and Bottom 8% excluded)*

	Height	BU [MWd/MTU]									
	[ft]	9000	10000	11000	12000	13000	14000	16000	18000	20000	22000
[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	1.0596	1.0666	1.0994	1.1221	1.1550	1.1587	1.2048	1.2273	1.2303	1.2378
7	1.20	1.1222	1.1285	1.1613	1.1834	1.2154	1.2165	1.2583	1.2758	1.2739	1.2771
8	1.40	1.1636	1.1681	1.1989	1.2190	1.2479	1.2453	1.2804	1.2922	1.2854	1.2841
9	1.60	1.2002	1.2025	1.2307	1.2482	1.2734	1.2671	1.2955	1.3020	1.2908	1.2860
10	1.80	1.2156	1.2160	1.2412	1.2562	1.2777	1.2685	1.2913	1.2940	1.2803	1.2734
11	2.00	1.1906	1.1896	1.2115	1.2242	1.2422	1.2315	1.2501	1.2508	1.2373	1.2303
12	2.20	1.1589	1.1564	1.1747	1.1851	1.1993	1.1875	1.2023	1.2017	1.1893	1.1829
13	2.40	1.1847	1.1799	1.1944	1.2018	1.2118	1.1972	1.2075	1.2044	1.1914	1.1841
14	2.60	1.2245	1.2162	1.2276	1.2322	1.2378	1.2204	1.2263	1.2210	1.2078	1.1994
15	2.80	1.2350	1.2288	1.2339	1.2356	1.2380	1.2192	1.2219	1.2147	1.2015	1.1934
16	3.00	1.2248	1.2229	1.2208	1.2193	1.2194	1.2003	1.2009	1.1902	1.1801	1.1733
17	3.20	1.2196	1.2169	1.2110	1.2072	1.2037	1.1845	1.1840	1.1683	1.1660	1.1612
18	3.40	1.2210	1.2184	1.2079	1.2054	1.1946	1.1760	1.1735	1.1566	1.1590	1.1604
19	3.60	1.2303	1.2253	1.2115	1.2098	1.1958	1.1771	1.1719	1.1578	1.1590	1.1656
20	3.80	1.2435	1.2345	1.2197	1.2172	1.2004	1.1810	1.1712	1.1627	1.1616	1.1738
21	4.00	1.2381	1.2268	1.2118	1.2085	1.1891	1.1708	1.1658	1.1543	1.1556	1.1692
22	4.20	1.2013	1.1896	1.1745	1.1712	1.1511	1.1362	1.1321	1.1236	1.1266	1.1414
23	4.40	1.1660	1.1551	1.1407	1.1356	1.1170	1.1038	1.1001	1.0952	1.0990	1.1147
24	4.60	1.1927	1.1811	1.1659	1.1574	1.1381	1.1249	1.1195	1.1162	1.1189	1.1348
25	4.80	1.2343	1.2217	1.2055	1.1932	1.1729	1.1592	1.1516	1.1492	1.1521	1.1661
26	5.00	1.2483	1.2349	1.2185	1.2033	1.1830	1.1699	1.1609	1.1602	1.1644	1.1762
27	5.20	1.2403	1.2261	1.2104	1.1931	1.1739	1.1612	1.1517	1.1530	1.1588	1.1686
28	5.40	1.2328	1.2185	1.2037	1.1854	1.1672	1.1532	1.1423	1.1455	1.1528	1.1603
29	5.60	1.2331	1.2193	1.2053	1.1875	1.1681	1.1550	1.1413	1.1448	1.1527	1.1578
30	5.80	1.2424	1.2279	1.2145	1.1957	1.1761	1.1640	1.1508	1.1497	1.1574	1.1591
31	6.00	1.2563	1.2394	1.2274	1.2079	1.1909	1.1783	1.1671	1.1615	1.1643	1.1655
32	6.20	1.2512	1.2344	1.2224	1.2055	1.1920	1.1780	1.1684	1.1622	1.1593	1.1636
33	6.40	1.2147	1.2028	1.1878	1.1762	1.1650	1.1506	1.1440	1.1372	1.1335	1.1415
34	6.61	1.1844	1.1763	1.1595	1.1520	1.1431	1.1283	1.1242	1.1167	1.1121	1.1230
35	6.81	1.2150	1.2076	1.1890	1.1824	1.1743	1.1574	1.1537	1.1442	1.1387	1.1490
36	7.01	1.2609	1.2537	1.2330	1.2268	1.2191	1.1994	1.1958	1.1862	1.1775	1.1863
37	7.21	1.2775	1.2715	1.2498	1.2448	1.2384	1.2172	1.2145	1.2054	1.1945	1.2014
38	7.41	1.2709	1.2666	1.2446	1.2419	1.2374	1.2154	1.2146	1.2057	1.1942	1.1986
39	7.61	1.2639	1.2612	1.2396	1.2384	1.2357	1.2132	1.2139	1.2053	1.1931	1.1951
40	7.81	1.2649	1.2624	1.2447	1.2413	1.2402	1.2192	1.2192	1.2106	1.1974	1.1964
41	8.01	1.2740	1.2688	1.2558	1.2508	1.2515	1.2321	1.2310	1.2221	1.2076	1.2022
42	8.21	1.2850	1.2774	1.2676	1.2624	1.2628	1.2452	1.2433	1.2339	1.2183	1.2088
43	8.41	1.2741	1.2664	1.2590	1.2538	1.2542	1.2391	1.2370	1.2278	1.2120	1.1982
44	8.61	1.2300	1.2224	1.2182	1.2136	1.2144	1.2030	1.2023	1.1944	1.1802	1.1644
45	8.81	1.1901	1.1825	1.1816	1.1774	1.1789	1.1710	1.1726	1.1652	1.1556	1.1441
46	9.01	1.2143	1.2073	1.2099	1.2041	1.2087	1.2005	1.1997	1.1887	1.1807	1.1709
47	9.21	1.2475	1.2460	1.2496	1.2480	1.2501	1.2461	1.2338	1.2277	1.2129	1.2056
48	9.41	1.2500	1.2549	1.2586	1.2631	1.2610	1.2642	1.2514	1.2413	1.2302	1.2222
49	9.61	1.2330	1.2377	1.2427	1.2527	1.2472	1.2585	1.2557	1.2361	1.2368	1.2233
50	9.81	1.2177	1.2176	1.2235	1.2385	1.2322	1.2489	1.2554	1.2349	1.2412	1.2235
51	10.01	1.2042	1.2058	1.2092	1.2270	1.2265	1.2409	1.2579	1.2407	1.2493	1.2349
52	10.21	1.1916	1.1969	1.1994	1.2156	1.2215	1.2364	1.2617	1.2481	1.2595	1.2507
53	10.41	1.1705	1.1804	1.1813	1.1990	1.2074	1.2276	1.2566	1.2483	1.2631	1.2616
54	10.61	1.1226	1.1350	1.1361	1.1563	1.1653	1.1904	1.2239	1.2198	1.2399	1.2468
55	10.81	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
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 20,000 MWD/MTU and 22,000 MWD/MTU is adequate for addressing burnups beyond 22,000 MWD/MTU.**

Table 5: R_J Margin Decrease Factors associated with Figures 6, 7, and 8 (ROS2) and Table 4

Cycle Burnup (MWD/MTU)	R_J Penalty Multiplier	Cycle Burnup (MWD/MTU)	R_J Penalty Multiplier	Cycle Burnup (MWD/MTU)	R_J Penalty Multiplier
150	1.020	7183	1.001	14216	1.012
322	1.019	7354	1.000	14387	1.013
493	1.018	7526	1.000	14559	1.013
665	1.016	7697	1.000	14730	1.012
836	1.014	7869	1.000	14902	1.012
1008	1.011	8041	1.000	15073	1.003
1179	1.009	8212	1.003	15245	1.002
1351	1.007	8384	1.004	15416	1.001
1522	1.004	8555	1.005	15588	1.001
1694	1.002	8727	1.005	15760	1.000
1865	1.001	8898	1.004	15931	1.000
2037	1.000	9070	1.004	16103	1.000
2208	1.000	9241	1.007	16274	1.000
2380	1.000	9413	1.008	16446	1.000
2551	1.000	9584	1.007	16617	1.000
2723	1.000	9756	1.008	16789	1.000
2895	1.000	9927	1.011	16960	1.000
3066	1.000	10099	1.015	17132	1.000
3238	1.000	10270	1.017	17303	1.000
3409	1.000	10442	1.020	17475	1.000
3581	1.000	10614	1.020	17646	1.000
3752	1.000	10785	1.021	17818	1.000
3924	1.000	10957	1.023	17989	1.000
4095	1.000	11128	1.028	18161	1.000
4267	1.003	11300	1.029	18333	1.000
4438	1.006	11471	1.028	18504	1.000
4610	1.009	11643	1.027	18676	1.000
4781	1.011	11814	1.024	18847	1.000
4953	1.012	11986	1.021	19019	1.000
5124	1.014	12157	1.017	19190	1.000
5296	1.015	12329	1.014	19362	1.000
5468	1.015	12500	1.007	19533	1.000
5639	1.014	12672	1.004	19705	1.000
5811	1.013	12843	1.002	19876	1.000
5982	1.012	13015	1.000	20048	1.000
6154	1.010	13187	1.000	20219	1.000
6325	1.009	13358	1.000	20391	1.000
6497	1.007	13530	1.000	20562	1.000
6668	1.004	13701	1.008		
6840	1.003	13873	1.010		
7011	1.002	14044	1.011		

Values may be interpolated to the surveillance cycle burnup. The R_j factor value for the last burnup step shall be used for all burnups greater than the last burnup step.

Table 6: Required THERMAL POWER Limits and AFD Reductions

RAOC Operating Space	Required $F_Q^W(z)$ Margin Improvement (%)	Required THERMAL POWER Limit (%RTP)	Reference AFD Figure
ROS1 (Figure 5)	> 0	< 50	N/A
ROS2 (Figure 6)	≤ 2.8	≤ 95	Use Figure 7
	> 2.8 and ≤ 6.1	≤ 90	Use Figure 8
	> 6.1	< 50	N/A

Figure 1

Reactor Core Safety Limits

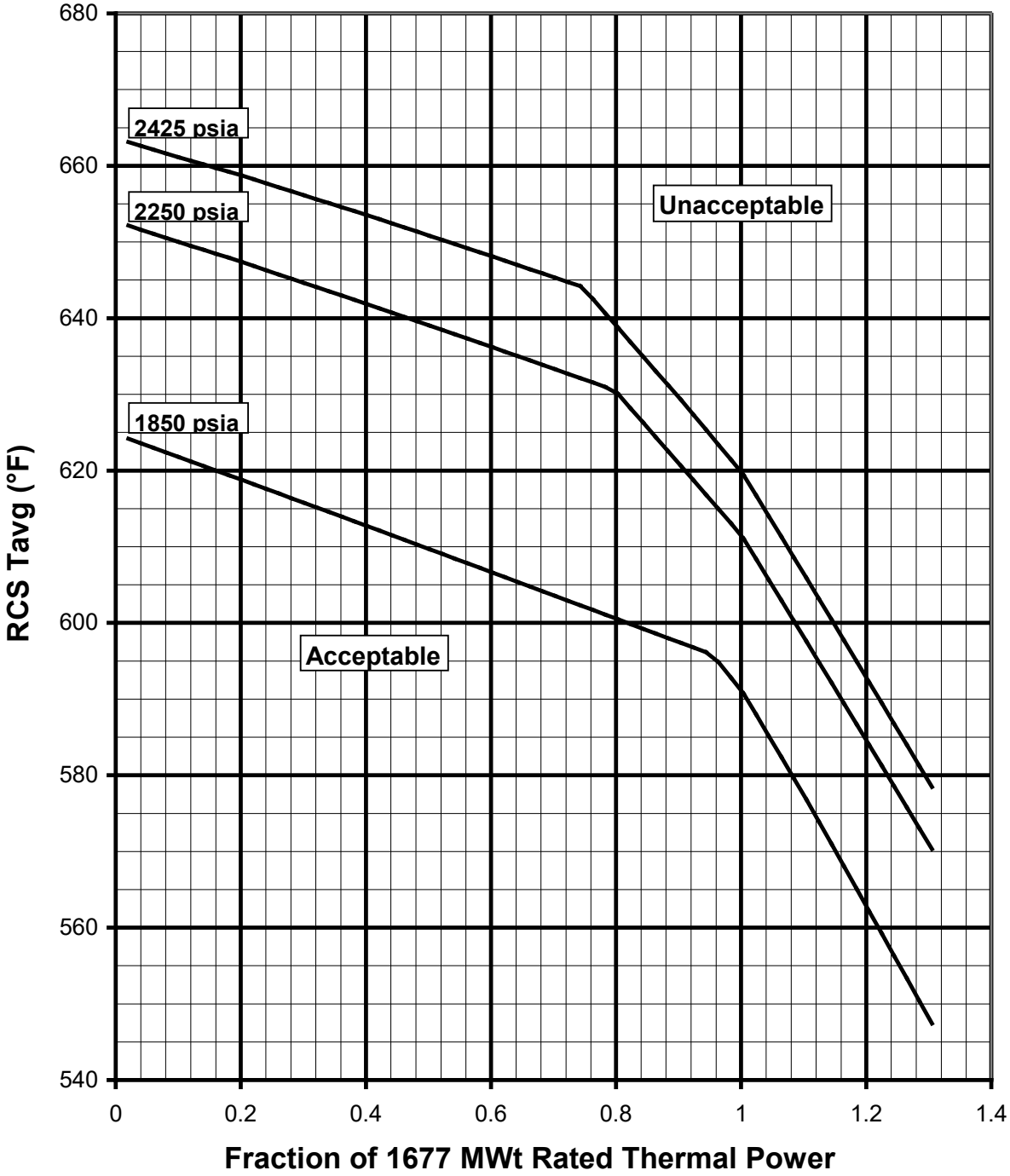
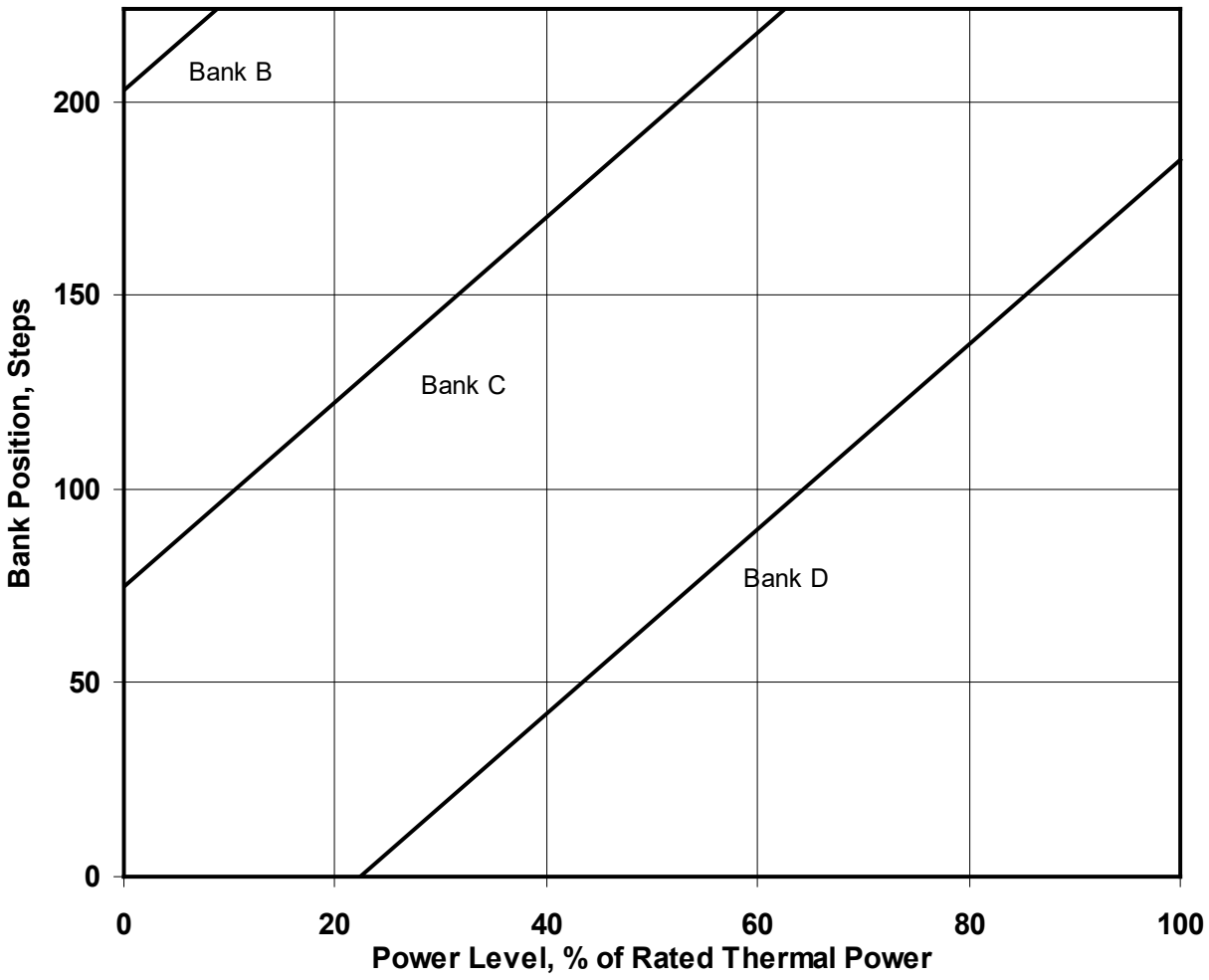


Figure 2
Rod Insertion Limit, 128 Step Tip-to-Tip

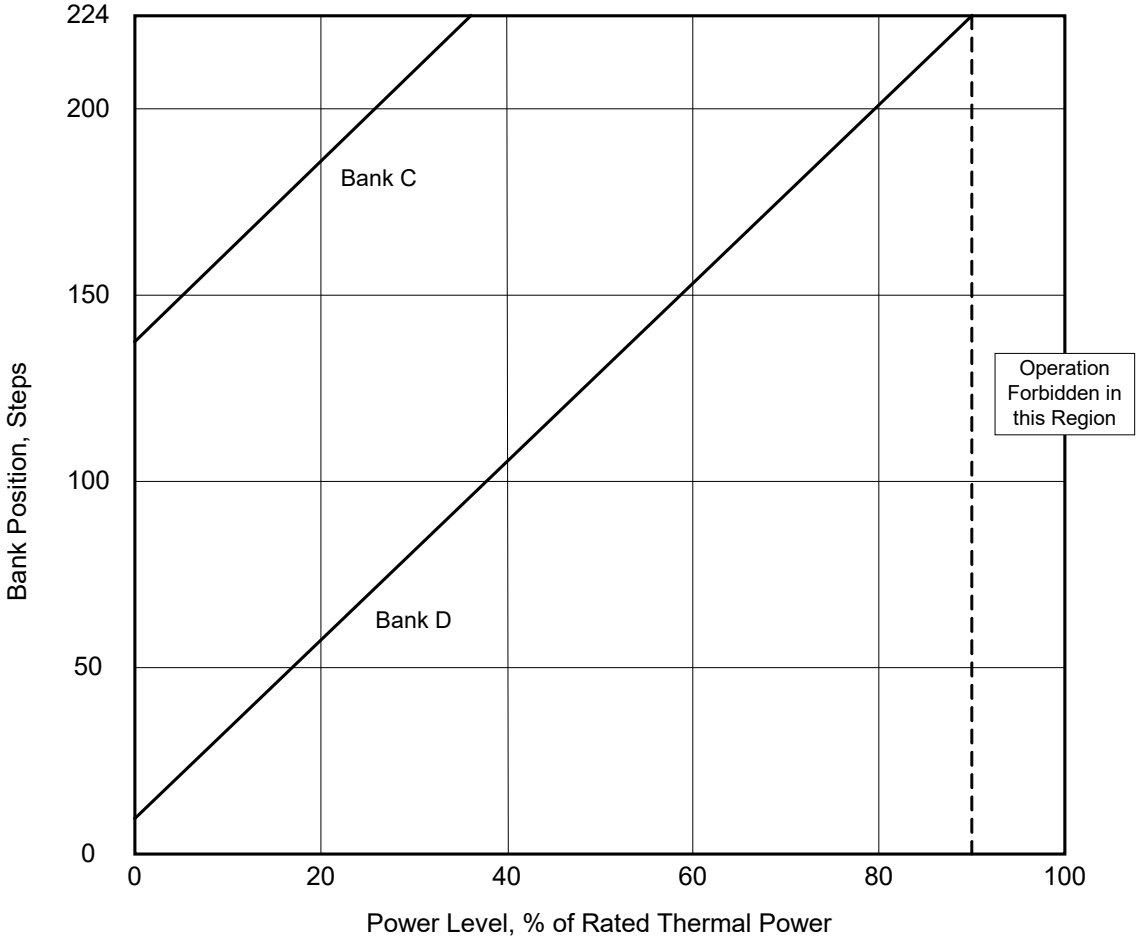


Bank Positions Given By:

- 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)

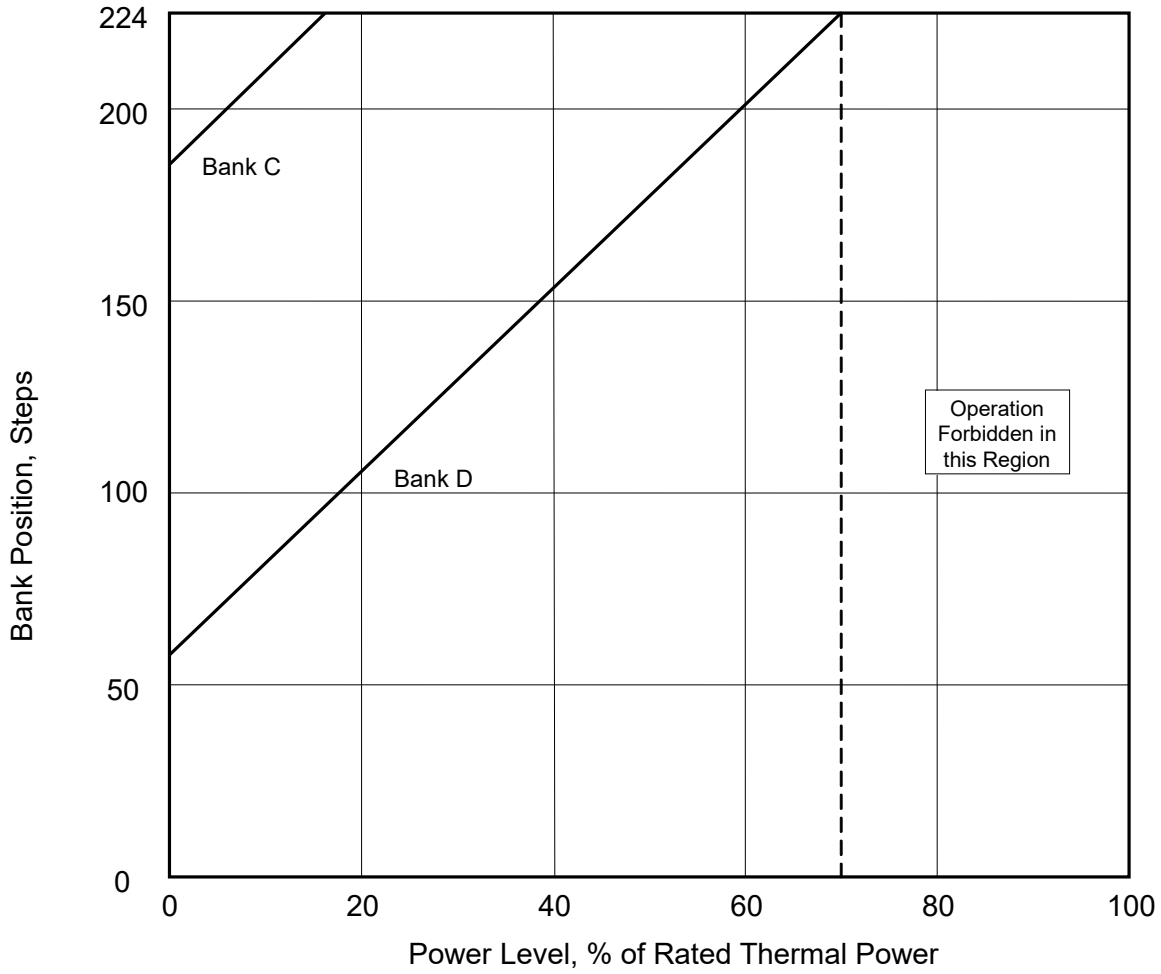


Bank Positions Given By:

- 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 ROS1 (Tables 2 and 3)

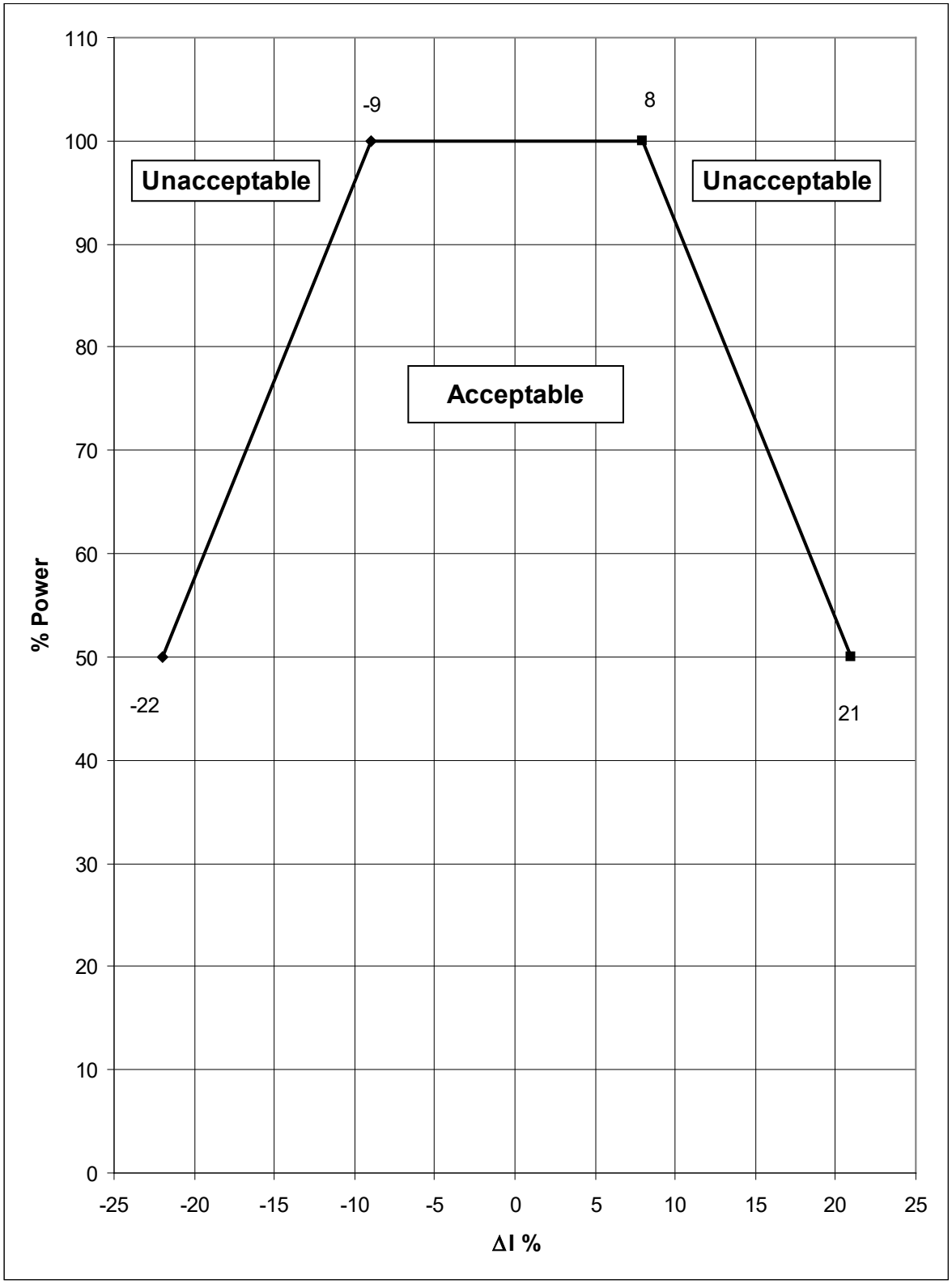


Figure 6
Flux Difference Operating Envelope associated with ROS2 (Tables 4 and 5)

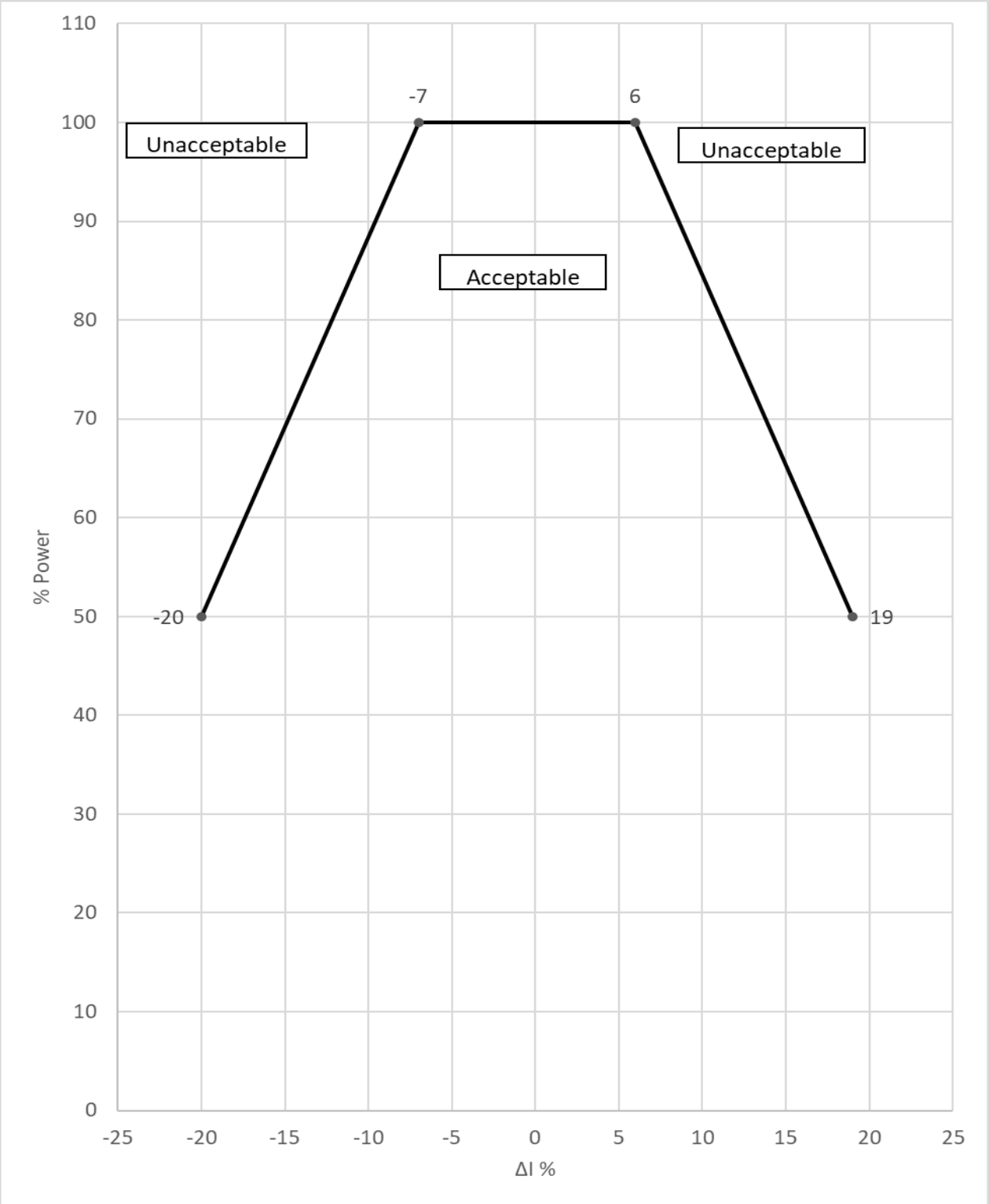


Figure 7
Flux Difference Operating Envelope associated with ROS2 95% THERMAL POWER Required Action (Tables 4, 5, and 6)

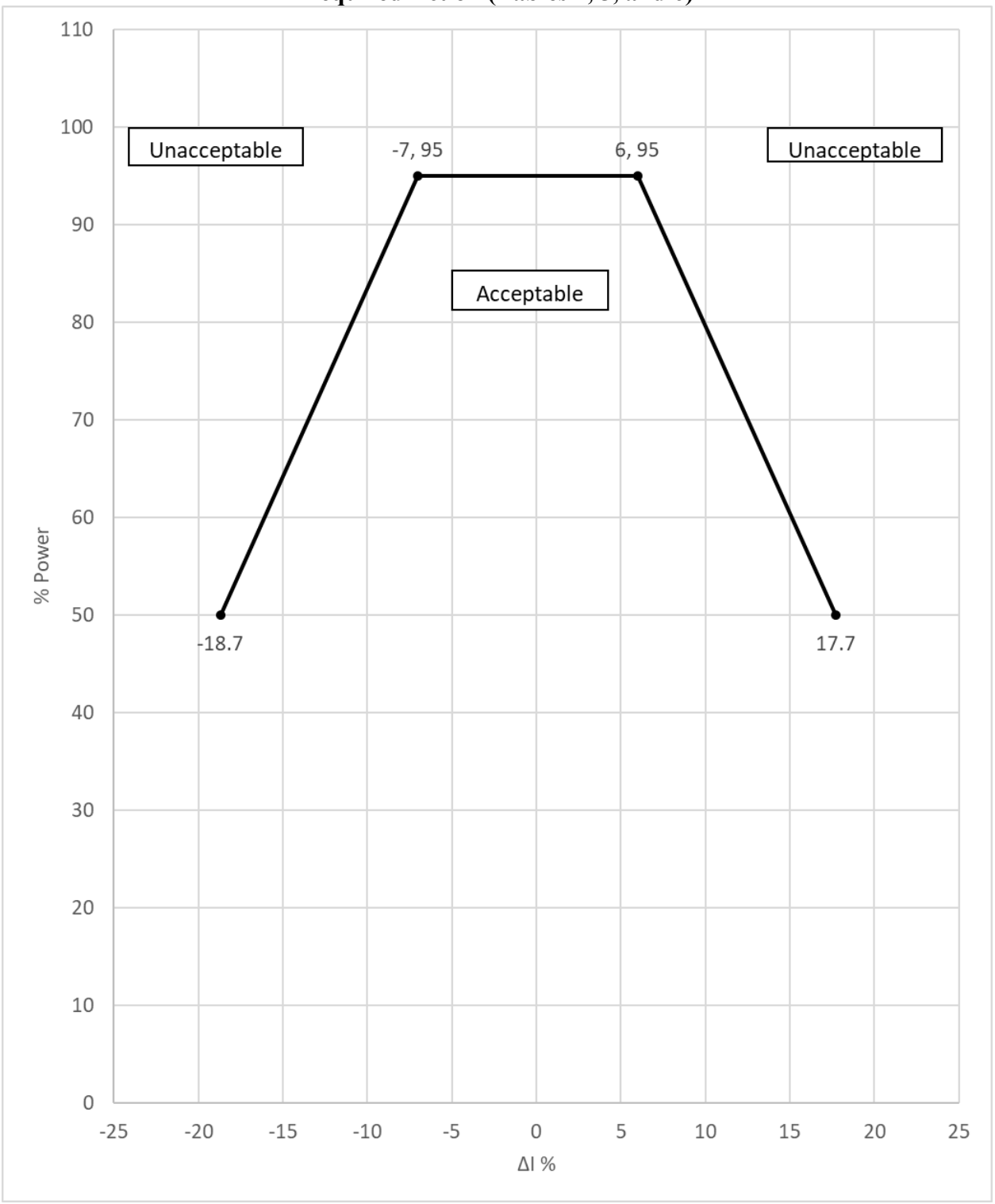


Figure 8
Flux Difference Operating Envelope associated with ROS2 90% THERMAL POWER Required Action (Tables 4, 5, and 6)