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MAY 2 9 2019

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U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
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Serial No.	19-234
NSSL/MLC	R0
Docket No.	50-423
License No.	NPF-49

DOMINION ENERGY NUCLEAR CONNECTICUT, INC.
MILLSTONE POWER STATION UNIT 3
CORE OPERATING LIMITS REPORT, CYCLE 20

In accordance with the Millstone Power Station Unit 3 (MPS3) Technical Specifications (TSs), Section 6.9.1.6.d, Dominion Energy Nuclear Connecticut, Inc., hereby submits, as Enclosure 1, the Cycle 20 Core Operating Limits Report (COLR).

The changes to the MPS3 COLR for Cycle 20 fall into four major categories:

(1) Changes to the COLR to reflect the Cycle 20 reload design.

(2) Changes which support the implementation of Dominion Energy Reload and Safety Analysis Methodologies at MPS3. Since first use of these methodologies is occurring in Cycle 20, methods changes are included as part of the Cycle 20 COLR.

(3) Enhancements for clarification of existing language in the MPS3 COLR. Specifically, the language of each COLR parameter was revised to match the language of the Technical Specification (TS) on which it is based.

(4) Editorial and formatting changes to enhance readability and the flow of information.

The COLR has been incorporated into the MPS3 Technical Requirements Manual.

If you have any questions or require additional information, please contact Jeffry A. Langan at (860) 444-5544.

Sincerely,

L. J. Armstrong
Director, Nuclear Station Safety and Licensing - Millstone

Enclosures: (1)

Commitments made in this letter: None.

A001
NRR

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ENCLOSURE 1

CORE OPERATING LIMITS REPORT, CYCLE 20

DOMINION ENERGY NUCLEAR CONNECTICUT, INC.
MILLSTONE POWER STATION UNIT 3

TECHNICAL REQUIREMENTS MANUAL

APPENDIX 8.1

CORE OPERATING LIMITS REPORT

CYCLE 20

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Millstone Unit 3
Cycle 20
CORE OPERATING LIMITS REPORT

INTRODUCTION

This CORE OPERATING LIMITS REPORT (COLR) for Millstone Unit 3 Cycle 20 has been prepared in accordance with the requirements of Technical Specification 6.9.1.6.a. The Technical Specifications affected by this report are listed below.

2.1.1	Reactor Core Safety Limits
2.2.1	Limiting Safety System Settings
3/4.1.1.1.1	SHUTDOWN MARGIN - MODES 1 and 2
3/4.1.1.1.2	SHUTDOWN MARGIN - MODES 3, 4 and 5 Loops Filled
3/4.1.1.2	SHUTDOWN MARGIN - COLD SHUTDOWN - Loops Not Filled
3/4.1.1.3	Moderator Temperature Coefficient
3/4.1.3.5	Shutdown Rod Insertion Limits
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3/4.2.1.1	AXIAL FLUX DIFFERENCE
3/4.2.2.1	Heat Flux Hot Channel Factor
3/4.2.3.1	RCS Total Flow Rate and Nuclear Enthalpy Rise Hot Channel Factor
3/4.2.5	DNB Parameters
3/4.3.5	Shutdown Margin Monitor
3/4.9.1.1	Refueling Operations Boron Concentration

The cycle-specific parameter limits for the specifications listed above are presented in the following subsections. These limits have been developed using the NRC-approved methodologies specified in Technical Specification 6.9.1.6.b.

Cycle-specific values are presented in **bold**. Text in *italics* is provided for information only.

2.0 SAFETY LIMITS AND LIMITING SAFETY SYSTEM SETTINGS

2.1 Safety Limits

Reactor Core

2.1.1 The combination of THERMAL POWER, Reactor Coolant System highest loop average temperature, and pressurizer pressure shall not exceed the limits shown in **Figure 1**.

2.2 Limiting Safety System Settings

Reactor Trip System Instrumentation Setpoints

2.2.1 The Reactor Trip System Instrumentation and Interlock Setpoints shall be set consistent with the Nominal Trip Setpoint values shown in Table 2.2-1.

Table 2.2-1 Note 1: Overtemperature ΔT

$$\left(\frac{\Delta T}{\Delta T_0}\right)\frac{(1+\tau_1 s)}{(1+\tau_2 s)} \leq K_1 - K_2 \frac{(1+\tau_4 s)}{(1+\tau_5 s)}(T - T') + K_3 (P - P') - f_1(\Delta I)$$

Where:

ΔT is measured Reactor Coolant System ΔT, °F;

ΔT_0 is loop specific indicated ΔT at RATED THERMAL POWER, °F;

$\frac{(1+\tau_1 s)}{(1+\tau_2 s)}$ is the function generated by the lead-lag compensator on measured ΔT;

τ_1 and τ_2 are the time constants utilized in the lead-lag compensator for ΔT, $\tau_1 \geq$ **8 sec**, $\tau_2 \leq$ **3 sec**;

$K_1 \leq$ **1.20;**

$K_2 \geq$ **0.025 / °F;**

$\frac{(1+\tau_4 s)}{(1+\tau_5 s)}$ is the function generated by the lead-lag compensator for T_{avg};

τ_4 and τ_5 are the time constants utilized in the lead-lag compensator for T_{avg}, $\tau_4 \geq$ **20 sec**, $\tau_5 \leq$ **4 sec;**

T is measured Reactor Coolant System average temperature, °F;

T' is loop specific indicated T_{avg} at RATED THERMAL POWER, $\leq$ **587.1 °F**;

$K_3 \geq$ **0.00113 / psi;**

P is measured pressurizer pressure, psia;

P' is nominal pressurizer pressure, ≥ **2250 psia**;

s is the Laplace transform operator, sec^{-1};

and $f_1(\Delta I)$ is a function of the indicated difference between top and bottom detectors of the power range neutron ion chambers; with nominal gains to be selected based on measured instrument response during plant startup tests calibrations such that:

1. For $q_t - q_b$ between **-18%** and **+10%**, $f_1(\Delta I) \geq$ **0**, where q_t and q_b are percent RATED THERMAL POWER in the upper and lower halves of the core, respectively, and $q_t + q_b$ is the total THERMAL POWER in percent RATED THERMAL POWER;
2. For each percent that the magnitude of $q_t - q_b$ exceeds **-18%**, the ΔT Trip Setpoint shall be automatically reduced by ≥ **3.75%** of its value at RATED THERMAL POWER;
3. For each percent that the magnitude of $q_t - q_b$ exceeds **+10%**, the ΔT Trip Setpoint shall be automatically reduced by ≥ **2.14%** of its value at RATED THERMAL POWER.

Table 2.2-1 Note 3: Overpower ΔT

$$\left(\frac{\Delta T}{\Delta T_0}\right)\frac{(1+\tau_1 s)}{(1+\tau_2 s)} \leq K_4 - K_6\ (T - T")$$

Where:

ΔT is measured Reactor Coolant System ΔT, °F;

ΔT_0 is loop specific indicated ΔT at RATED THERMAL POWER, °F;

$\frac{(1+\tau_1 s)}{(1+\tau_2 s)}$ is the function generated by the lead-lag compensator on measured ΔT;

τ_1 and τ_2 are the time constants utilized in the lead-lag compensator for ΔT, $\tau_1 \geq$ **8 sec**, $\tau_2 \leq$ **3 sec**;

$K_4 \leq$ **1.10;**

T is measured average Reactor Coolant System temperature, °F;

T" is loop specific indicated T_{avg} at RATED THERMAL POWER, $\leq$ **587.1 °F**;

$K_6 \geq$ **0.0015 / °F** when T > T" and $K_6 \leq$ **0 / °F** when T $\leq$ T";

s is the Laplace transform operator, sec^{-1};

3.0/4.0 LIMITING CONDITIONS FOR OPERATION AND SURVEILLANCE REQUIREMENTS

3/4.1 Reactivity Control Systems

3/4.1.1.1 Boration Control

SHUTDOWN MARGIN - MODES 1 and 2

3.1.1.1.1 The SHUTDOWN MARGIN shall be greater than or equal to **1.3% Δk/k.**

The COLR limit of Specification 4.1.1.1.1 is defined in Specification 3.1.1.1.1.

SHUTDOWN MARGIN - MODES 3, 4 and 5 Loops Filled

3.1.1.1.2 The SHUTDOWN MARGIN shall be greater than or equal to the limits shown in

- **Figure 2** for MODE 3,
- **Figure 3** for MODE 4, and
- **Figure 4** for MODE 5 with RCS Loops Filled.

The COLR limit of Specification 4.1.1.1.2.1 is defined in Specification 3.1.1.1.2.

SHUTDOWN MARGIN - COLD SHUTDOWN - Loops Not Filled

3.1.1.2 The SHUTDOWN MARGIN shall be greater than or equal to

a. the limits shown in **Figure 5** for MODE 5 with RCS loops not filled or

b. the limits shown in **Figure 4** for MODE 5 with RCS loops filled with the chemical and volume control system (CVCS) aligned to preclude reactor coolant system boron concentration reduction.

The COLR limit of Specification 4.1.1.2.1 is defined in Specification 3.1.1.2.

Moderator Temperature Coefficient

3.1.1.3 The moderator temperature coefficient (MTC) shall be within the limits specified below:

The maximum upper limit shall be less positive than $+0.5 \times 10^{-4}$ Δk/k/°F for all the rods withdrawn, beginning of cycle life (BOL), condition for power levels up to 70% RATED THERMAL POWER with a linear ramp to 0 Δk/k/ °F at 100% RATED THERMAL POWER.

The MTC EOL limit is:

The ARO/EOL/RTP MTC shall be less negative than **-5.35×10^{-4} Δk/k/°F (-53.5 pcm/°F).**

The MTC 300 ppm surveillance limit is:

The 300 ppm/ARO/RTP MTC shall be less negative than or equal to **-4.6×10^{-4} Δk/k/°F (-46 pcm/°F).**

Where:

- BOL stands for Beginning of Cycle of Life
- ARO stands for All Rods Out
- EOL stands for End of Cycle Life
- RTP stands for RATED THERMAL POWER

The COLR limits of Specification 4.1.1.3 are defined by Specification 3.1.1.3 limits given above.

3/4.1.3 Moveable Control Assemblies

Shutdown Rod Insertion Limits

3.1.3.5 All shutdown rods shall be at least **225 steps** withdrawn

The COLR limit of Specification 4.1.3.5 is defined in Specification 3.1.3.5.

Control Rod Insertion Limits

3.1.3.6 The control banks shall be limited in physical insertion

- as shown in **Figure 6** for control banks B, C, and D, and
- control bank A shall be at least **225 steps** withdrawn

The insertion limits of Specification 4.1.3.6 are defined in Specification 3.1.3.6.

3/4.2 Power Distribution Limits

3/4.2.1 AXIAL FLUX DIFFERENCE

3.2.1.1 The indicated AXIAL FLUX DIFFERENCE (AFD) shall be maintained within the limits shown in **Figure 7**.

The AFD limits of Specifications 4.2.1.1.1 and 4.2.1.1.2 are defined in Specification 3.2.1.1.

3/4.2.2 Heat Flux Hot Channel Factor - $F_Q(Z)$

3.2.2.1 $F_Q(Z)$, as approximated by $F_Q^M(Z)$, shall be within the limits specified below:

$$F_Q^M(Z) \leq \frac{F_Q^{RTP}}{P} \times K(Z) \text{ ; for } P > 0.5$$

$$F_Q^M(Z) \leq \frac{F_Q^{RTP}}{0.5} \times K(Z) \text{ ; for } P \leq 0.5$$

Where: $P = \dfrac{THERMAL\ POWER}{RATED\ THERMAL\ POWER}$

F_Q^{RTP} = **2.60**

K(Z) = the normalized $F_Q(Z)$ as a function of core height as shown in **Figure 8**.

The Heat Flux Hot Channel Factor non-equilibrium limit is:

$$F_Q^M(Z) \leq \frac{F_Q^{RTP} \times K(Z)}{P \times N(Z)} \quad ; \text{for } P > 0.5$$

$$F_Q^M(Z) \leq \frac{F_Q^{RTP} \times K(Z)}{0.5 \times N(Z)} \quad ; \text{for } P \leq 0.5$$

Where: $P = \dfrac{THERMAL\ \ POWER}{RATED\ \ THERMAL\ \ POWER}$

F_Q^{RTP} = **2.60**

K(Z) = the normalized $F_Q(Z)$ as a function of core height as shown in **Figure 8**

$$N(z) = \frac{F_Q(z),\ \text{Maximum Condition I}}{F_Q(z),\ \text{Equilibrium Condition I}}$$

N(z) values are calculated for each flux map using analytically derived $F_Q(Z)$ values, consistent with the methodology described in VEP-NE-1.

The factors in **Table 1** shall be used for surveillance requirement 4.2.2.1.2.

The values provided in **Table 2** shall be used to reduce the normal operating space for $F_Q^M(Z)$ exceeding its non-equilibrium limits.

The Heat Flux Hot Channel Factor limits of Specifications 4.2.2.1.2 are defined in Specification 3.2.2.1 and the Heat Flux Hot Channel Factor non-equlibrium limit given above.

3/4.2.3 RCS Flow Rate and Nuclear Enthalpy Rise Hot Channel Factor

3.2.3.1 The indicated Reactor Coolant System (RCS) total flow rate and $F^N_{\Delta H}$ shall be maintained as follows:

a. RCS Total Flow Rate ≥ 363,200 gpm and greater than or equal to **379,200 gpm**, and

b. $F^N_{\Delta H} \leq F^{RTP}_{\Delta H}\,[1.0 + PF_{\Delta H}\,(1.0 - P)]$

Where: $P = \dfrac{THERMAL\ \ POWER}{RATED\ \ THERMAL\ \ POWER}$

$F^{RTP}_{\Delta H}$ = $F^N_{\Delta H}$ limit at RATED THERMAL POWER = **1.586**

$PF_{\Delta H}$ = the power factor multiplier for $F^N_{\Delta H}$ = **0.3 for P < 1.0**

The COLR limits of Specification 4.2.3.1.3 are defined in Specification 3.2.3.1.a.

3/4.2.5 DNB Parameters

3.2.5 The following DNB-related parameters shall be maintained within the limits specified below

a. Reactor Coolant System T_{avg} shall be maintained ≤ **593.5°F**

b. Pressurizer Pressure shall be maintained ≥ **2204 psia**[1]

The COLR limits of Specification 4.2.5 are defined in Specification 3.2.5.

[1]Limit not applicable during either a THERMAL POWER ramp in excess of 5% of RATED THERMAL POWER per minute or a THERMAL POWER step in excess of 10% of RATED THERMAL POWER.

3/4.3 Instrumentation

3/4.3.5 Shutdown Margin Monitor

3.3.5 Two channels of Shutdown Margin Monitors shall be OPERABLE

a. With a minimum count rate and alarm ratio setting as shown below, or

b. If the minimum count rate in Specification 3.3.5.a cannot be met, then the Shutdown Margin Monitors may be made OPERABLE with a lower minimum count rate and alarm ratio setting as shown below by borating the Reactor Coolant System above the requirements of Specification 3.1.1.1.2 or 3.1.1.2. The additional boration shall be:

1. A minimum of 150 ppm above the SHUTDOWN MARGIN requirements specified in **Figure 2** for MODE 3, or

2. A minimum of 350 ppm above the SHUTDOWN MARGIN requirements specified in the

- **Figure 3** for MODE 4
- **Figure 4** for MODE 5 with RCS loops filled, and
- **Figure 5** for MODE 5 with RCS loops not filled.

Tech. Spec. LCO	SMM Alarm Ratio Setting	Min. Count Rate (counts/sec)
3.3.5.a	**1.50**	**1.0**
	1.25	**0.6**
3.3.5.b.1	**1.50**	**0.50**
	1.25	**0.35**
3.3.5.b.2	**1.50**	**0.35**
	1.25	**0.25**

The combination of the SMM Alarm Ratio setting and minimum count rate accounts for the time lag between the indicated and actual count rates, as well as other uncertainties. The specified SMM Alarm Ratio setting ensures that the assumption that an alarm is generated at flux doubling in the Boron Dilution Event analysis remain valid. The count rate is displayed on the SMM.

The COLR limits of Specification 4.3.5 are defined in Specification 3.3.5.

3/4.9 Refueling Operations

3/4.9.1 Boron Concentration

3.9.1.1 The boron concentration of all filled portions of the Reactor Coolant System and the refueling canal shall be maintained sufficient to ensure that the more restrictive of the following reactivity conditions is met; either:

a. A K_{eff} of 0.95 or less, or

b. A boron concentration of greater than or equal to **2600 ppm**[2]

Additionally, the CVCS valves of Specification 4.1.1.2.2 shall be closed and secured in position.

[2]This boron concentration bounds the condition of keff ≤ 0.95 (all rods in less the most reactive two rods) and subcriticality (keff ≤ 1.0 with all rods out).

Figure 1—Reactor Core Safety Limits

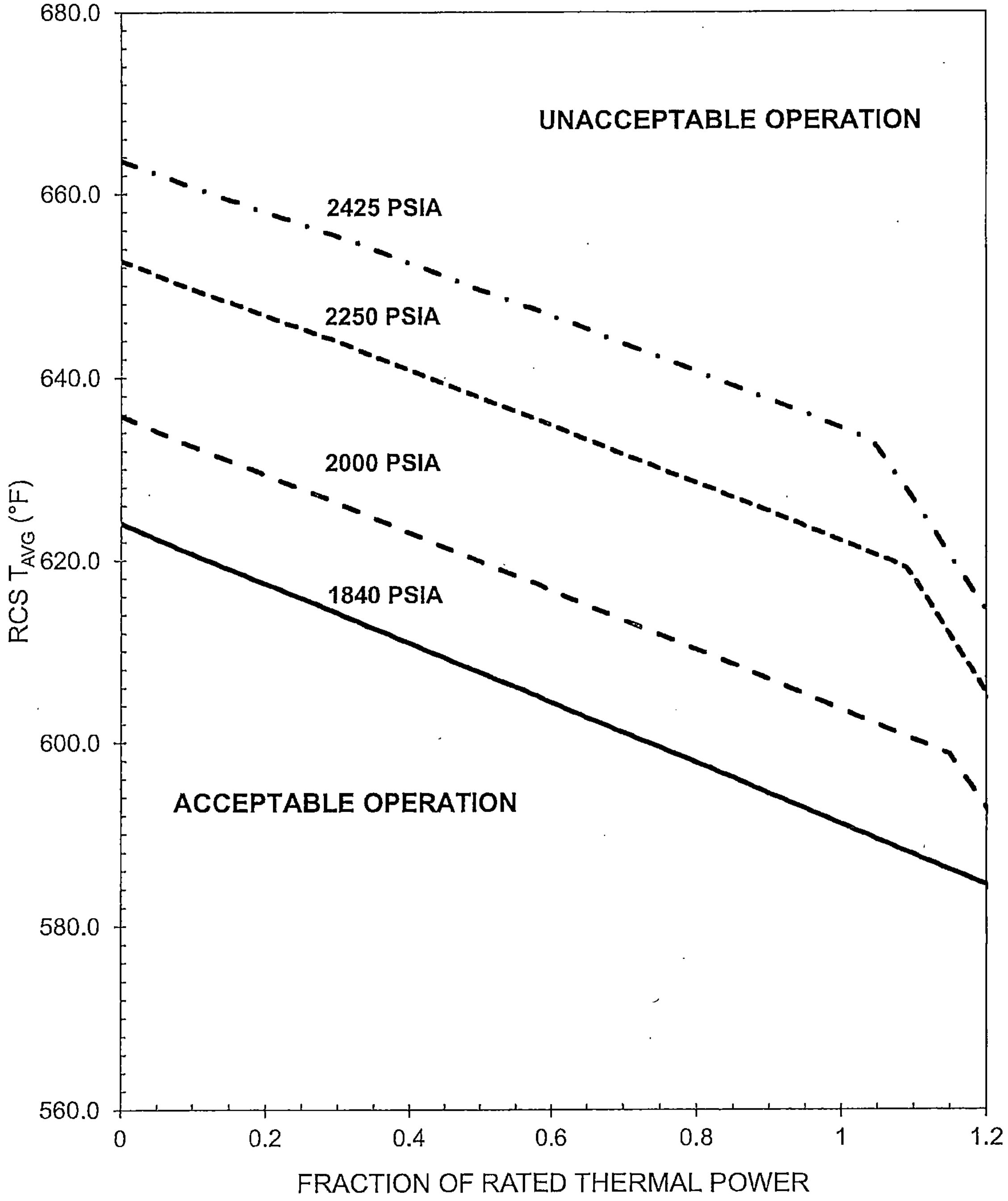


Figure 2—Required SHUTDOWN MARGIN for MODE 3

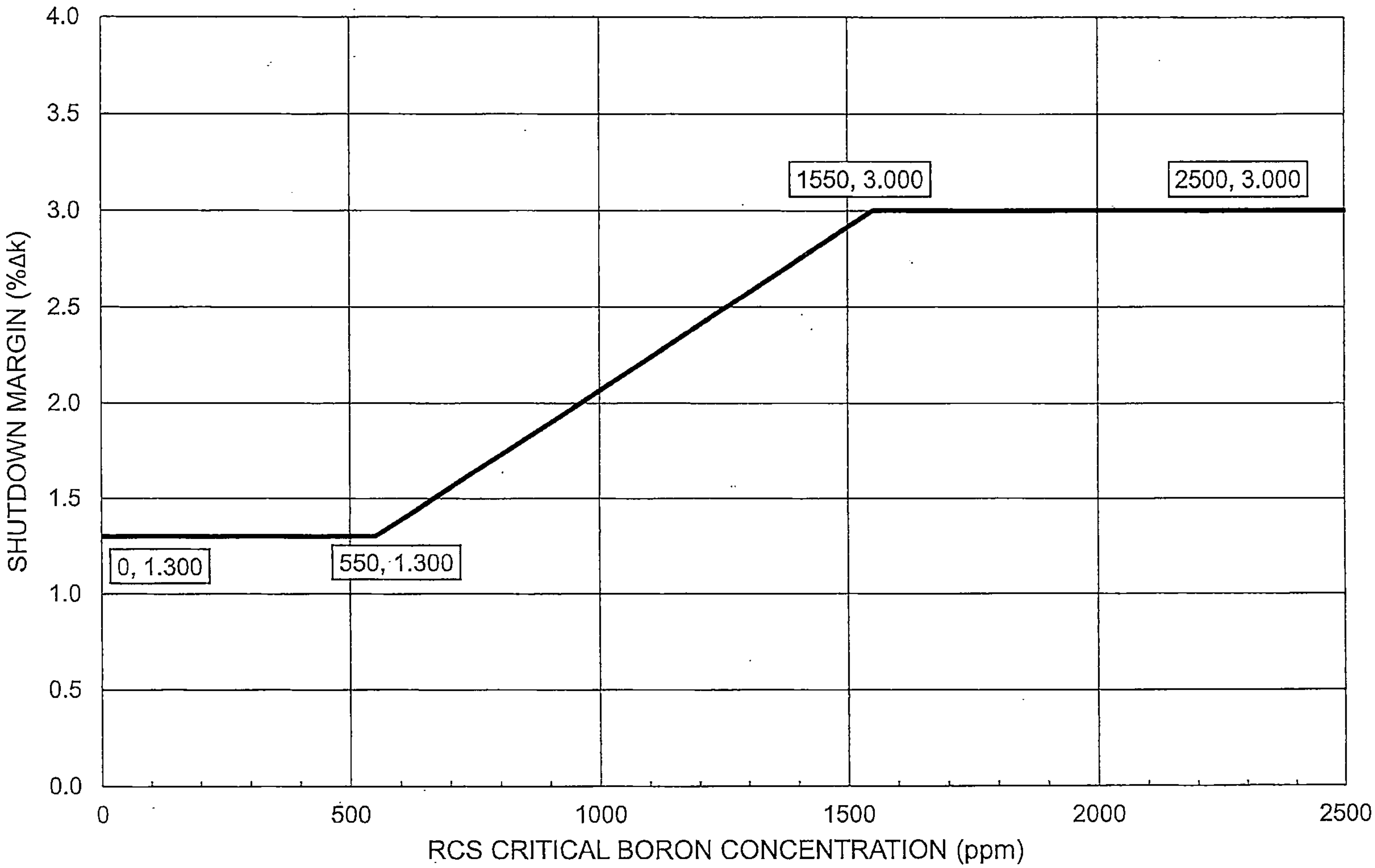


Figure 3—Required SHUTDOWN MARGIN for MODE 4

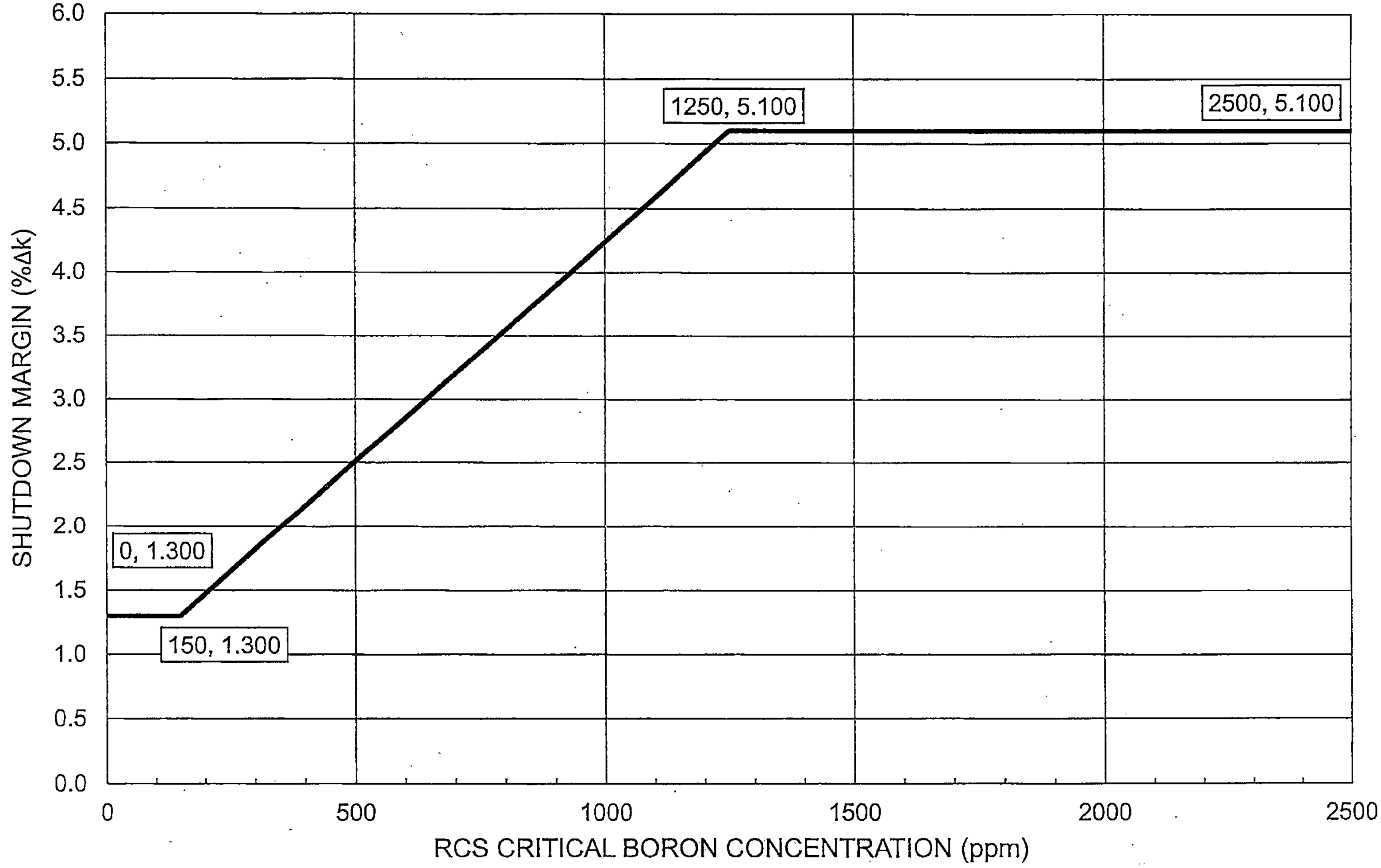


Figure 4—Required SHUTDOWN MARGIN for MODE 5 with RCS Loops Filled

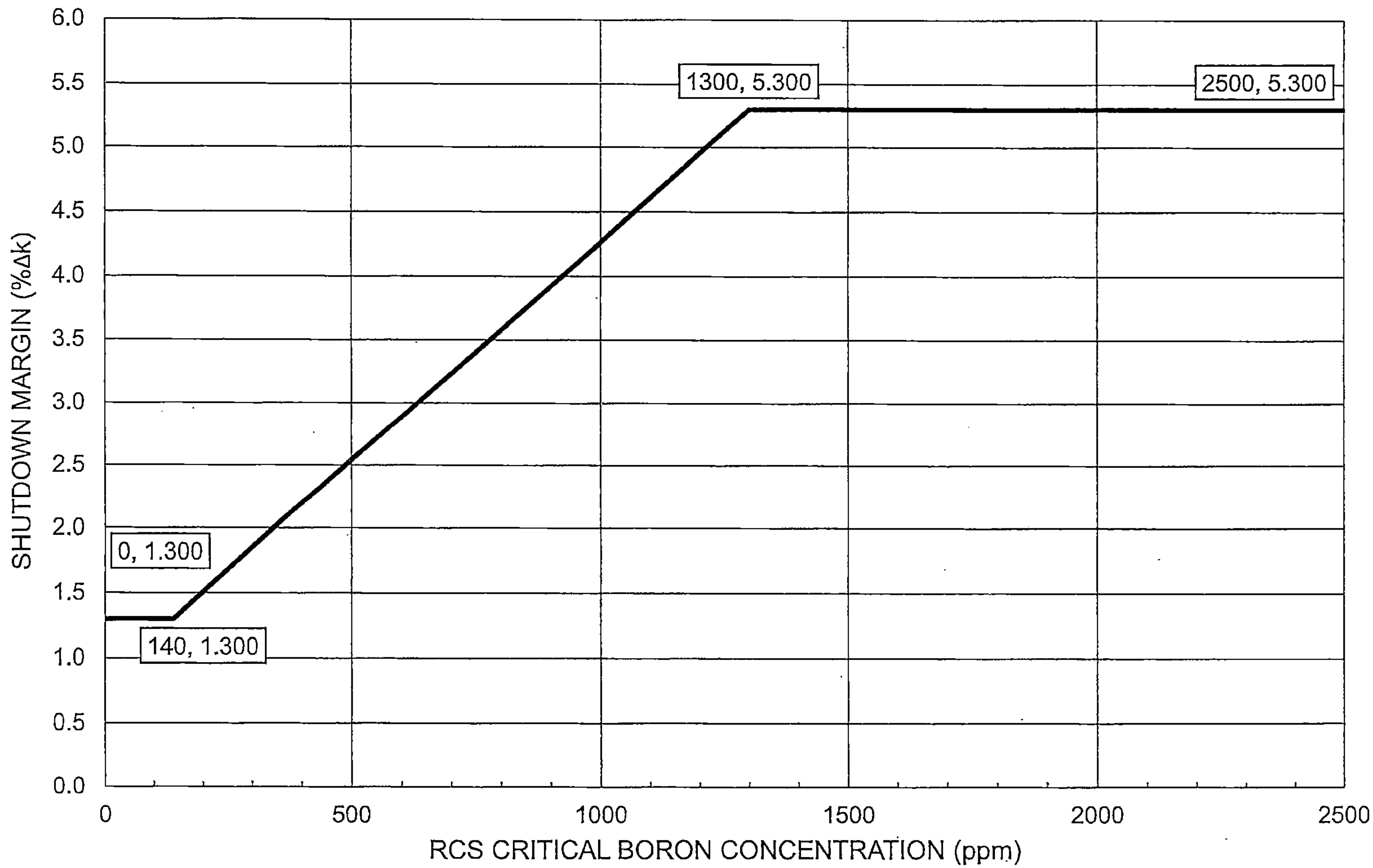


Figure 5—Required SHUTDOWN MARGIN for COLD SHUTDOWN with RCS Loops Not Filled

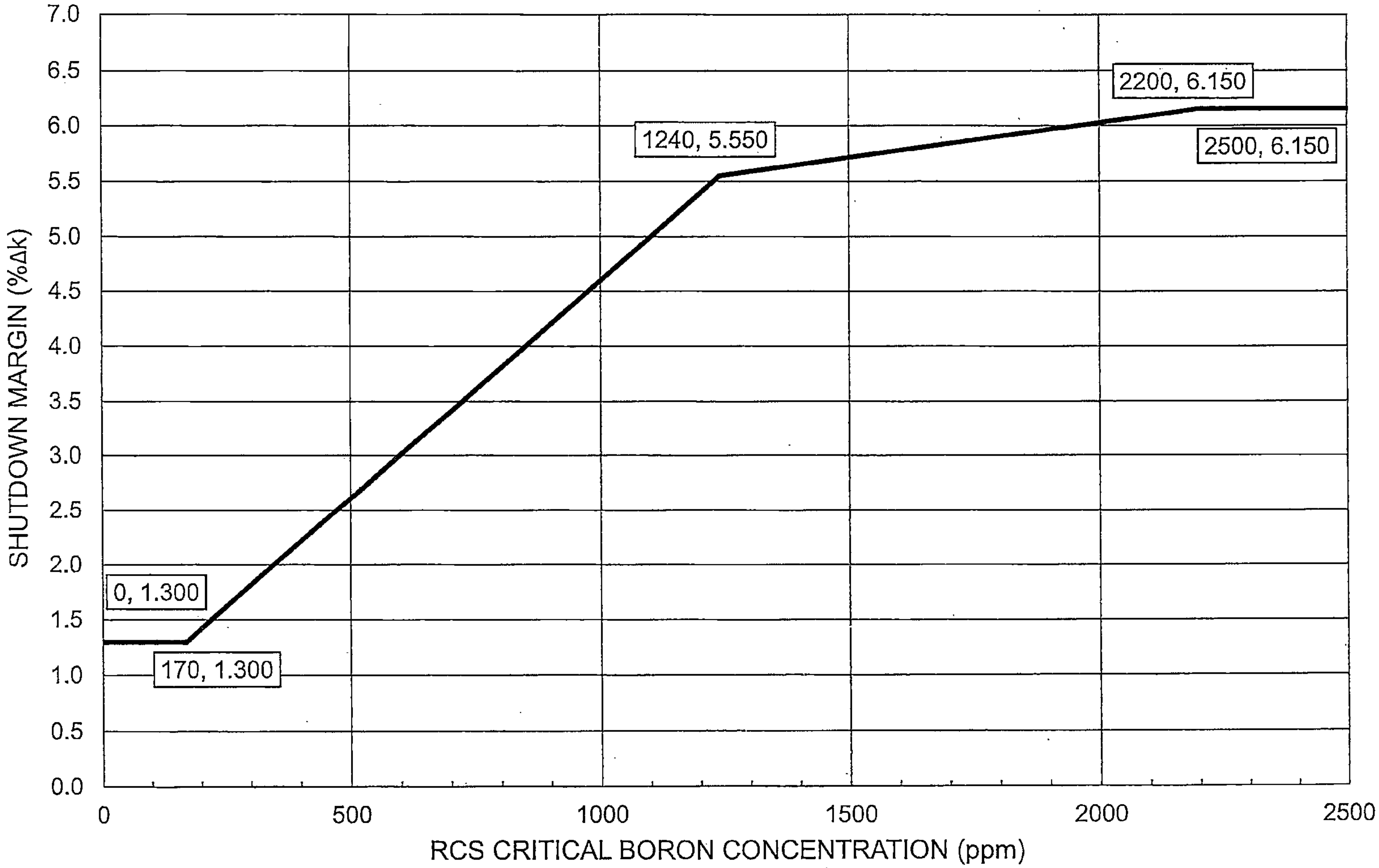


Figure 6—Control Rod Bank Insertion Limits versus RATED THERMAL POWER

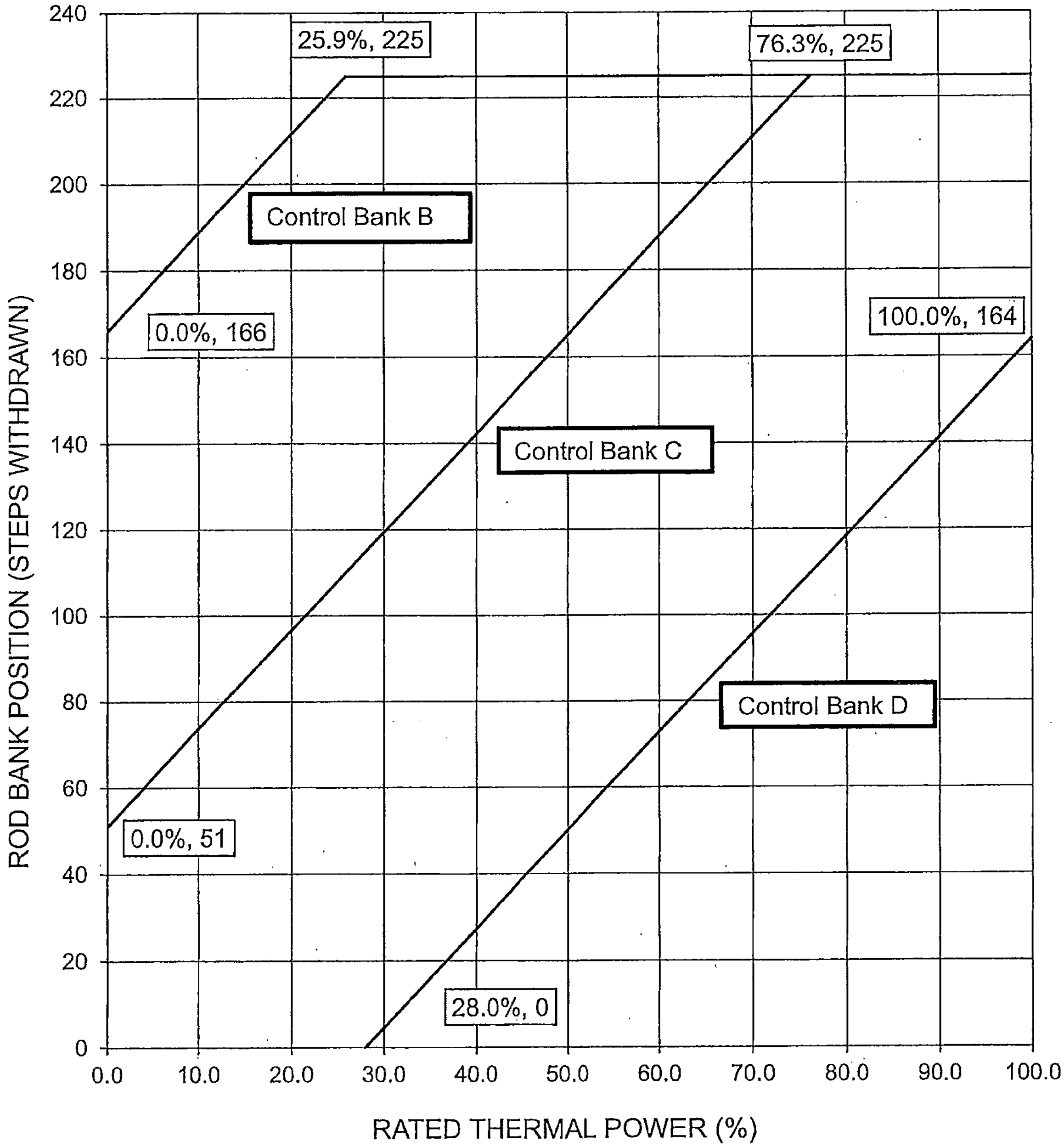


Figure 7—AXIAL FLUX DIFFERENCE Limits as a Function of RATED THERMAL POWER

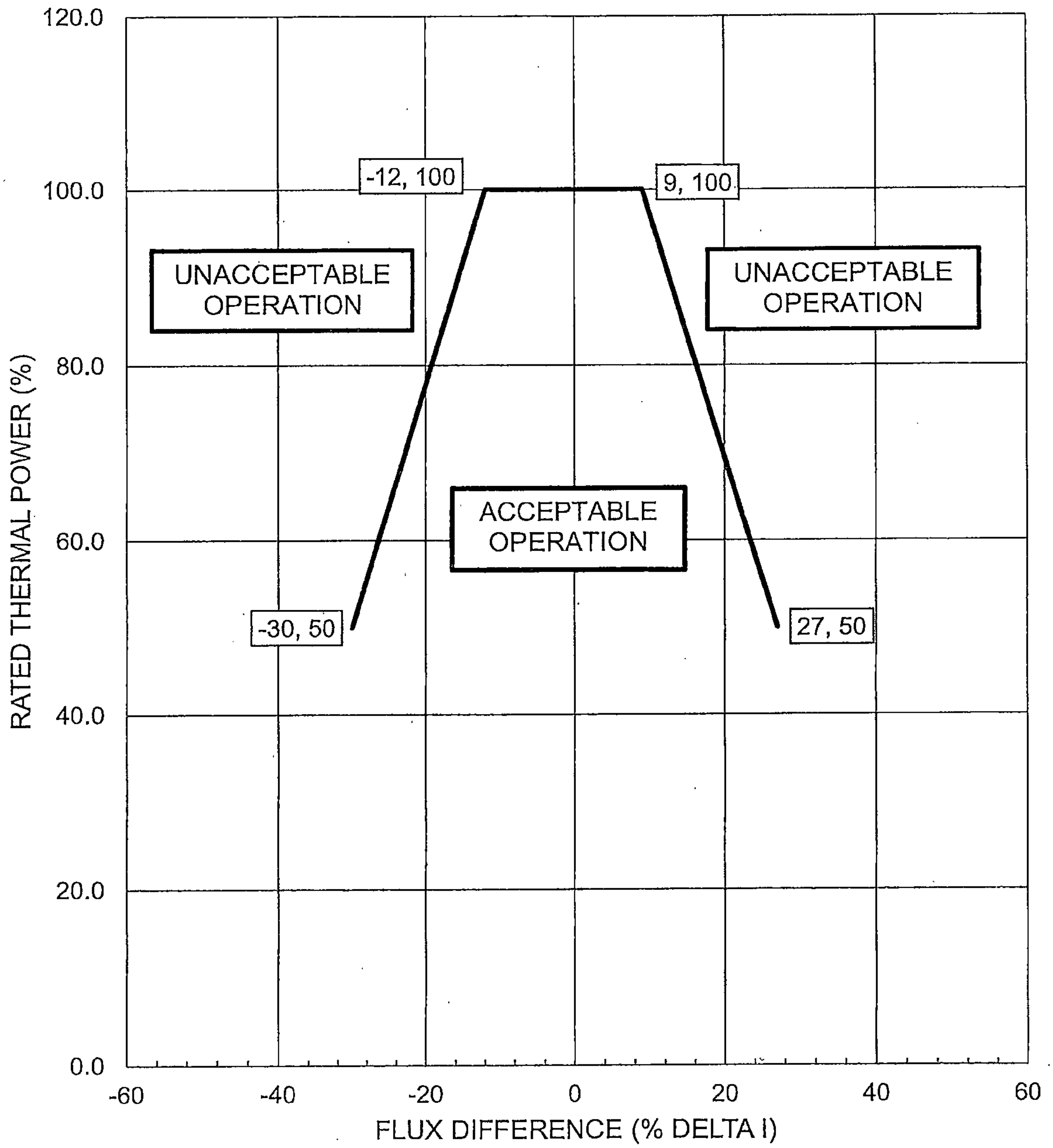
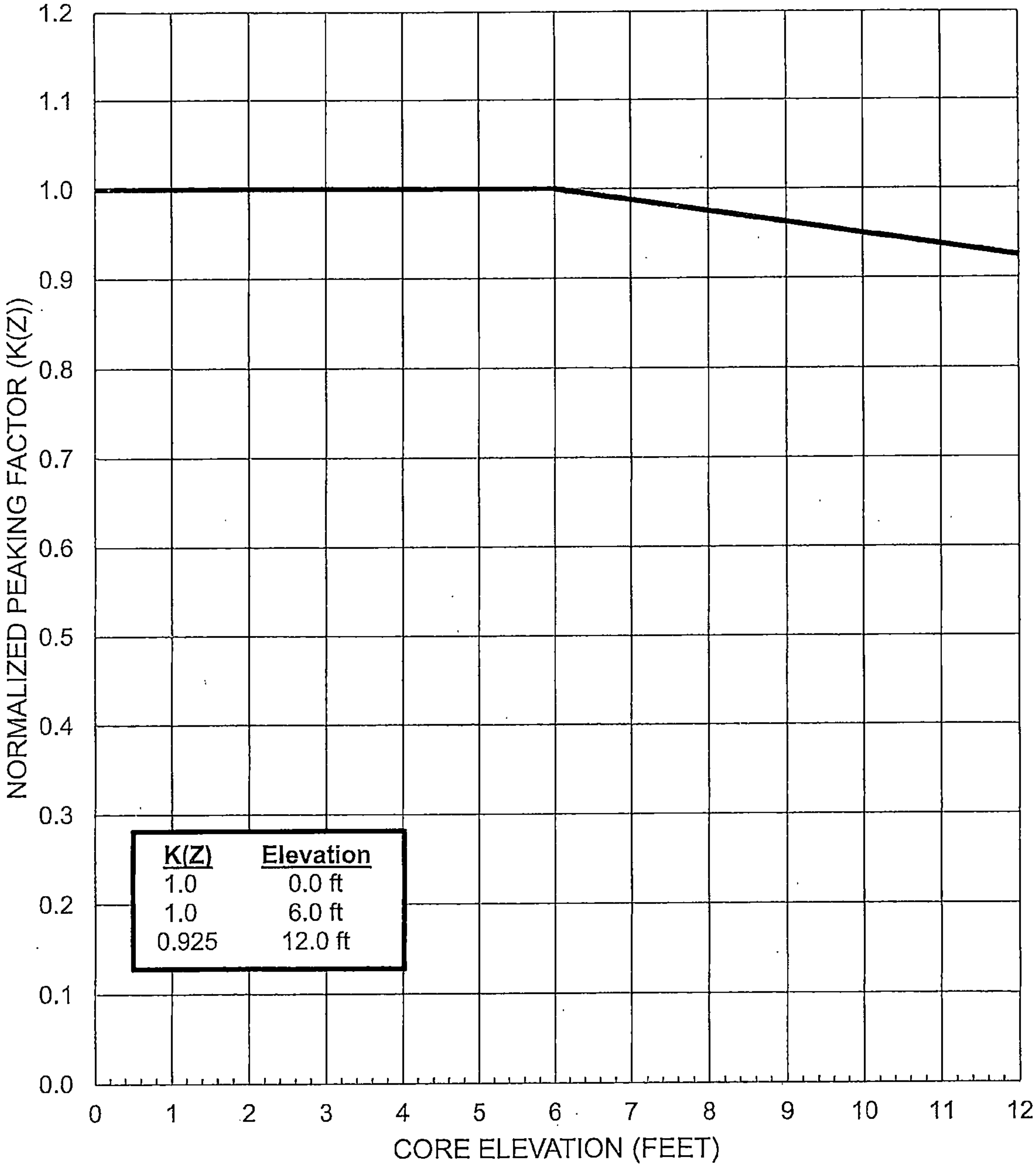


Figure 8—K(Z) - Normalized $F_Q(Z)$ as a Function of Core Height



K(Z)	Elevation
1.0	0.0 ft
1.0	6.0 ft
0.925	12.0 ft

Table 1
Penalty Factors for Flux Map Analysis

Burnup (MWD/MTU)	Penalty (%)
0-999	4.0
1000-1999	3.0
2000-2999	2.0
3000-3999	2.0
4000-4999	2.0
5000-6999	2.0
7000-8999	2.0
9000-10999	2.0
11000-12999	2.0
13000-14999	2.0
15000-16999	2.0
17000-18999	2.0
19000-EOC	2.0

Table 2
Required Normal Operating Space Reductions for $F_Q(Z)$ Exceeding Its Non-Equilibrium Limits

Required Non-Equilibrium $F_Q(Z)$ Margin Improvement (%)	Required THERMAL POWER Limit (%RTP)	Required Negative Band AFD Reduction (%AFD)	Required Positive Band AFD Reduction (%AFD)
> 0% and ≤ 1%	≤ 99.0%	≥ 1.5%	≥ 1.5%
> 1% and ≤ 2%	≤ 97.0%	≥ 1.5%	≥ 2.5%
> 2% and ≤ 3%	≤ 96.0%	≥ 3.0%	≥ 4.0%
> 3%	≤ 50%	N/A	N/A

*AFD Limits are provided in COLR Figure 7.

ANAYLTICAL METHODS / REFERENCES

The analytical methods used to determine the core operating limits shall be those previously reviewed and approved by the NRC, specifically those described in the following documents.

1. VEP-FRD-42-A, Revision 2, Minor Revision 2, "Reload Nuclear Design Methodology," October 2017.

   Methodology for Specifications:

   - 2.1.1 Reactor Core Safety Limits
   - 3.1.1.1.1 SHUTDOWN MARGIN – MODES 1 AND 2
   - 3.1.1.1.2 SHUTDOWN MARGIN – MODES 3, 4, and 5 Loops Filled
   - 3.1.1.2 SHUTDOWN MARGIN – COLD SHUTDOWN – Loops Not Filled
   - 3.1.1.3 Moderator Temperature Coefficient
   - 3.1.3.5 Shutdown Rod Insertion Limits
   - 3.1.3.6 Control Rod Insertion Limits
   - 3.2.2.1 Heat Flux Hot Channel Factor
   - 3.2.3.1 Nuclear Enthalpy Rise Hot Channel Factor
   - 3.3.5 Shutdown Margin Monitor
   - 3.9.1.1 Refueling Operations Boron Concentration

2. VEP-NE-1-A, Revision 0, Minor Revision 3, "Relaxed Power Distribution Control Methodology and Associated FQ Surveillance Technical Specifications," October 2017.

   Methodology for Specifications:

   - 3.2.1.1 AXIAL FLUX DIFFERENCE
   - 3.2.2.1 Heat Flux Hot Channel Factor

3. WCAP-16009-P-A, "Realistic Large-Break LOCA Evaluation Methodology Using the Automated Statistical Treatment of Uncertainty Method (ASTRUM)," January 2005 (Westinghouse Proprietary).

   Methodology for Specification:

   - 3.2.2.1 Heat Flux Hot Channel Factor

4. WCAP-10054-P-A, "Westinghouse Small Break ECCS Evaluation Model Using the NOTRUMP Code," August 1985 (Westinghouse Proprietary).

   Methodology for Specification:

   - 3.2.2.1 Heat Flux Hot Channel Factor

5. WCAP-10054-P-A, Addendum 2, Revision 1, "Addendum to the Westinghouse Small Break ECCS Evaluation Model Using the NOTRUMP Code: Safety Injection into the Broken Loop and COSI Condensation Model," July 1997 (Westinghouse Proprietary).

   Methodology for Specification:

   - 3.2.2.1 Heat Flux Hot Channel Factor

6. WCAP-10079-P-A, "NOTRUMP - A Nodal Transient Small Break and General Network Code," August 1985 (Westinghouse Proprietary).

   Methodology for Specification:

   - 3.2.2.1 Heat Flux Hot Channel Factor

7. WCAP-12610-P-A, "VANTAGE+ Fuel Assembly Report," April 1995 (Westinghouse Proprietary).

   Methodology for Specification:

   - 3.2.2.1 Heat Flux Hot Channel Factor

8. WCAP-12610-P-A & CENPD-404-P-A, Addendum 1-A, "Optimized ZIRLO™," July 2006 (Westinghouse Proprietary).

   Methodology for Specification:

   - 3.2.2.1 Heat Flux Hot Channel Factor

9. WCAP-11946, "Safety Evaluation Supporting a More Negative EOL Moderator Temperature Coefficient Technical Specification for the Millstone Nuclear Power Station Unit 3," September 1988 (Westinghouse Proprietary).

   Methodology for Specification:

   - 3.1.1.3 Moderator Temperature Coefficient

10. WCAP-8745-P-A, "Design Bases for the Thermal Overpower ΔT and Thermal Overtemperature ΔT Trip Functions," September 1986 (Westinghouse Proprietary).

    Methodology for Specification:

    - 2.2.1 Overtemperature ΔT and Overpower ΔT Setpoints

11. VEP-NE-2-A, Revision 0, "Statistical DNBR Evaluation Methodology," June 1987.

    Methodology for Specification:

    - 3.2.3.1 RCS Flow Rate, Nuclear Enthalpy Rise Hot Channel Factor
    - 3.2.5 DNB Parameters

12. DOM-NAF-2-P-A, Revision 0, Minor Revision 3, "Reactor Core Thermal-Hydraulics Using the VIPRE-D Computer Code," including Appendix C, "Qualification of the Westinghouse WRB-2M CHF Correlation in the Dominion VIPRE-D Computer Code," and Appendix D, "Qualification of the ABB-NV and WLOP CHF Correlations in the Dominion VIPRE-D Computer Code," September 2014.

    Methodology for Specification:

    - 3.2.3.1 RCS Flow Rate, Nuclear Enthalpy Rise Hot Channel Factor
    - 3.2.5 DNB Parameters