VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

November 9, 2022

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

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VIRGINIA ELECTRIC AND POWER COMPANY (DOMINION ENERGY VIRGINIA)
NORTH ANNA POWER STATION UNIT 1
CORE OPERATING LIMITS REPORT
NORTH ANNA UNIT 1, CYCLE 30, PATTERN AOD, REVISION 1

The North Anna Power Station Unit 1 Core Operating Limits Report (COLR) has been revised to reflect the reload design evaluations supporting Cycle 30 as a result of reload pattern re-design. Therefore, pursuant to Technical Specification 5.6.5.d, attached is a copy of the COLR for North Anna Unit 1, Cycle 30, Pattern AOD, Revision 1.

If you have any questions or require additional information, please contact Yan Gao at (804) 273-2768.

Sincerely,

B. E. Standley

B. E. Standley, Director

Nuclear Regulatory Affairs
Dominion Energy Services, Inc. for
Virginia Electric and Power Company

Attachment: COLR-N1C30, Revision 1, Core Operating Limits Report

Commitments: None.

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ATTACHMENT

COLR-N1C30, Revision 1

Core Operating Limits Report

NORTH ANNA POWER STATION UNIT 1
VIRGINIA ELECTRIC AND POWER COMPANY
(DOMINION ENERGY VIRGINIA)

N1C30 CORE OPERATING LIMITS REPORT

INTRODUCTION

The Core Operating Limits Report (COLR) for North Anna Unit 1 Cycle 30 has been prepared in accordance with North Anna Technical Specification 5.6.5. The technical specifications affected by this report are listed below:

TS 2.1.1	Reactor Core Safety Limits
TS 3.1.1	Shutdown Margin (SDM)
TS 3.1.3	Moderator Temperature Coefficient (MTC)
TS 3.1.4	Rod Group Alignment Limits
TS 3.1.5	Shutdown Bank Insertion Limit
TS 3.1.6	Control Bank Insertion Limits
TS 3.1.9	PHYSICS TESTS Exceptions – Mode 2
TS 3.2.1	Heat Flux Hot Channel Factor
TS 3.2.2	Nuclear Enthalpy Rise Hot Channel Factor ($F^N_{\Delta H}$)
TS 3.2.3	Axial Flux Difference (AFD)
TS 3.3.1	Reactor Trip System (RTS) Instrumentation
TS 3.4.1	RCS Pressure, Temperature, and Flow DNB Limits
TS 3.5.6	Boron Injection Tank (BIT)
TS 3.9.1	Boron Concentration

In addition, a technical requirement (TR) in the NAPS Technical Requirements Manual (TRM) refers to the COLR:

TR 3.1.1	Boration Flow Paths – Operating

The analytical methods used to determine the core operating limits are those previously approved by the NRC and discussed in the documents listed in the References Section.

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

REFERENCES

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

   Methodology for:
   TS 3.1.1 – Shutdown Margin
   TS 3.1.3 – Moderator Temperature Coefficient
   TS 3.1.4 – Rod Group Alignment Limits
   TS 3.1.5 – Shutdown Bank Insertion Limit
   TS 3.1.6 – Control Bank Insertion Limits
   TS 3.1.9 – Physics Tests Exceptions – Mode 2
   TS 3.2.1 – Heat Flux Hot Channel Factor
   TS 3.2.2 – Nuclear Enthalpy Rise Hot Channel Factor
   TS 3.5.6 – Boron Injection Tank (BIT) and
   TS 3.9.1 – Boron Concentration

2. WCAP-16996-P-A, Rev. 1, "Realistic LOCA Evaluation Methodology Applied to the Full Spectrum of Break Sizes (FULL SPECTRUM LOCA Methodology)," November 2016.

   Methodology for: TS 3.2.1 – Heat Flux Hot Channel Factor

3. EMF-2328(P)(A), "PWR Small Break LOCA Evaluation Model, S-RELAP5 Based," as supplemented by ANP-3467P, Revision 0, "North Anna Fuel-Vendor Independent Small Break LOCA Analysis," as approved by NRC Safety Evaluation Report dated March 19, 2021.

   Methodology for: TS 3.2.1 – Heat Flux Hot Channel Factor

4. WCAP-12610-P-A, "VANTAGE+ FUEL ASSEMBLY – REFERENCE CORE REPORT," April 1995.

   Methodology for:
   TS 2.1.1 – Reactor Core Safety Limits
   TS 3.2.1 – Heat Flux Hot Channel Factor

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

   Methodology for:
   TS 3.2.2 – Nuclear Enthalpy Rise Hot Channel Factor and
   TS 3.4.1 – RCS Pressure, Temperature and Flow DNB Limits

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

   Methodology for:
   TS 3.2.1 – Heat Flux Hot Channel Factor and
   TS 3.2.3 – Axial Flux Difference

7. WCAP-8745-P-A, "Design Bases for the Thermal Overpower ΔT and Thermal Overtemperature ΔT Trip Functions," September 1986.

   Methodology for:
   TS 2.1.1 – Reactor Core Safety Limits and
   TS 3.3.1 – Reactor Trip System Instrumentation

8. WCAP-14483-A, "Generic Methodology for Expanded Core Operating Limits Report," January 1999.

   Methodology for:
   TS 2.1.1 – Reactor Core Safety Limits
   TS 3.1.1 – Shutdown Margin
   TS 3.1.4 – Rod Group Alignment Limits
   TS 3.1.9 – Physics Tests Exceptions – Mode 2
   TS 3.3.1 – Reactor Trip System Instrumentation
   TS 3.4.1 – RCS Pressure, Temperature, and Flow DNB Limits
   TS 3.5.6 – Boron Injection Tank (BIT) and
   TS 3.9.1 – Boron Concentration

9. 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," August 2010 and Appendix D, "Qualification of the ABB-NV and WLOP CHF Correlations in the Dominion VIPRE-D Computer Code," September 2014.

   Methodology for:
   TS 3.2.2 – Nuclear Enthalpy Rise Hot Channel Factor and
   TS 3.4.1 – RCS Pressure, Temperature and Flow DNB Limits

10. WCAP-12610-P-A and CENPD-404-P-A, Addendum 1-A, "Optimized ZIRLO™," July 2006.

    Methodology for:
    TS 2.1.1 – Reactor Core Safety Limits and
    TS 3.2.1 – Heat Flux Hot Channel Factor

2.0 SAFETY LIMITS (SLs)

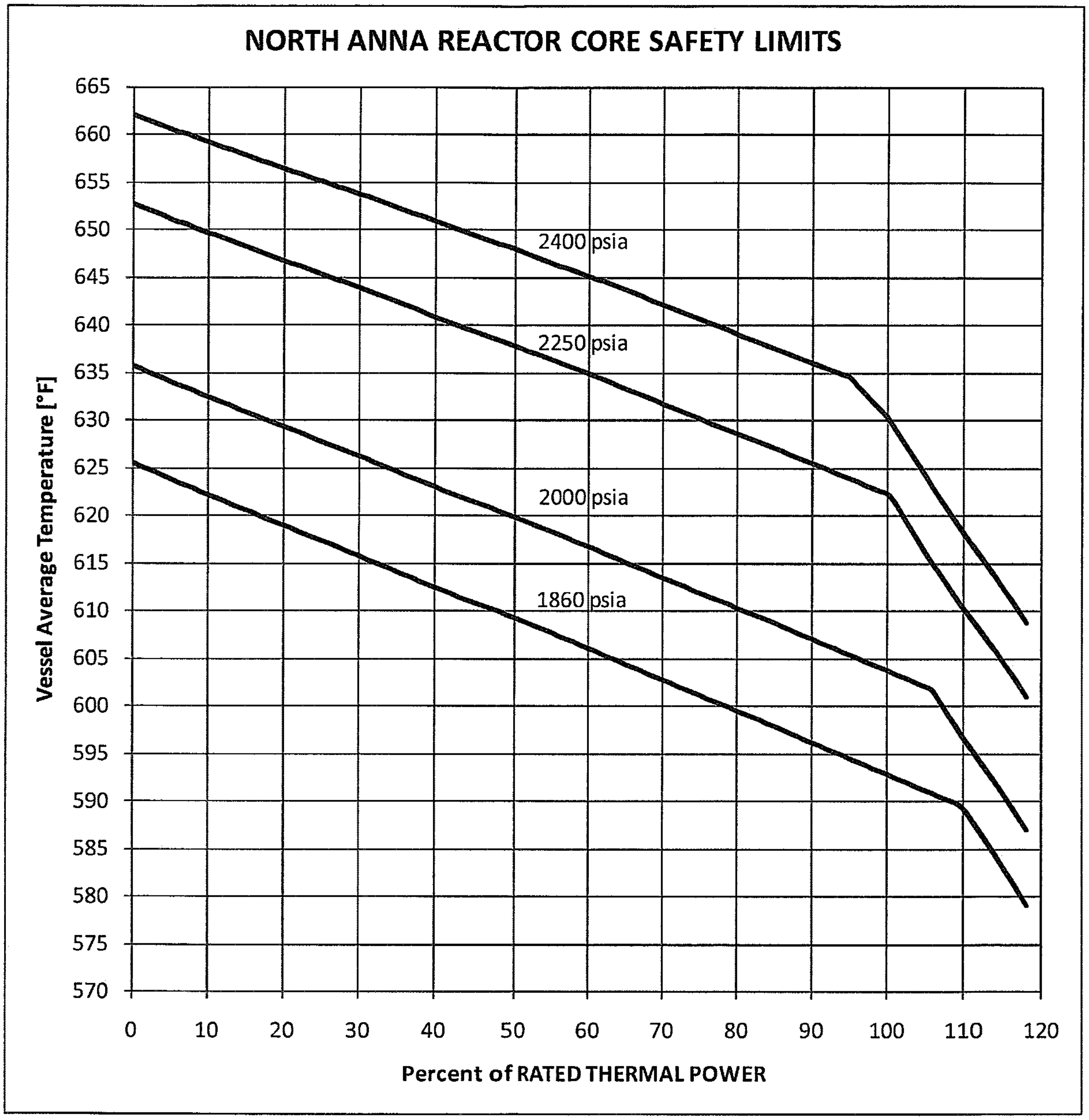
2.1 SLs

2.1.1 Reactor Core SLs

In MODES 1 and 2, the combination of THERMAL POWER, Reactor Coolant System (RCS) highest loop average temperature, and pressurizer pressure shall not exceed the limits specified in **COLR Figure 2.1-1**; and the following SLs shall not be exceeded.

2.1.1.1 The departure from nucleate boiling ratio (DNBR) shall be maintained greater than or equal to the 95/95 DNBR criterion for the DNB correlations and methodologies specified in the References Section.

COLR Figure 2.1-1



3.1 REACTIVITY CONTROL SYSTEMS

3.1.1 SHUTDOWN MARGIN (SDM)

LCO 3.1.1 SDM shall be **$\geq$ 1.77 % Δk/k.**

3.1.3 Moderator Temperature Coefficient (MTC)

LCO 3.1.3 The MTC shall be maintained within the limits specified below. The upper limit of MTC is **+0.6 x 10^{-4} Δk/k/°F**, when < 70% RTP, and **0.0 Δk/k/°F** when ≥ 70% RTP.

The BOC/ARO-MTC shall be **≤ +0.6 x 10^{-4} Δk/k/°F** (upper limit), when < 70% RTP, and **≤ 0.0 Δk/k/°F** when ≥ 70% RTP.

The EOC/ARO/RTP-MTC shall be less negative than **–5.0 x 10^{-4} Δk/k/°F** (lower limit).

The MTC surveillance limits are:

The 300 ppm/ARO/RTP-MTC should be less negative than or equal to **–4.0 x 10^{-4} Δk/k/°F** [Note 1].

The 60 ppm/ARO/RTP-MTC should be less negative than or equal to **–4.7 x 10^{-4} Δk/k/°F** [Note 2].

SR 3.1.3.2 Verify MTC is within **–5.0 x 10^{-4} Δk/k/°F** (lower limit).

Note 1: If the MTC is more negative than **–4.0 x 10^{-4} Δk/k/°F**, SR 3.1.3.2 shall be repeated once per 14 EFPD during the remainder of the fuel cycle.

Note 2: SR 3.1.3.2 need not be repeated if the MTC measured at the equivalent of equilibrium RTP-ARO boron concentration of ≤ 60 ppm is less negative than **–4.7 x 10^{-4} Δk/k/°F.**

3.1.4 Rod Group Alignment Limits

Required Action A.1.1 Verify SDM to be ≥ **1.77 % Δk/k.**

Required Action B.1.1 Verify SDM to be ≥ **1.77 % Δk/k.**

Required Action D.1.1 Verify SDM to be ≥ **1.77 % Δk/k.**

3.1.5 Shutdown Bank Insertion Limits

LCO 3.1.5 Each shutdown bank shall be withdrawn to at least **225** steps.

Required Action A.1.1 Verify SDM to be ≥ **1.77 % Δk/k.**

Required Action B.1 Verify SDM to be ≥ **1.77 % Δk/k.**

SR 3.1.5.1 Verify each shutdown bank is withdrawn to at least **225** steps.

3.1.6 Control Bank Insertion Limits

LCO 3.1.6 Control banks shall be limited in physical insertion as shown in **COLR Figure 3.1-1.** Sequence of withdrawal shall be A, B, C and D, in that order; and the overlap limit during withdrawal shall be **97** steps.

Required Action A.1.1 Verify SDM to be ≥ **1.77 % Δk/k.**

Required Action B.1.1 Verify SDM to be ≥ **1.77 % Δk/k.**

Required Action C.1 Verify SDM to be ≥ **1.77 % Δk/k.**

SR 3.1.6.1 Verify estimated critical control bank position is within the insertion limits specified in **COLR Figure 3.1-1.**

SR 3.1.6.2 Verify each control bank is within the insertion limits specified in **COLR Figure 3.1-1**.

SR 3.1.6.3 Verify each control bank not fully withdrawn from the core is within the sequence and overlap limits specified in **LCO 3.1.6 above.**

3.1.9 PHYSICS TESTS Exceptions – MODE 2

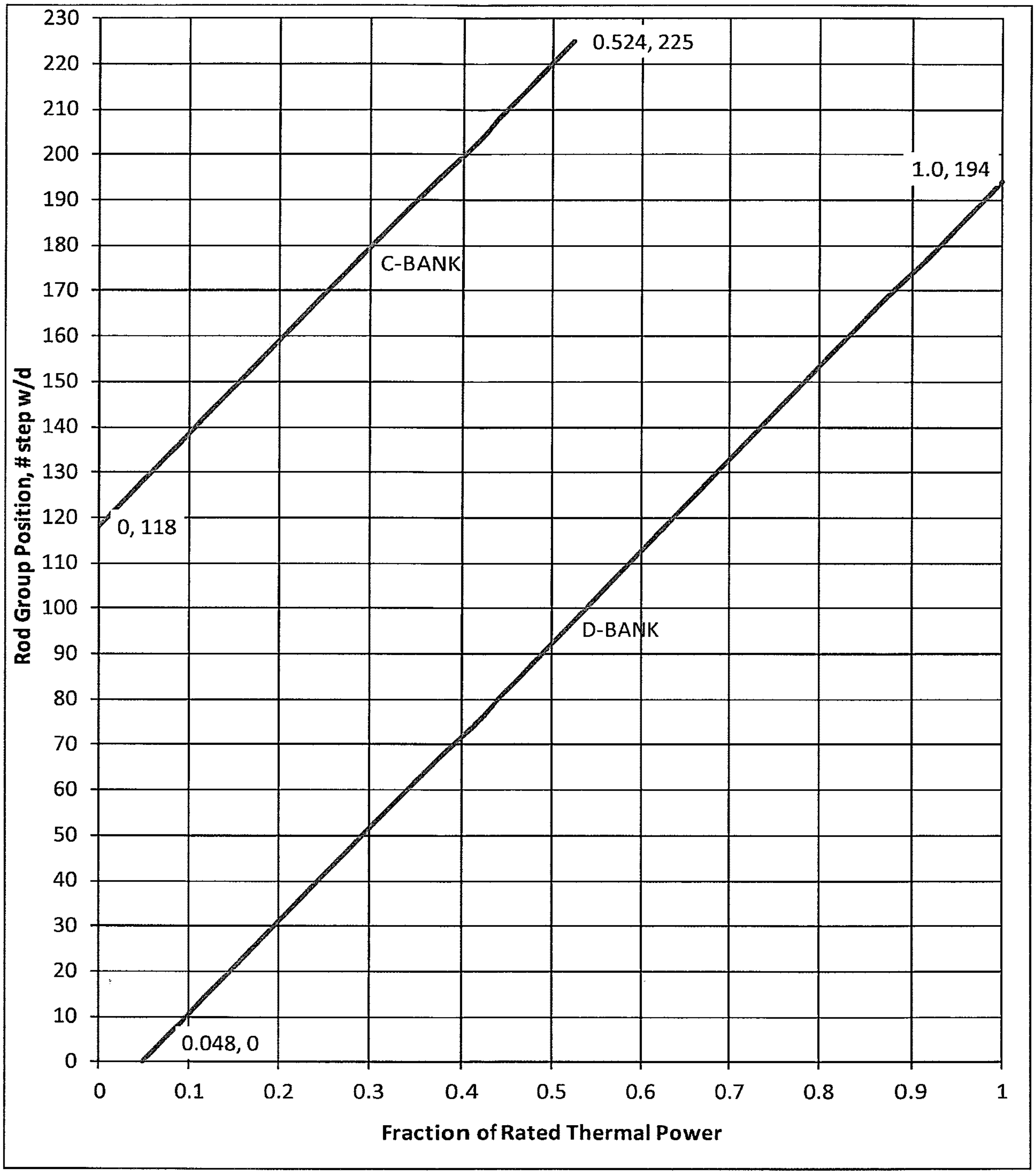
LCO 3.1.9.b SDM is ≥ **1.77 % Δk/k.**

SR 3.1.9.4 Verify SDM to be ≥ **1.77 % Δk/k.**

COLR Figure 3.1-1

North Anna 1 Cycle 30
Control Rod Bank Insertion Limits

Fully w/d position = 225 steps



3.2 POWER DISTRIBUTION LIMITS

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

LCO 3.2.1 $F_Q(Z)$, as approximated by $F_Q^E(Z)$ and $F_Q^T(Z)$, shall be within the limits specified below.

CFQ = 2.32

The Heat Flux Hot Channel Factor, $F_Q(Z)$, shall be limited by the following relationships:

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

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

where: $$P = \frac{THERMAL\ POWER}{RATED\ THERMAL\ POWER}\text{; and}$$

K(Z) is provided in **COLR Figure 3.2-1**

$F_Q^E(Z)$ is an excellent approximation for $F_Q(Z)$ when the reactor is at the steady-state power.

$F_Q(Z)$ from the incore flux map results is increased by 1.03 for fuel manufacturing tolerances and 1.05 for measurement uncertainty to obtain $F_Q^E(Z)$.

$$F_Q^E(Z) = F_Q(Z) * (1.03) * (1.05)$$

The expression for $F_Q^T(Z)$ is:

$$F_Q^T(Z) = F_Q^E(Z) * N(Z)$$

where:

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

The discussion in the Bases Section B 3.2.1 for this LCO requires the application of a cycle dependent non-equilibrium multiplier, N(Z), to the steady state $F_Q^E(Z)$. N(Z) values are calculated for each flux map using analytically derived $F_Q(Z)$ values (scaled by relative power), consistent with the methodology described in VEP-NE-1. N(Z) accounts for power distribution transients encountered during normal operation.

The cycle-specific penalty factors are presented in **COLR Table 3.2-1.**

Also discussed is the application of the appropriate factor to account for potential increases in $F_Q(Z)$ *between surveillances. This factor is determined on a cycle specific basis and is dependent on the predicted increases in steady-state and transient* $F_Q(Z)/K(Z)$ *versus burnup. A minimum value of 2% is used should any increase in steady-state or transient measured or predicted peaking factor be determined unless frequent flux mapping is invoked (7 EFPD).*

The required operating space reductions are included in **COLR Table 3.2-2.**

Should $F_Q^T(Z)$ *exceed its limits the normal operating space should be reduced to gain peaking factor margins. The determination and verification of the margin improvements along with the corresponding required reductions in the Thermal Power Limit and AFD Bands are performed on a cycle-specific basis.*

COLR Table 3.2-1

N1C30 Penalty Factors for Flux Map Analysis

Burnup (MWD/MTU)	Penalty Factor %
0 - 499	2.0
500 - 999	4.5
1000 - 1999	3.5
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

Notes:

1. *Penalty Factors are not required for initial power ascension flux maps.*
2. *All full power maps shall apply a Penalty Factor unless frequent flux mapping is invoked (≤ 7 EFPD).*

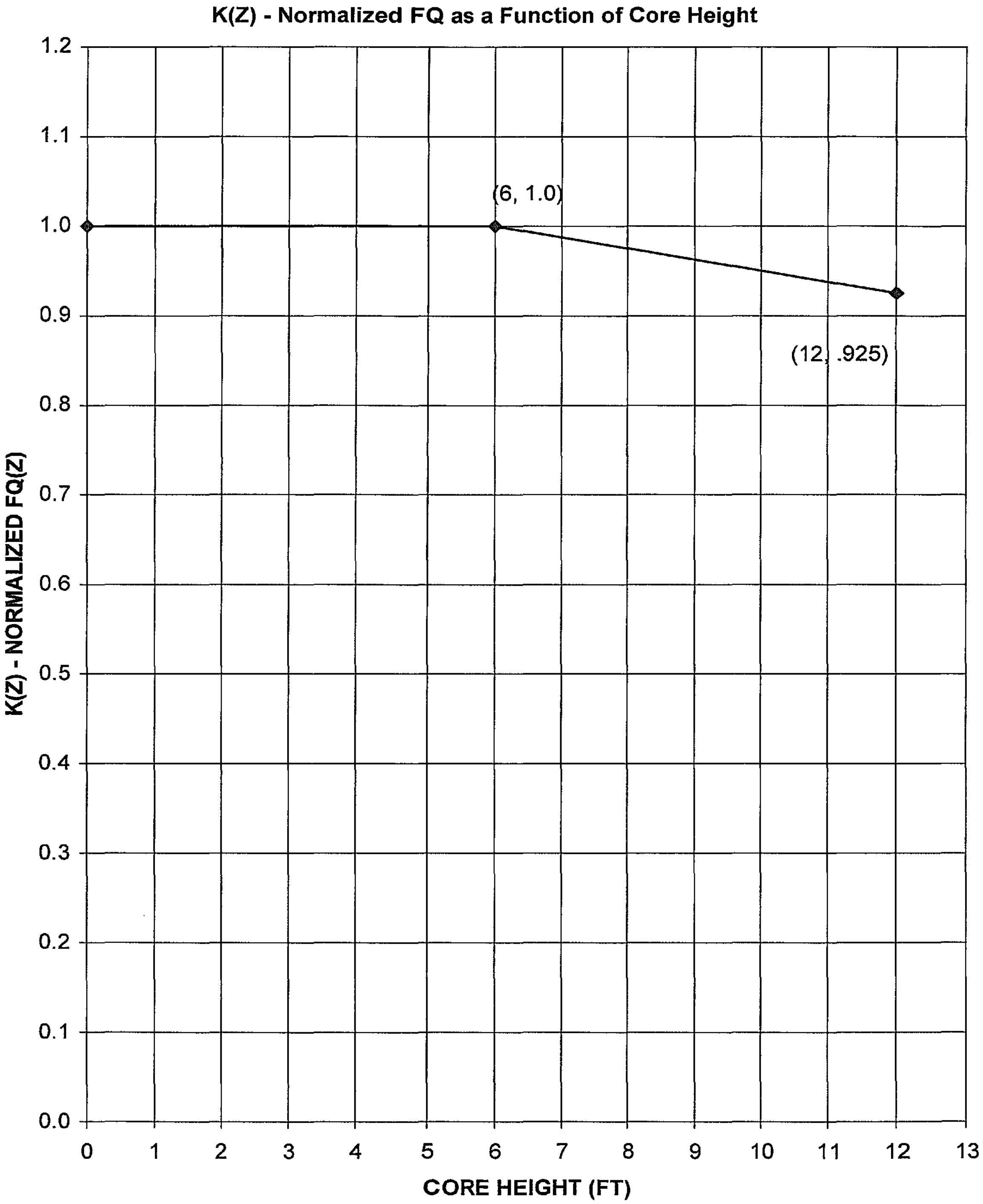
COLR Table 3.2-2

N1C30 Required Operating Space Reductions for $F_Q^T(Z)$ Exceeding its Limits

Required $F_Q^T(Z)$ Margin Improvement	Required THERMAL POWER Limit (% RTP)	Negative AFD Band Reduction from AFD Limits* (% AFD)	Positive AFD Band Reduction from AFD Limits* (% AFD)
>0% and ≤ 1%	≤ 98.0%	≥ 0.5%	≥ 1.0%
> 1% and ≤ 2%	≤ 96.0%	≥ 1.0%	≥ 2.5%
> 2% and ≤ 3%	≤ 95.0%	≥ 1.5%	≥ 3.5%
> 3%	≤ 50%	N/A	N/A

* Axial Flux Difference Limits are provided in COLR Figure 3.2-2

COLR Figure 3.2-1



3.2.2 Nuclear Enthalpy Rise Hot Channel Factor ($F^N_{\Delta H}$)

LCO 3.2.2 $F^N_{\Delta H}$ shall be within the limits specified below.

$$\mathbf{F^N_{\Delta H} \leq 1.587\{1 + 0.3(1 - P)\}}$$

where: $$P = \frac{THERMAL\ POWER}{RATED\ THERMAL\ POWER}$$

SR 3.2.2.1 Verify $F^N_{\Delta H}$ is within limits specified above.

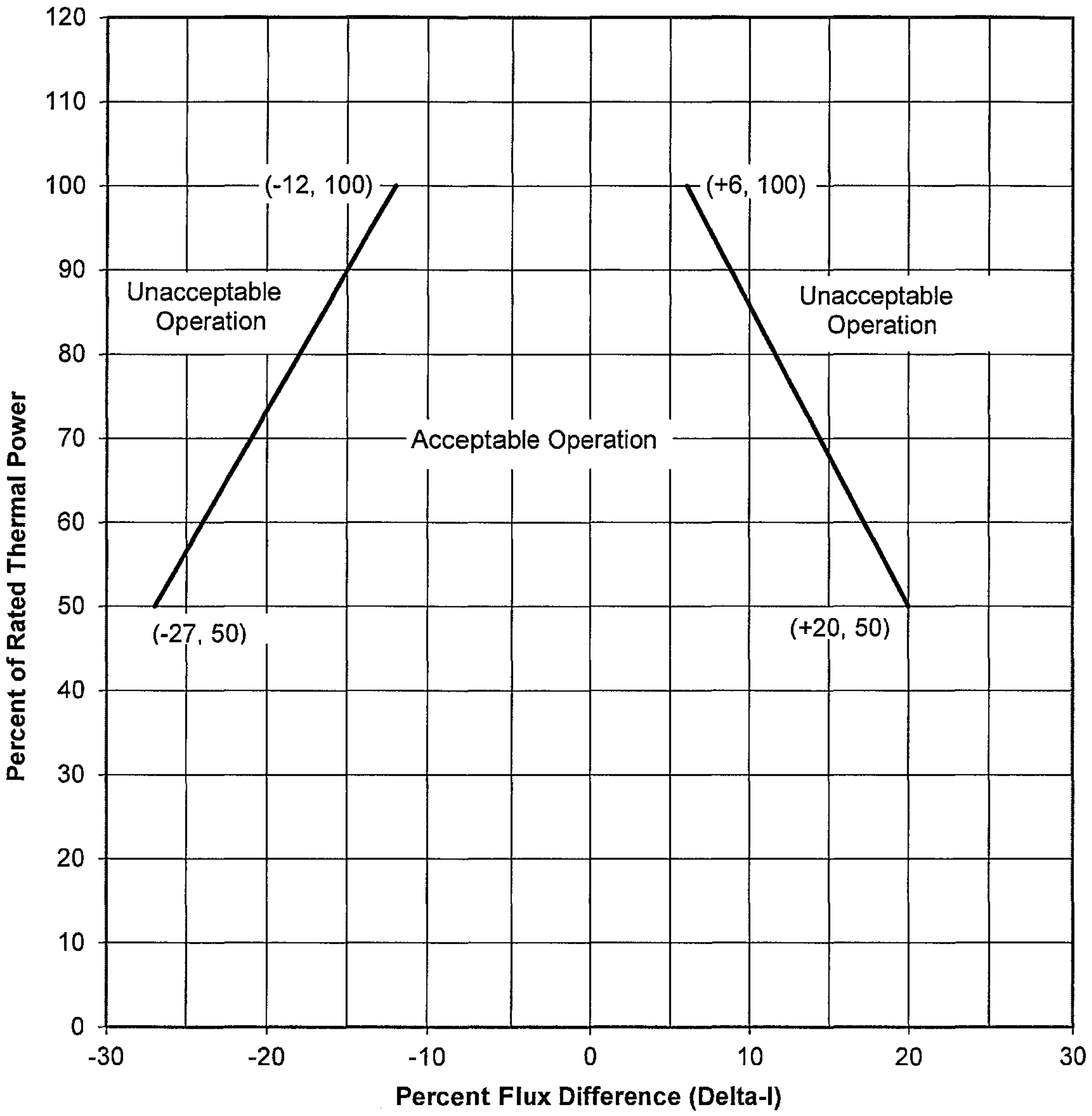
3.2.3 AXIAL FLUX DIFFERENCE (AFD)

LCO 3.2.3 The AFD in % flux difference units shall be maintained within the limits specified in **COLR Figure 3.2-2**.

COLR Figure 3.2-2

North Anna 1 Cycle 30

Axial Flux Difference Limits



3.3 INSTRUMENTATION

3.3.1 Reactor Trip System (RTS) Instrumentation

TS Table 3.3.1-1 Note 1: Overtemperature ΔT

The Overtemperature ΔT Function Allowable Value shall not exceed the following nominal trip setpoint by more than 2% of ΔT span, with the numerical values of the parameters as specified below.

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

where:

ΔT	is measured RCS ΔT, °F
ΔT_0	is the indicated ΔT at RTP, °F
s	is the Laplace transform operator, sec^{-1}
T	is the measured RCS average temperature, °F
T'	is the nominal T_{avg} at RTP, $\le$ **586.8 °F**
P	is the measured pressurizer pressure, psig
P'	is the nominal RCS operating pressure, $\ge$ **2235 psig**

$K_1 \le$ **1.2715** $K_2 \ge$ **0.02174 /°F** $K_3 \ge$ **0.001145 /psig**

τ_1, τ_2 = *time constants utilized in the lead-lag controller for* T_{avg}

$\tau_1 \ge$ **23.75 sec** $\tau_2 \le$ **4.4 sec**

$(1+\tau_1 s)/(1+\tau_2 s)$ = *function generated by the lead-lag controller for* T_{avg} *dynamic compensation*

$$f_1(\Delta I) \ge \begin{cases} \mathbf{0.0291}\{\mathbf{-13.0} - (q_t - q_b)\} & \text{when } (q_t - q_b) < \mathbf{-13.0\%} \text{ RTP} \\ \mathbf{0} & \text{when } \mathbf{-13.0\%} \text{ RTP} \le (q_t - q_b) \le \mathbf{+7.0\%} \text{ RTP} \\ \mathbf{0.0251}\{(q_t - q_b) - \mathbf{7.0}\} & \text{when } (q_t - q_b) > \mathbf{+7.0\%} \text{ RTP} \end{cases}$$

Where q_t and q_b are percent RTP in the upper and lower halves of the core, respectively, and $q_t + q_b$ is the total THERMAL POWER in percent RTP.

TS Table 3.3.1-1 Note 2: Overpower ΔT

The Overpower ΔT Function Allowable Value shall not exceed the following nominal trip setpoint by more than 2% of ΔT span, with the numerical values of the parameters as specified below.

$$\Delta T \leq \Delta T_0 \left\{ K_4 - K_5 \left[\frac{\tau_3 s}{1+\tau_3 s} \right] T - K_6 [T - T'] - f_2(\Delta I) \right\}$$

where: ΔT	is measured RCS ΔT, °F.
ΔT_0	is the indicated ΔT at RTP, °F.
s	is the Laplace transform operator, sec^{-1}.
T	is the measured RCS average temperature, °F.
T′	is the nominal T_{avg} at RTP, **≤ 586.8 °F.**

$K_4 \leq$ **1.0865**

$K_5 \geq$	**0.0198 /°F**	for increasing T_{avg}	$K_6 \geq$	**0.00162 /°F**	when $T > T'$
	0 /°F	for decreasing T_{avg}		**0 /°F**	when $T \leq T'$

τ_3 = *time constant utilized in the rate lag controller for* T_{avg}

$\tau_3 \geq$ **9.5 sec**

$\tau_3 s/(1+\tau_3 s)$ = *function generated by the rate lag controller for* T_{avg} *dynamic compensation*

$f_2(\Delta I) = \mathbf{0}$, **for all ΔI.**

3.4 REACTOR COOLANT SYSTEM (RCS)

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

LCO 3.4.1 RCS DNB parameters for pressurizer pressure, RCS average temperature, and RCS total flow rate shall be within the limits specified below:

a. Pressurizer pressure is greater than or equal to **2205 psig**;

b. RCS average temperature is less than or equal to **591 °F**; and

c. RCS total flow rate is greater than or equal to **295,000 gpm**.

SR 3.4.1.1 Verify pressurizer pressure is greater than or equal to **2205 psig**.

SR 3.4.1.2 Verify RCS average temperature is less than or equal to **591 °F**.

SR 3.4.1.3 Verify RCS total flow rate is greater than or equal to **295,000 gpm**.

SR 3.4.1.4 -----------------------------NOTE---
Not required to be performed until 30 days after ≥ 90% RTP.

Verify by precision heat balance that
RCS total flow rate is ≥ **295,000 gpm**.

3.5 EMERGENCY CORE COOLING SYSTEMS (ECCS)

3.5.6 Boron Injection Tank (BIT)

Required Action B.2 Borate to a SDM ≥ **1.77 % Δk/k at 200 °F**.

3.9 REFUELING OPERATIONS

3.9.1 Boron Concentration

LCO 3.9.1 Boron concentrations of the Reactor Coolant System (RCS), the refueling canal, and the refueling cavity shall be maintained ≥ **2600 ppm**.

SR 3.9.1.1 Verify boron concentration is within the limit specified above.

NAPS TECHNICAL REQUIREMENTS MANUAL

TRM 3.1 REACTIVITY CONTROL SYSTEMS

TR 3.1.1 Boration Flow Paths – Operating

Required Action D.2 Borate to a SHUTDOWN MARGIN **≥ 1.77 % Δk/k at 200 °F**, after xenon decay.