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May 7, 2013

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

Serial No. 13-281
NLOS /ETS
Docket No. 50-339
License No. NPF-7

VIRGINIA ELECTRIC AND POWER COMPANY (DOMINION)
NORTH ANNA POWER STATION UNIT 2
CYCLE 23 CORE OPERATING LIMITS REPORT, REVISIONS 1 AND 2

Pursuant to North Anna Technical Specification 5.6.5.d, attached are copies of the Dominion Core Operating Limits Report for North Anna Unit 2 Cycle 23, Pattern BND, Revisions 1 and 2. Revision 1 was only applicable to operating Modes 6 and 5 with RCS Temperature less than 140 °F and the RCS vented. Revision 2 replaces Revision 1 and is applicable to all operating Modes.

If you have any questions regarding this submittal, please contact Mr. Thomas Shaub at (804) 273-2763.

Sincerely,

T. R. Huber, Director
Nuclear Licensing and Operations Support
Dominion Resources Services, Inc.
for Virginia Electric and Power Company

Attachments:

1. Core Operating Limits Report for North Anna Unit 2 Cycle 23 - Pattern BND, Revision 1.
2. Core Operating Limits Report for North Anna Unit 2 Cycle 23 - Pattern BND, Revision 2.

Commitments made in this letter: None

A001
NRR

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Serial No. 13-281
Docket No. 50-339

ATTACHMENT 1

CORE OPERATING LIMITS REPORT FOR NORTH ANNA UNIT 2
CYCLE 23 PATTERN BND, REVISION 1

OPERATING MODES 6 and 5 with RCS Temperature < 140 °F, RCS Vented ONLY

NORTH ANNA POWER STATION
VIRGINIA ELECTRIC AND POWER COMPANY (DOMINION)

N2C23 CORE OPERATING LIMITS REPORT

OPERATING MODES 6 and 5 with RCS Temperature < 140 °F, RCS Vented ONLY

The Core Operating Limits Report (COLR) for North Anna Unit 2 Cycle 23 has been prepared in accordance with North Anna Technical Specification 5.6.5. This COLR is only applicable to MODES 5 (at RCS Temperature less than 140 °F, RCS vented) and 6 of operation. A COLR applicable to all MODES of operation will be issued concurrently with a Reload Safety Evaluation supporting all MODES of operation.

The technical specifications affected by this report are listed below. TS items which are not applicable in MODES 5 (at RCS Temperature less than 140 °F, RCS vented) and 6 are marked "**Not Applicable**":

Not Applicable: TS 2.1.1 Reactor Core Safety Limits
TS 3.1.1 Shutdown Margin (SDM)
Not Applicable: TS 3.1.3 Moderator Temperature Coefficient (MTC)
Not Applicable: TS 3.1.4 Rod Group Alignment Limits
Not Applicable: TS 3.1.5 Shutdown Bank Insertion Limit
Not Applicable: TS 3.1.6 Control Bank Insertion Limits
Not Applicable: TS 3.1.9 PHYSICS TESTS Exceptions – Mode 2
Not Applicable: TS 3.2.1 Heat Flux Hot Channel Factor
Not Applicable: TS 3.2.2 Nuclear Enthalpy Rise Hot Channel Factor ($F^N_{\Delta H}$)
Not Applicable: TS 3.2.3 Axial Flux Difference (AFD)
Not Applicable: TS 3.3.1 Reactor Trip System (RTS) Instrumentation
Not Applicable: TS 3.4.1 RCS Pressure, Temperature, and Flow DNB Limits
Not Applicable: 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:

Not Applicable: 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, Rev. 2.1-A, "Reload Nuclear Design Methodology," August 2003.

   Methodology for:
   TS 3.1.1 – Shutdown Margin,
   Not Applicable: TS 3.1.3 – Moderator Temperature Coefficient,
   Not Applicable: TS 3.1.4 – Rod Group Alignment Limits
   Not Applicable: TS 3.1.5 – Shutdown Bank Insertion Limit,
   Not Applicable: TS 3.1.6 – Control Bank Insertion Limits,
   Not Applicable: TS 3.1.9 – Physics Tests Exceptions – Mode 2,
   Not Applicable: TS 3.2.1 – Heat Flux Hot Channel Factor,
   Not Applicable: TS 3.2.2 – Nuclear Enthalpy Rise Hot Channel Factor
   Not Applicable: TS 3.5.6 – Boron Injection Tank (BIT) and
   TS 3.9.1 – Boron Concentration

2. Plant-specific adaptation of WCAP-16009-P-A, "Realistic Large Break LOCA Evaluation Methodology Using the Automated Statistical Treatment of Uncertainty Method (ASTRUM)," as approved by NRC Safety Evaluation Report dated February 29, 2012.

   Not Applicable: Methodology for: TS 3.2.1 – Heat Flux Hot Channel Factor

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

   Not Applicable: Methodology for: TS 3.2.1 – Heat Flux Hot Channel Factor

4. WCAP-10079-P-A, "NOTRUMP, A Nodal Transient Small Break and General Network Code," August 1985.

   Not Applicable: Methodology for: TS 3.2.1 – Heat Flux Hot Channel Factor

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

   Methodology for:
   Not Applicable: TS 2.1.1 – Reactor Core Safety Limits
   Not Applicable: TS 3.2.1 – Heat Flux Hot Channel Factor

6. VEP-NE-2, Rev. 0-A, Statistical DNBR Evaluation Methodology, June 1987.

   Methodology for:
   Not Applicable: TS 3.2.2 – Nuclear Enthalpy Rise Hot Channel Factor and
   Not Applicable: TS 3.4.1 – RCS Pressure, Temperature and Flow DNB Limits

7. VEP-NE-1, Rev. 0.1-A, Relaxed Power Distribution Control Methodology and Associated FQ Surveillance Technical Specifications, August 2003.

   Methodology for:
   Not Applicable: TS 3.2.1 – Heat Flux Hot Channel Factor and
   Not Applicable: TS 3.2.3 – Axial Flux Difference

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

   Methodology for:
   Not Applicable: TS 2.1.1 – Reactor Core Safety Limits and
   Not Applicable: TS 3.3.1 – Reactor Trip System Instrumentation

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

   Methodology for:
   Not Applicable: TS 2.1.1 – Reactor Core Safety Limits,
   TS 3.1.1 – Shutdown Margin,
   Not Applicable: TS 3.1.4 – Rod Group Alignment Limits
   Not Applicable: TS 3.1.9 – Physics Tests Exceptions – Mode 2
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   Not Applicable: TS 3.5.6 – Boron Injection Tank (BIT) and
   TS 3.9.1 – Boron Concentration

10. BAW-10227P-A, Rev. 0, "Evaluation of Advanced Cladding and Structural Material (M5) in PWR Reactor Fuel," February 2000.

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    Not Applicable: TS 3.2.1 – Heat Flux Hot Channel Factor

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12. EMF-96-029 (P) (A), Rev. 0, "Reactor Analysis System for PWRs," January 1997.

    Not Applicable: Methodology for: TS 3.2.1 - Heat Flux Hot Channel Factor

13. BAW-10168P-A, Rev. 3, "RSG LOCA - BWNT Loss-of-Coolant Accident Evaluation Model for Recirculating Steam Generator Plants," December 1996. Volume II only (SBLOCA models).

    Not Applicable: Methodology for: TS 3.2.1 - Heat Flux Hot Channel Factor

14. DOM-NAF-2, Rev. 0.2- P-A, "Reactor Core Thermal-Hydraulics Using the VIPRE-D Computer Code," including Appendix A, "Qualification of the F-ANP BWU CHF Correlations in the Dominion VIPRE-D Computer Code," and Appendix C, "Qualification of the Westinghouse WRB-2M CHF Correlation in the Dominion VIPRE-D Computer Code," August 2010.

    Methodology for:
    Not Applicable: TS 3.2.2 – Nuclear Enthalpy Rise Hot Channel Factor and
    Not Applicable: TS 3.4.1 – RCS Pressure, Temperature and Flow DNB Limits

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

    Methodology for:
    Not Applicable: TS 2.1.1 – Reactor Core Safety Limits and
    Not Applicable: TS 3.2.1 – Heat Flux Hot Channel Factor

Note: *The North Anna COLR lists multiple methodologies that are used to verify Technical Specifications parameters. This is due to the transition from AREVA fuel to Westinghouse fuel which requires the use of different vendor proprietary methodologies to verify the two fuel products meet the applicable regulatory limits.*

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.

Not Applicable: 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.

Not Applicable: 2.1.1.2 The peak fuel centerline temperature shall be maintained < 5080°F, decreasing by 58°F per 10,000 MWD/MTU of burnup, for Westinghouse fuel and < 5173°F, decreasing by 65°F per 10,000 MWD/MTU of burnup, for AREVA fuel.

COLR Figure 2.1-1

Not Applicable

3.1 REACTIVITY CONTROL SYSTEMS

3.1.1 SHUTDOWN MARGIN (SDM)

LCO 3.1.1 SDM shall be ≥ **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 **NOT APPLICABLE**, when < 70% RTP, and **NOT APPLICABLE** when ≥ 70% RTP.

The BOC/ARO-MTC shall be ≤ **NOT APPLICABLE** (upper limit), when < 70% RTP, and ≤ **NOT APPLICABLE** when ≥ 70% RTP.

The EOC/ARO/RTP-MTC shall be less negative than **NOT APPLICABLE** (lower limit).

The MTC surveillance limits are:

The 300 ppm/ARO/RTP-MTC should be less negative than or equal to **NOT APPLICABLE** [Note 2].

The 60 ppm/ARO/RTP-MTC should be less negative than or equal to **NOT APPLICABLE** [Note 3].

SR 3.1.3.2 Verify MTC is within **NOT APPLICABLE** (lower limit).

Note 2: If the MTC is more negative than **NOT APPLICABLE**, SR 3.1.3.2 shall be repeated once per 14 EFPD during the remainder of the fuel cycle.

Note 3: 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 **NOT APPLICABLE**.

3.1.4 Rod Group Alignment Limits

Required Action A.1.1 Verify SDM to be ≥ **NOT APPLICABLE.**

Required Action B.1.1 Verify SDM to be ≥ **NOT APPLICABLE.**

Required Action D.1.1 Verify SDM to be ≥ **NOT APPLICABLE.**

3.1.5 Shutdown Bank Insertion Limits

LCO 3.1.5 Each shutdown bank shall be withdrawn to at least **NOT APPLICABLE** steps.

Required Action A.1.1 Verify SDM to be ≥ **NOT APPLICABLE.**

Required Action B.1 Verify SDM to be ≥ **NOT APPLICABLE.**

SR 3.1.5.1 Verify each shutdown bank is withdrawn to at least **NOT APPLICABLE** 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 **NOT APPLICABLE** steps.

Required Action A.1.1 Verify SDM to be ≥ **NOT APPLICABLE.**

Required Action B.1.1 Verify SDM to be ≥ **NOT APPLICABLE.**

Required Action C.1 Verify SDM to be ≥ **NOT APPLICABLE.**

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 ≥ **NOT APPLICABLE.**

SR 3.1.9.4 Verify SDM to be ≥ **NOT APPLICABLE.**

COLR Figure 3.1-1

NOT APPLICABLE

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 $F_Q^M(Z)$, shall be within the limits specified below.

CFQ = NOT APPLICABLE

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

$$F_Q^M(Z) \leq \frac{CFQ}{P} \frac{K(Z)}{N(Z)} \qquad \text{for } P > 0.5$$

$$F_Q^M(Z) \leq \frac{CFQ}{0.5} \frac{K(Z)}{N(Z)} \qquad \text{for } P \leq 0.5$$

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

K(Z) is provided in **COLR Figure 3.2-1.**
N(Z) is a cycle-specific non-equilibrium multiplier on $F_Q^M(Z)$ to account for power distribution transients during normal operation, provided in **COLR Table 3.2-1.**

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 CFQ limit. N(Z) accounts for power distribution transients encountered during normal operation. As function N(Z) is dependent on the predicted equilibrium $F_Q(Z)$ and is sensitive to the axial power distribution, it is typically generated from the actual EOC burnup distribution that can only be obtained after the shutdown of the previous cycle. The cycle-specific N(Z) function is presented in **COLR Table 3.2-1**.

COLR Table 3.2-1

NOT APPLICABLE

N(z) data will be provided in a revision of the COLR.

These decks are generated for normal operation flux maps that are typically taken at full power ARO. Additional N(z) decks may be generated, if necessary, consistent with the methodology described in the RPDC topical (Reference 7). EOR is defined as Hot Full Power End of Reactivity.

COLR Figure 3.2-1

NOT APPLICABLE

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.

$\mathbf{F^N_{\Delta H} \leq}$ **NOT APPLICABLE**

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

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

NOT APPLICABLE

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.

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

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, ≤ **NOT APPLICABLE**
P is the measured pressurizer pressure, psig
P' is the nominal RCS operating pressure, ≥ **NOT APPLICABLE**

K_1 ≤ **NOT APPLICABLE** K_2 ≥ **NOT APPLICABLE**
K_3 ≥ **NOT APPLICABLE**

τ_1, τ_2 = time constants utilized in the lead-lag controller for T_{avg}
τ_1 ≥ **NOT APPLICABLE** τ_2 ≤ **NOT APPLICABLE**

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

$f_1(\Delta I)$ ≥ **NOT APPLICABLE**{**NOT APPLICABLE** – $(q_t - q_b)$}
when $(q_t - q_b)$ < **NOT APPLICABLE** RTP
NOT APPLICABLE
when **NOT APPLICABLE** RTP ≤ $(q_t - q_b)$ ≤ **NOT APPLICABLE** RTP
NOT APPLICABLE{$(q_t - q_b)$ – **NOT APPLICABLE**}
when $(q_t - q_b)$ > **NOT APPLICABLE** RTP

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.

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

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, ≤ **NOT APPLICABLE.**

K_4 ≤ **NOT APPLICABLE**
K_5 ≥ **NOT APPLICABLE** for increasing T_{avg}
K_6 ≥ **NOT APPLICABLE /°F** when T > T′
NOT APPLICABLE for decreasing T_{avg}
NOT APPLICABLE when T ≤ T′

τ_3 = time constant utilized in the rate lag controller for T_{avg}
τ_3 ≥ **NOT APPLICABLE**

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

$f_2(\Delta I)$ = **NOT APPLICABLE**

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 **NOT APPLICABLE**

b. RCS average temperature is less than or equal to **NOT APPLICABLE**; and

c. RCS total flow rate is greater than or equal to **NOT APPLICABLE.**

SR 3.4.1.1 Verify pressurizer pressure is greater than or equal to **NOT APPLICABLE.**

SR 3.4.1.2 Verify RCS average temperature is less than or equal to **NOT APPLICABLE.**

SR 3.4.1.3 Verify RCS total flow rate is greater than or equal to **NOT APPLICABLE.**

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 ≥ **NOT APPLICABLE**

3.5 EMERGENCY CORE COOLING SYSTEMS (ECCS)

3.5.6 Boron Injection Tank (BIT)

Required Action B.2 Borate to a SDM ≥ **NOT APPLICABLE**.

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 ≥ **NOT APPLICABLE** after xenon decay.

ATTACHMENT 2

CORE OPERATING LIMITS REPORT FOR NORTH ANNA UNIT 2 CYCLE 23 PATTERN BND, REVISION 2

NORTH ANNA POWER STATION
VIRGINIA ELECTRIC AND POWER COMPANY (DOMINION)

N2C23 CORE OPERATING LIMITS REPORT

INTRODUCTION

The Core Operating Limits Report (COLR) for North Anna Unit 2 Cycle 23 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, Rev. 2.1-A, "Reload Nuclear Design Methodology," August 2003.

   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. Plant-specific adaptation of WCAP-16009-P-A, "Realistic Large Break LOCA Evaluation Methodology Using the Automated Statistical Treatment of Uncertainty Method (ASTRUM)," as approved by NRC Safety Evaluation Report dated February 29, 2012.

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   Methodology for: TS 3.2.1 – Heat Flux Hot Channel Factor

4. WCAP-10079-P-A, "NOTRUMP, A Nodal Transient Small Break and General Network Code," August 1985.

   Methodology for: TS 3.2.1 – Heat Flux Hot Channel Factor

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

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   TS 3.2.2 – Nuclear Enthalpy Rise Hot Channel Factor and
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    Methodology for:
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    TS 3.2.1 – Heat Flux Hot Channel Factor

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    Methodology for: TS 3.2.1 - Heat Flux Hot Channel Factor

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

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2.0 SAFETY LIMITS (SLs)

2.1 SLs

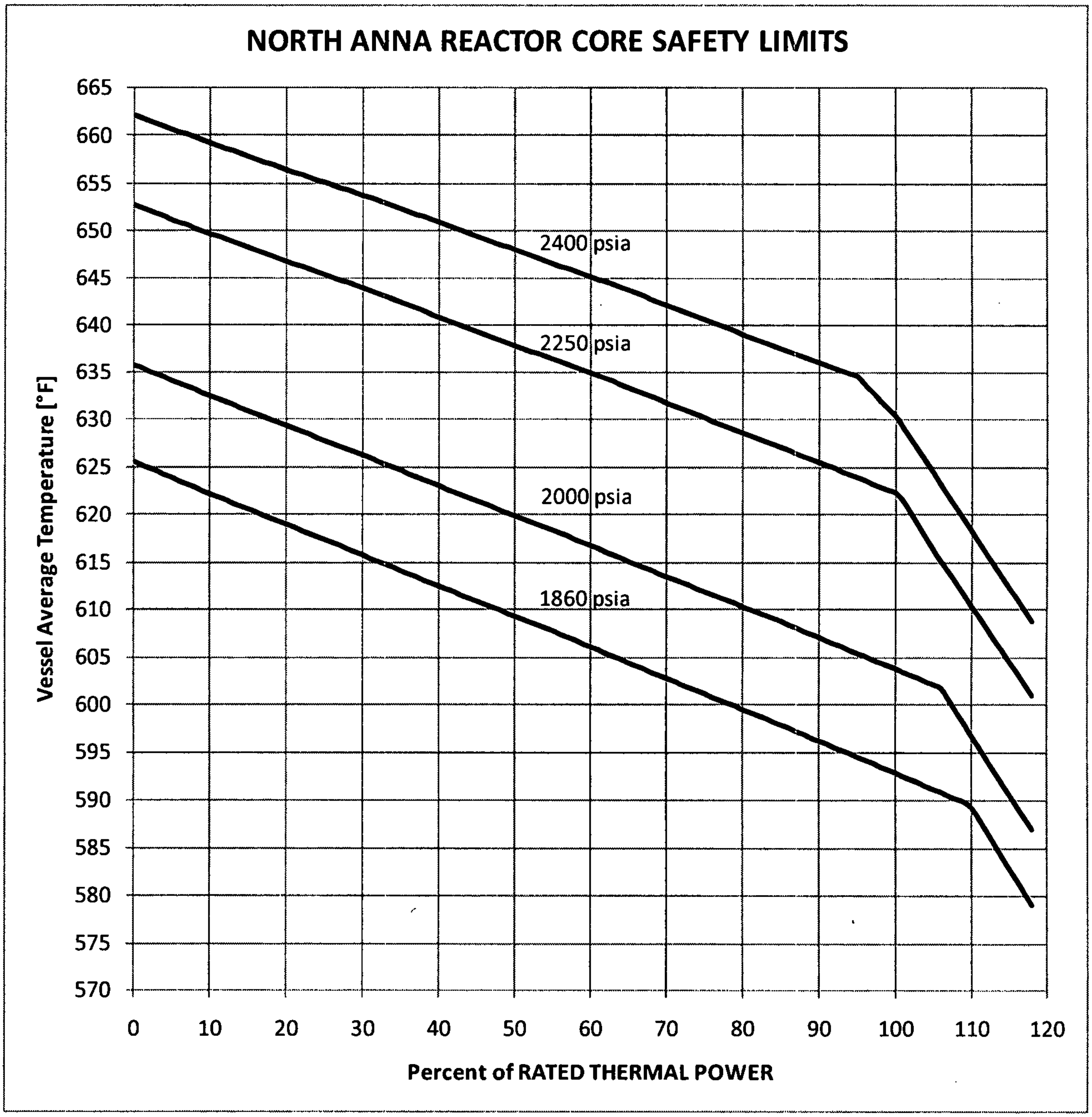
2.1.1 Reactor Core SLs

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.

2.1.1.2 The peak fuel centerline temperature shall be maintained < 5080°F, decreasing by 58°F per 10,000 MWD/MTU of burnup, for Westinghouse fuel and < 5173°F, decreasing by 65°F per 10,000 MWD/MTU of burnup, for AREVA fuel.

COLR Figure 2.1-1



3.1 REACTIVITY CONTROL SYSTEMS

3.1.1 SHUTDOWN MARGIN (SDM)

LCO 3.1.1 SDM shall be ≥ **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 2].

The 60 ppm/ARO/RTP-MTC should be less negative than or equal to **–4.7 x 10^{-4} Δk/k/°F** [Note 3].

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

Note 2: 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 3: 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 **230** 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 **230** 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 **102** 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**.

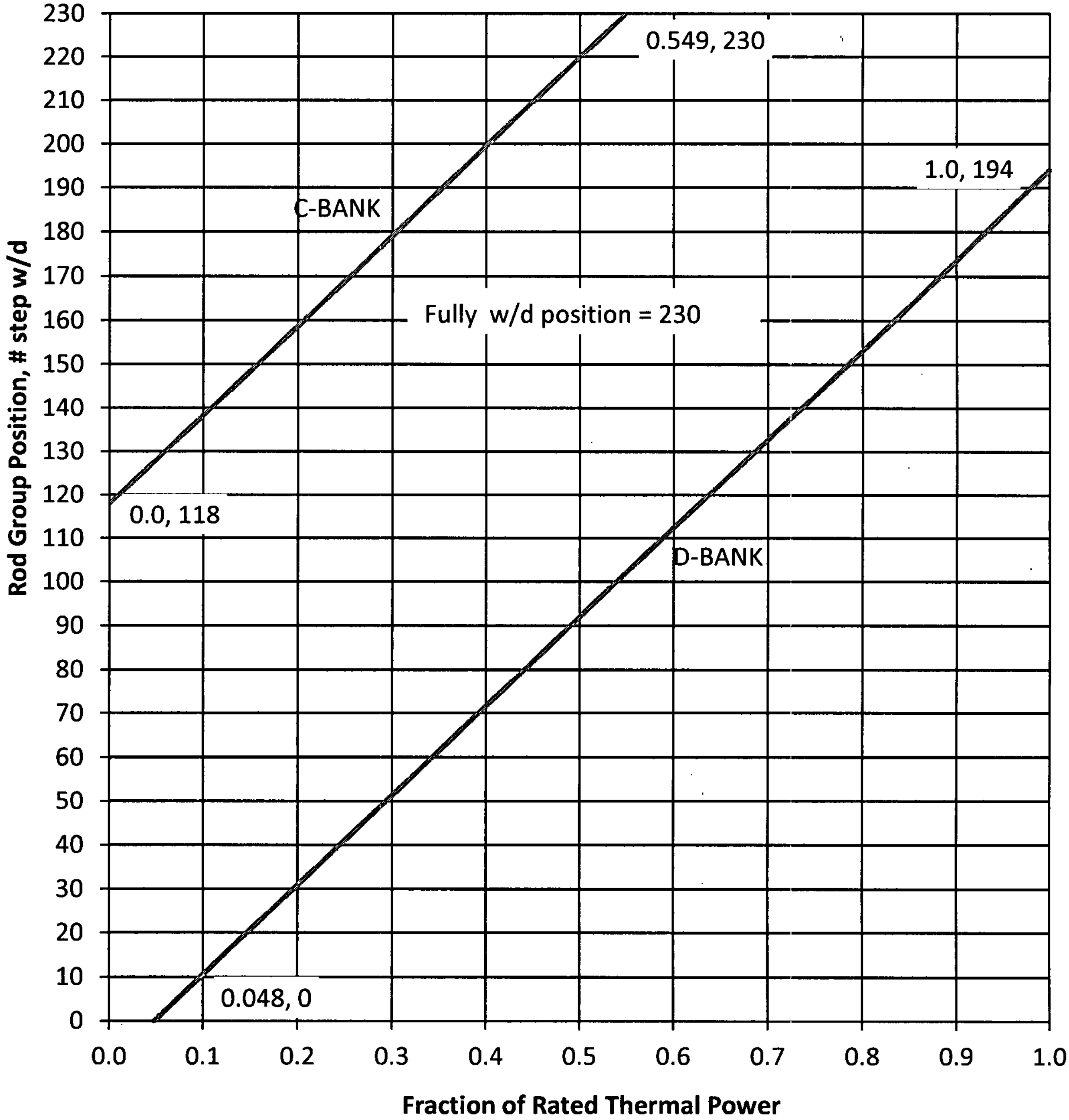
3.1.9 PHYSICS TESTS Exceptions – MODE 2

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 2 Cycle 23
Control Rod Bank Insertion Limits



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 $F_Q^M(Z)$, shall be within the limits specified below.

CFQ = 2.32

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

$$F_Q^M(Z) \le \frac{CFQ}{P} \frac{K(Z)}{N(Z)} \qquad \text{for } P > 0.5$$

$$F_Q^M(Z) \le \frac{CFQ}{0.5} \frac{K(Z)}{N(Z)} \qquad \text{for } P \le 0.5$$

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

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

N(Z) is a cycle-specific non-equilibrium multiplier on $F_Q^M(Z)$ to account for power distribution transients during normal operation, provided in **COLR Table 3.2-1.**

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 CFQ limit. N(Z) accounts for power distribution transients encountered during normal operation. As function N(Z) is dependent on the predicted equilibrium $F_Q(Z)$ and is sensitive to the axial power distribution, it is typically generated from the actual EOC burnup distribution that can only be obtained after the shutdown of the previous cycle. The cycle-specific N(Z) function is presented in **COLR Table 3.2-1**.

COLR Table 3.2-1

N2C23 Normal Operation N(Z)

NODE	HEIGHT (FEET)	0 to 1000 MWD/MTU	1000 to 3000 MWD/MTU	3000 to 5000 MWD/MTU	5000 to 7000 MWD/MTU	7000 to 9000 MWD/MTU
10	10.2	1.115	1.106	1.114	1.119	1.134
11	10.0	1.114	1.107	1.113	1.117	1.131
12	9.8	1.112	1.115	1.118	1.118	1.128
13	9.6	1.112	1.126	1.126	1.123	1.125
14	9.4	1.113	1.131	1.131	1.123	1.121
15	9.2	1.119	1.135	1.135	1.127	1.125
16	9.0	1.128	1.145	1.144	1.143	1.141
17	8.8	1.138	1.153	1.153	1.160	1.160
18	8.6	1.144	1.156	1.155	1.168	1.168
19	8.4	1.148	1.156	1.157	1.174	1.174
20	8.2	1.154	1.156	1.161	1.182	1.182
21	8.0	1.157	1.156	1.165	1.187	1.186
22	7.8	1.159	1.158	1.168	1.189	1.189
23	7.6	1.159	1.159	1.170	1.189	1.188
24	7.4	1.158	1.158	1.171	1.188	1.188
25	7.2	1.155	1.155	1.171	1.187	1.188
26	7.0	1.151	1.151	1.169	1.186	1.189
27	6.8	1.150	1.150	1.169	1.184	1.190
28	6.6	1.147	1.147	1.167	1.179	1.190
29	6.4	1.140	1.140	1.163	1.171	1.189
30	6.2	1.130	1.130	1.156	1.159	1.186
31	6.0	1.124	1.124	1.152	1.151	1.186
32	5.8	1.119	1.119	1.142	1.143	1.180
33	5.6	1.112	1.111	1.122	1.134	1.167
34	5.4	1.107	1.107	1.107	1.128	1.152
35	5.2	1.104	1.104	1.105	1.124	1.146
36	5.0	1.104	1.108	1.110	1.122	1.137
37	4.8	1.104	1.115	1.115	1.118	1.122
38	4.6	1.106	1.122	1.122	1.118	1.115
39	4.4	1.109	1.126	1.126	1.120	1.118
40	4.2	1.112	1.131	1.131	1.121	1.121
41	4.0	1.118	1.136	1.136	1.122	1.125
42	3.8	1.127	1.140	1.141	1.121	1.131
43	3.6	1.138	1.145	1.146	1.121	1.138
44	3.4	1.147	1.147	1.148	1.125	1.143
45	3.2	1.156	1.152	1.150	1.132	1.145
46	3.0	1.167	1.161	1.150	1.137	1.145
47	2.8	1.179	1.175	1.154	1.144	1.146
48	2.6	1.192	1.189	1.163	1.150	1.147
49	2.4	1.206	1.203	1.174	1.159	1.154
50	2.2	1.220	1.213	1.183	1.172	1.169
51	2.0	1.233	1.223	1.192	1.182	1.179
52	1.8	1.241	1.233	1.201	1.188	1.181

These decks are generated for normal operation flux maps that are typically taken at full power ARO. Additional N(z) decks may be generated, if necessary, consistent with the methodology described in the RPDC topical (Reference 7). EOR is defined as Hot Full Power End of Reactivity.

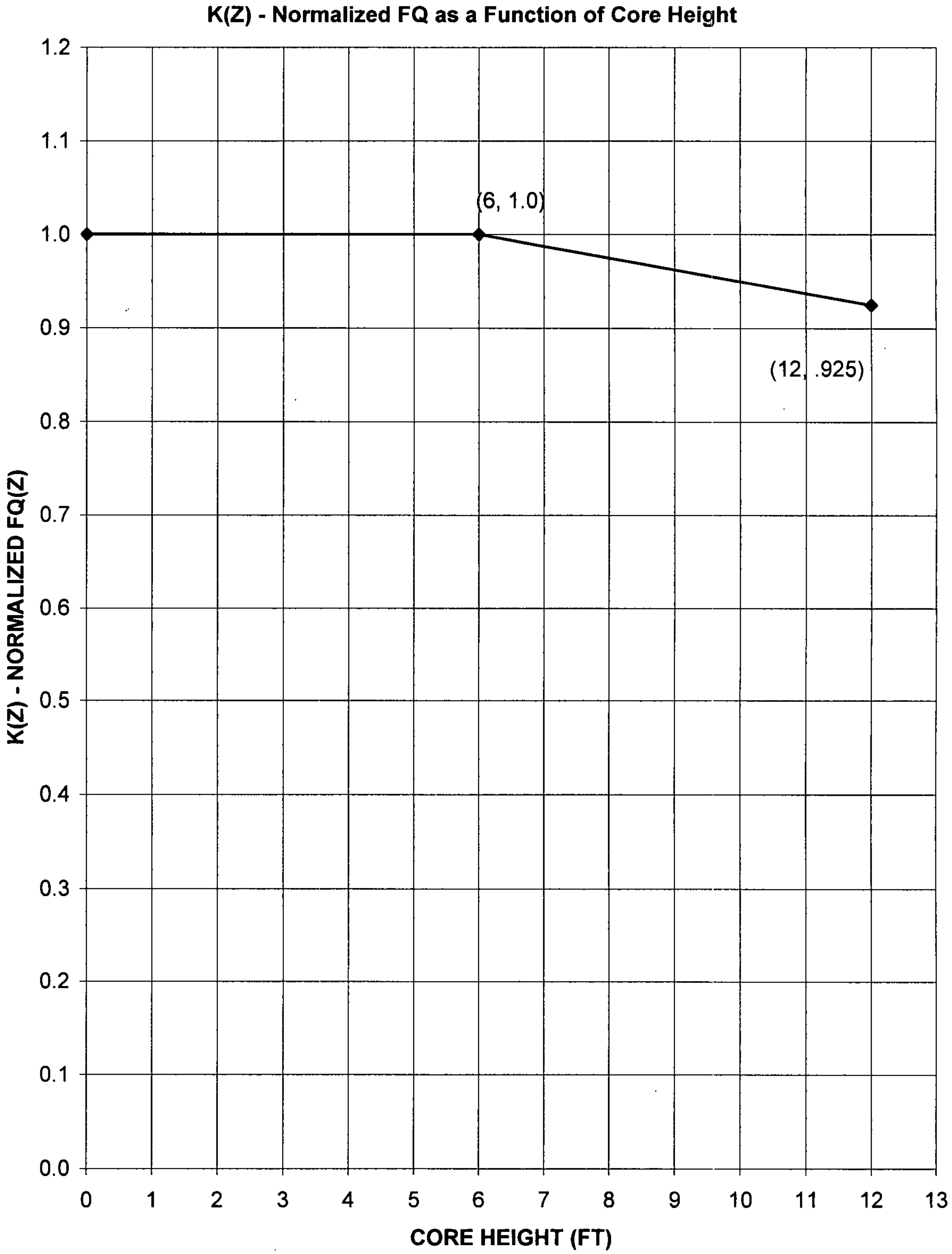
COLR Table 3.2-1 (continued)

N2C23 Normal Operation N(Z)

NODE	HEIGHT (FEET)	9000 to 11000 MWD/MTU	11000 to 13000 MWD/MTU	13000 to 15000 MWD/MTU	15000 to 17000 MWD/MTU	17000 to EOR MWD/MTU
10	10.2	1.134	1.115	1.115	1.115	1.079
11	10.0	1.131	1.114	1.114	1.114	1.091
12	9.8	1.128	1.118	1.115	1.112	1.099
13	9.6	1.128	1.127	1.120	1.112	1.105
14	9.4	1.129	1.130	1.121	1.110	1.109
15	9.2	1.134	1.134	1.126	1.116	1.116
16	9.0	1.143	1.145	1.141	1.131	1.132
17	8.8	1.154	1.158	1.158	1.150	1.150
18	8.6	1.159	1.164	1.164	1.158	1.159
19	8.4	1.164	1.170	1.170	1.169	1.169
20	8.2	1.173	1.182	1.182	1.188	1.188
21	8.0	1.178	1.190	1.190	1.201	1.201
22	7.8	1.180	1.191	1.191	1.206	1.206
23	7.6	1.181	1.193	1.193	1.213	1.213
24	7.4	1.182	1.197	1.197	1.224	1.224
25	7.2	1.185	1.198	1.198	1.231	1.231
26	7.0	1.188	1.198	1.198	1.233	1.233
27	6.8	1.191	1.199	1.199	1.235	1.235
28	6.6	1.190	1.200	1.200	1.236	1.236
29	6.4	1.189	1.202	1.202	1.237	1.237
30	6.2	1.186	1.202	1.202	1.234	1.234
31	6.0	1.185	1.203	1.203	1.234	1.234
32	5.8	1.180	1.199	1.199	1.227	1.227
33	5.6	1.169	1.188	1.188	1.211	1.211
34	5.4	1.157	1.176	1.175	1.195	1.195
35	5.2	1.152	1.171	1.170	1.189	1.189
36	5.0	1.144	1.162	1.163	1.180	1.180
37	4.8	1.131	1.147	1.152	1.164	1.165
38	4.6	1.127	1.137	1.145	1.153	1.158
39	4.4	1.132	1.134	1.143	1.152	1.160
40	4.2	1.135	1.134	1.140	1.153	1.163
41	4.0	1.137	1.136	1.138	1.151	1.163
42	3.8	1.138	1.137	1.137	1.145	1.160
43	3.6	1.139	1.140	1.140	1.138	1.154
44	3.4	1.142	1.144	1.144	1.129	1.148
45	3.2	1.145	1.148	1.148	1.129	1.147
46	3.0	1.145	1.151	1.151	1.138	1.149
47	2.8	1.146	1.154	1.154	1.153	1.158
48	2.6	1.147	1.156	1.156	1.161	1.165
49	2.4	1.152	1.160	1.161	1.172	1.177
50	2.2	1.164	1.168	1.169	1.185	1.191
51	2.0	1.172	1.174	1.177	1.197	1.204
52	1.8	1.173	1.176	1.179	1.204	1.213

These decks are generated for normal operation flux maps that are typically taken at full power ARO. Additional N(z) decks may be generated, if necessary, consistent with the methodology described in the RPDC topical (Reference 7). EOR is defined as Hot Full Power End of Reactivity.

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.

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

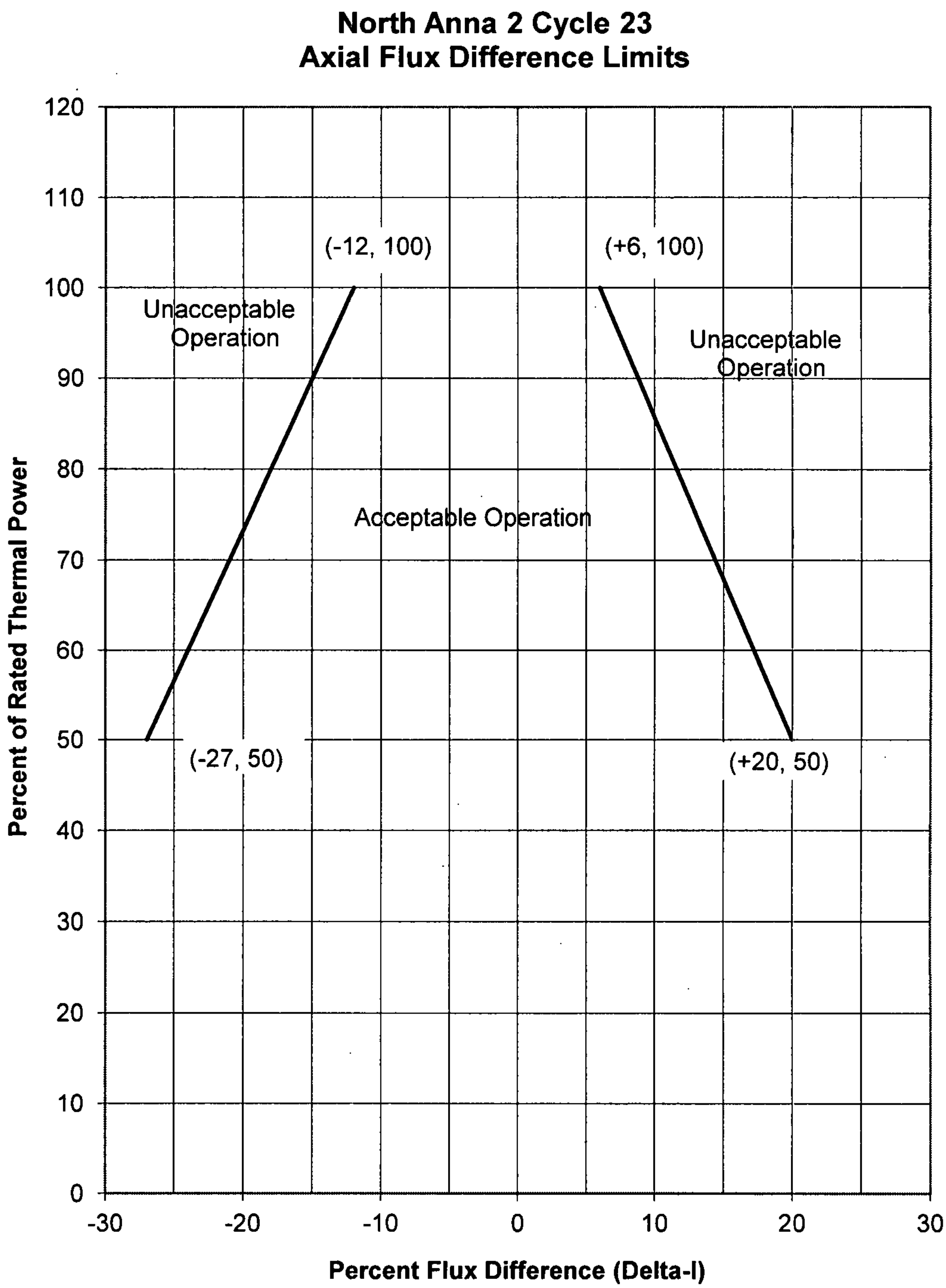
where: $P = \dfrac{THERMAL\ POWER}{RATED\ THERMAL\ POWER}$

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



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.

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

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, ≤ **586.8 °F**

P is the measured pressurizer pressure, psig

P′ is the nominal RCS operating pressure, ≥ **2235 psig**

$K_1 \leq$ **1.2715** $K_2 \geq$ **0.02174 /°F** $K_3 \geq$ **0.001145 /psig**

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

$\tau_1 \geq$ **23.75 sec** $\tau_2 \leq$ **4.4 sec**

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

$f_1(\Delta I) \geq$	**0.0291**{-13.0 – ($q_t - q_b$)}	when ($q_t - q_b$) < **–13.0%** RTP
	0	when **–13.0%** RTP ≤ ($q_t - q_b$) ≤ **+7.0%** RTP
	0.0251{($q_t - q_b$) – **7.0**}	when ($q_t - q_b$) > **+7.0%** RTP

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

$f_2(\Delta I)$ = **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.