VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

April 24, 2003

United States Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555-0001

Serial No.: 03-068A
NL&OS/MM
Docket No.: 50-339
License No.: NPF-7

VIRGINIA ELECTRIC AND POWER COMPANY (DOMINION)
NORTH ANNA POWER STATION UNIT 2
CORE OPERATING LIMITS REPORT

By letter dated January 23, 2003 (Serial No. 03-068), Dominion submitted the Core Operating Limits Report for North Anna Unit 2 Cycle 16 Pattern TP, Rev. 1. In that report, the value of the rod overlap was incorrectly documented as 98 steps in lieu of 100 steps withdrawn. The correct value was implemented at the plant. Revision 2 to this report is being issued to correct the error in reported value of control rod overlap.

No new commitments are intended by this letter. If you have any questions or require additional information, please contact us.

Very truly yours,

C. L. Funderburk
Director – Nuclear Licensing & Operations Support

Attachment

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A001

CORE OPERATING LIMITS REPORT Rev 2
North Anna 2 Cycle 16 Pattern TP

April 2003

N2C16 CORE OPERATING LIMITS REPORT

INTRODUCTION

The Core Operating Limits Report (COLR) for North Anna Unit 2 Cycle 16 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 3.1.5	Shutdown Bank Insertion Limit
TS 3.1.6	Control Bank Insertion Limits
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 3.9.1	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 for determining the core operating limits are those previously approved by the NRC and are discussed in the documents listed in the References Section. **Cycle-specific** values are presented **in bold**, while text in *italics* is provided for information only.

REFERENCES

1. VEP-FRD-42 Rev 1-A, Reload Nuclear Design Methodology, September 1986; Supplement 1, November 1993; Supplement 2, September 1996.

   (Methodology for TS 3.1.1 – Shutdown Margin, TS 3.1.3 – Moderator Temperature Coefficient, TS 3.1.5 – Shutdown Bank Insertion Limit, TS 3.1.6 - Control Bank Insertion Limits, TS 3.2.1 - Heat Flux Hot Channel Factor, TS 3.2.2 – Nuclear Enthalpy Rise Hot Channel Factor and TS 3.9.1 – Boron Concentration)

2. WCAP-9220-P-A Rev1, Westinghouse ECCS Evaluation Model – 1981 Version, February 1982.

   (Methodology for TS 3.2.1 - Heat Flux Hot Channel Factor)

3. WCAP-9561-P-A Rev 1 Add. 3, BART A-1: A Computer Code for the Best Estimate Analysis of Reflood Transients – Special Report: Thimble Modeling in W ECCS Evaluation Model, July 1986.

   (Methodology for TS 3.2.1 - Heat Flux Hot Channel Factor)

4. WCAP-10266-P-A Rev 2, The 1981 Version of the Westinghouse ECCS Evaluation Model Using the BASH Code, March 1987.

   (Methodology for TS 3.2.1 - Heat Flux Hot Channel Factor)

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

   (Methodology for TS 3.2.1 - Heat Flux Hot Channel Factor)

6. 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)

7. WCAP-12610-P-A, VANTAGE+ Fuel Assembly - Reference Core Report, April 1995.

   (Methodology for TS 3.2.1 - Heat Flux Hot Channel Factor)

8. VEP-NE-2-A, 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)

9. VEP-NE-3-A, Qualification of the WRB-1 CHF Correlation in the Virginia Power COBRA Code, July 1990.

(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. VEP-NE-1-A, Virginia Power Relaxed Power Distribution Control Methodology and Associated FQ Surveillance Technical Specifications, March 1986; Supplement 1, September 1996.

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

11. 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)

12. 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 3.3.1 – Reactor Trip System Instrumentation, TS 3.4.1 – RCS Pressure, Temperature, and Flow DNB Limits and TS 3.9.1 – Boron Concentration)

2.0 SAFETY LIMITS (SLs)

2.1 SLs

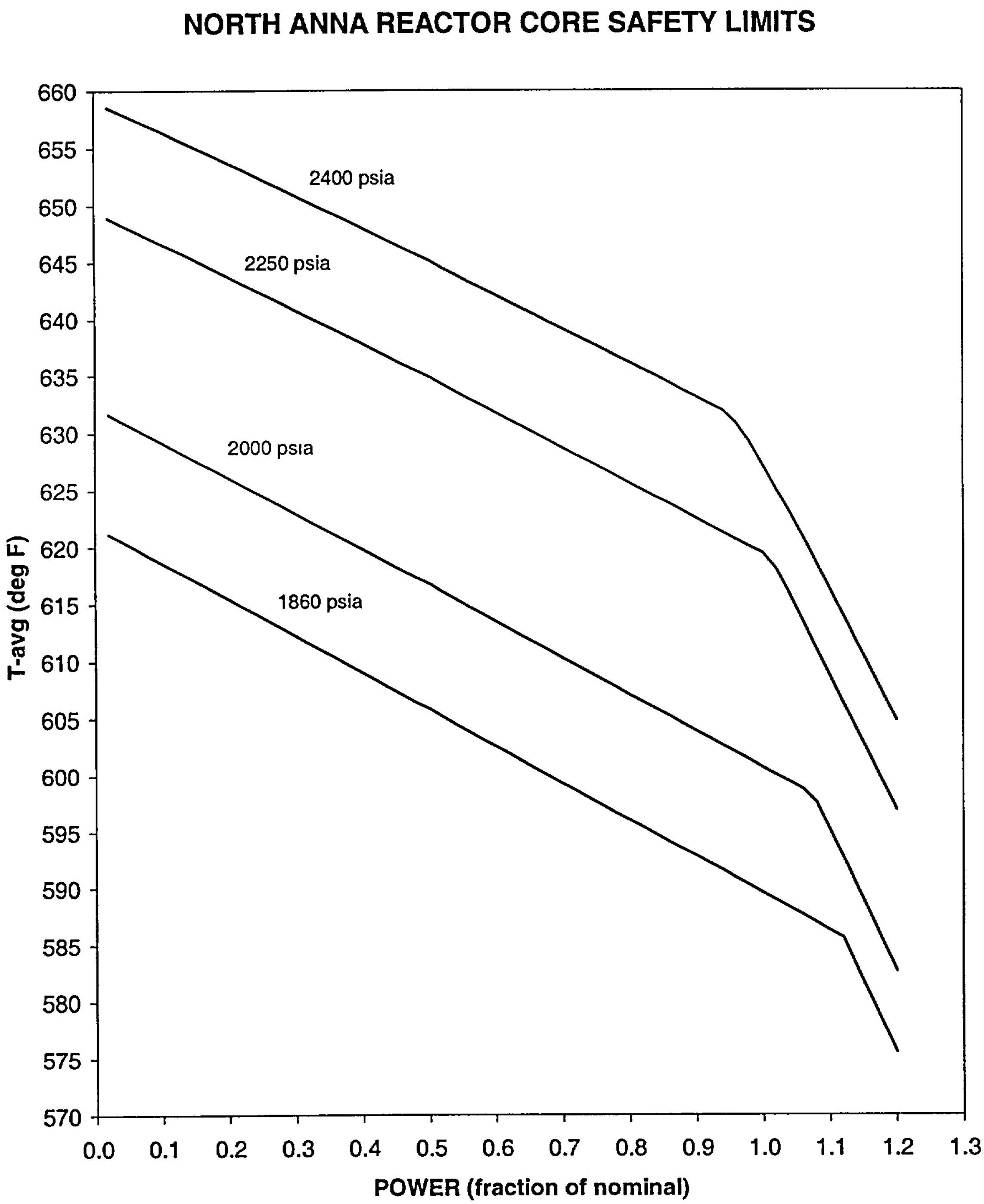
2.1.1 Reactor Core SLs

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 < 4700 ^{0}F.

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/^{0}F, when < 70% RTP, and 0.0 Δk/k/^{0}F when ≥ 70% RTP.**

The BOC/ARO-MTC shall be ≤ +0.6 x 10^{-4} Δk/k/^{0}F (upper limit), when < 70% RTP, and ≤ 0.0 Δk/k/^{0}F when ≥ 70% RTP.

The EOC/ARO/RTP-MTC shall be less negative than –5.0 x 10^{-4} Δk/k/^{0}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/^{0}F [Note 2].

The 60 ppm/ARO/RTP-MTC should be less negative than or equal to –4.7 x 10^{-4} Δk/k/^{0}F [Note 3].

SR 3.1.3.2 Verify MTC is within **–5.0 x 10^{-4} Δk/k/^{0}F (lower limit).**

Note 2: If the MTC is more negative than **–4.0 x 10^{-4} Δk/k/^{0}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/^{0}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 228 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 228 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 100 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.**

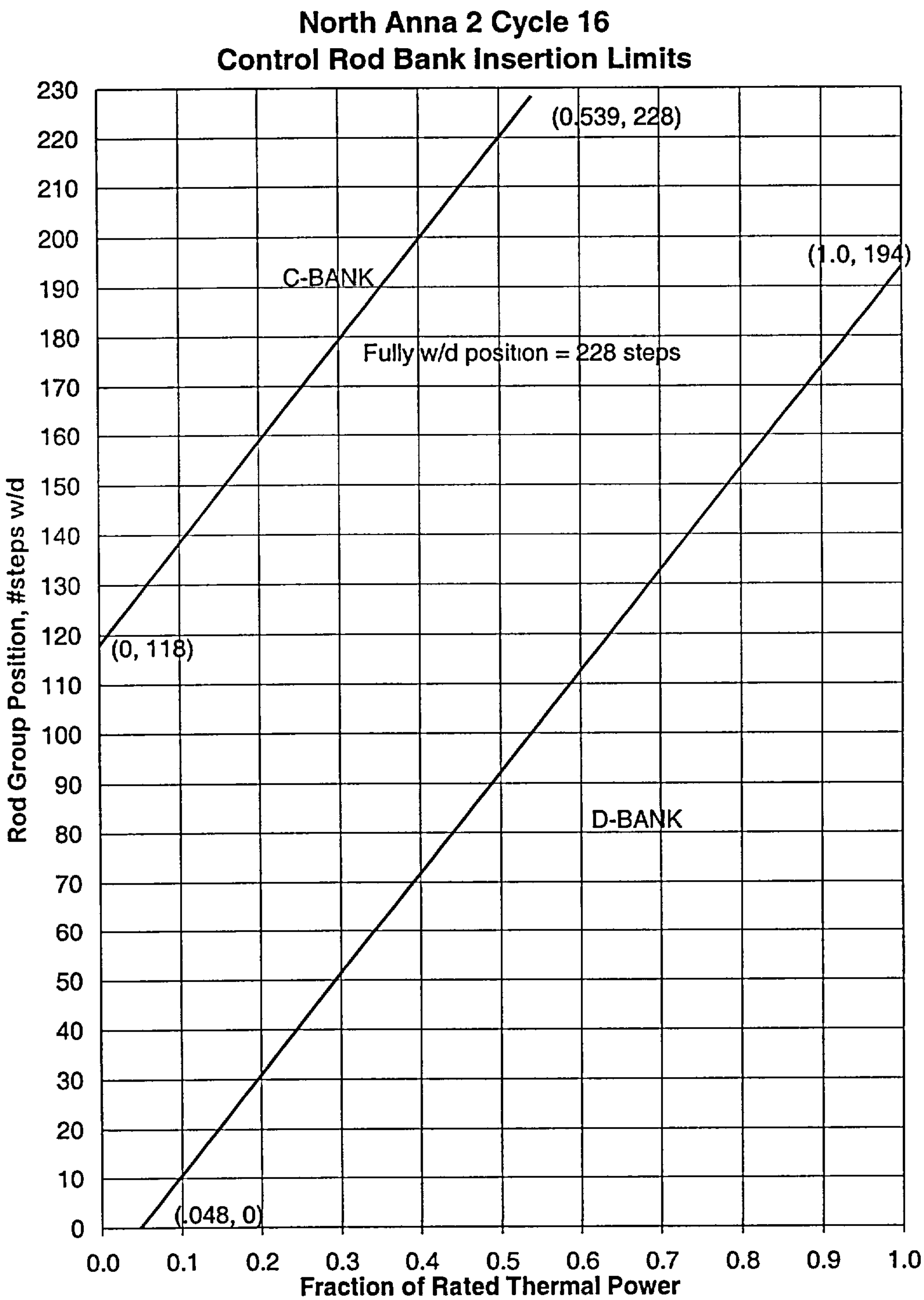
SR 3.1.6.3 Verify each control bank not fully withdrawn from the core is within the sequence and overlap limits specified in **LCO 3.1.6 above.**

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



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.**

The change in the $F_Q(Z)$ limit for coastdown operation is accommodated by defining a variable quantity, CFQ as indicated below. Then, the following expressions apply to both normal operation and Tavg coastdown regimes.

CFQ = 2.19, for normal operation at full power;

CFQ = 2.15, for flux map immediately preceding EOC temperature coastdown and during subsequent power coastdown operation.

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

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

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

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

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

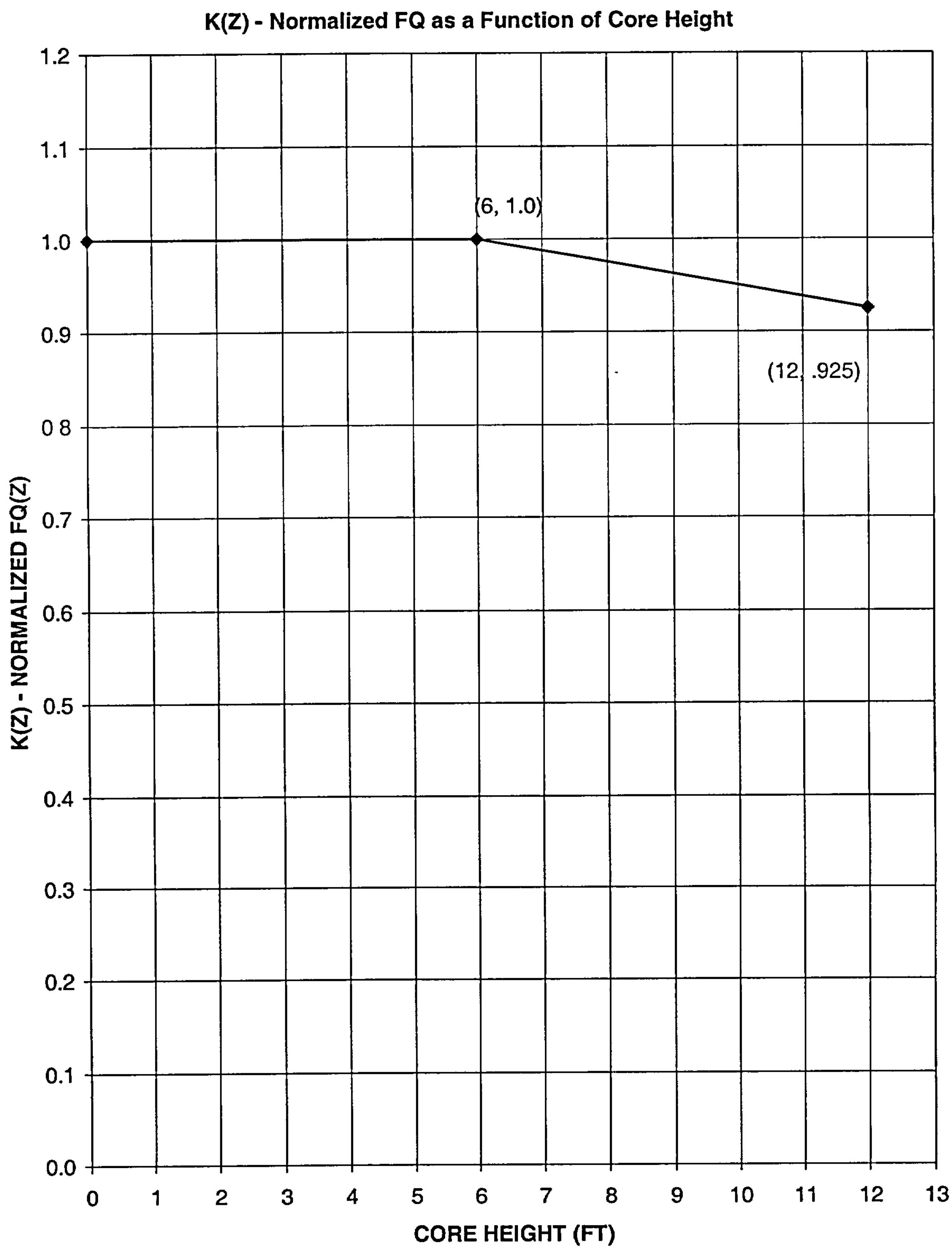
The discussion in the Bases Section B 3.2.1 for this LCO requires the application of a cycle dependent non-equilibrium multiplier, N(Z), to the measured peaking factor, $F_Q^M(Z)$, before comparing it to the limit. N(Z) accounts for power distribution transients encountered during normal operation. As function N(Z) is dependent on the predicted equilibrium $F_Q(Z)$ and is sensitive to the axial power distribution, it must be 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
N2C16 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	9000 to 20400 MWD/MTU
10	10.2	1.112	1.112	1.148	1.148	1.148	1.148
11	10 0	1.111	1.111	1.148	1.148	1.148	1.148
12	9.8	1.110	1.110	1.146	1.146	1.146	1.146
13	9.6	1.109	1.109	1 146	1.146	1.146	1.145
14	9.4	1.108	1.108	1.147	1.147	1.147	1.146
15	9.2	1.110	1.110	1.151	1.151	1.151	1.150
16	9.0	1.111	1.111	1.153	1.153	1.153	1.156
17	8 8	1.115	1.115	1.156	1.156	1.156	1.162
18	8.6	1.119	1.119	1.160	1.160	1.160	1.167
19	8.4	1.126	1.126	1.163	1.163	1.163	1.170
20	8.2	1.133	1.133	1.167	1.167	1.167	1.172
21	8.0	1.139	1.139	1.170	1.170	1.170	1.174
22	7.8	1.142	1.142	1.172	1.172	1.172	1.177
23	7 6	1.142	1.142	1.172	1 172	1.172	1.181
24	7.4	1 139	1.139	1.170	1.170	1.170	1.187
25	7 2	1.137	1.137	1 167	1.167	1.167	1.191
26	7 0	1.134	1.134	1.162	1.162	1.162	1.191
27	6.8	1.131	1.131	1.157	1.157	1.157	1.189
28	6 6	1.126	1.126	1.152	1.152	1.152	1.184
29	6.4	1.121	1.121	1.146	1.146	1.146	1.177
30	6.2	1.114	1.114	1.141	1.141	1.141	1.168
31	6.0	1.106	1.106	1.137	1.137	1.137	1.162
32	5.8	1.098	1.098	1.132	1.132	1.132	1.156
33	5.6	1.091	1.091	1.125	1.125	1.125	1.152
34	5.4	1.088	1.088	1.117	1.117	1.117	1.145
35	5.2	1.087	1.087	1.107	1.108	1.108	1.134
36	5 0	1.091	1.091	1.103	1.103	1.103	1.124
37	4.8	1.096	1.096	1.104	1.105	1.105	1.120
38	4.6	1.106	1.106	1.110	1.109	1.109	1.120
39	4.4	1.119	1.119	1.120	1.111	1.111	1.124
40	4.2	1.132	1.132	1.131	1.115	1.115	1.126
41	4.0	1.144	1.144	1.144	1.120	1.120	1.127
42	3.8	1.156	1.156	1.156	1.124	1.124	1.127
43	3.6	1.167	1.167	1.167	1.128	1.128	1.128
44	3.4	1.178	1.178	1.177	1.130	1.130	1.129
45	3.2	1.187	1.187	1.187	1.134	1.134	1.133
46	3.0	1.196	1.196	1.196	1.141	1.141	1.140
47	2.8	1.204	1.204	1.204	1.151	1.151	1.150
48	2.6	1.212	1.212	1.212	1.159	1.159	1.158
49	2.4	1.218	1.218	1.218	1.167	1.167	1.166
50	2.2	1.225	1.225	1.225	1.174	1.174	1.173
51	2.0	1.231	1.231	1.231	1.182	1.182	1.182
52	1.8	1.237	1.237	1.237	1.191	1.191	1.193

These decks were generated for normal operation flux maps which are typically taken at full power. Additional N(z) decks may be generated if necessary, consistent with the methodology described in the RPDC topical.

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.**

$$F^N_{\Delta H} \leq 1.49\{1 + 0.3(1 - P)\}$$

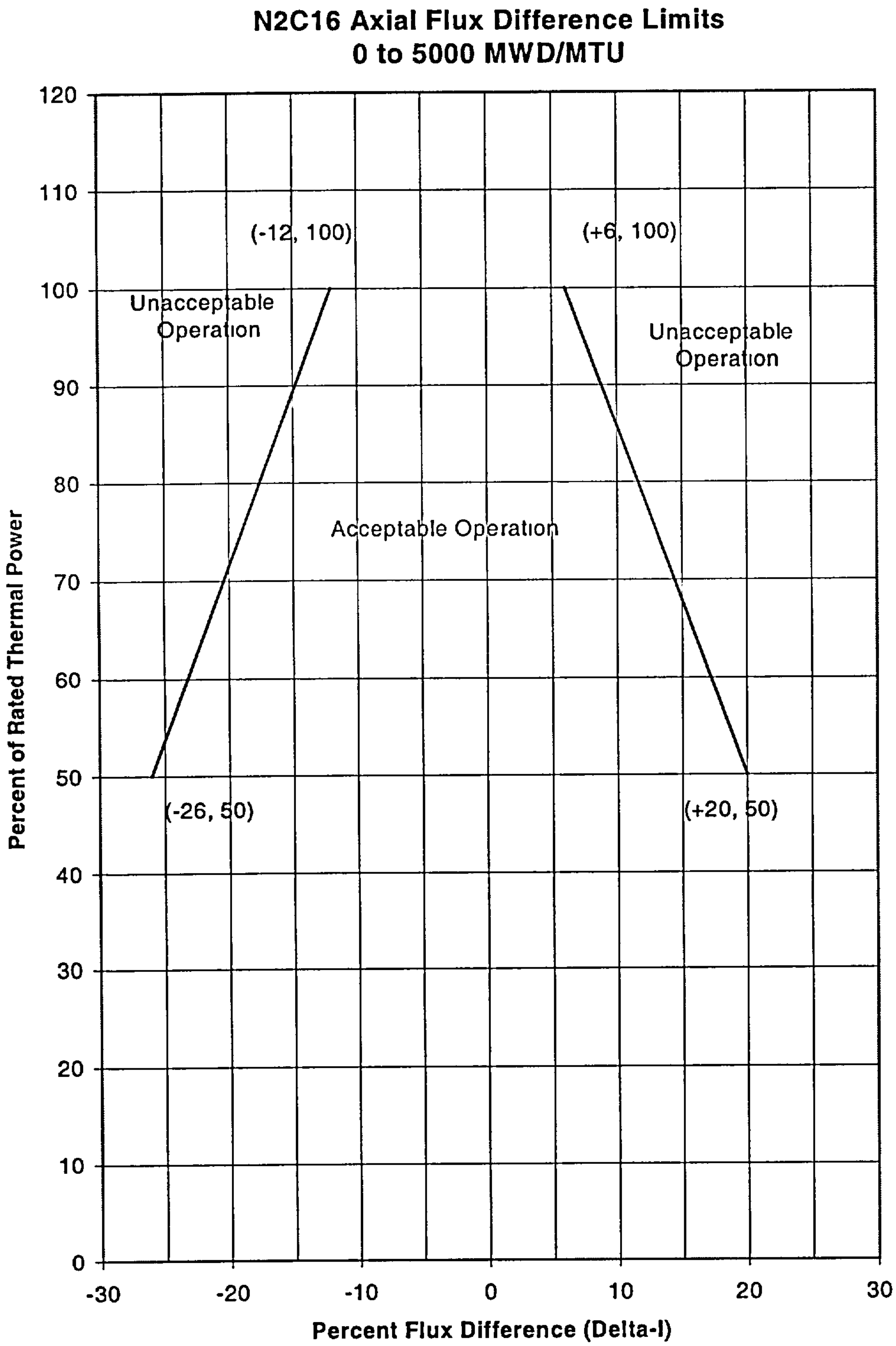
where: $P = \dfrac{THERMAL\ POWER}{RATED\ THERMAL\ POWER}$

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

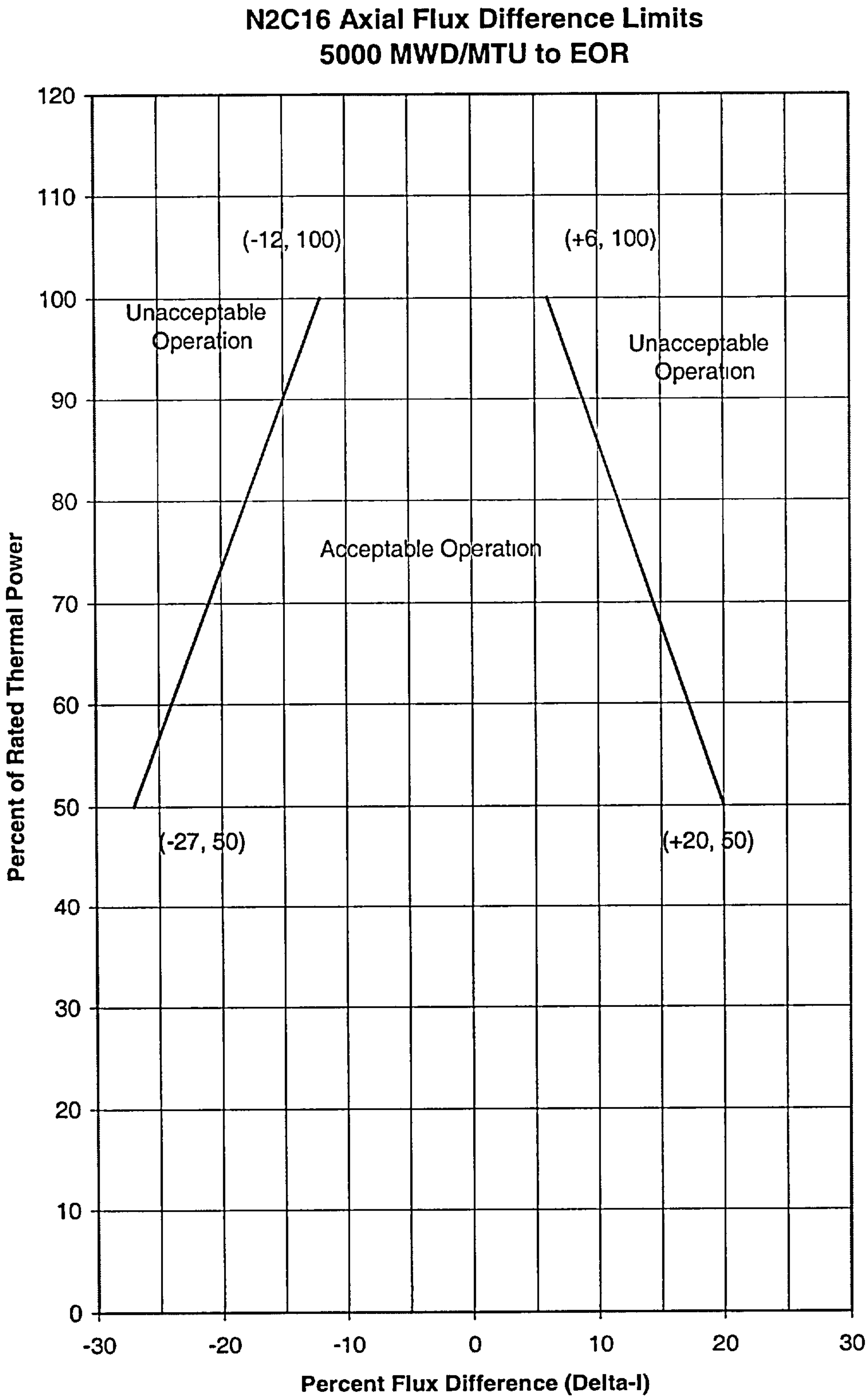
3.2.3 AXIAL FLUX DIFFERENCE (AFD)

LCO 3.2.3 The AFD in % flux difference units shall be maintained within the limits specified in **COLR Figures 3.2-2, 3.2-3 and 3.2-4.**

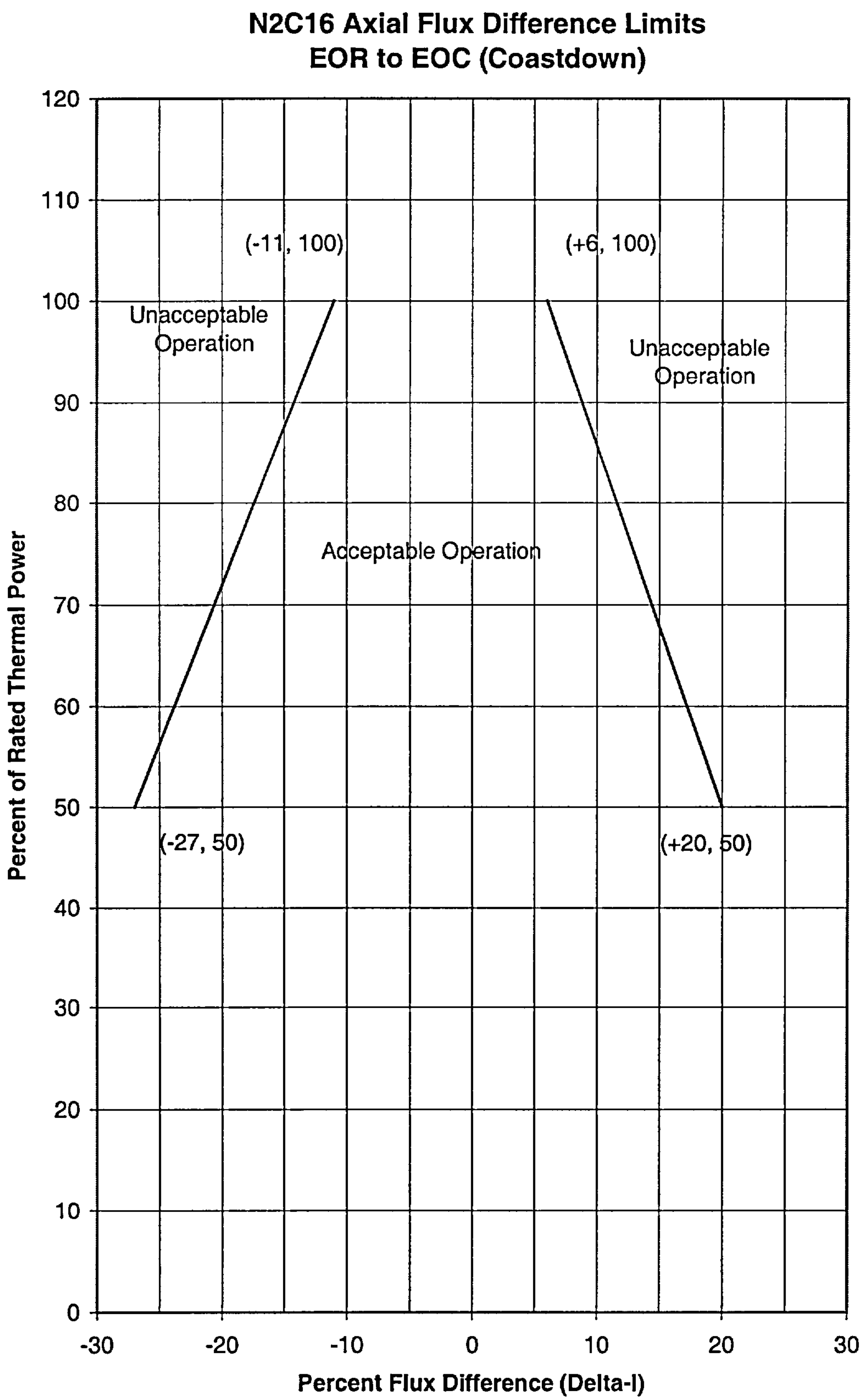
COLR Figure 3.2-2



COLR Figure 3.2-3



COLR Figure 3.2-4



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, ^{0}F.

ΔT_0 is the indicated ΔT at RTP, ^{0}F.

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

T is the measured RCS average temperature, ^{0}F.

T' is the nominal T_{avg} at RTP, **≤ 586.8 ^{0}F.**

P is the measured pressurizer pressure, psig.

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

K_1 ≤ **1.2715** K_2 ≥ **0.02172 /^{0}F** K_3 ≥ **0.001144 /psig**

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

τ_1 ≥ **23.75 sec** τ_2 ≤ **4.4 sec**

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

$f_1(\Delta I) \geq$	**0.0165{−44 − ($q_t - q_b$)}**	when ($q_t - q_b$) < **−44%** RTP
	0	when **−44%** RTP ≤ ($q_t - q_b$) ≤ **+3%** RTP
	0.0198{($q_t - q_b$) − 3}	when ($q_t - q_b$) > **+3%** RTP
	[See footnote]#	

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.

Footnote: The units for $f_1(\Delta I) = 0$ in the North Anna TS and NUREG-1431 are incorrectly specified as "% of RTP." $f_1(\Delta I)$ being dimensionless should have no units. This discrepancy is being addressed by the North Anna Corrective Action System.

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, ^{0}F.
ΔT_0 is the indicated ΔT at RTP, ^{0}F.

s is the Laplace transform operator, sec^{-1}.
T is the measured RCS average temperature, ^{0}F.
T' is the nominal T_{avg} at RTP, **≤ 586.8 ^{0}F.**

K_4 **≤ 1.0865**
K_5 **≥ 0.0197 /^{0}F** for increasing T_{avg}
0 /^{0}F for decreasing T_{avg}

K_6 **≥ 0.00162 /^{0}F** when T > T'
0 /^{0}F when T ≤ T'

τ_3 = time constant utilized in the rate lag controller for T_{avg}
τ_3 **≥ 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 ^{0}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** ^{0}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 an SDM $\geq$ **1.77 % Δk/k at 200 ^{0}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**.

Note: The refueling boron concentration satisfies the more restrictive of the following conditions: (a) $k_{eff} \leq 0.95$*, or (b) boron concentration ≥ 2600 ppm.*

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

TRM 3.1 REACTIVITY CONTROL SYSTEMS

TR 3.1.1 Boration Flow Paths – Operating

Required Action E.2 Borate to a SHUTDOWN MARGIN $\geq$ **1.77 % $\Delta k/k$ at 200 ^{0}F, after xenon decay.**