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

Pursuant to North Anna Technical Specification 5.6.5.d, attached is a copy of Dominion's Core Operating Limits Report for North Anna Unit 2 Cycle 19 Pattern ABU, Revision 1.

If you have any questions or require additional information, please contact Mr. Tom Shaub at 804/273-2763.

Very truly yours,

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Commitments: None

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CORE OPERATING LIMITS REPORT
Revision 1
North Anna Unit 2 Cycle 19 Pattern APU

April 2007

N2C19 CORE OPERATING LIMITS REPORT

INTRODUCTION

The Core Operating Limits Report (COLR) for North Anna Unit 2 Cycle 19 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 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 3.1.5 – 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. 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)

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

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

4. 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)

5. 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)

6. BAW-10227P-A, "Evaluation of Advanced Cladding and Structural Material (M5) in PWR Reactor Fuel."

   (Methodology for TS 2.1.1 – Reactor Core Safety Limits, TS 3.2.1 - Heat Flux Hot Channel Factor)

7. EMF-2103 (P) (A), "Realistic Large Break LOCA Methodology for Pressurized Water Reactors."

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

8. EMF-96-029 (P) (A), "Reactor Analysis System for PWRs."

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

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

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

10. DOM-NAF-2-A, "Reactor Core Thermal-Hydraulics Using the VIPRE-D Computer Code," including Appendix A, "Qualification of the F-ANP BWU CHF Correlations in the VIPRE-D Computer Code."

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

2.0 SAFETY LIMITS (SLs)

2.1 SLs

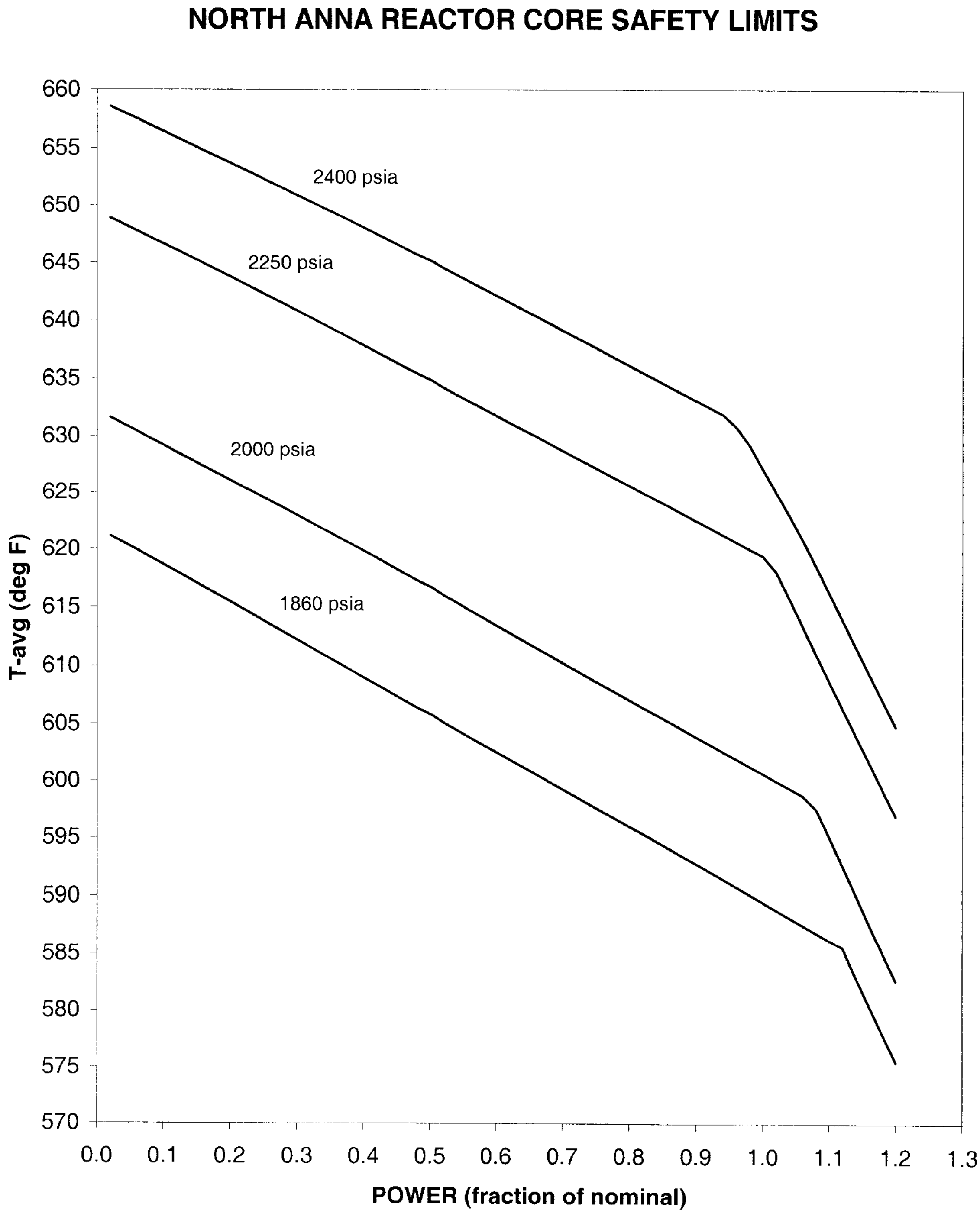
2.1.1 Reactor Core SLs

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.

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 < 5173°F, decreasing by 65°F per 10,000 MWD/MTU of burnup.

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 **227 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 **227 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 **99 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**.

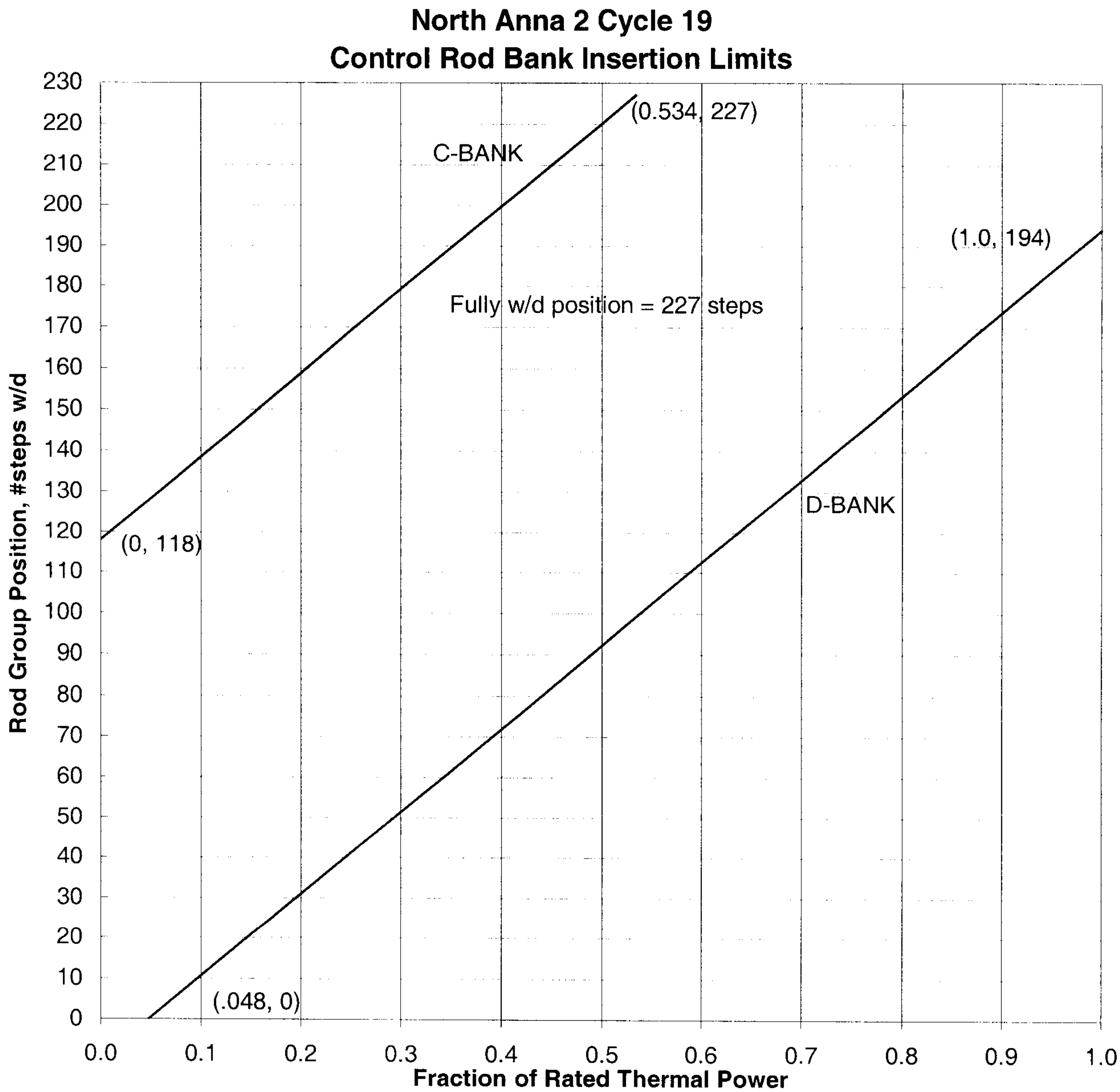
SR 3.1.6.3 Verify each control bank not fully withdrawn from the core is within the sequence and overlap limits specified in **LCO 3.1.6 above**.

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.**

CFQ = 2.32

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

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

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

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 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 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
N2C19 Normal Operation N(Z)

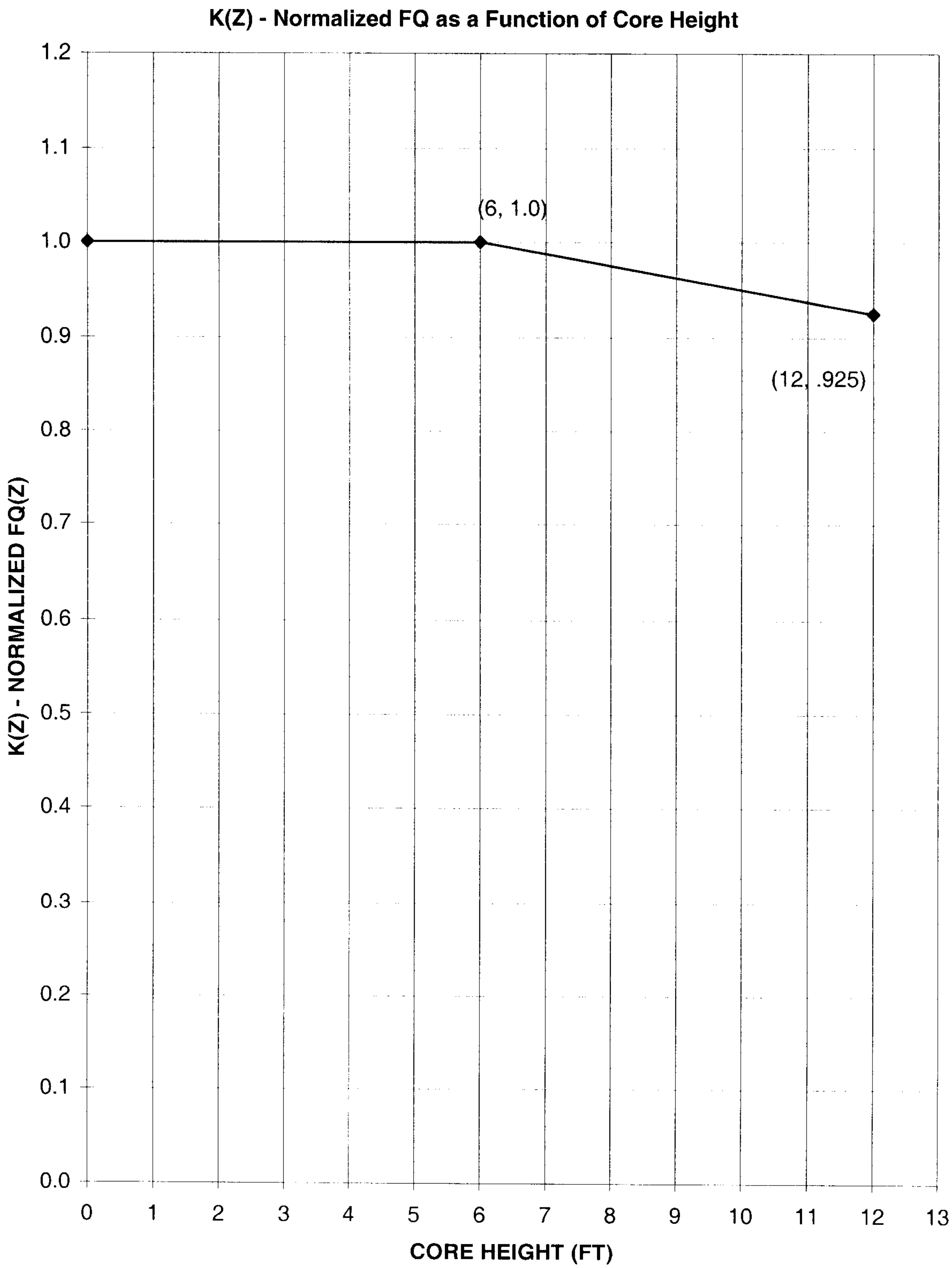
NODE	HEIGHT (FEET)	0 to 1000 MWD/MTU	1000 to 3000 MWD/MTU	3000 to 5000 MWD/MTU	5000 to 7000 MWD/MTU	7000 to 9000 MWD/MTU
10	10.2	1.092	1.095	1.113	1.119	1.130
11	10.0	1.099	1.103	1.112	1.118	1.130
12	9.8	1.108	1.112	1.114	1.121	1.134
13	9.6	1.117	1.120	1.120	1.126	1.142
14	9.4	1.122	1.124	1.123	1.125	1.144
15	9.2	1.126	1.129	1.129	1.127	1.146
16	9.0	1.138	1.143	1.143	1.143	1.152
17	8.8	1.149	1.156	1.156	1.160	1.160
18	8.6	1.151	1.163	1.163	1.167	1.166
19	8.4	1.151	1.166	1.166	1.171	1.171
20	8.2	1.154	1.171	1.171	1.178	1.178
21	8.0	1.155	1.173	1.173	1.182	1.182
22	7.8	1.156	1.173	1.173	1.184	1.185
23	7.6	1.156	1.171	1.171	1.184	1.186
24	7.4	1.156	1.167	1.167	1.184	1.187
25	7.2	1.153	1.163	1.163	1.183	1.187
26	7.0	1.150	1.159	1.159	1.180	1.185
27	6.8	1.149	1.157	1.156	1.179	1.184
28	6.6	1.147	1.152	1.152	1.176	1.181
29	6.4	1.141	1.142	1.143	1.169	1.175
30	6.2	1.132	1.130	1.134	1.159	1.166
31	6.0	1.126	1.123	1.133	1.154	1.162
32	5.8	1.120	1.119	1.131	1.146	1.154
33	5.6	1.109	1.109	1.121	1.128	1.134
34	5.4	1.102	1.102	1.111	1.114	1.119
35	5.2	1.099	1.099	1.107	1.110	1.115
36	5.0	1.102	1.102	1.103	1.109	1.113
37	4.8	1.106	1.106	1.098	1.105	1.106
38	4.6	1.111	1.111	1.097	1.104	1.104
39	4.4	1.114	1.114	1.099	1.105	1.105
40	4.2	1.119	1.119	1.106	1.108	1.107
41	4.0	1.125	1.125	1.114	1.113	1.109
42	3.8	1.131	1.131	1.124	1.116	1.108
43	3.6	1.137	1.137	1.132	1.119	1.110
44	3.4	1.140	1.140	1.137	1.121	1.119
45	3.2	1.144	1.144	1.140	1.125	1.133
46	3.0	1.150	1.150	1.145	1.133	1.144
47	2.8	1.161	1.161	1.152	1.142	1.153
48	2.6	1.171	1.171	1.160	1.146	1.156
49	2.4	1.185	1.185	1.173	1.155	1.163
50	2.2	1.203	1.203	1.190	1.171	1.181
51	2.0	1.215	1.215	1.201	1.182	1.193
52	1.8	1.218	1.218	1.203	1.184	1.195

COLR Table 3.2-1 (cont.)
N2C19 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	1.130	1.133	1.133	1.108	1.114
11	10.0	1.129	1.131	1.131	1.107	1.114
12	9.8	1.134	1.128	1.128	1.107	1.112
13	9.6	1.142	1.126	1.126	1.110	1.111
14	9.4	1.144	1.122	1.122	1.109	1.105
15	9.2	1.146	1.124	1.124	1.115	1.108
16	9.0	1.151	1.137	1.139	1.135	1.130
17	8.8	1.159	1.154	1.158	1.158	1.157
18	8.6	1.164	1.159	1.163	1.164	1.164
19	8.4	1.170	1.164	1.168	1.169	1.169
20	8.2	1.178	1.173	1.178	1.182	1.182
21	8.0	1.183	1.178	1.185	1.191	1.191
22	7.8	1.185	1.180	1.186	1.193	1.193
23	7.6	1.186	1.180	1.190	1.195	1.197
24	7.4	1.187	1.181	1.198	1.200	1.204
25	7.2	1.187	1.183	1.203	1.203	1.208
26	7.0	1.185	1.185	1.205	1.204	1.209
27	6.8	1.184	1.187	1.206	1.206	1.211
28	6.6	1.181	1.187	1.206	1.206	1.211
29	6.4	1.175	1.186	1.206	1.206	1.211
30	6.2	1.165	1.182	1.202	1.202	1.207
31	6.0	1.161	1.183	1.202	1.202	1.207
32	5.8	1.154	1.178	1.196	1.196	1.199
33	5.6	1.142	1.163	1.179	1.179	1.182
34	5.4	1.131	1.148	1.163	1.162	1.164
35	5.2	1.127	1.143	1.157	1.156	1.158
36	5.0	1.122	1.134	1.147	1.149	1.153
37	4.8	1.111	1.119	1.130	1.140	1.146
38	4.6	1.105	1.110	1.121	1.133	1.139
39	4.4	1.103	1.111	1.125	1.129	1.134
40	4.2	1.108	1.115	1.133	1.133	1.133
41	4.0	1.118	1.120	1.141	1.140	1.135
42	3.8	1.126	1.126	1.147	1.146	1.136
43	3.6	1.133	1.133	1.149	1.149	1.138
44	3.4	1.138	1.139	1.151	1.150	1.142
45	3.2	1.143	1.143	1.150	1.150	1.147
46	3.0	1.148	1.146	1.148	1.152	1.151
47	2.8	1.153	1.148	1.147	1.155	1.155
48	2.6	1.155	1.147	1.144	1.154	1.153
49	2.4	1.163	1.151	1.147	1.157	1.158
50	2.2	1.181	1.162	1.156	1.165	1.172
51	2.0	1.193	1.171	1.164	1.172	1.184
52	1.8	1.195	1.172	1.166	1.173	1.189

These decks were 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. 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.**

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

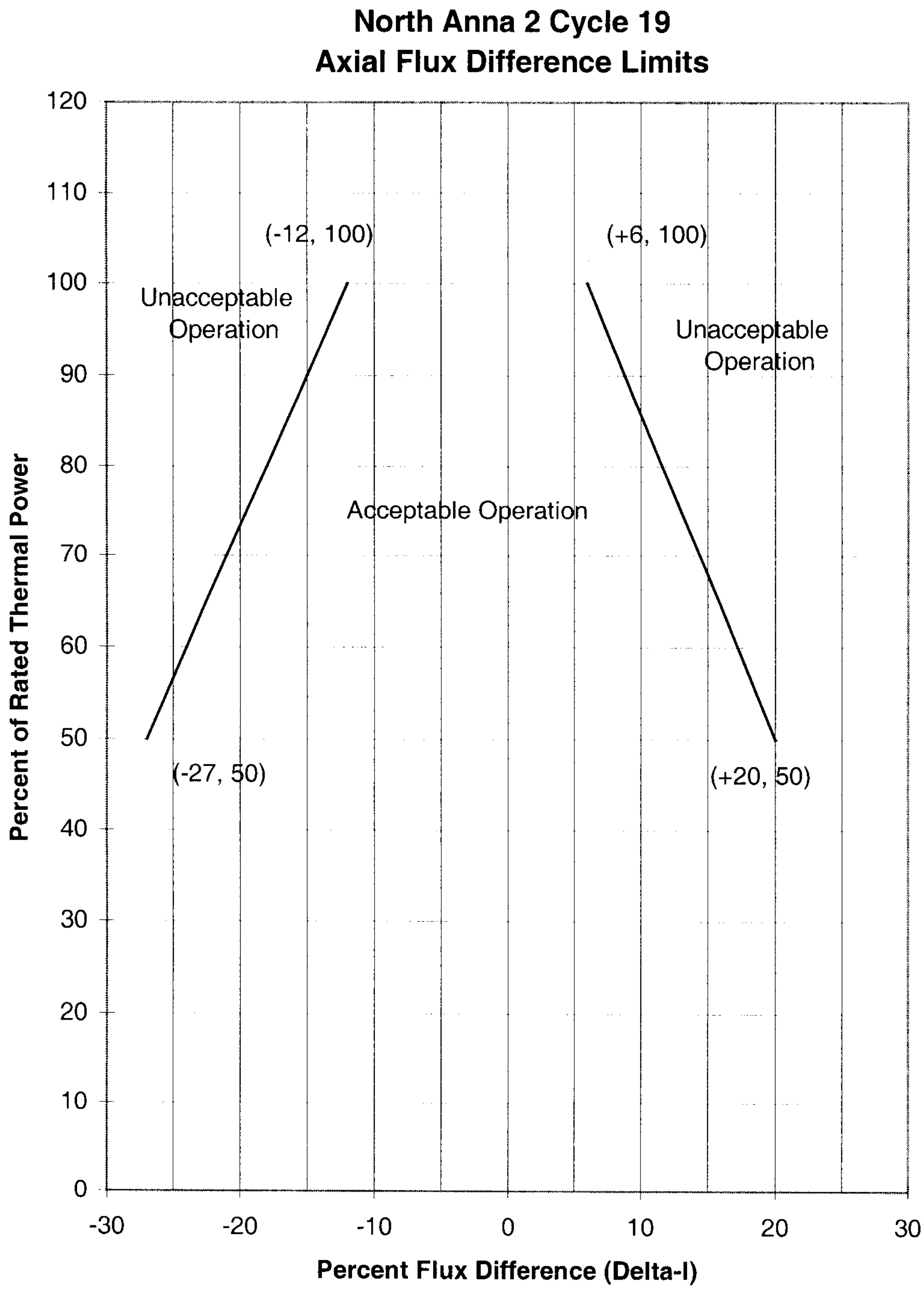
where: $$P = \frac{THERMAL\ POWER}{RATED\ THERMAL\ POWER}$$

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



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, ≤ **586.8 °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 /°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

$f_1(\Delta I)$ ≥ **0.0165{−35 − ($q_t - q_b$)}**	when ($q_t - q_b$) < **−35%** RTP
0	when **−35%** RTP ≤ ($q_t - q_b$) ≤ **+3%** RTP
0.0198{($q_t - q_b$) − 3}	when ($q_t - q_b$) > **+3%** 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 ≤ **1.0865**

K_5 ≥ **0.0197 /°F** for increasing T_{avg}

0 /°F for decreasing T_{avg}

K_6 ≥ **0.00162 /°F** when T > T'

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 °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 an 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**.

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