

Dominion Energy Services, Inc.  
5000 Dominion Boulevard, Glen Allen, VA 23060  
DominionEnergy.com



April 19, 2018

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

Serial No.: 18-158  
NRA/DEA: R0  
Docket No.: 50-338  
License No.: NPF-4

**VIRGINIA ELECTRIC AND POWER COMPANY (DOMINION ENERGY VIRGINIA)**  
**NORTH ANNA POWER STATION UNIT 1**  
**CORE OPERATING LIMITS REPORT**  
**CYCLE 27 PATTERN LNK REVISION 1**

Pursuant to North Anna Technical Specification 5.6.5.d, attached is a copy of the Dominion Core Operating Limits Report (COLR) for North Anna Unit 1 Cycle 27, Pattern LNK, Revision 1, Addendum 0. The COLR was revised to incorporate shutdown data.

If you have any questions or require additional information, please contact Ms. Diane Aitken at (804) 273-2694.

Sincerely,

A handwritten signature in black ink, appearing to read "B. L. Stanley".

B. L. Stanley, Director  
Nuclear Regulatory Affairs  
Dominion Energy Services, Inc. for  
Virginia Electric and Power Company

Attachment:

COLR-N1C27, Revision 1, Core Operating Limits Report, North Anna Unit 1 Cycle 27  
Pattern LNK

Commitment Summary: There are no new commitments contained in this letter.

A001  
NRR

cc: U.S. Nuclear Regulatory Commission  
Region II  
Marquis One Tower  
245 Peachtree Center Avenue, NE  
Suite 1200  
Atlanta, Georgia 30303-1257

Mr. James R. Hall  
NRC Senior Project Manager  
U. S. Nuclear Regulatory Commission  
One White Flint North  
Mail Stop 08 B-1A  
11555 Rockville Pike  
Rockville, Maryland 20852-2738

NRC Senior Resident Inspector  
North Anna Power Station

**ATTACHMENT**

**COLR-N1C27, Revision 1**  
**CORE OPERATING LIMITS REPORT**  
**North Anna Unit 1 Cycle 27 Pattern LNK**

**North Anna Power Station Units 1 and 2**  
**Virginia Electric and Power Company**

## N1C27 CORE OPERATING LIMITS REPORT

### INTRODUCTION

The Core Operating Limits Report (COLR) for North Anna Unit 1 Cycle 27 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 ( $F_{\Delta H}^N$ )
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. 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.

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.

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

5. 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

6. 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

7. 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
8. WCAP-8745-P-A, "Design Bases for the Thermal Overpower  $\Delta T$  and Thermal Overtemperature  $\Delta T$  Trip Functions," September 1986.  
Methodology for:  
TS 2.1.1 – Reactor Core Safety Limits and  
TS 3.3.1 – Reactor Trip System Instrumentation
9. 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
10. 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
11. 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

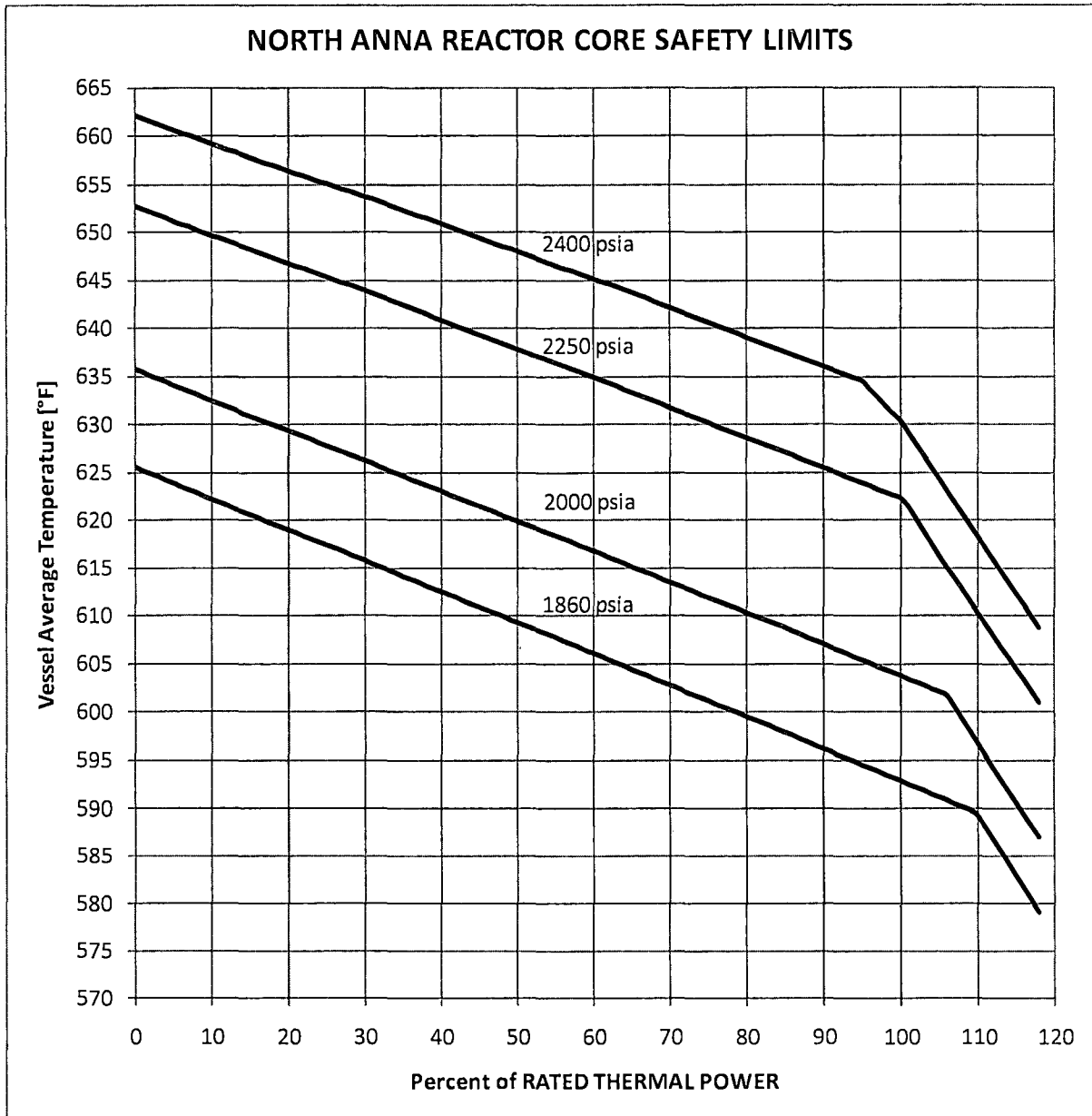
2.1.1 Reactor Core SLs

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.

2.1.1.2 The peak fuel centerline temperature shall be maintained  $< 5080^{\circ}\text{F}$ , decreasing by  $58^{\circ}\text{F}$  per 10,000 MWD/MTU of burnup, for Westinghouse fuel *and*  $< 5173^{\circ}\text{F}$ , decreasing by  $65^{\circ}\text{F}$  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  $\geq 1.77\% \Delta k/k$ .

#### 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  $+0.6 \times 10^{-4} \Delta k/k/^\circ F$ , when  $< 70\%$  RTP, and  $0.0 \Delta k/k/^\circ F$  when  $\geq 70\%$  RTP.

The BOC/ARO-MTC shall be  $\leq +0.6 \times 10^{-4} \Delta k/k/^\circ F$  (upper limit), when  $< 70\%$  RTP, and  $\leq 0.0 \Delta k/k/^\circ F$  when  $\geq 70\%$  RTP.

The EOC/ARO/RTP-MTC shall be less negative than  $-5.0 \times 10^{-4} \Delta k/k/^\circ F$  (lower limit).

The MTC surveillance limits are:

The 300 ppm/ARO/RTP-MTC should be less negative than or equal to  $-4.0 \times 10^{-4} \Delta k/k/^\circ F$  [Note 1].

The 60 ppm/ARO/RTP-MTC should be less negative than or equal to  $-4.7 \times 10^{-4} \Delta k/k/^\circ F$  [Note 2].

SR 3.1.3.2 Verify MTC is within  $-5.0 \times 10^{-4} \Delta k/k/^\circ F$  (lower limit).

Note 1: If the MTC is more negative than  $-4.0 \times 10^{-4} \Delta k/k/^\circ F$ , 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  $\leq 60$  ppm is less negative than  $-4.7 \times 10^{-4} \Delta k/k/^\circ F$ .

3.1.4 Rod Group Alignment Limits

Required Action A.1.1 Verify SDM to be  $\geq 1.77\% \Delta k/k$ .

Required Action B.1.1 Verify SDM to be  $\geq 1.77\% \Delta k/k$ .

Required Action D.1.1 Verify SDM to be  $\geq 1.77\% \Delta k/k$ .

3.1.5 Shutdown Bank Insertion Limits

LCO 3.1.5 Each shutdown bank shall be withdrawn to at least **226** steps.

Required Action A.1.1 Verify SDM to be  $\geq 1.77\% \Delta k/k$ .

Required Action B.1 Verify SDM to be  $\geq 1.77\% \Delta k/k$ .

SR 3.1.5.1 Verify each shutdown bank is withdrawn to at least **226** 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 **98** steps.

Required Action A.1.1 Verify SDM to be  $\geq 1.77\% \Delta k/k$ .

Required Action B.1.1 Verify SDM to be  $\geq 1.77\% \Delta k/k$ .

Required Action C.1 Verify SDM to be  $\geq 1.77\% \Delta k/k$ .

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**.

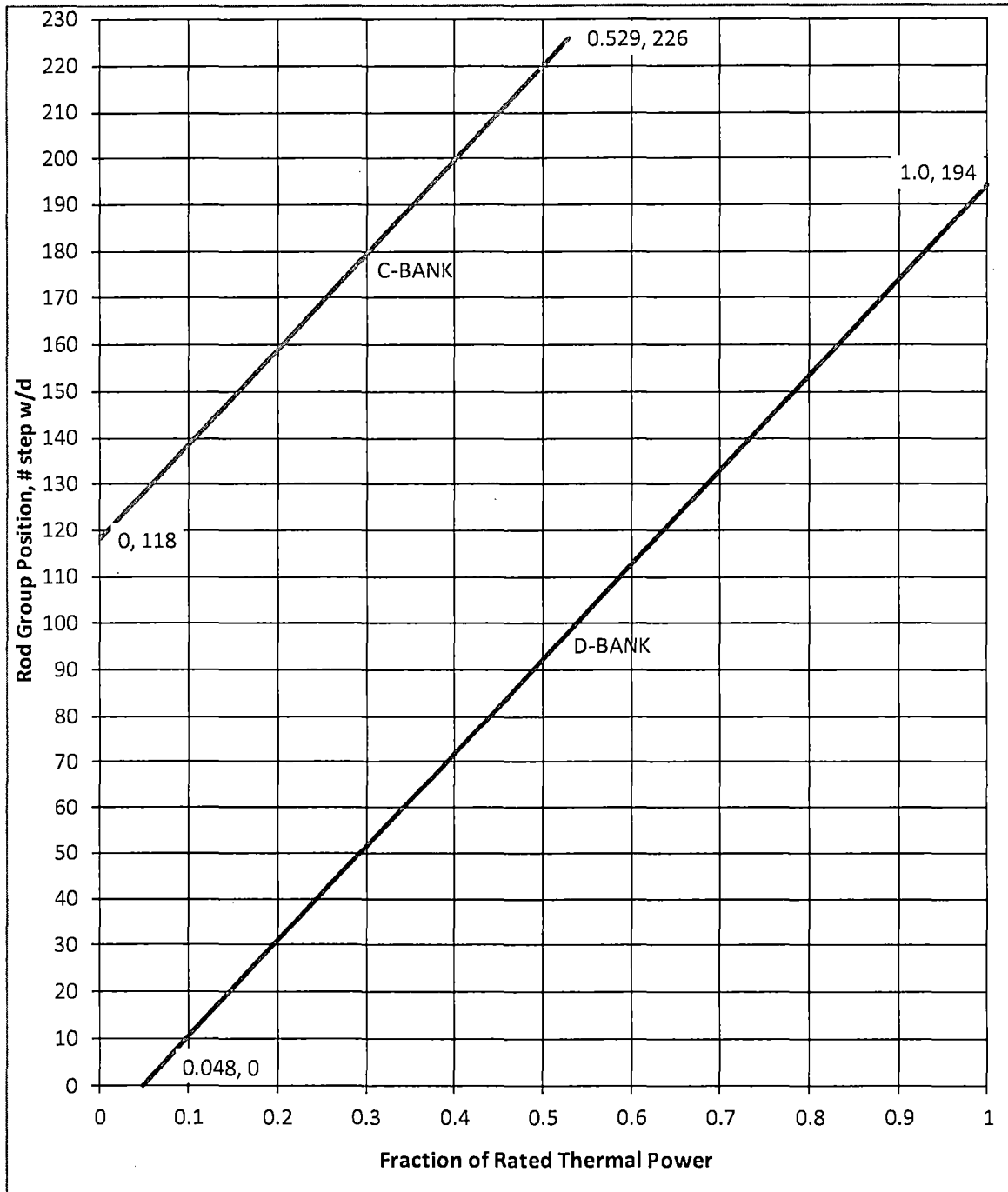
SR 3.1.6.3 Verify each control bank not fully withdrawn from the core is within the sequence and overlap limits specified in **LCO 3.1.6 above**.

3.1.9 PHYSICS TESTS Exceptions – MODE 2

LCO 3.1.9.b SDM is  $\geq 1.77\% \Delta k/k$ .

SR 3.1.9.4 Verify SDM to be  $\geq 1.77\% \Delta k/k$ .

**COLR Figure 3.1-1**  
**North Anna 1 Cycle 27**  
**Control Rod Bank Insertion Limits**  
Fully w/d position = 226 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:

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

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

where:  $P = \frac{THERMAL POWER}{RATED THERMAL POWER}$  ; 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  $N(Z)$  is a cycle-specific non-equilibrium multiplier on  $F_Q^E(Z)$  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 steady state  $F_Q^E(Z)$ .  $N(Z)$  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 penalty factors are presented in **COLR Table 3.2-2**.

*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). These values are typically generated from the actual EOC burnup distribution that can only be obtained after the shutdown of the previous cycle.*

The required operating space reductions are included in **COLR Table 3.2-3**.

*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. These values are typically generated from the actual EOC burnup distribution that can only be obtained after the shutdown of the previous cycle.*

COLR Table 3.2-1  
N1C27 Normal Operation N(Z)

NODE	HEIGHT (FEET)	0 to 1000 MWD/MTU	1000 to 2000 MWD/MTU	2000 to 3000 MWD/MTU	3000 to 4000 MWD/MTU	4000 to 5000 MWD/MTU	5000 to 7000 MWD/MTU	7000 to 9000 MWD/MTU
5	11.2	1.109	1.114	1.123	1.135	1.147	1.161	1.163
6	11.0	1.113	1.115	1.122	1.134	1.150	1.160	1.162
7	10.8	1.115	1.115	1.121	1.133	1.153	1.159	1.161
8	10.6	1.111	1.112	1.119	1.131	1.153	1.157	1.159
9	10.4	1.105	1.108	1.118	1.129	1.150	1.154	1.157
10	10.2	1.102	1.106	1.116	1.128	1.146	1.153	1.155
11	10.0	1.104	1.109	1.116	1.127	1.141	1.152	1.156
12	9.8	1.108	1.112	1.117	1.127	1.138	1.152	1.157
13	9.6	1.111	1.115	1.120	1.128	1.138	1.154	1.158
14	9.4	1.113	1.117	1.124	1.130	1.140	1.156	1.161
15	9.2	1.115	1.120	1.128	1.134	1.144	1.160	1.165
16	9.0	1.119	1.122	1.132	1.139	1.149	1.165	1.170
17	8.8	1.122	1.124	1.133	1.144	1.153	1.168	1.174
18	8.6	1.122	1.124	1.132	1.144	1.153	1.167	1.176
19	8.4	1.120	1.122	1.130	1.141	1.151	1.164	1.176
20	8.2	1.117	1.119	1.127	1.137	1.148	1.161	1.175
21	8.0	1.115	1.117	1.125	1.134	1.145	1.160	1.174
22	7.8	1.111	1.112	1.120	1.129	1.139	1.157	1.171
23	7.6	1.104	1.104	1.111	1.120	1.130	1.149	1.163
24	7.4	1.095	1.096	1.102	1.110	1.119	1.138	1.163
25	7.2	1.090	1.090	1.096	1.104	1.112	1.132	1.146
26	7.0	1.089	1.089	1.095	1.103	1.112	1.129	1.142
27	6.8	1.087	1.086	1.092	1.100	1.108	1.124	1.134
28	6.6	1.078	1.077	1.081	1.088	1.095	1.108	1.117
29	6.4	1.063	1.062	1.065	1.069	1.075	1.085	1.093
30	6.2	1.049	1.048	1.049	1.052	1.056	1.064	1.073
31	6.0	1.039	1.038	1.039	1.042	1.045	1.053	1.062
32	5.8	1.037	1.036	1.037	1.039	1.043	1.050	1.057
33	5.6	1.045	1.044	1.045	1.046	1.048	1.051	1.055
34	5.4	1.060	1.060	1.059	1.058	1.058	1.057	1.056
35	5.2	1.076	1.076	1.074	1.072	1.070	1.066	1.062
36	5.0	1.089	1.089	1.087	1.084	1.082	1.078	1.071
37	4.8	1.098	1.098	1.096	1.093	1.091	1.088	1.081
38	4.6	1.104	1.103	1.101	1.099	1.097	1.095	1.088
39	4.4	1.111	1.110	1.108	1.105	1.102	1.100	1.094
40	4.2	1.123	1.123	1.120	1.116	1.112	1.109	1.101
41	4.0	1.144	1.144	1.140	1.135	1.128	1.122	1.111
42	3.8	1.162	1.162	1.159	1.152	1.143	1.135	1.122
43	3.6	1.171	1.171	1.167	1.159	1.150	1.143	1.132
44	3.4	1.172	1.172	1.169	1.161	1.152	1.146	1.140
45	3.2	1.176	1.176	1.173	1.165	1.155	1.150	1.148
46	3.0	1.188	1.188	1.185	1.175	1.165	1.157	1.155
47	2.8	1.202	1.203	1.199	1.188	1.177	1.165	1.161
48	2.6	1.216	1.215	1.211	1.201	1.188	1.175	1.164
49	2.4	1.227	1.226	1.221	1.212	1.198	1.184	1.167
50	2.2	1.238	1.239	1.235	1.222	1.207	1.193	1.172
51	2.0	1.249	1.254	1.254	1.232	1.216	1.202	1.180
52	1.8	1.260	1.268	1.269	1.241	1.225	1.210	1.188
53	1.6	1.269	1.276	1.272	1.250	1.233	1.217	1.195
54	1.4	1.277	1.279	1.268	1.257	1.240	1.224	1.201

COLR Table 3.2-1 (continued)  
N1C27 Normal Operation N(Z)

NODE	HEIGHT (FEET)	0 to 1000 MWD/MTU	1000 to 2000 MWD/MTU	2000 to 3000 MWD/MTU	3000 to 4000 MWD/MTU	4000 to 5000 MWD/MTU	5000 to 7000 MWD/MTU	7000 to 9000 MWD/MTU
55	1.2	1.284	1.284	1.271	1.264	1.247	1.229	1.205
56	1.0	1.291	1.293	1.285	1.270	1.252	1.235	1.210
57	0.8	1.297	1.303	1.302	1.276	1.258	1.240	1.215

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)  
N1C27 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 19000 MWD/MTU	19000 to EOR MWD/MTU
5	11.2	1.163	1.159	1.153	1.147	1.144	1.141
6	11.0	1.162	1.158	1.152	1.147	1.143	1.141
7	10.8	1.161	1.157	1.151	1.146	1.143	1.140
8	10.6	1.159	1.155	1.149	1.144	1.141	1.139
9	10.4	1.157	1.153	1.147	1.143	1.140	1.139
10	10.2	1.155	1.152	1.147	1.143	1.140	1.139
11	10.0	1.156	1.153	1.149	1.145	1.141	1.140
12	9.8	1.157	1.155	1.151	1.147	1.143	1.141
13	9.6	1.158	1.156	1.152	1.147	1.142	1.140
14	9.4	1.161	1.158	1.153	1.148	1.142	1.140
15	9.2	1.165	1.162	1.157	1.152	1.148	1.147
16	9.0	1.171	1.169	1.165	1.162	1.160	1.160
17	8.8	1.176	1.175	1.173	1.172	1.173	1.173
18	8.6	1.178	1.178	1.177	1.176	1.178	1.180
19	8.4	1.178	1.178	1.177	1.177	1.179	1.180
20	8.2	1.177	1.177	1.177	1.177	1.179	1.179
21	8.0	1.177	1.177	1.178	1.178	1.181	1.182
22	7.8	1.174	1.176	1.177	1.178	1.181	1.182
23	7.6	1.169	1.171	1.173	1.175	1.177	1.178
24	7.4	1.161	1.165	1.167	1.168	1.170	1.171
25	7.2	1.154	1.159	1.161	1.163	1.165	1.166
26	7.0	1.149	1.154	1.157	1.159	1.162	1.164
27	6.8	1.141	1.144	1.148	1.151	1.155	1.157
28	6.6	1.122	1.126	1.130	1.133	1.136	1.138
29	6.4	1.099	1.103	1.107	1.109	1.111	1.113
30	6.2	1.079	1.084	1.088	1.090	1.092	1.093
31	6.0	1.068	1.074	1.078	1.080	1.083	1.085
32	5.8	1.063	1.068	1.073	1.075	1.079	1.081
33	5.6	1.060	1.064	1.068	1.069	1.072	1.074
34	5.4	1.058	1.062	1.064	1.064	1.065	1.066
35	5.2	1.061	1.065	1.065	1.065	1.065	1.064
36	5.0	1.069	1.073	1.073	1.073	1.072	1.072
37	4.8	1.079	1.082	1.083	1.083	1.083	1.082
38	4.6	1.086	1.090	1.091	1.091	1.091	1.091
39	4.4	1.092	1.095	1.096	1.096	1.096	1.096
40	4.2	1.098	1.102	1.103	1.103	1.103	1.102
41	4.0	1.107	1.110	1.111	1.112	1.112	1.111
42	3.8	1.117	1.120	1.121	1.122	1.122	1.121
43	3.6	1.126	1.129	1.130	1.131	1.131	1.131
44	3.4	1.135	1.138	1.139	1.140	1.140	1.140
45	3.2	1.144	1.147	1.148	1.150	1.150	1.149
46	3.0	1.153	1.155	1.157	1.159	1.159	1.159
47	2.8	1.161	1.164	1.166	1.168	1.169	1.169
48	2.6	1.164	1.171	1.175	1.177	1.178	1.178
49	2.4	1.165	1.177	1.183	1.185	1.186	1.186
50	2.2	1.168	1.182	1.188	1.192	1.194	1.195
51	2.0	1.174	1.185	1.191	1.199	1.203	1.204
52	1.8	1.181	1.188	1.194	1.203	1.210	1.211
53	1.6	1.187	1.192	1.197	1.206	1.213	1.215
54	1.4	1.192	1.196	1.201	1.209	1.214	1.216



COLR Table 3.2-1 (continued)  
N1C27 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 19000 MWD/MTU	19000 to EOR MWD/MTU
55	1.2	1.196	1.202	1.207	1.212	1.215	1.218
56	1.0	1.201	1.207	1.212	1.217	1.220	1.222
57	0.8	1.206	1.212	1.217	1.222	1.225	1.227

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 3.2-2  
N1C27 Penalty Factors for Flux Map Analysis**

Burnup (MWD/MTU)	Penalty Factor %
0-999	3.00
1000-1999	3.50
2000-2999	2.00
3000-3999	2.00
4000-4999	2.00
5000-6999	2.00
7000-8999	2.00
9000-10999	2.00
11000-12999	2.00
13000-14999	2.00
15000-16999	2.00
17000-18999	2.00
19000-EOC	2.00

*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 ( $\leq 7$  EFPD).*

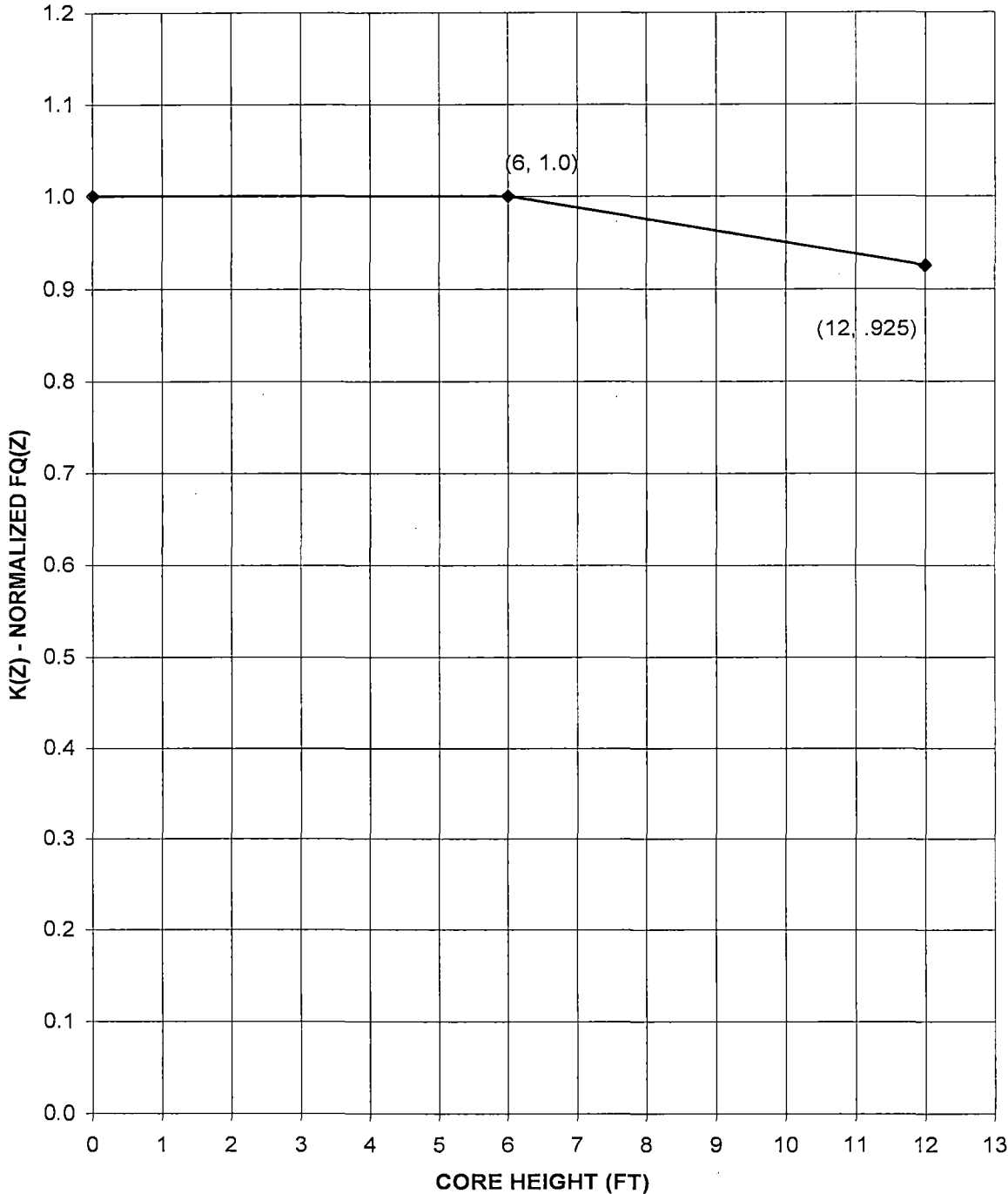
**COLR Table 3.2-3  
N1C27 Required Operating Space Reductions for  $F_Q^T(Z)$  Exceeding its Limits**

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)
$\leq 1\%$	$\leq 98.0$	$\geq 0.5$	$\geq 1.0$
$> 1\%$ and $\leq 2\%$	$\leq 96.0$	$\geq 1.0$	$\geq 2.0$
$> 2\%$ and $\leq 3\%$	$\leq 95.0$	$\geq 1.5$	$\geq 4.0$
$> 3\%$	$\leq 50$	N/A	N/A

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

COLR Figure 3.2-1

K(Z) - Normalized FQ as a Function of Core Height



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

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

$$F_{\Delta H}^N \leq 1.587\{1 + 0.3(1 - P)\}$$

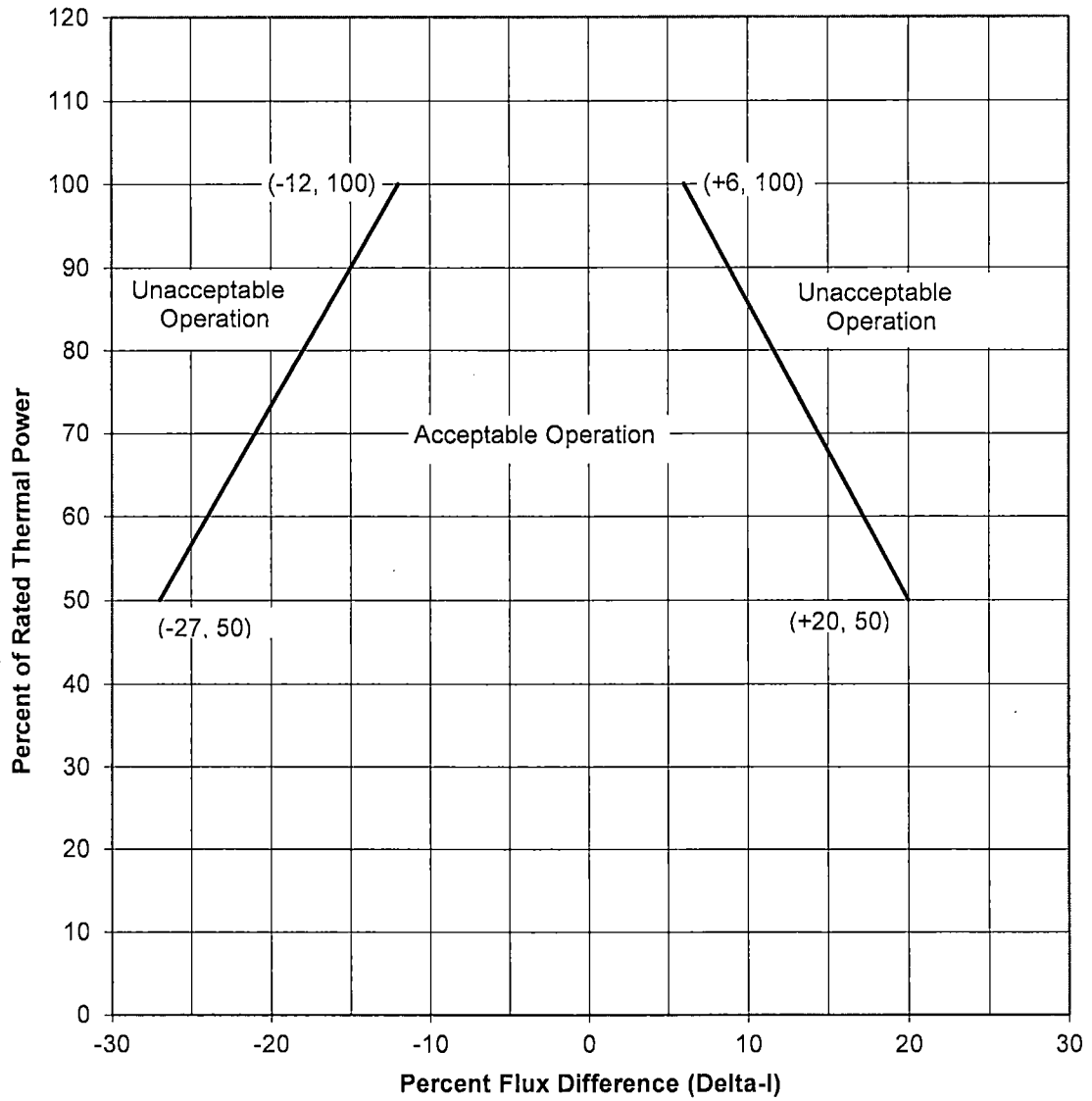
where: 
$$P = \frac{\text{THERMAL POWER}}{\text{RATED THERMAL POWER}}$$

SR 3.2.2.1 Verify  $F_{\Delta H}^N$  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 27**  
**Axial Flux Difference Limits**



### 3.3 INSTRUMENTATION

#### 3.3.1 Reactor Trip System (RTS) Instrumentation

##### TS Table 3.3.1-1 Note 1: Overtemperature $\Delta T$

The Overtemperature  $\Delta T$  Function Allowable Value shall not exceed the following nominal trip setpoint by more than 2% of  $\Delta T$  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:  $\Delta T$  is measured RCS  $\Delta T$ , °F  
 $\Delta T_0$  is the indicated  $\Delta T$  at RTP, °F  
 $s$  is the Laplace transform operator, sec<sup>-1</sup>  
 $T$  is the measured RCS average temperature, °F  
 $T'$  is the nominal  $T_{avg}$  at RTP,  $\leq 586.8$  °F  
 $P$  is the measured pressurizer pressure, psig  
 $P'$  is the nominal RCS operating pressure,  $\geq 2235$  psig

$$K_1 \leq 1.2715 \qquad K_2 \geq 0.02174 / ^\circ\text{F} \qquad K_3 \geq 0.001145 / \text{psig}$$

$\tau_1, \tau_2 =$  time constants utilized in the lead-lag controller for  $T_{avg}$

$$\tau_1 \geq 23.75 \text{ sec} \qquad \tau_2 \leq 4.4 \text{ sec}$$

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

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

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  $\Delta T$

The Overpower  $\Delta T$  Function Allowable Value shall not exceed the following nominal trip setpoint by more than 2% of  $\Delta T$  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:  $\Delta T$  is measured RCS  $\Delta T$ , °F.  
 $\Delta T_0$  is the indicated  $\Delta T$  at RTP, °F.  
 $s$  is the Laplace transform operator,  $\text{sec}^{-1}$ .  
 $T$  is the measured RCS average temperature, °F.  
 $T'$  is the nominal  $T_{\text{avg}}$  at RTP,  $\leq 586.8$  °F.

$$K_4 \leq 1.0865$$

$$K_5 \geq \begin{matrix} 0.0198 / ^\circ\text{F} & \text{for increasing } T_{\text{avg}} \\ 0 / ^\circ\text{F} & \text{for decreasing } T_{\text{avg}} \end{matrix} \quad K_6 \geq \begin{matrix} 0.00162 / ^\circ\text{F} & \text{when } T > T' \\ 0 / ^\circ\text{F} & \text{when } T \leq T' \end{matrix}$$

$\tau_3 =$  time constant utilized in the rate lag controller for  $T_{\text{avg}}$

$$\tau_3 \geq 9.5 \text{ sec}$$

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

$$f_2(\Delta I) = 0, \text{ for all } \Delta I.$$

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  $\geq 90\%$  RTP.  
-----  
Verify by precision heat balance that  
RCS total flow rate is  $\geq$  **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  $\geq 1.77\%$   $\Delta k/k$  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  $\geq$  **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  $\geq 1.77\% \Delta k/k$   
at 200 °F, after xenon decay.