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Attention: Document Control Desk
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Byron Station, Unit 2
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NRC Docket No. STN 50-455

Subject: Byron Station Unit 2 Cycle 13 Core Operating Limits Report

In accordance with Technical Specification 5.6.5, "Core Operating Limits Report (COLR)," we are submitting the Unit 2 Cycle 13 COLR revision 0.

Should you have any questions concerning these reports, please contact William Grundmann, Regulatory Assurance Manager, at (815) 406-2800.

Respectfully,

Stephen E. Kuczynski

Stephen E Kuczynski
Site Vice President
Byron Nuclear Generating Station

Attachment: 1) Byron Station Unit 2 Cycle 13 COLR, revision 0

SEK/JL/rah

ATTACHMENT 1

Byron Station Unit 2 Cycle 13 Core Operating Limits Report
Revision 0

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 13

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Byron Station Unit 2 Cycle 13 has been prepared in accordance with the requirements of Technical Specification 5.6.5 (ITS).

The Technical Specifications affected by this report are listed below:

SL	2.1.1	Reactor Core Safety Limits (SLs)
LCO	3.1.1	SHUTDOWN MARGIN (SDM)
LCO	3.1.3	Moderator Temperature Coefficient (MTC)
LCO	3.1.4	Rod Group Alignment Limits
LCO	3.1.5	Shutdown Bank Insertion Limits
LCO	3.1.6	Control Bank Insertion Limits
LCO	3.1.8	PHYSICS TESTS Exceptions – MODE 2
LCO	3.2.1	Heat Flux Hot Channel Factor ($F_Q(Z)$)
LCO	3.2.2	Nuclear Enthalpy Rise Hot Channel Factor ($F^N_{\Delta H}$)
LCO	3.2.3	AXIAL FLUX DIFFERENCE (AFD)
LCO	3.2.5	Departure from Nucleate Boiling Ratio (DNBR)
LCO	3.3.1	Reactor Trip System (RTS) Instrumentation
LCO	3.3.9	Boron Dilution Protection System (BDPS)
LCO	3.4.1	Reactor Coolant System (RCS) Pressure, Temperature, and Flow Departure from Nucleate Boiling (DNB) Limits
LCO	3.9.1	Boron Concentration

The portions of the Technical Requirements Manual affected by this report are listed below:

TRM TLCO 3.1.b	Boration Flow Paths – Operating
TRM TLCO 3.1.d	Charging Pumps – Operating
TRM TLCO 3.1.f	Borated Water Sources – Operating
TRM TLCO 3.1.g	Position Indication System – Shutdown
TRM TLCO 3.1.h	Shutdown Margin (SDM) – MODE 1 and MODE 2 with keff ≥ 1.0
TRM TLCO 3.1.i	Shutdown Margin (SDM) – MODE 5
TRM TLCO 3.1.j	Shutdown and Control Rods
TRM TLCO 3.1.k	Position Indication System – Shutdown (Special Test Exception)

2.0 OPERATING LIMITS

The cycle-specific parameter limits for the specifications listed in Section 1.0 are presented in the following subsections. These limits are applicable for the entire cycle unless otherwise identified. These limits have been developed using the NRC-approved methodologies specified in Technical Specification 5.6.5.

2.1 Reactor Core Safety Limits (SLs) (SL 2.1.1)

2.1.1 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 Figure 2.1.1.

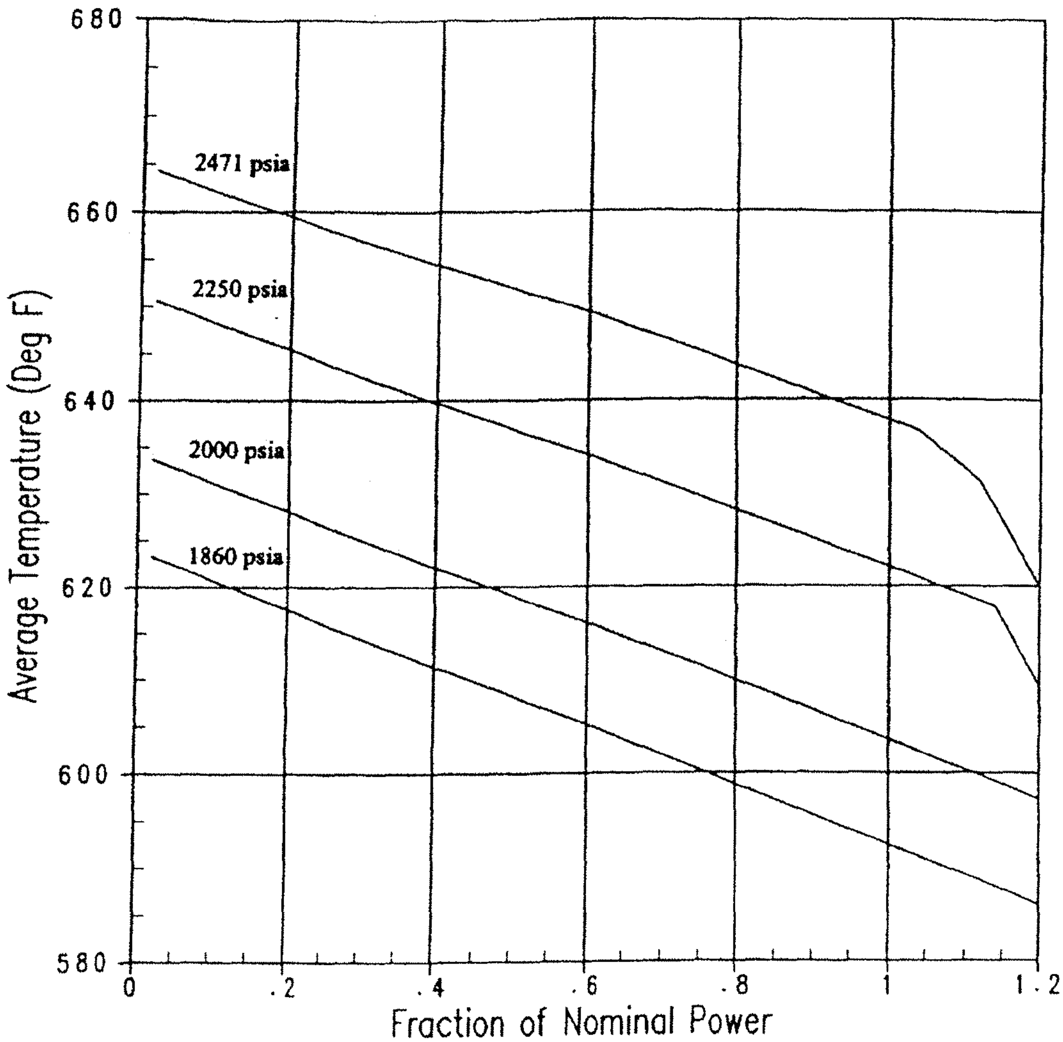


Figure 2.1.1: Reactor Core Limits

2.2 SHUTDOWN MARGIN (SDM)

The SDM limit for MODES 1, 2, 3, and 4 is:

2.2.1 The SDM shall be greater than or equal to 1.3% Δk/k (LCOs 3.1.1, 3.1.4, 3.1.5, 3.1.6, 3.1.8, 3.3.9; TRM TLCOs 3.1.b, 3.1.d, 3.1.f, 3.1.h, and 3.1.j).

The SDM limit for MODE 5 is:

2.2.2 SDM shall be greater than or equal to 1.3% Δk/k (LCO 3.1.1, LCO 3.3.9; TRM TLCOs 3.1.i and 3.1.j).

2.3 Moderator Temperature Coefficient (MTC) (LCO 3.1.3)

The Moderator Temperature Coefficient (MTC) limits are:

2.3.1 The BOL/ARO/HZP-MTC upper limit shall be $+1.68 \times 10^{-5}$ Δk/k/°F.

2.3.2 The EOL/ARO/HFP-MTC lower limit shall be -4.6×10^{-4} Δk/k/°F.

2.3.3 The EOL/ARO/HFP-MTC Surveillance limit at 300 ppm shall be -3.7×10^{-4} Δk/k/°F.

2.3.4 The EOL/ARO/HFP-MTC Surveillance limit at 60 ppm shall be -4.3×10^{-4} Δk/k/°F.

where: BOL stands for Beginning of Cycle Life
ARO stands for All Rods Out
HZP stands for Hot Zero Thermal Power
EOL stands for End of Cycle Life
HFP stands for Hot Full Thermal Power

2.4 Shutdown Bank Insertion Limits (LCO 3.1.5)

2.4.1 All shutdown banks shall be fully withdrawn to at least 224 steps.

2.5 Control Bank Insertion Limits (LCO 3.1.6)

2.5.1 The control banks, with Bank A greater than or equal to 224 steps, shall be limited in physical insertion as shown in Figure 2.5.1.

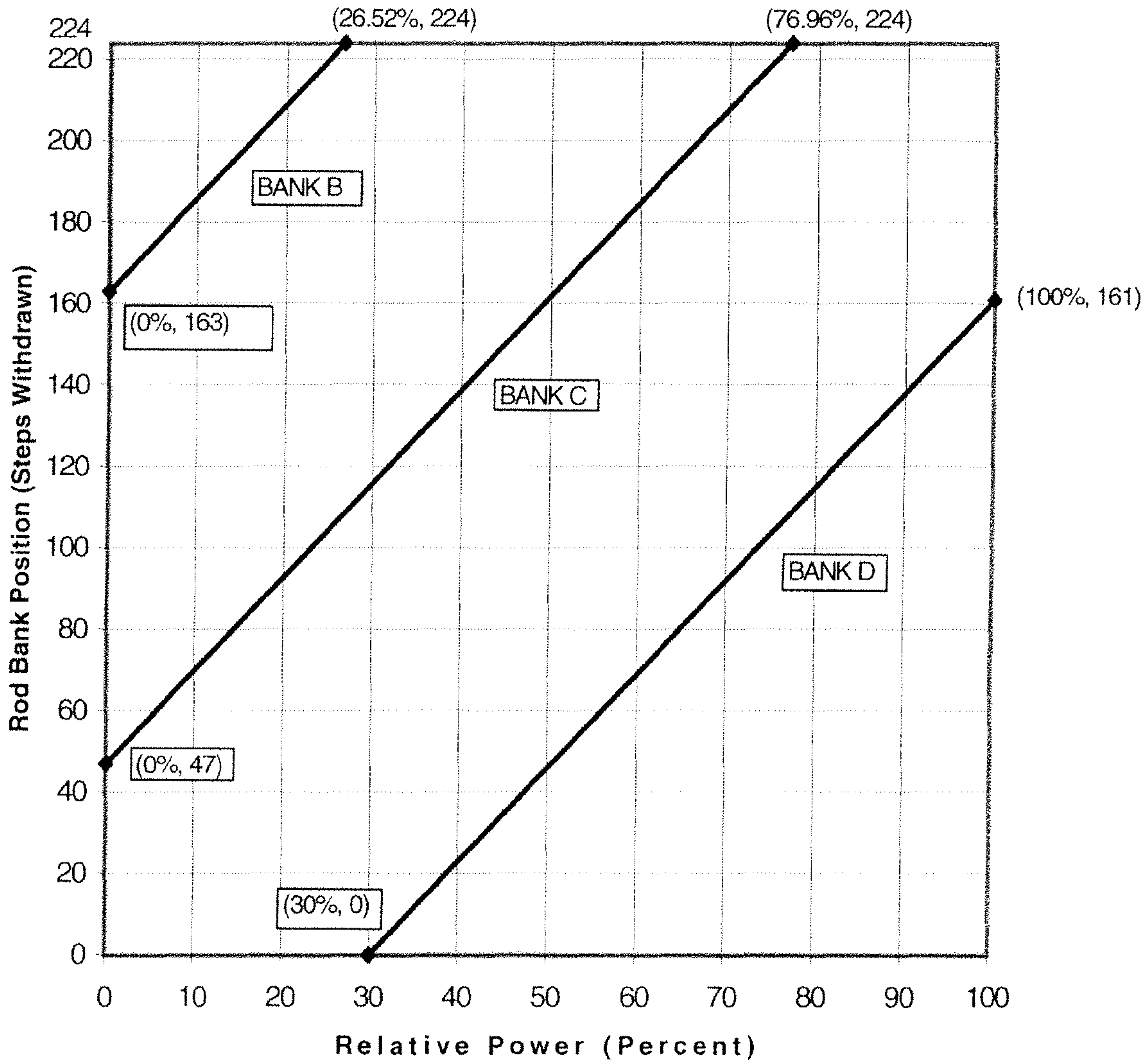
2.5.2 Each control bank shall be considered fully withdrawn from the core at greater than or equal to 224 steps.

2.5.3 The control banks shall be operated in sequence by withdrawal of Bank A, Bank B, Bank C and Bank D. The control banks shall be sequenced in reverse order upon insertion.

2.5.4 Each control bank not fully withdrawn from the core shall be operated with the following overlap limits as a function of park position:

Park Position (step)	Overlap Limit (step)
231	115

Figure 2.5.1:
Control Bank Insertion Limits Versus Percent Rated Thermal Power



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

2.6.1 Total Peaking Factor:

$$F_Q(Z) \le \frac{F_Q^{RTP}}{0.5} x K(Z) \quad \text{for } P \le 0.5$$

$$F_Q(Z) \le \frac{F_Q^{RTP}}{P} x K(Z) \quad \text{for } P > 0.5$$

where: P = the ratio of THERMAL POWER to RATED THERMAL POWER

F_Q^{RTP} = 2.60

K(Z) is provided in Figure 2.6.1.

2.6.2 W(Z) Values:

a) When PDMS is OPERABLE, W(Z) = 1.00000 for all axial points.

b) When PDMS is inoperable, W(Z) is provided in Table 2.6.2.a.

The normal operation W(Z) values have been determined at burnups of 150, 6000, 14000, and 20000 MWD/MTU.

Table 2.6.2.b shows the $F^C_Q(z)$ penalty factors that are greater than 2% per 31 Effective Full Power Days (EFPD). These values shall be used to increase the $F^W_Q(z)$ as per Surveillance Requirement 3.2.1.2. A 2% penalty factor shall be used at all cycle burnups that are outside the range of Table 2.6.2.b.

2.6.3 Uncertainty:

The uncertainty, U_{FQ}, to be applied to the Heat Flux Hot Channel Factor $F_Q(Z)$ shall be calculated by the following formula

$$U_{FQ} = U_{qu} \bullet U_e$$

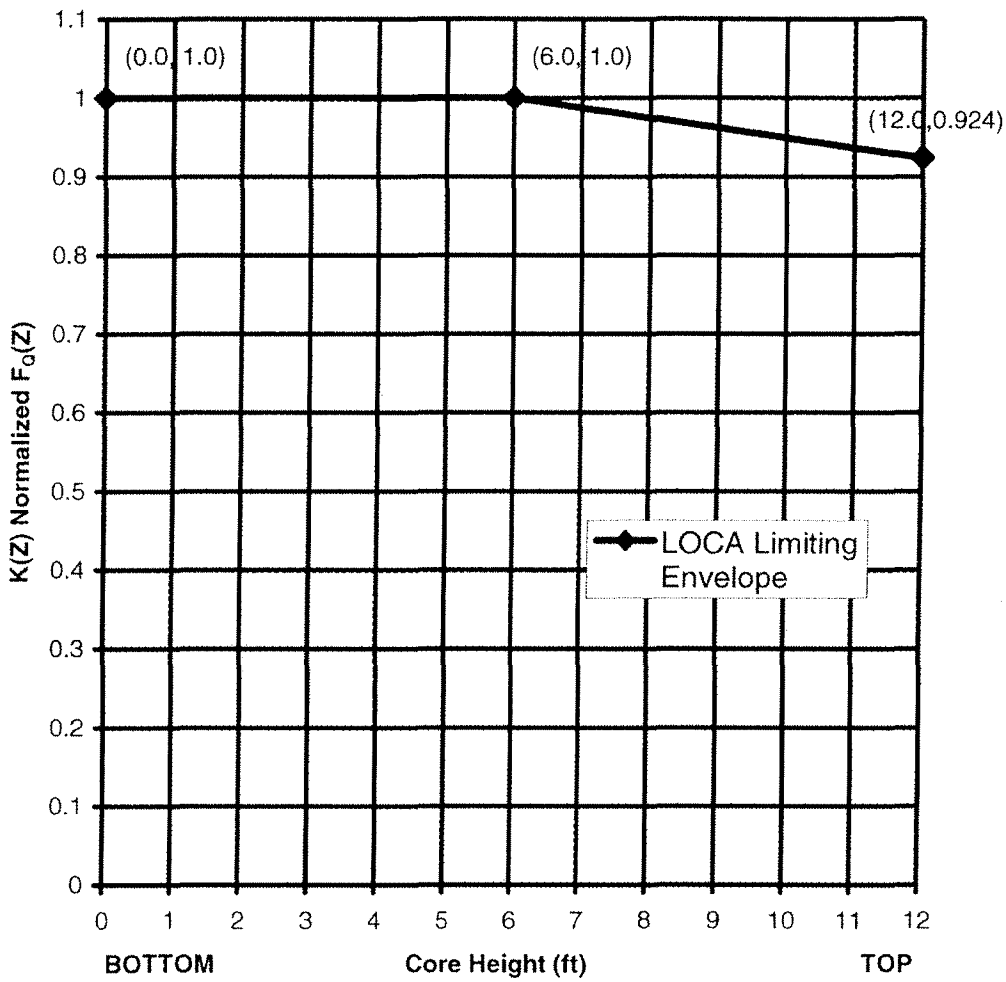
where:

U_{qu} = Base F_Q measurement uncertainty = 1.05 when PDMS is inoperable (U_{qu} is defined by PDMS when OPERABLE.)
U_e = Engineering uncertainty factor = 1.03

2.6.4 PDMS Alarms:

$F_Q(Z)$ Warning Setpoint ≥ 2% of $F_Q(Z)$ Margin
$F_Q(Z)$ Alarm Setpoint ≥ 0% of $F_Q(Z)$ Margin

Figure 2.6.1
K(Z) - Normalized $F_Q(Z)$ as a Function of Core Height



CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 13

Table 2.6.2.a

W(Z) versus Core Height
(Top and Bottom 15% Excluded per WCAP-10216)

Height (feet)	150 MWD/MTU	6000 MWD/MTU	14000 MWD/MTU	20000 MWD/MTU
0.00 (core bottom)	1.0000	1.0000	1.0000	1.0000
0.20	1.0000	1.0000	1.0000	1.0000
0.40	1.0000	1.0000	1.0000	1.0000
0.60	1.0000	1.0000	1.0000	1.0000
0.80	1.0000	1.0000	1.0000	1.0000
1.00	1.0000	1.0000	1.0000	1.0000
1.20	1.0000	1.0000	1.0000	1.0000
1.40	1.0000	1.0000	1.0000	1.0000
1.60	1.0000	1.0000	1.0000	1.0000
1.80	1.2061	1.2169	1.2897	1.2720
2.00	1.2002	1.1986	1.2759	1.2600
2.20	1.1867	1.1779	1.2591	1.2434
2.40	1.1784	1.1604	1.2443	1.2277
2.60	1.1646	1.1431	1.2266	1.2091
2.80	1.1600	1.1399	1.2108	1.1915
3.00	1.1561	1.1370	1.2011	1.1780
3.20	1.1502	1.1323	1.1906	1.1770
3.40	1.1443	1.1285	1.1836	1.1750
3.60	1.1374	1.1218	1.1796	1.1720
3.80	1.1315	1.1170	1.1758	1.1680
4.00	1.1269	1.1144	1.1716	1.1654
4.20	1.1243	1.1115	1.1658	1.1780
4.40	1.1221	1.1096	1.1596	1.1887
4.60	1.1186	1.1055	1.1509	1.1990
4.80	1.1152	1.1025	1.1427	1.2064
5.00	1.1116	1.0993	1.1444	1.2117
5.20	1.1062	1.0954	1.1450	1.2139
5.40	1.1016	1.0925	1.1455	1.2148
5.60	1.1043	1.0981	1.1441	1.2123
5.80	1.1129	1.1037	1.1528	1.2228
6.00	1.1228	1.1082	1.1644	1.2364
6.20	1.1405	1.1119	1.1740	1.2460
6.40	1.1562	1.1214	1.1807	1.2538
6.60	1.1700	1.1352	1.1864	1.2576
6.80	1.1827	1.1481	1.1901	1.2594
7.00	1.1935	1.1590	1.1909	1.2583
7.20	1.2024	1.1681	1.1899	1.2523
7.40	1.2093	1.1801	1.1878	1.2453
7.60	1.2123	1.1921	1.1827	1.2333
7.80	1.2153	1.2060	1.1778	1.2214
8.00	1.2154	1.2190	1.1699	1.2095
8.20	1.2106	1.2305	1.1609	1.1931
8.40	1.2115	1.2438	1.1530	1.1812
8.60	1.2148	1.2528	1.1502	1.1702
8.80	1.2162	1.2639	1.1485	1.1642
9.00	1.2200	1.2720	1.1507	1.1578
9.20	1.2230	1.2771	1.1509	1.1485
9.40	1.2270	1.2888	1.1520	1.1460
9.60	1.2320	1.3018	1.1523	1.1920
9.80	1.2450	1.3140	1.1660	1.2310
10.00	1.2610	1.3262	1.1940	1.2670
10.20	1.2860	1.3364	1.2190	1.3000
10.40	1.0000	1.0000	1.0000	1.0000
10.60	1.0000	1.0000	1.0000	1.0000
10.80	1.0000	1.0000	1.0000	1.0000
11.00	1.0000	1.0000	1.0000	1.0000
11.20	1.0000	1.0000	1.0000	1.0000
11.40	1.0000	1.0000	1.0000	1.0000
11.60	1.0000	1.0000	1.0000	1.0000
11.80	1.0000	1.0000	1.0000	1.0000
12.00 (core top)	1.0000	1.0000	1.0000	1.0000

Note: W(Z) values at 20000 MWD/MTU may be applied to cycle burnups greater than 20000 MWD/MTU to prevent W(Z) function extrapolation

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Table 2.6.2.b

Penalty Factors in Excess of 2% per 31 EFPD

Cycle Burnup (MWD/MTU)	Penalty Factor $F^C_Q(z)$
840	1.0200
1012	1.0220
1185	1.0248
1357	1.0266
1530	1.0280
1702	1.0292
1875	1.0309
2047	1.0332
2220	1.0338
2392	1.0340
2565	1.0342
2737	1.0344
2910	1.0342
3082	1.0335
3255	1.0320
3427	1.0300
3600	1.0271
3772	1.0233
3945	1.0200

Notes:

Linear interpolation is adequate for intermediate cycle burnups.

All cycle burnups outside the range of the table shall use a 2% penalty factor for compliance with the 3.2.1.2 Surveillance Requirements.

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

2.7.1 $F^N_{\Delta H} \leq F^{RTP}_{\Delta H}[1.0 + PF_{\Delta H}(1.0 - P)]$

where: P = the ratio of THERMAL POWER to RATED THERMAL POWER
$F^{RTP}_{\Delta H} = 1.70$
$PF_{\Delta H} = 0.3$

2.7.2 Uncertainty when PDMS is inoperable

The uncertainty, $U_{F\Delta H}$, to be applied to the Nuclear Enthalpy Rise Hot Channel Factor $F^N_{\Delta H}$ shall be calculated by the following formula:

$U_{F\Delta H} = U_{F\Delta Hm}$

where:

$U_{F\Delta Hm}$ = Base $F^N_{\Delta H}$ measurement uncertainty = 1.04

2.7.3 PDMS Alarms:

$F^N_{\Delta H}$ Warning Setpoint ≥ 2% of $F^N_{\Delta H}$ Margin
$F^N_{\Delta H}$ Alarm Setpoint ≥ 0% of $F^N_{\Delta H}$ Margin

2.8 AXIAL FLUX DIFFERENCE (AFD) (LCO 3.2.3)

2.8.1 When PDMS is inoperable, the AXIAL FLUX DIFFERENCE (AFD) Acceptable Operation Limits are provided in Figure 2.8.1 or the latest valid PDMS Surveillance Report, whichever is more conservative.

2.8.2 When PDMS is OPERABLE, no AFD Acceptable Operation Limits are applicable.

2.9 Departure from Nucleate Boiling Ratio (DNBR) (LCO 3.2.5)

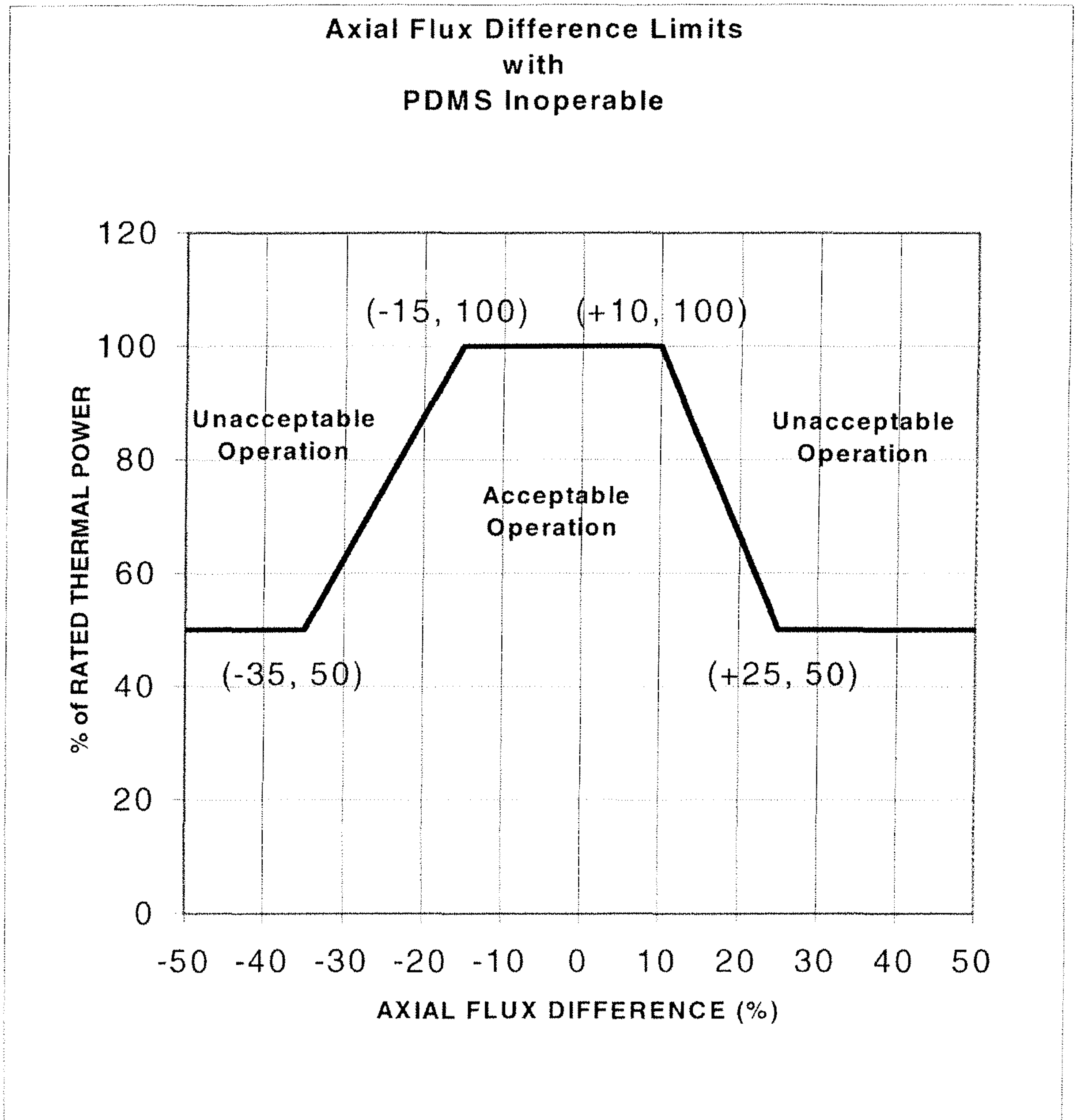
2.9.1 $DNBR_{APSL} \geq 1.536$

The Axial Power Shape Limiting DNBR ($DNBR_{APSL}$) is applicable with THERMAL POWER ≥ 50% RTP when PDMS is OPERABLE.

2.9.2 PDMS Alarms:

DNBR Warning Setpoint ≥ 2% of DNBR Margin
DNBR Alarm Setpoint ≥ 0% of DNBR Margin

Figure 2.8.1 Axial Flux Difference Limits as a Function of Rated Thermal Power



2.10 Reactor Trip System (RTS) Instrumentation (LCO 3.3.1) - Overtemperature ΔT Setpoint Parameter Values

2.10.1 The Overtemperature ΔT reactor trip setpoint K_1 shall be equal to 1.325.

2.10.2 The Overtemperature ΔT reactor trip setpoint T_{avg} coefficient K_2 shall be equal to 0.0297 / °F.

2.10.3 The Overtemperature ΔT reactor trip setpoint pressure coefficient K_3 shall be equal to 0.00181 / psi.

2.10.4 The nominal T_{avg} at RTP (indicated) T′ shall be less than or equal to 588.0 °F.

2.10.5 The nominal RCS operating pressure (indicated) P′ shall be equal to 2235 psig.

2.10.6 The measured reactor vessel ΔT lead/lag time constant τ_1 shall be equal to 8 sec.

2.10.7 The measured reactor vessel ΔT lead/lag time constant τ_2 shall be equal to 3 sec.

2.10.8 The measured reactor vessel ΔT lag time constant τ_3 shall be less than or equal to 2 sec.

2.10.9 The measured reactor vessel average temperature lead/lag time constant τ_4 shall be equal to 33 sec.

2.10.10 The measured reactor vessel average temperature lead/lag time constant τ_5 shall be equal to 4 sec.

2.10.11 The measured reactor vessel average temperature lag time constant τ_6 shall be less than or equal to 2 sec.

2.10.12 The f_1 (ΔI) "positive" breakpoint shall be +10% ΔI.

2.10.13 The f_1 (ΔI) "negative" breakpoint shall be -18% ΔI.

2.10.14 The f_1 (ΔI) "positive" slope shall be +3.47% / % ΔI.

2.10.15 The f_1 (ΔI) "negative" slope shall be -2.61% / % ΔI.

2.11 Reactor Trip System (RTS) Instrumentation (LCO 3.3.1) - Overpower ΔT Setpoint Parameter Values

2.11.1 The Overpower ΔT reactor trip setpoint K_4 shall be equal to 1.072.

2.11.2 The Overpower ΔT reactor trip setpoint T_{avg} rate/lag coefficient K_5 shall be equal to 0.02 / °F for increasing $T_{avg.}$

2.11.3 The Overpower ΔT reactor trip setpoint T_{avg} rate/lag coefficient K_5 shall be equal to 0 / °F for decreasing $T_{avg.}$

2.11.4 The Overpower ΔT reactor trip setpoint T_{avg} heatup coefficient K_6 shall be equal to 0.00245 / °F when $T > T''$.

2.11.5 The Overpower ΔT reactor trip setpoint T_{avg} heatup coefficient K_6 shall be equal to 0 / °F when $T \leq T''$.

2.11.6 The nominal T_{avg} at RTP (indicated) T'' shall be less than or equal to 588.0 °F

2.11.7 The measured reactor vessel ΔT lead/lag time constant τ_1 shall be equal to 8 sec.

2.11.8 The measured reactor vessel ΔT lead/lag time constant τ_2 shall be equal to 3 sec.

2.11.9 The measured reactor vessel ΔT lag time constant τ_3 shall be less than or equal to 2 sec.

2.11.10 The measured reactor vessel average temperature lag time constant τ_6 shall be less than or equal to 2 sec.

2.11.11 The measured reactor vessel average temperature rate/lag time constant τ_7 shall be equal to 10 sec.

2.11.12 The $f_2(\Delta I)$ "positive" breakpoint shall be 0 for all ΔI.

2.11.13 The $f_2(\Delta I)$ "negative" breakpoint shall be 0 for all ΔI.

2.11.14 The $f_2(\Delta I)$ "positive" slope shall be 0 for all ΔI.

2.11.15 The $f_2(\Delta I)$ "negative" slope shall be 0 for all ΔI.

2.12 Reactor Coolant System (RCS) Pressure, Temperature, and Flow Departure from Nucleate Boiling (DNB) Limits (LCO 3.4.1)

2.12.1 The pressurizer pressure shall be greater than or equal to 2209 psig.

2.12.2 The RCS average temperature (T_{avg}) shall be less than or equal to 593.1 °F.

2.12.3 The RCS total flow rate shall be greater than or equal to 386,000 gpm.

2.13 Boron Concentration

2.13.1 The refueling boron concentration shall be greater than or equal to the value given in the Table below (LCO 3.9.1). The reported value also bounds the end-of-cycle requirements for the previous cycle.

2.13.2 To maintain keff ≤ 0.987 with all shutdown and control rods fully withdrawn in MODES 3, 4, or 5 (TRM TLCO 3.1.g Required Action B.2 and TRM TLCO 3.1.k.2), the Reactor Coolant System boron concentration shall be greater than or equal to the values given in the Table below.

COLR Section	Conditions	Boron Concentration (ppm)
2.13.1	Refueling	1728
2.13.2	a) prior to initial criticality	1790
2.13.2	b) all other times in core life	1995