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United States Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Byron Station Unit 2
Facility Operating License No. NPF-66
NRC Docket No. STN 50-455

Subject: Byron Station Unit 2 Cycle 10 Core Operating Limits Report

In accordance with Technical Specification 5.6.5, "Core Operating Limits Report (COLR)," Item d., we are submitting the COLR for Byron Station Unit 2, Cycle 10.

Should you have any questions concerning this report, please contact P. Reister, Regulatory Assurance Manager, at (815) 234-5441, extension 2280.

Respectfully,

Richard P. Lopriore
Site Vice President
Byron Nuclear Generating Station

Attachment: Byron Station Unit 2 Cycle 10 COLR

RPL/JL/keh/dpk

cc: Regional Administrator – NRC Region III
NRC Senior Resident Inspector – Byron Station

A001

ATTACHMENT

Byron Station Unit 2 Cycle 10 Core Operating Limits Report

NUCLEAR FUEL MANAGEMENT DEPARTMENT
TRANSMITTAL OF DESIGN INFORMATION (TODI)

☒ SAFETY RELATED ☐ NON-SAFETY RELATED ☐ REGULATORY RELATED	Originating Organization ☒ Nuclear Fuel Management ☐ Other (specify) _____	TODI No. NFM0100028 Rev. No. 0 Page 1 of 16

Station Byron Unit 2 Cycle 10 Generic _____

To: Kenneth N. Kovar - Byron

Subject Byron Unit 2 Cycle 10 Core Operating Limits Report in ITS Format and W(z) Function

Brian L. Manges Preparer	Brian L Manges Preparer's Signature	3/15/2001 Date
Tyrone L. Stevens Reviewer	Tyrone L Stevens Reviewer's Signature	3/15/01 Date
D. Redden NFM Supervisor	E. Young NFM Supervisor's Signature	3/15/01 Date

Status of Information:
☒ Verified
☐ Unverified
☐ Engineering Judgement

Method and Schedule of Verification for Unverified TODIs: _____

Description of Information:

Attached is the Byron Unit 2 Cycle 10 Core Operating Limits Report (COLR) in the ITS format and W(z) function.

Purpose of Information:
The COLR incorporates the Cycle 10 specific 3411 MWt data **which is ONLY valid for Cycle 10 operation from 0 to 3000 MWD/MTU.** Byron Station is requested to perform a Plant Review of this document. Upon completion of the Plant Review, Byron Station is to transmit the COLR portion to the Nuclear Regulatory Commission pursuant to Technical Specification 5.6.5. Please provide NFM (Brian Manges) with a copy of Byron Station's completed Plant Review and COLR submittal to the NRC.

Source of Information:

1. 01CB-G-034 (CAC-01-77), "Byron Unit 2 Cycle 10 COLR Data for 3411 MWt Operation", dated March 12 ,2001
2. 01CB-G-040 (CAC-01-82), "DNBR Limits for COLR", dated March 15, 2001

Supplemental Distribution: P. E. Reister / J. Langan (BY)

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Byron Station Unit 2 Cycle 10 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
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) DNB Parameters
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 Limits (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.

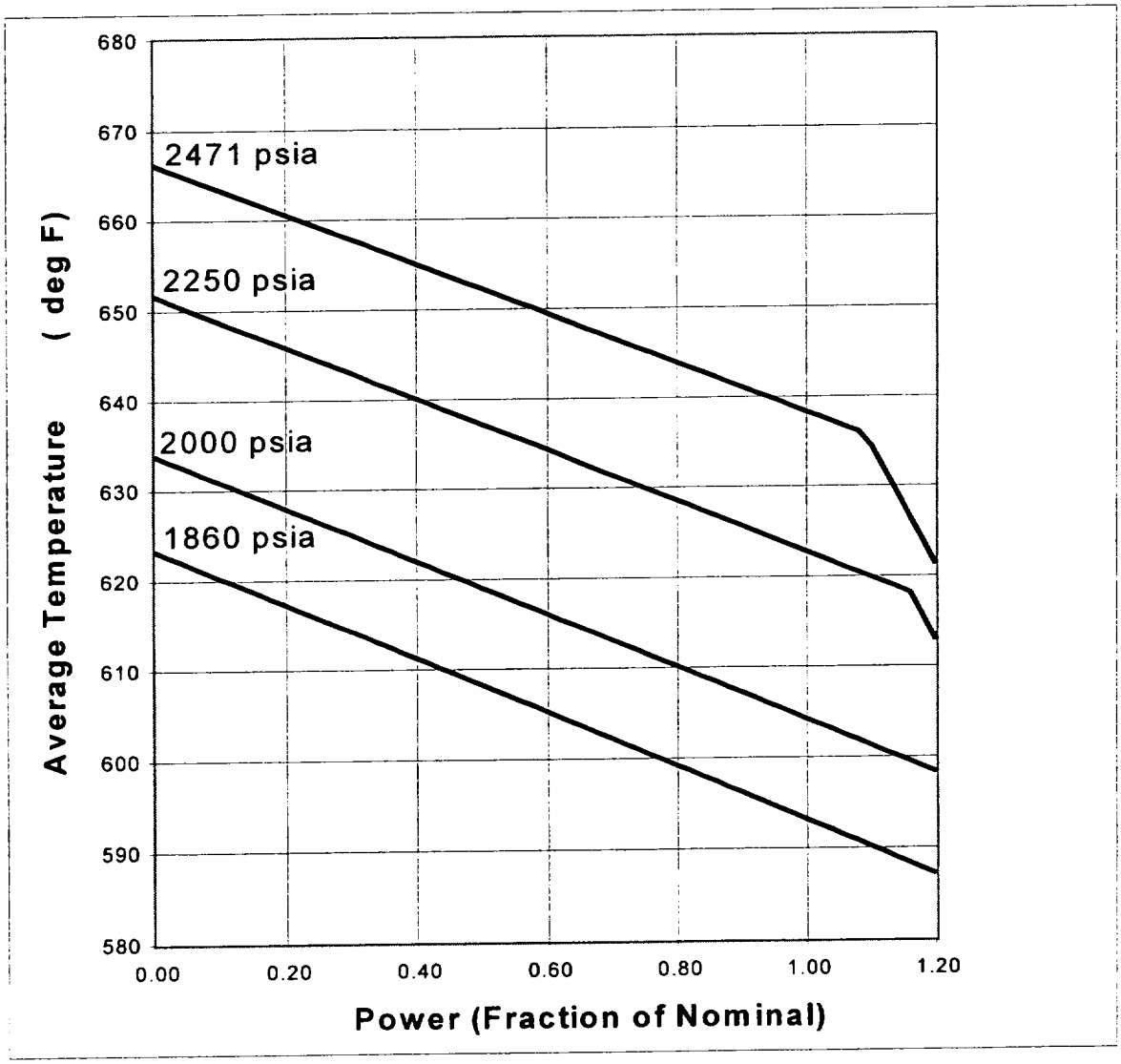


Figure 2.1.1: Reactor Core Limits

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% $\Delta k/k$ (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 limits for MODE 5 are:

2.2.2.1 SDM shall be greater than or equal to 1.0% $\Delta k/k$ (LCO 3.1.1).

2.2.2.2 SDM shall be greater than or equal to 1.3% $\Delta k/k$ (LCO 3.3.9; TRM TLCO 3.1.i and 3.1.j).

2.3 Moderator Temperature Coefficient (LCO 3.1.3)

The Moderator Temperature Coefficient (MTC) limits are:

2.3.1 The BOL/ARO/HZP-MTC upper limit shall be $+2.0 \times 10^{-5}$ $\Delta k/k/°F$.

2.3.2 The EOL/ARO/HFP-MTC lower limit shall be -4.1×10^{-4} $\Delta k/k/°F$.

2.3.3 The EOL/ARO/HFP-MTC Surveillance limit at 300 ppm shall be less negative than or equal to -3.2×10^{-4} $\Delta k/k/°F$.

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 Limit (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)

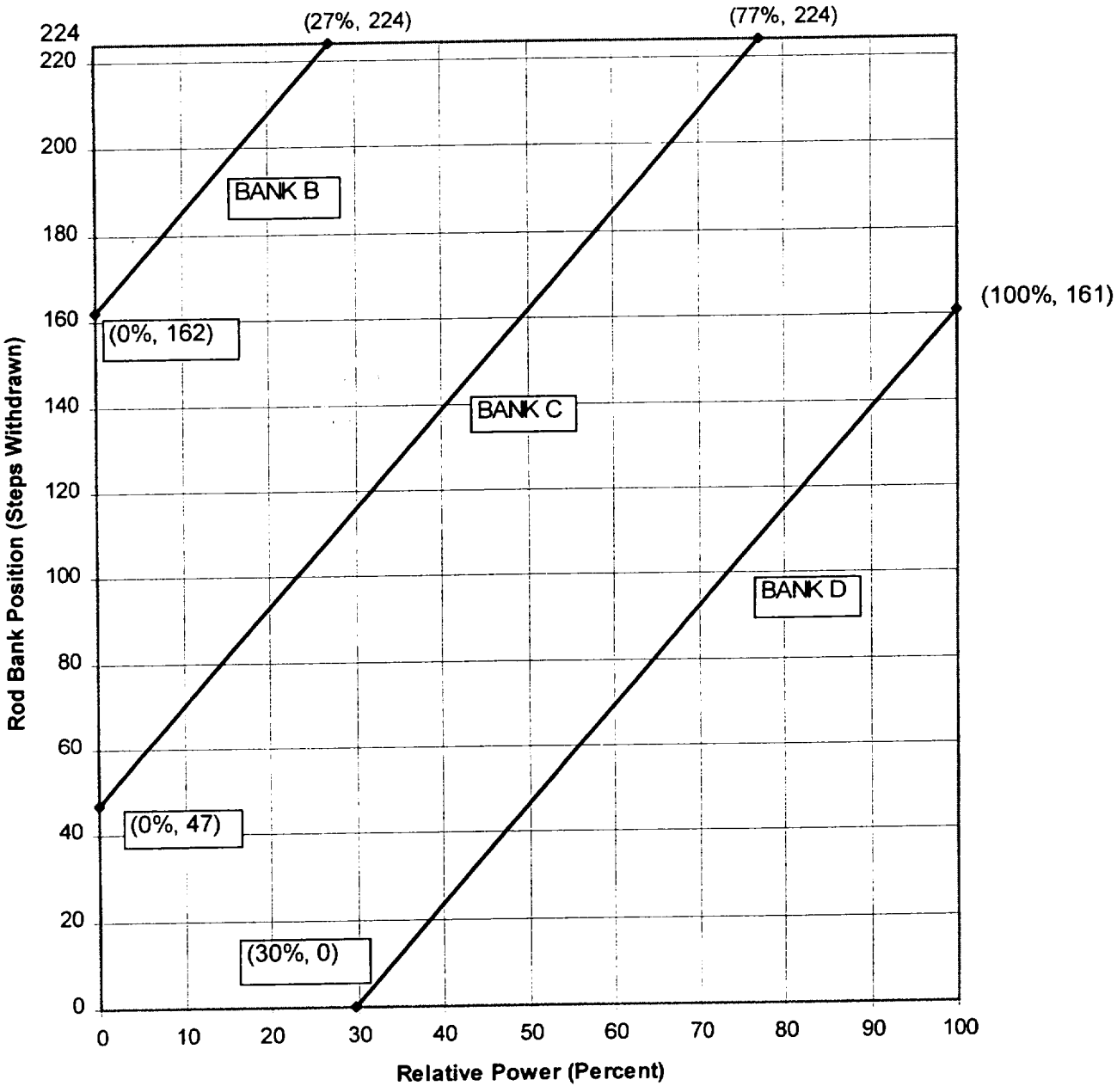
2.5.1 The control banks shall be limited in physical insertion as shown in Figure 2.5.1.

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 a 110 step overlap limit.

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

$$F_Q(Z) \leq \frac{F_Q^{RTP}}{0.5} xK(Z) \quad \text{for } P \leq 0.5$$

$$F_Q(Z) \leq \frac{F_Q^{RTP}}{P} xK(Z) \quad \text{for } P > 0.5$$

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

F_Q^{RTP} = 2.60

K(Z) for assembly average burnup > 4000 MWD/MTU is provided in Figure 2.6.1. K(Z) for assembly average burnup ≤ 4000 MWD/MTU is provided in Figure 2.6.1.a.

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 Figures 2.6.2.a through 2.6.2.c

The normal operation W(Z) values have been determined at burnups of 150, 1950 and 4000 MWD/MTU.

For this cycle, the $F^C_Q(z)$ penalty factors are equal to 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. The 2% penalty factor shall be used at all cycle burnups.

Multiplication Factor = 1.02

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 FQ measurement uncertainty = 1.05 when PDMS is Inoperable
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 (Assembly BU > 4000 MWD/MTU)

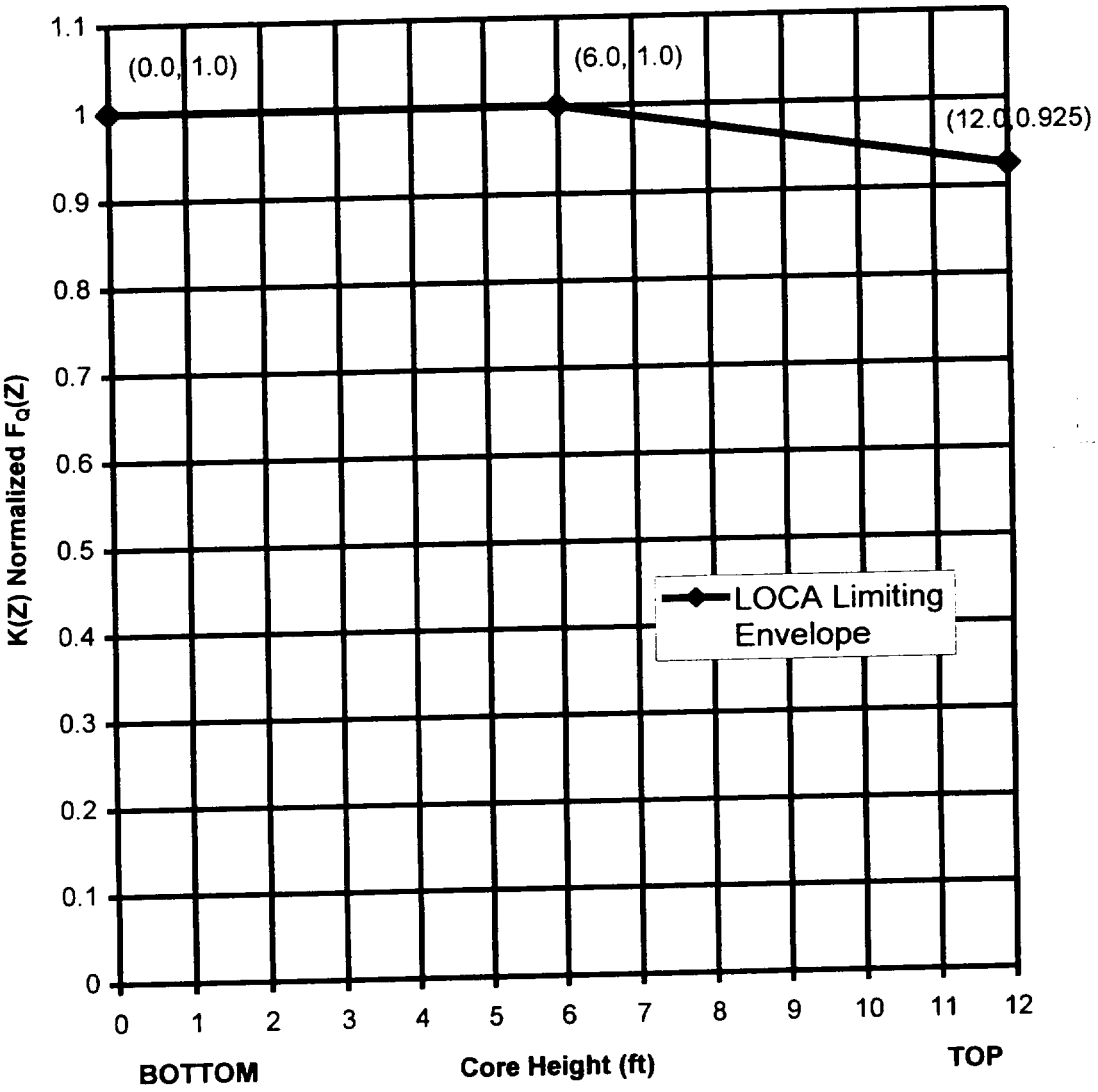
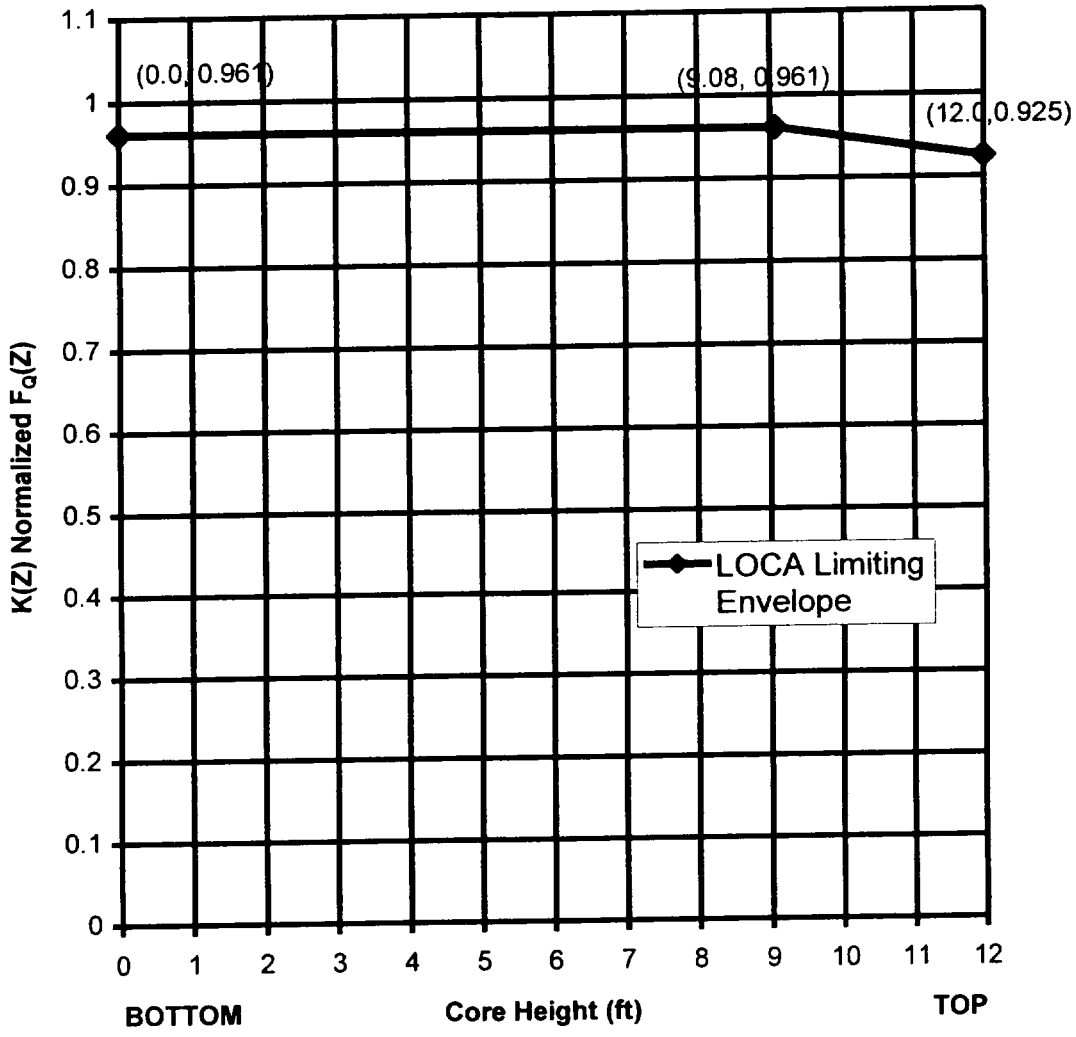


Figure 2.6.1.a: K(Z) - Normalized $F_Q(Z)$ as a Function of Core Height (Assembly BU ≤ 4000 MWD/MTU)



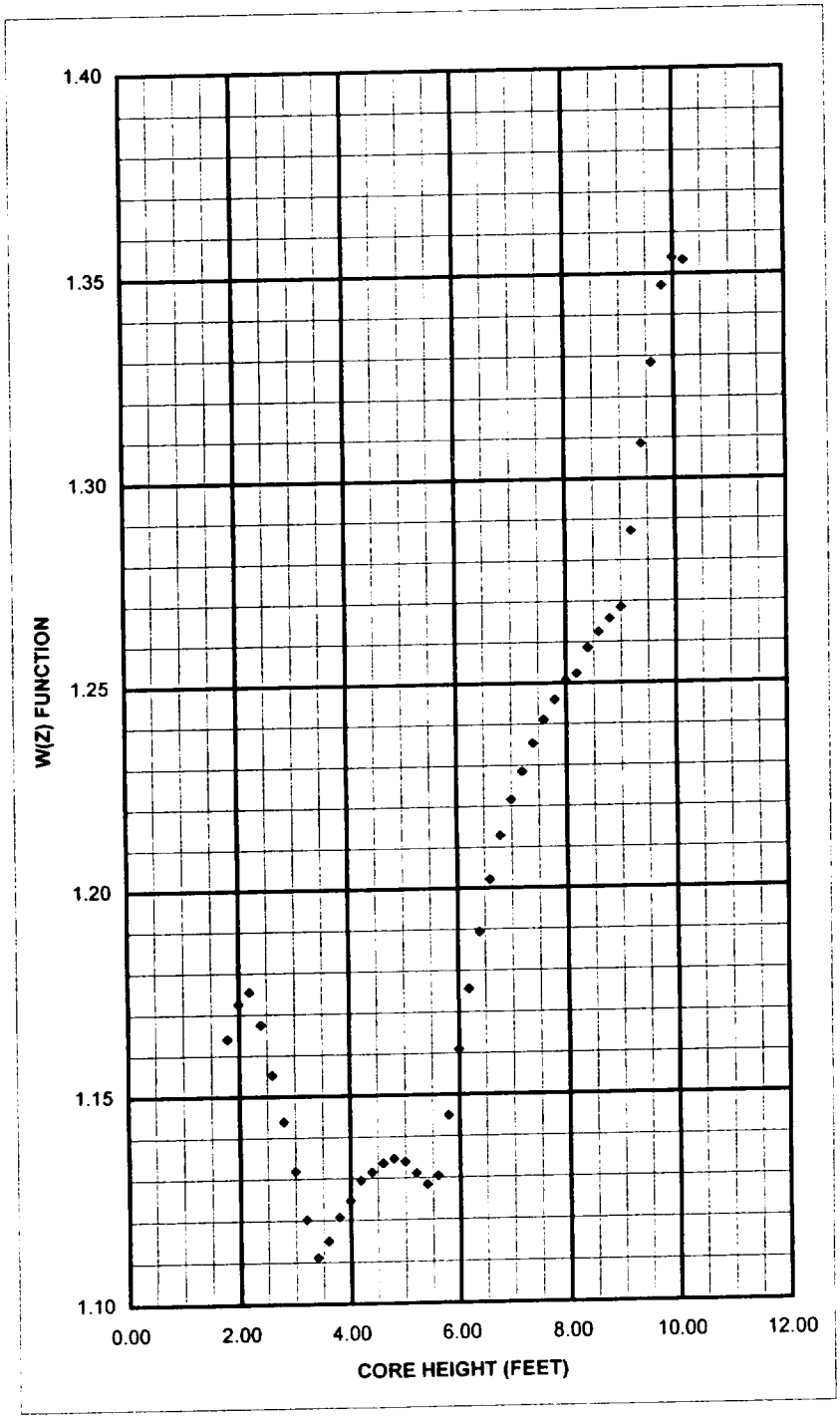
CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 10

Height Feet	MAX W(Z)
0.00	1.0000
0.20	1.0000
0.40	1.0000
0.60	1.0000
0.80	1.0000
1.00	1.0000
1.20	1.0000
1.40	1.0000
1.60	1.0000
1.80	1.1640
2.00	1.1725
2.20	1.1754
2.40	1.1674
2.60	1.1551
2.80	1.1438
3.00	1.1318
3.20	1.1202
3.40	1.1111
3.60	1.1150
3.80	1.1207
4.00	1.1246
4.20	1.1295
4.40	1.1314
4.60	1.1335
4.80	1.1346
5.00	1.1338
5.20	1.1311
5.40	1.1284
5.60	1.1304
5.80	1.1449
6.00	1.1609
6.20	1.1755
6.40	1.1893
6.60	1.2020
6.80	1.2128
7.00	1.2216
7.20	1.2284
7.40	1.2353
7.60	1.2410
7.80	1.2459
8.00	1.2506
8.20	1.2523
8.40	1.2585
8.60	1.2624
8.80	1.2657
9.00	1.2684
9.20	1.2871
9.40	1.3085
9.60	1.3283
9.80	1.3471
10.00	1.3538
10.20	1.3532
10.40	1.0000
10.60	1.0000
10.80	1.0000
11.00	1.0000
11.20	1.0000
11.40	1.0000
11.60	1.0000
11.80	1.0000
12.00	1.0000

Byron Unit 2 Cycle 10

Figure 2.6.2.a

Summary of W(Z) Function at 150 MWD/MTU
(Top and Bottom 15% Excluded per WCAP-10216)



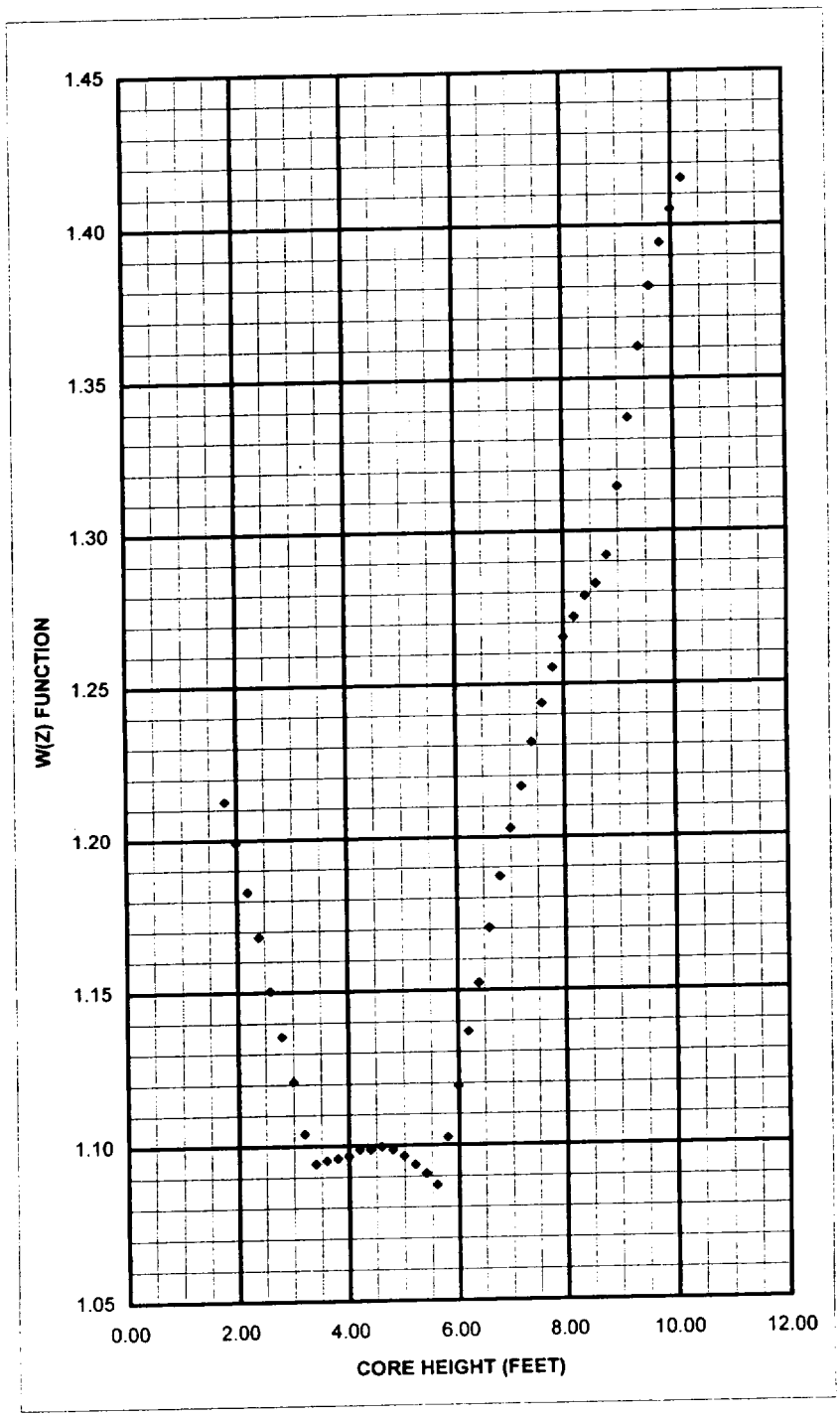
CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 10

Height Feet	MAX W(Z)
0.00	1.0000
0.20	1.0000
0.40	1.0000
0.60	1.0000
0.80	1.0000
1.00	1.0000
1.20	1.0000
1.40	1.0000
1.60	1.0000
1.80	1.2125
2.00	1.1987
2.20	1.1828
2.40	1.1680
2.60	1.1503
2.80	1.1355
3.00	1.1207
3.20	1.1039
3.40	1.0942
3.60	1.0952
3.80	1.0959
4.00	1.0966
4.20	1.0986
4.40	1.0986
4.60	1.0995
4.80	1.0985
5.00	1.0965
5.20	1.0937
5.40	1.0908
5.60	1.0871
5.80	1.1024
6.00	1.1189
6.20	1.1366
6.40	1.1523
6.60	1.1702
6.80	1.1870
7.00	1.2027
7.20	1.2165
7.40	1.2309
7.60	1.2436
7.80	1.2553
8.00	1.2652
8.20	1.2719
8.40	1.2788
8.60	1.2827
8.80	1.2920
9.00	1.3145
9.20	1.3371
9.40	1.3603
9.60	1.3800
9.80	1.3941
10.00	1.4050
10.20	1.4151
10.40	1.0000
10.60	1.0000
10.80	1.0000
11.00	1.0000
11.20	1.0000
11.40	1.0000
11.60	1.0000
11.80	1.0000
12.00	1.0000

Byron Unit 2 Cycle 10

Figure 2.6.2.b

Summary of W(Z) Function at 1950 MWD/MTU
(Top and Bottom 15% Excluded per WCAP-10216)



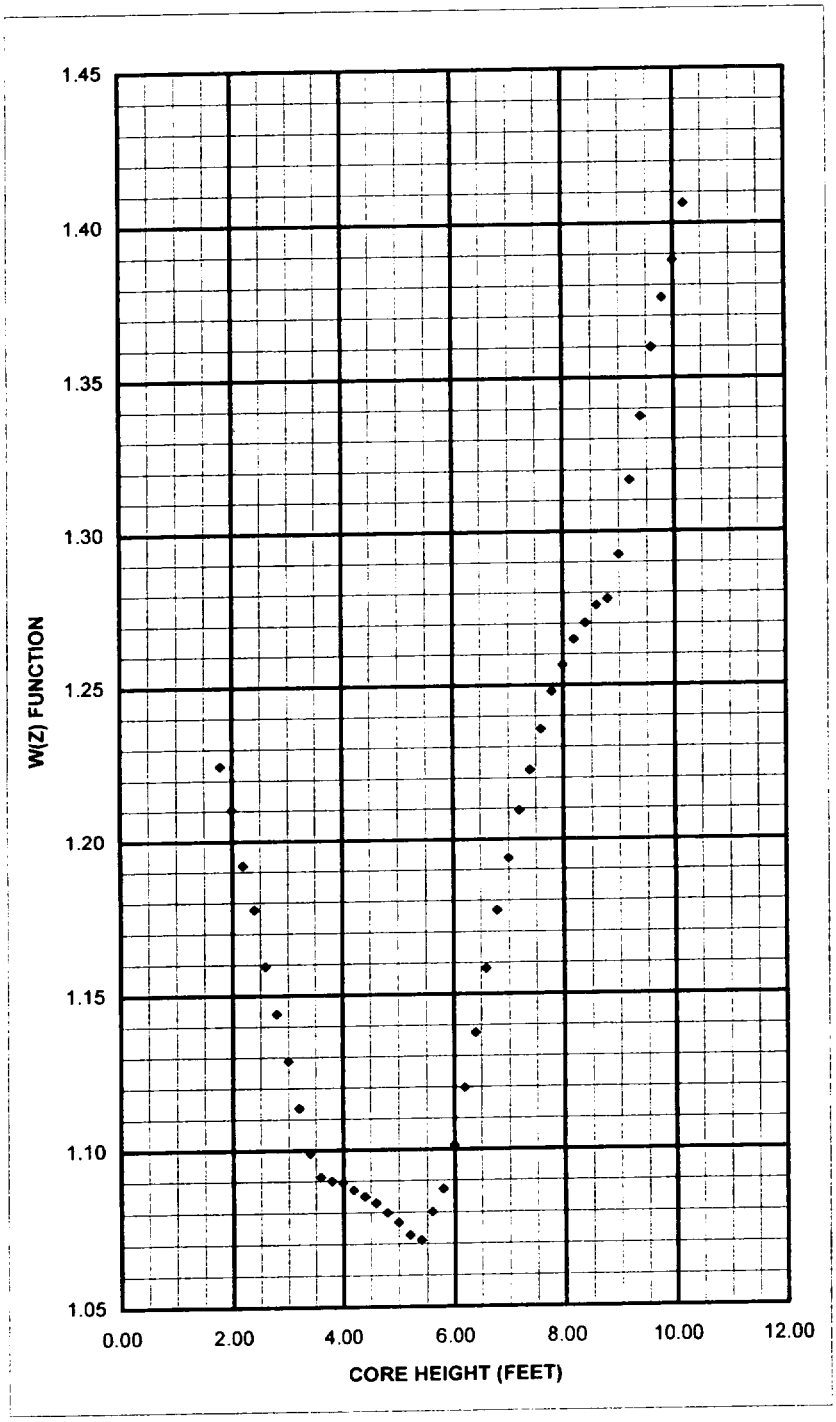
CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 10

Height Feet	MAX W(Z)
0.00	1.0000
0.20	1.0000
0.40	1.0000
0.60	1.0000
0.80	1.0000
1.00	1.0000
1.20	1.0000
1.40	1.0000
1.60	1.0000
1.80	1.2245
2.00	1.2102
2.20	1.1919
2.40	1.1776
2.60	1.1593
2.80	1.1440
3.00	1.1287
3.20	1.1134
3.40	1.0989
3.60	1.0913
3.80	1.0900
4.00	1.0894
4.20	1.0871
4.40	1.0850
4.60	1.0829
4.80	1.0798
5.00	1.0767
5.20	1.0726
5.40	1.0709
5.60	1.0800
5.80	1.0872
6.00	1.1012
6.20	1.1197
6.40	1.1374
6.60	1.1581
6.80	1.1768
7.00	1.1936
7.20	1.2093
7.40	1.2224
7.60	1.2357
7.80	1.2479
8.00	1.2564
8.20	1.2648
8.40	1.2701
8.60	1.2758
8.80	1.2779
9.00	1.2923
9.20	1.3166
9.40	1.3374
9.60	1.3598
9.80	1.3758
10.00	1.3880
10.20	1.4063
10.40	1.0000
10.60	1.0000
10.80	1.0000
11.00	1.0000
11.20	1.0000
11.40	1.0000
11.60	1.0000
11.80	1.0000
12.00	1.0000

Byron Unit 2 Cycle 10

Figure 2.6.2.c

Summary of W(Z) Function at 4000 MWD/MTU
(Top and Bottom 15% Excluded per WCAP-10216)



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 $F_{\Delta H}{}^N$ 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)

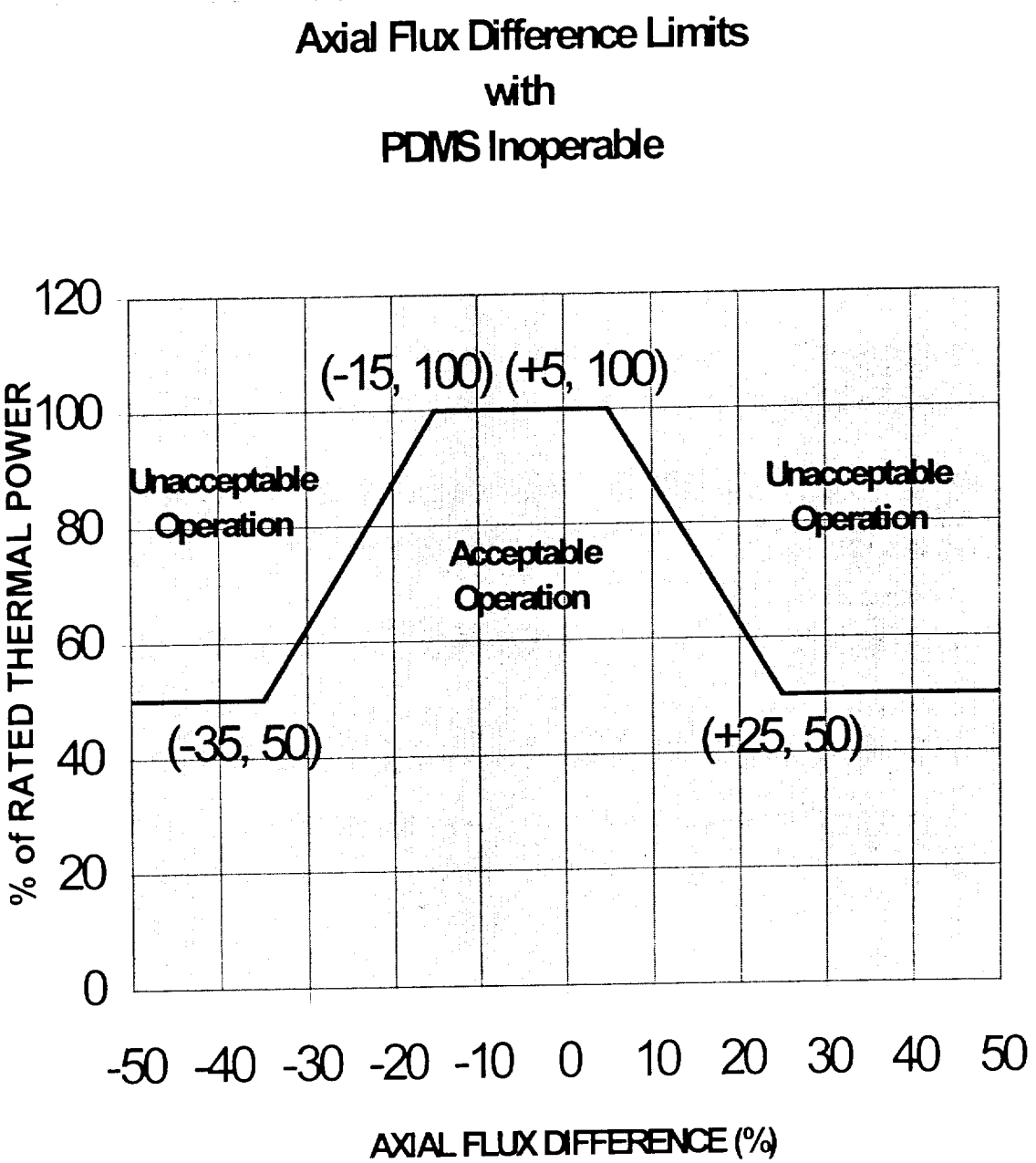
2.9.1 $DNBR_{APSL} \geq 1.572$

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 Overtemperature ΔT Setpoint Parameter Values (LCO 3.3.1)

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 / psig.

2.10.4 The nominal T_{avg} at RTP (indicated) T' shall be less than or equal to 588.4 °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 $f_1(\Delta I)$ "positive" breakpoint shall be +10% ΔI.

2.10.13 The $f_1(\Delta I)$ "negative" breakpoint shall be -24% ΔI.

2.10.14 The $f_1(\Delta I)$ "positive" slope shall be +4.11% / % ΔI.

2.10.15 The $f_1(\Delta I)$ "negative" slope shall be -3.35% / % ΔI.

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

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 588.4 °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) DNB Parameter Limits (LCO 3.4.1)

2.12.1 The pressurizer pressure shall be greater than or equal to 2219 psig.

2.12.2 The RCS average temperature (T_{avg}) shall be less than or equal to 591.2 °F.

2.12.3 The RCS total flow rate shall be greater than or equal to 371,400 gpm.

2.13 Boron Concentration

2.13.1 The refueling boron concentration shall be greater than or equal to 2000 ppm (LCO 3.9.1).

2.13.2 The Reactor Coolant System boron concentration shall be greater than or equal to 1705 ppm prior to initial criticality of Cycle 10, and greater than or equal to 1864 ppm at all other times in core life, to maintain adequate shutdown margin for MODES 3, 4, and 5 during performance of rod drop time measurements and during the surveillance of Digital Rod Position Indication (DRPI) for OPERABILITY (TLCO 3.1.g and TLCO 3.1.k)