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

Byron Station, Units 1 and 2
Facility Operating License Nos. NPF-37 and NPF-66
NRC Docket Nos. STN 50-454 and STN 50-455

Subject: Revision 3 to Byron Station, Unit 1 Cycle 12, Core Operating Limits Report and Revision 1 to Byron Station, Unit 2 Cycle 11, Core Operating Limits Report

In accordance with Technical Specification 5.6.5, "Core Operating Limits Report (COLR)," we are submitting the revised COLRs for Byron Station, Unit 1 Cycle 12, and Byron Station, Unit 2 Cycle 11. This revision of the Unit 1 and Unit 2 COLRs changes the minimum Reactor Coolant System total flow rate from 380,900 gpm to 386,000 gpm. This revision was necessary to correct a deficiency noted in the original cycle analyses involving the locked reactor coolant pump rotor. This issue has been placed in our corrective action program.

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

Respectfully,

Stephen Kuczynski

Stephen E. Kuczynski
Site Vice President
Byron Nuclear Generating Station

Attachments: 1) Byron Station, Unit 1 Cycle 12, COLR, Revision 3
2) Byron Station, Unit 2 Cycle 11, COLR, Revision 1

RPL/JL/rah

cc: Regional Administrator – NRC Region III
NRC Senior Resident Inspector – Byron Station
NRC Project Manager – NRR – Byron Station
Office of Nuclear Facility Safety – Illinois Department of Nuclear Safety

A001

Attachment 1

Byron Station, Unit 1 Cycle 12, COLR, Revision 3

CORE OPERATING LIMITS REPORT (COLR)

FOR

BYRON UNIT 1 CYCLE 12

Revision 3

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 12

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Byron Station Unit 1 Cycle 12 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 $\geq$ 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)

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 12

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.

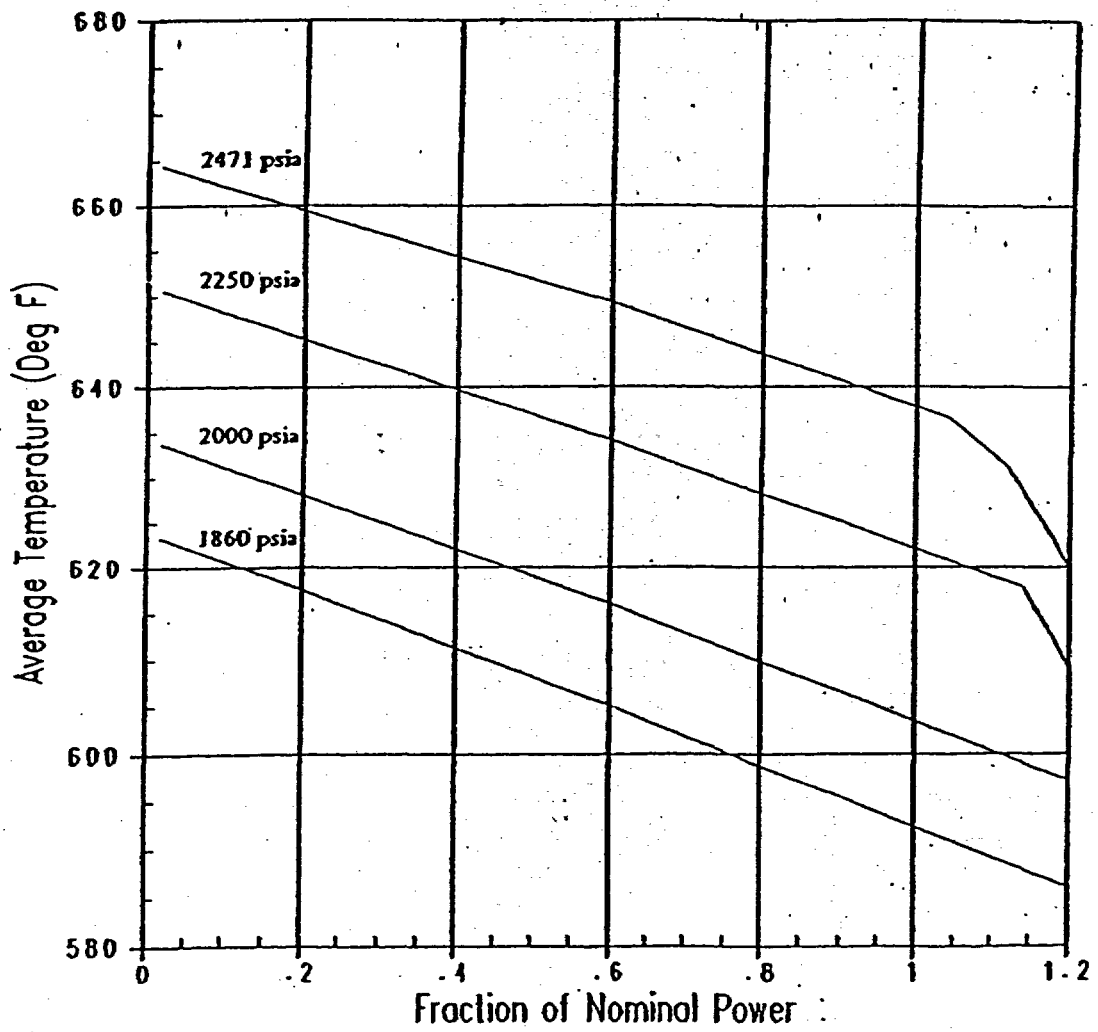


Figure 2.1.1: Reactor Core Limits

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 12

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 limit for MODE 5 is:

2.2.2 SDM shall be greater than or equal to 1.3% $\Delta k/k$ (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 $+2.11 \times 10^{-5}$ $\Delta k/k/°F$.

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

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

2.3.4 The EOL/ARO/HFP-MTC Surveillance limit at 60 ppm shall be -4.3×10^{-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 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)

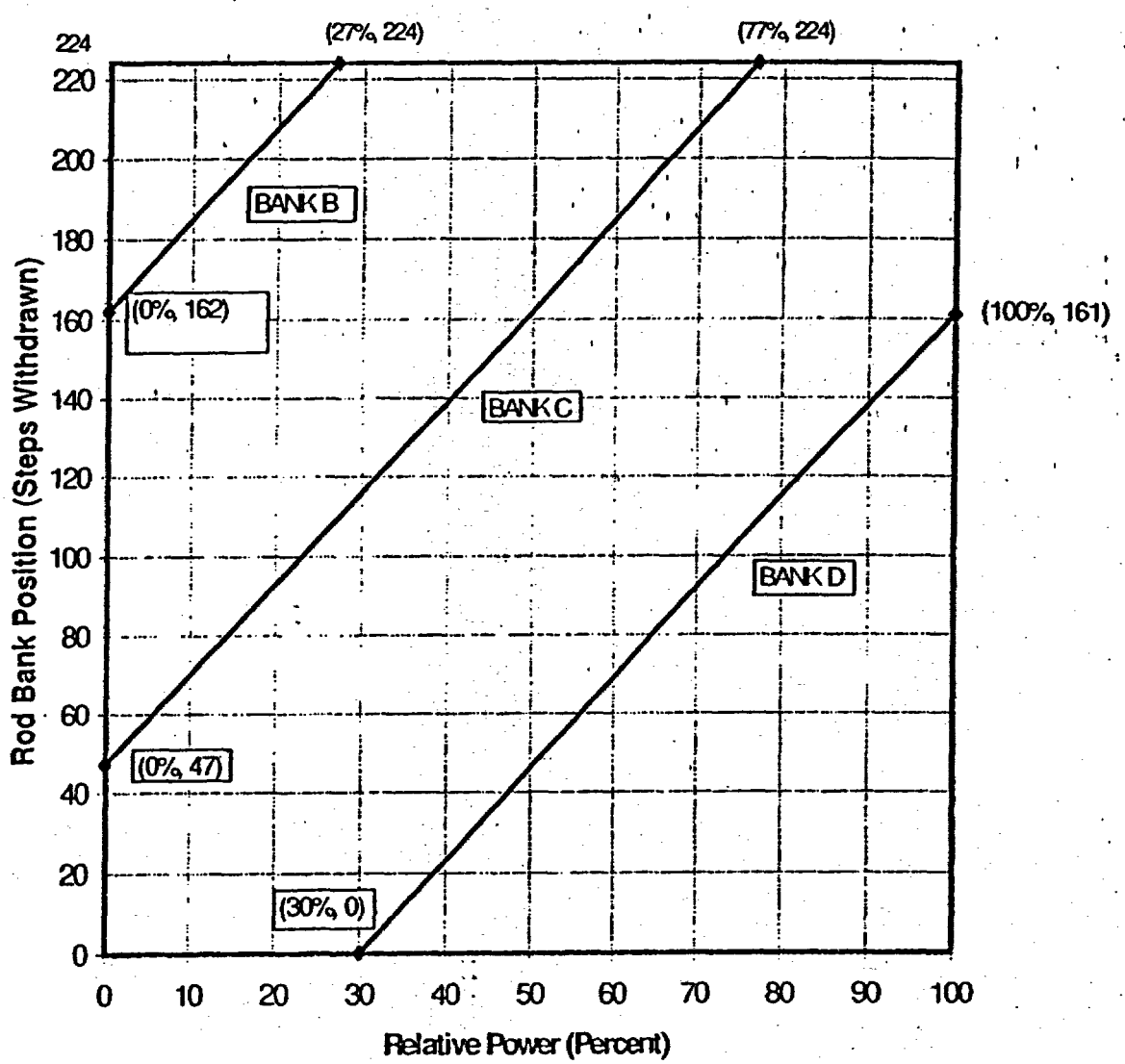
2.5.1 The control banks shall be limited in physical insertion as shown in Figure 2.5.1.

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 113 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

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

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

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 Figures 2.6.2.a through 2.6.2.d.

The normal operation W(Z) values have been determined at burnups of 1737, 6000, 14000, and 20000 MWD/MTU.

Table 2.6.2 shows the $F^C_O(z)$ penalty factors that are greater than 2% per 31 Effective Full Power Days. These values shall be used to increase the $F^W_O(z)$ 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.

2.6.3 Uncertainty:

The uncertainty, U_{FQ}, to be applied to the Heat Flux Hot Channel Factor $F_O(Z)$ 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_{qu} is defined by PDMS when operable.)

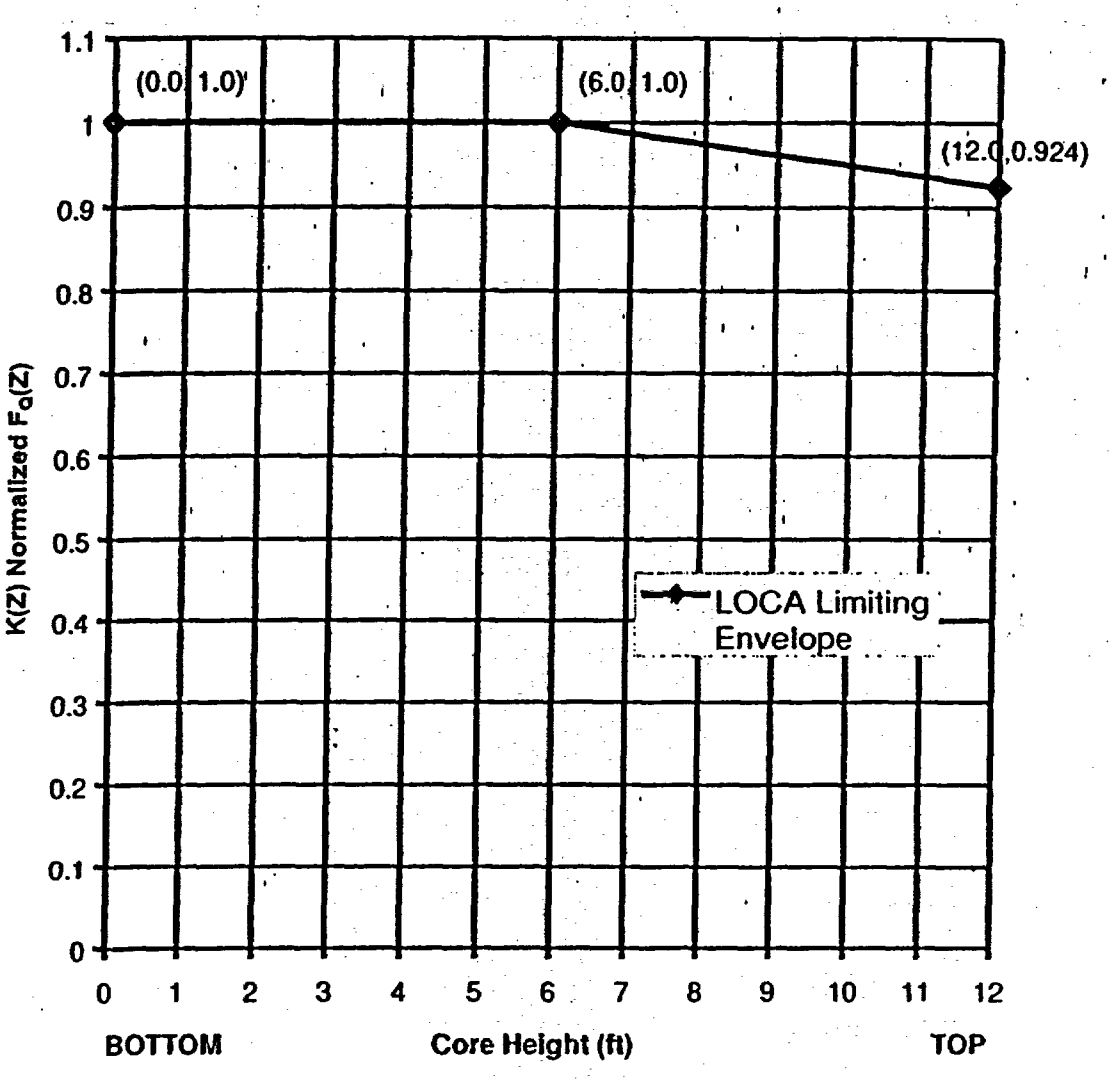
U_e = Engineering uncertainty factor = 1.03

2.6.4 PDMS Alarms:

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

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

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



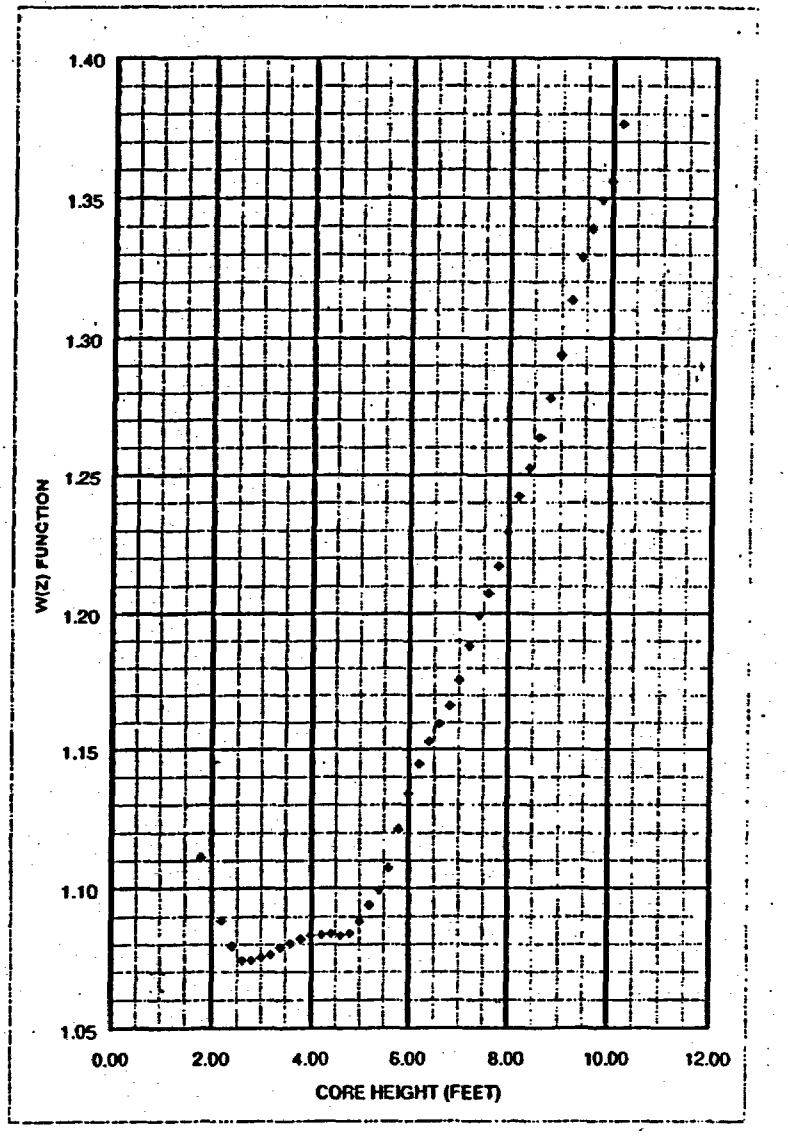
CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 12

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	1.1111
2.00	1.0999
2.20	1.0836
2.40	1.0794
2.60	1.0742
2.80	1.0743
3.00	1.0753
3.20	1.0762
3.40	1.0788
3.60	1.0802
3.80	1.0818
4.00	1.0830
4.20	1.0834
4.40	1.0837
4.60	1.0831
4.80	1.0837
5.00	1.0883
5.20	1.0941
5.40	1.0993
5.60	1.1073
5.80	1.1212
6.00	1.1340
6.20	1.1447
6.40	1.1529
6.60	1.1596
6.80	1.1661
7.00	1.1755
7.20	1.1881
7.40	1.1992
7.60	1.2073
7.80	1.2171
8.00	1.2295
8.20	1.2422
8.40	1.2523
8.60	1.2636
8.80	1.2781
9.00	1.2937
9.20	1.3135
9.40	1.3289
9.60	1.3390
9.80	1.3493
10.00	1.3558
10.20	1.3764
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 1 Cycle 12

Figure 2.6.2.a

Summary of W(Z) Function at 1737 MWD/MTU
(Top and Bottom 15% Excluded per WCAP-10216)



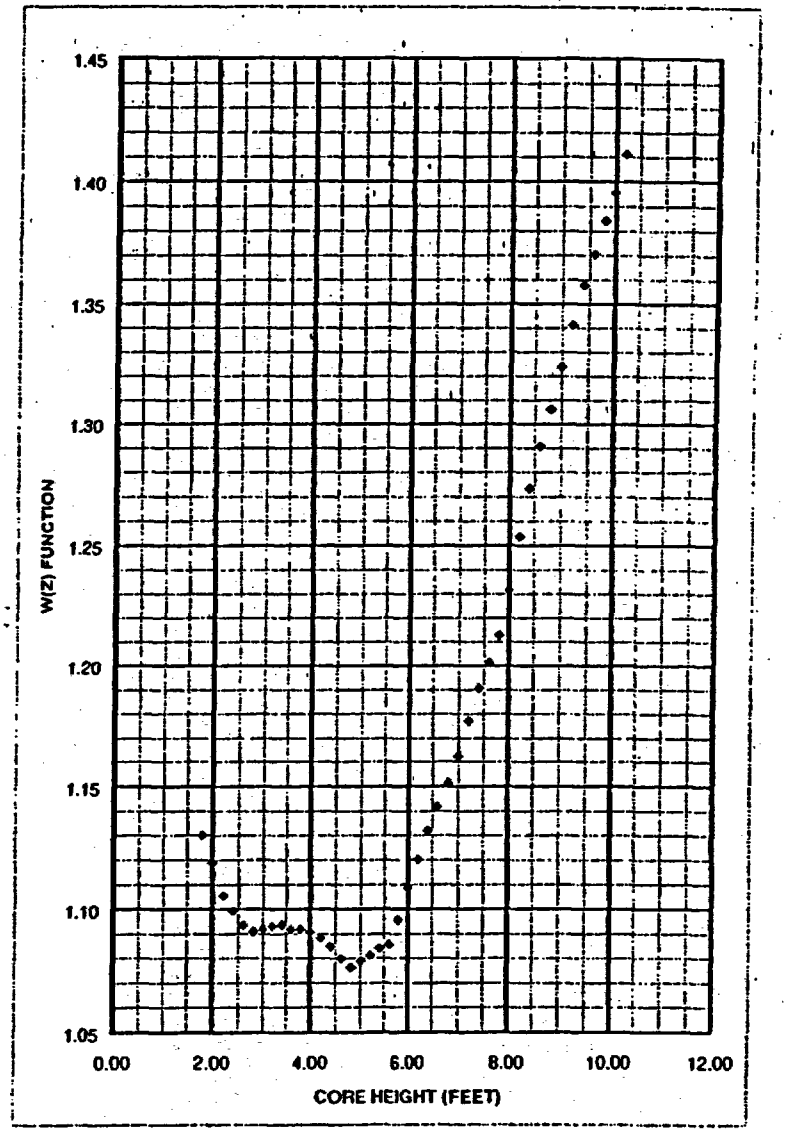
CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 12

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	1.1300
2.00	1.1188
2.20	1.1056
2.40	1.0991
2.60	1.0935
2.80	1.0911
3.00	1.0919
3.20	1.0930
3.40	1.0935
3.60	1.0919
3.80	1.0919
4.00	1.0909
4.20	1.0885
4.40	1.0849
4.60	1.0798
4.80	1.0761
5.00	1.0787
5.20	1.0812
5.40	1.0841
5.60	1.0858
5.80	1.0955
6.00	1.1087
6.20	1.1202
6.40	1.1319
6.60	1.1418
6.80	1.1515
7.00	1.1623
7.20	1.1770
7.40	1.1906
7.60	1.2014
7.80	1.2127
8.00	1.2316
8.20	1.2536
8.40	1.2734
8.60	1.2908
8.80	1.3063
9.00	1.3240
9.20	1.3413
9.40	1.3578
9.60	1.3705
9.80	1.3842
10.00	1.3956
10.20	1.4111
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 1 Cycle 12

Figure 2.6.2.b

Summary of W(Z) Function at 6000 MWD/MTU
(Top and Bottom 15% Excluded per WCAP-10216)



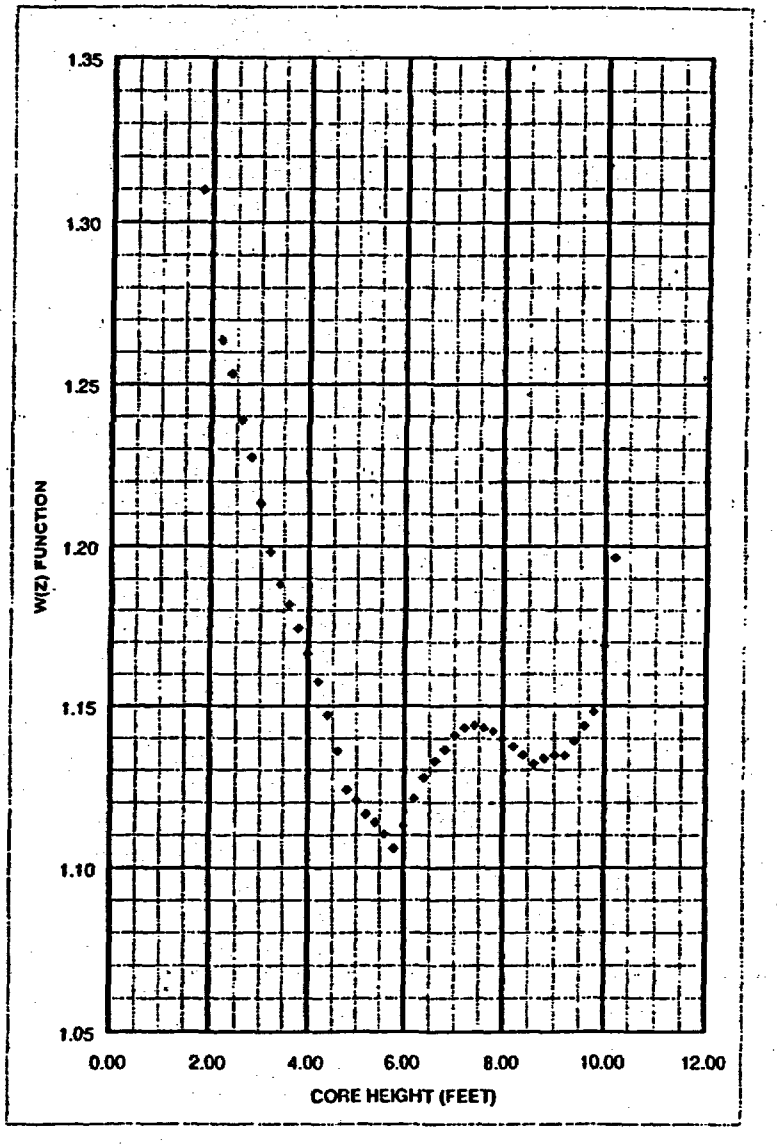
CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 12

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	1.3097
2.00	1.2901
2.20	1.2636
2.40	1.2531
2.60	1.2389
2.80	1.2274
3.00	1.2133
3.20	1.1983
3.40	1.1883
3.60	1.1818
3.80	1.1744
4.00	1.1662
4.20	1.1576
4.40	1.1473
4.60	1.1358
4.80	1.1240
5.00	1.1206
5.20	1.1164
5.40	1.1140
5.60	1.1103
5.80	1.1058
6.00	1.1130
6.20	1.1212
6.40	1.1277
6.60	1.1328
6.80	1.1363
7.00	1.1409
7.20	1.1432
7.40	1.1440
7.60	1.1432
7.80	1.1423
8.00	1.1400
8.20	1.1374
8.40	1.1346
8.60	1.1318
8.80	1.1335
9.00	1.1345
9.20	1.1344
9.40	1.1391
9.60	1.1438
9.80	1.1482
10.00	1.1689
10.20	1.1964
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 1 Cycle 12

Figure 2.6.2.c

Summary of W(Z) Function at 14000 MWD/MT U
(Top and Bottom 15% Excluded per WCAP-10216)



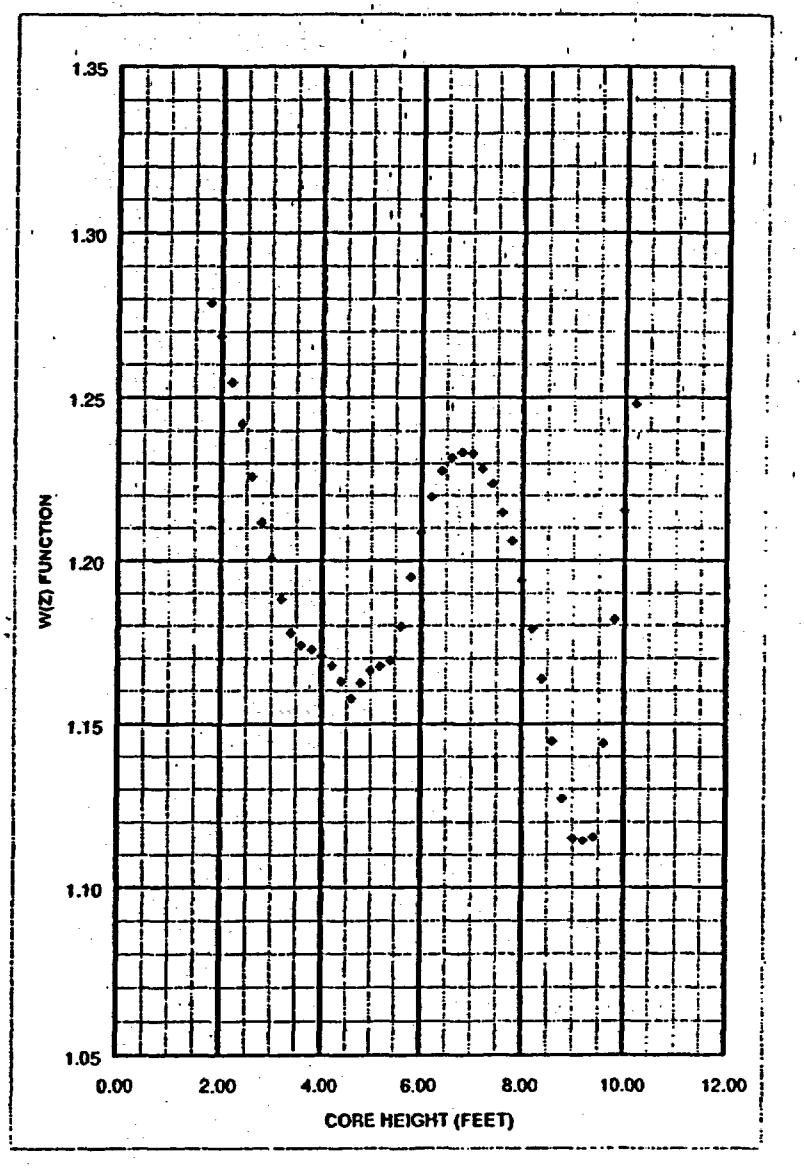
CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 12

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	1.2787
2.00	1.2686
2.20	1.2546
2.40	1.2420
2.60	1.2257
2.80	1.2116
3.00	1.2006
3.20	1.1882
3.40	1.1778
3.60	1.1739
3.80	1.1726
4.00	1.1705
4.20	1.1677
4.40	1.1629
4.60	1.1577
4.80	1.1624
5.00	1.1663
5.20	1.1675
5.40	1.1691
5.60	1.1797
5.80	1.1949
6.00	1.2087
6.20	1.2196
6.40	1.2276
6.60	1.2316
6.80	1.2333
7.00	1.2330
7.20	1.2283
7.40	1.2236
7.60	1.2147
7.80	1.2060
8.00	1.1940
8.20	1.1790
8.40	1.1636
8.60	1.1448
8.80	1.1270
9.00	1.1149
9.20	1.1143
9.40	1.1154
9.60	1.1442
9.80	1.1818
10.00	1.2154
10.20	1.2481
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 1 Cycle 12

Figure 2.6.2.d

Summary of W(Z) Function at 20000 MWD/MTU
(Top and Bottom 15% Excluded per WCAP-10216)



CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 12

Table 2.6.2

Penalty Factors in Excess of 2% per 31 EFPD

Cycle Burnup (MWD/MTU)	Penalty Factor - $F^C_Q(z)$ (%)
837	2.00
1009	2.78
1524	3.76
1695	3.90
1867	3.91
2039	3.81
2554	3.33
2726	3.33
2897	3.47
3584	4.67
3756	4.76
3928	4.66
4786	2.09
4958	2.00
13716	2.00
14231	2.67
14402	2.75
14574	2.75
14746	2.66
15433	2.00

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 $F_{\Delta H}^N$ 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)

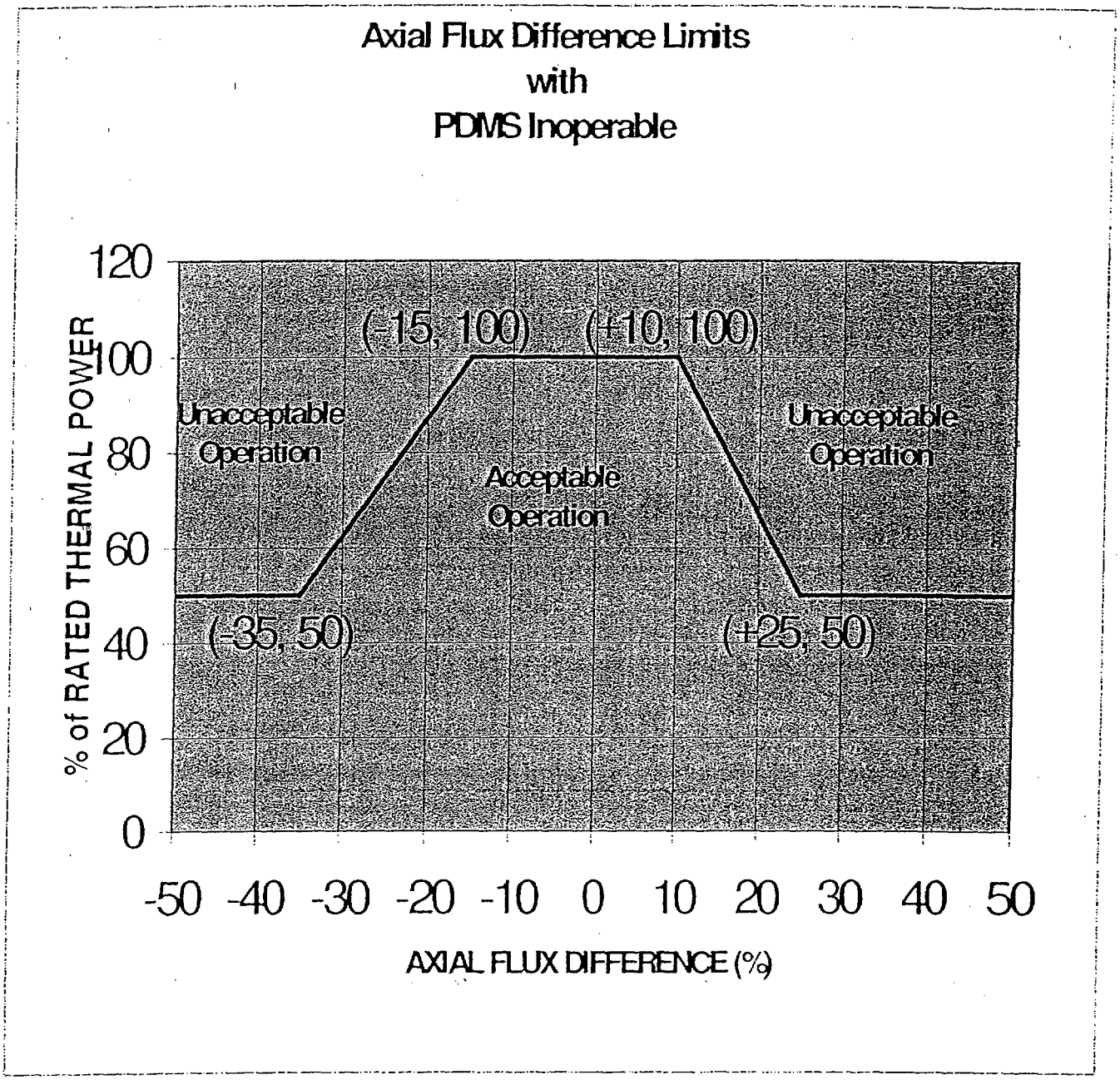
2.9.1 $DNBR_{APSL} \geq 1.536$

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.

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 12

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.

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 12

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 1756 ppm (LCO 3.9.1).

2.13.2 The Reactor Coolant System boron concentration shall be greater than or equal to 1831 ppm prior to initial criticality of Cycle 12, or greater than or equal to 2042 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 (TRM TLCOs 3.1.g and 3.1.k).

Attachment 2

Byron Station, Unit 2 Cycle 11, COLR, Revision 1

CORE OPERATING LIMITS REPORT (COLR)

FOR

BYRON UNIT 2 CYCLE 11

REVISION 1

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 11

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Byron Station Unit 2 Cycle 11 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)

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 11

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.

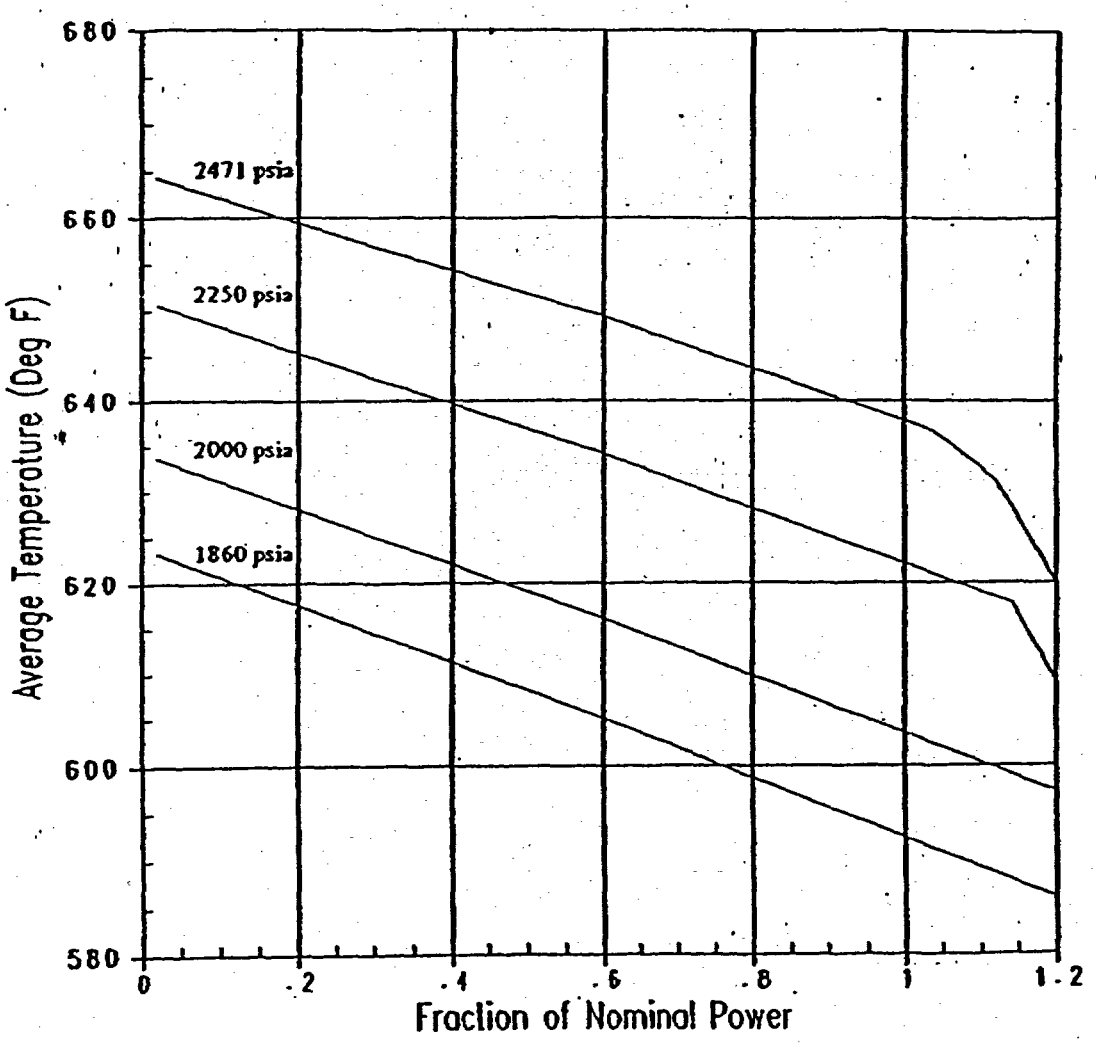


Figure 2.1.1: Reactor Core Limits

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 11

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 $+2.72 \times 10^{-5}$ 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 the Bank A greater than or equal to 224 steps, shall be limited in physical insertion as shown in Figure 2.5.1.

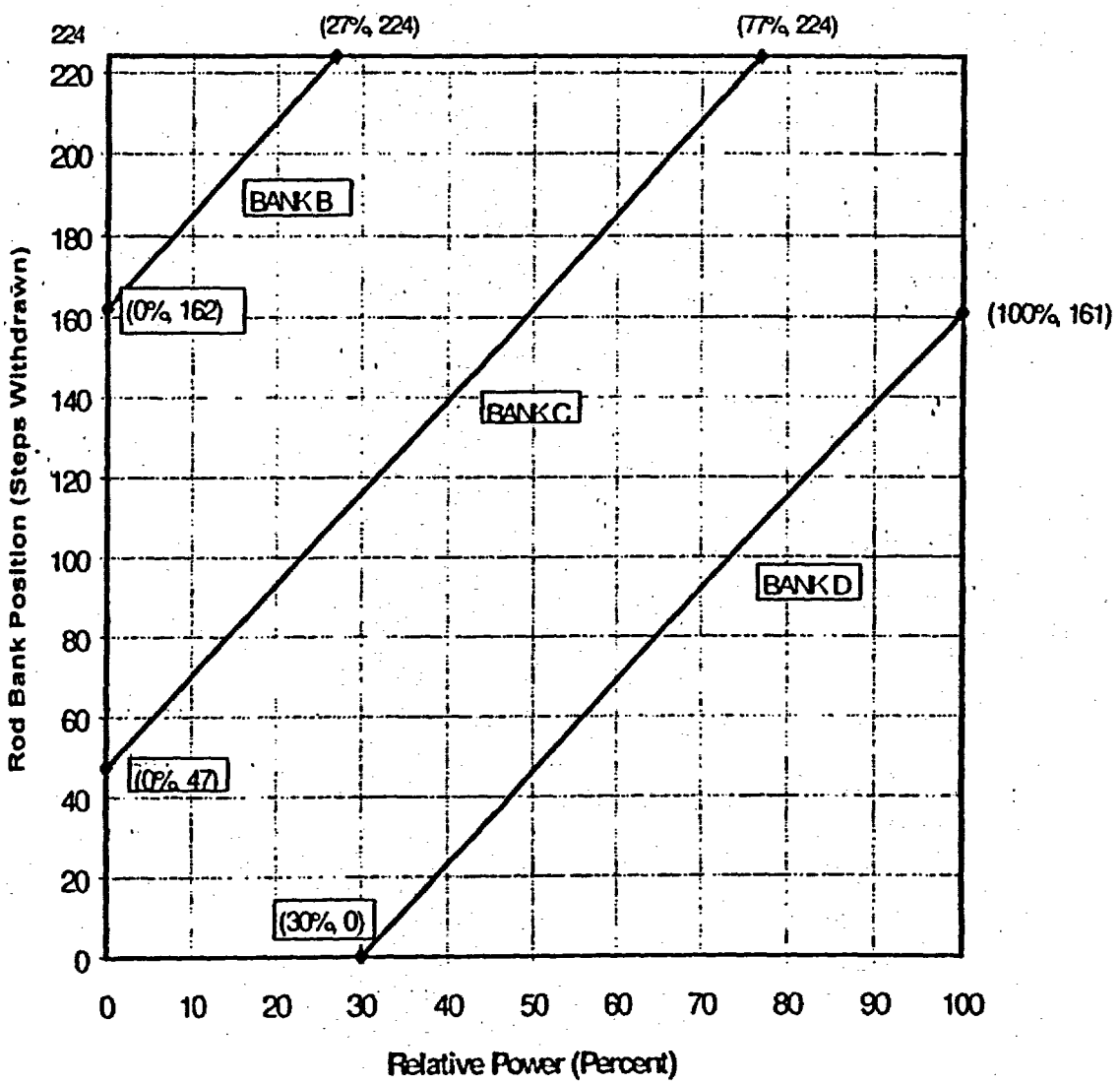
2.5.2 Each control bank shall be considered fully withdrawn from the core at greater than or equal to 224 steps.

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 a 113 Step overlap limit.

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 11

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:

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

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

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

$F_Q^{RTP} = 2.60$

K(Z) 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 Figures 2.6.2.a through 2.6.2.d.

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

Table 2.6.2 shows the $F^C_Q(z)$ penalty factors that are greater than 2% per 31 Effective Full Power Days. 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.

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:

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

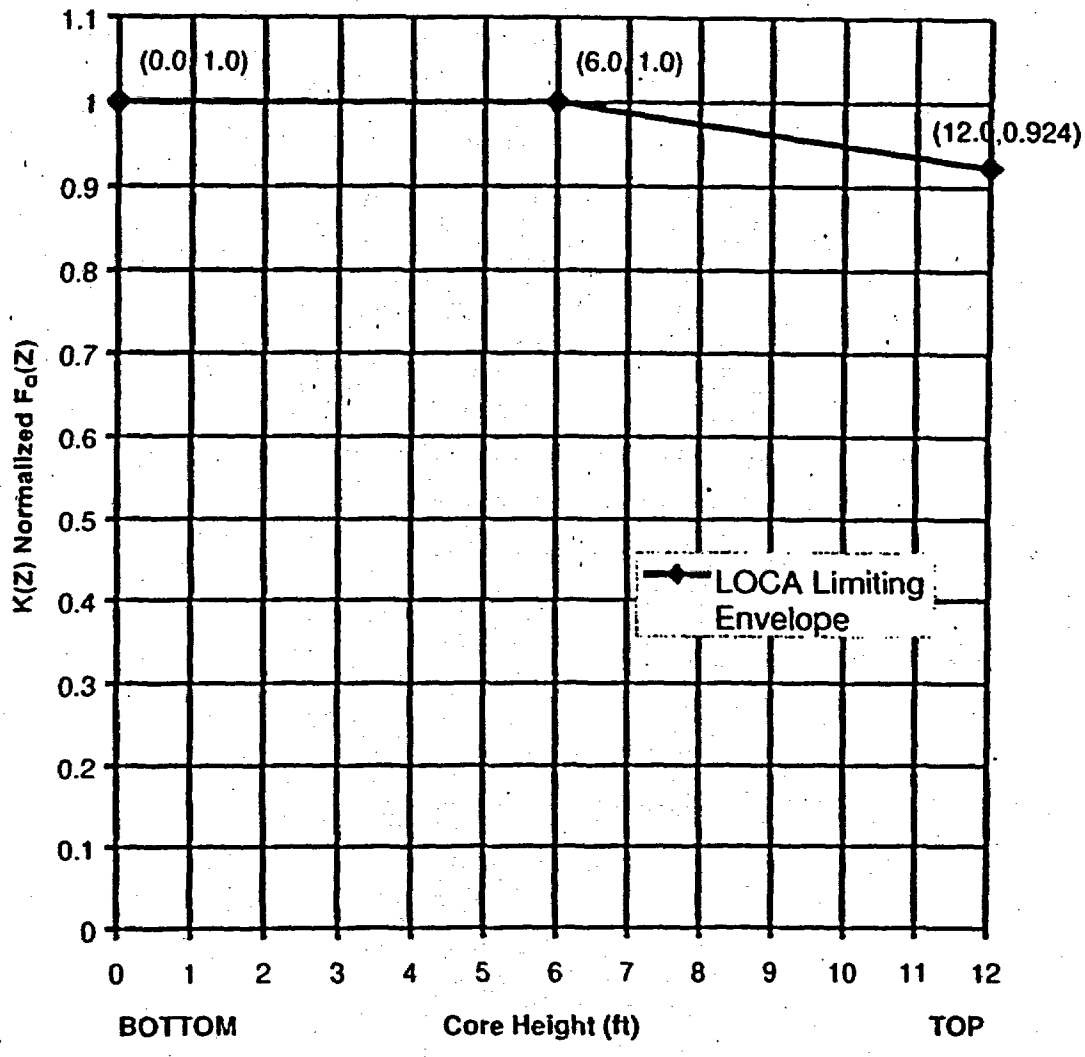
where:

U_{qu} = Base FQ measurement uncertainty = 1.05 when PDMS is inoperable. (U_{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



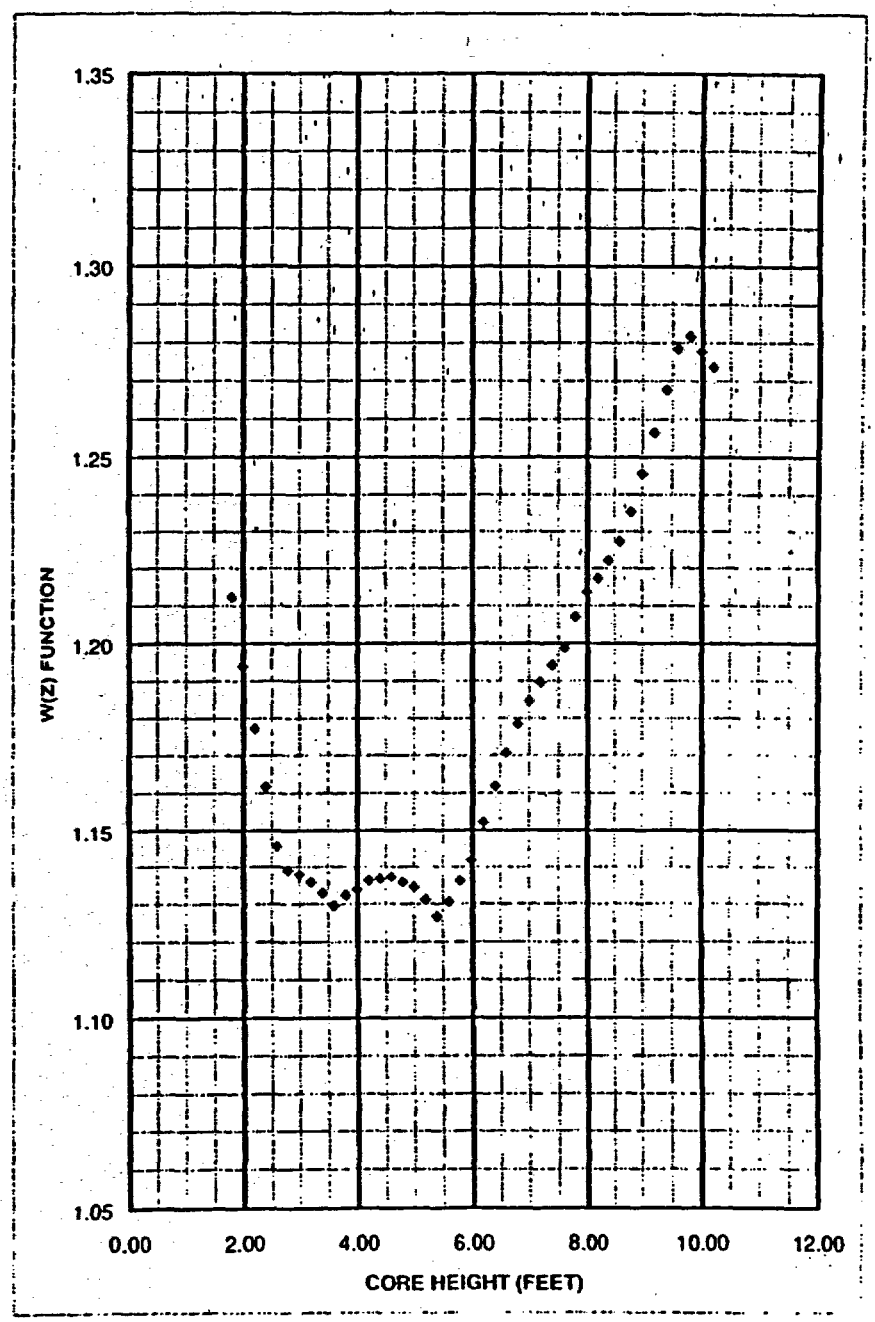
CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 11

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	1.2123
2.00	1.1939
2.20	1.1773
2.40	1.1617
2.60	1.1456
2.80	1.1389
3.00	1.1378
3.20	1.1357
3.40	1.1328
3.60	1.1296
3.80	1.1322
4.00	1.1337
4.20	1.1362
4.40	1.1366
4.60	1.1371
4.80	1.1357
5.00	1.1344
5.20	1.1310
5.40	1.1266
5.60	1.1305
5.80	1.1361
6.00	1.1417
6.20	1.1521
6.40	1.1619
6.60	1.1707
6.80	1.1785
7.00	1.1846
7.20	1.1896
7.40	1.1942
7.60	1.1987
7.80	1.2070
8.00	1.2137
8.20	1.2174
8.40	1.2221
8.60	1.2273
8.80	1.2353
9.00	1.2455
9.20	1.2564
9.40	1.2677
9.60	1.2783
9.80	1.2816
10.00	1.2777
10.20	1.2736
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 11

Figure 2.6.2.a

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



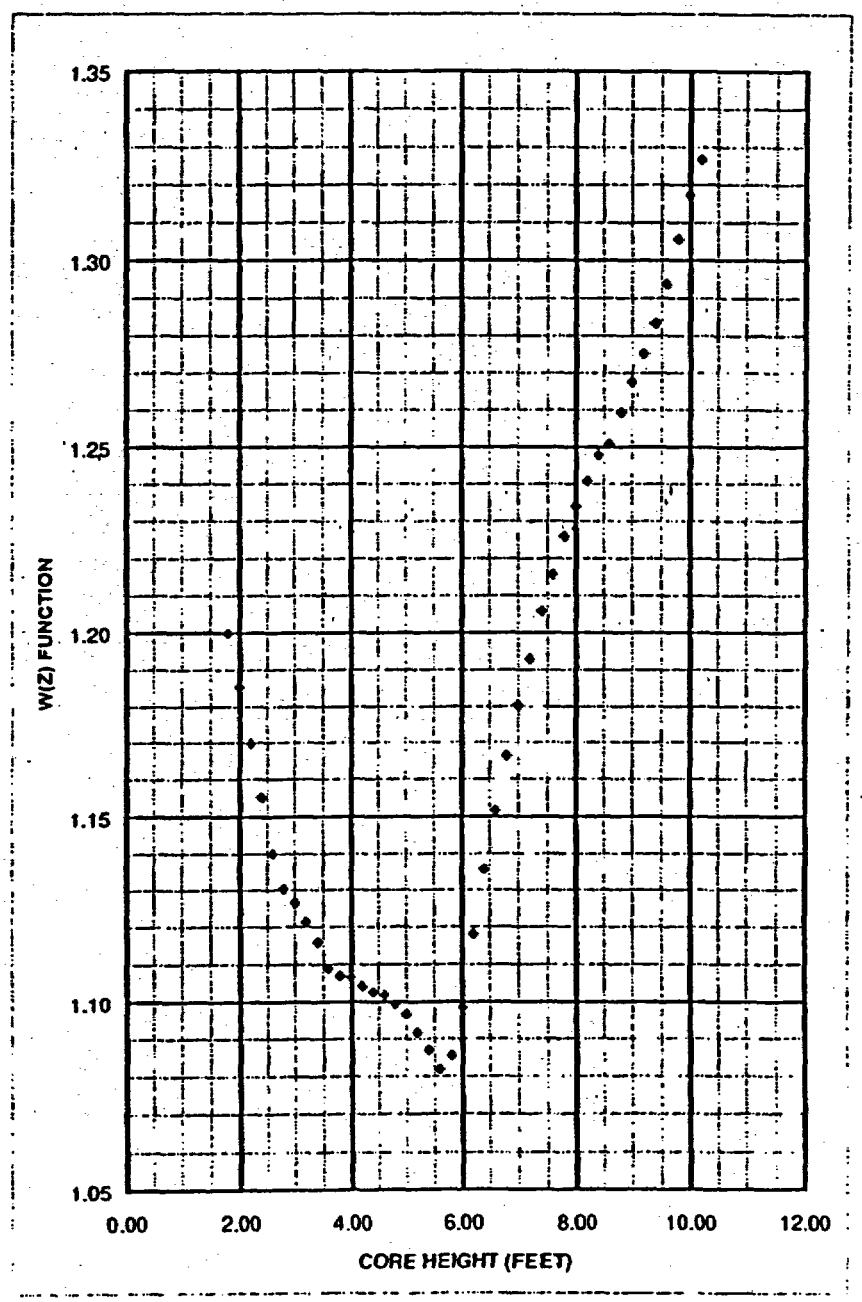
CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 11

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	1.1998
2.00	1.1853
2.20	1.1698
2.40	1.1552
2.60	1.1400
2.80	1.1303
3.00	1.1267
3.20	1.1214
3.40	1.1161
3.60	1.1089
3.80	1.1069
4.00	1.1065
4.20	1.1041
4.40	1.1026
4.60	1.1018
4.80	1.0993
5.00	1.0965
5.20	1.0916
5.40	1.0870
5.60	1.0818
5.80	1.0855
6.00	1.0984
6.20	1.1181
6.40	1.1357
6.60	1.1516
6.80	1.1664
7.00	1.1802
7.20	1.1928
7.40	1.2058
7.60	1.2158
7.80	1.2258
8.00	1.2339
8.20	1.2409
8.40	1.2479
8.60	1.2509
8.80	1.2593
9.00	1.2676
9.20	1.2751
9.40	1.2833
9.60	1.2937
9.80	1.3056
10.00	1.3173
10.20	1.3267
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 11

Figure 2.6.2.b

Summary of W(Z) Function at 6000 MWD/MTU
(Top and Bottom 15% Excluded per WCAP-10216)



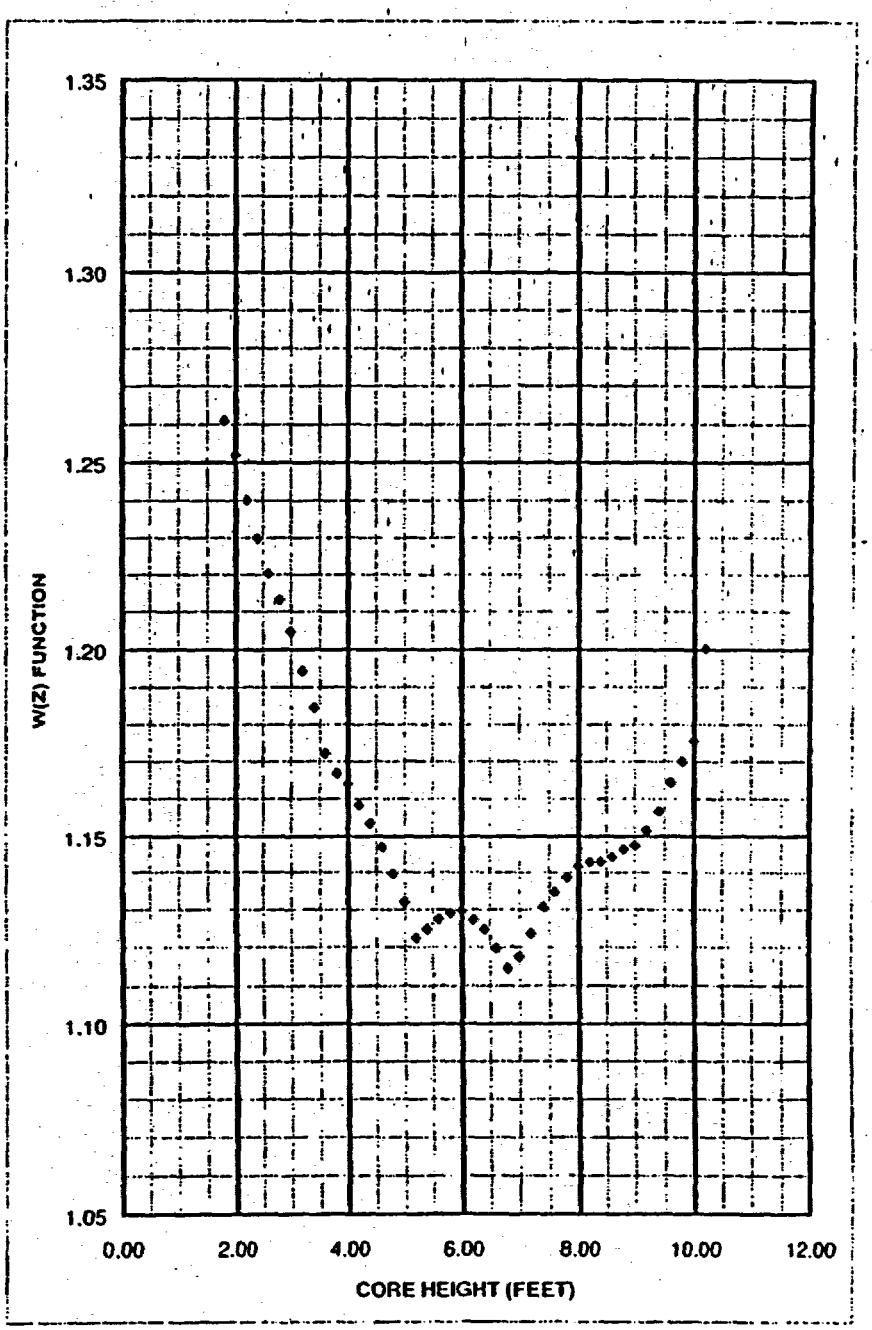
CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 11

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	1.2610
2.00	1.2520
2.20	1.2400
2.40	1.2298
2.60	1.2204
2.80	1.2133
3.00	1.2047
3.20	1.1943
3.40	1.1845
3.60	1.1722
3.80	1.1668
4.00	1.1639
4.20	1.1583
4.40	1.1534
4.60	1.1470
4.80	1.1396
5.00	1.1319
5.20	1.1225
5.40	1.1248
5.60	1.1274
5.80	1.1290
6.00	1.1296
6.20	1.1272
6.40	1.1248
6.60	1.1197
6.80	1.1145
7.00	1.1176
7.20	1.1236
7.40	1.1305
7.60	1.1346
7.80	1.1386
8.00	1.1417
8.20	1.1429
8.40	1.1430
8.60	1.1443
8.80	1.1464
9.00	1.1475
9.20	1.1515
9.40	1.1566
9.60	1.1643
9.80	1.1700
10.00	1.1755
10.20	1.2002
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 11

Figure 2.6.2.c

Summary of W(Z) Function at 14000 MWD/MTU
(Top and Bottom 15% Excluded per WCAP-10216)



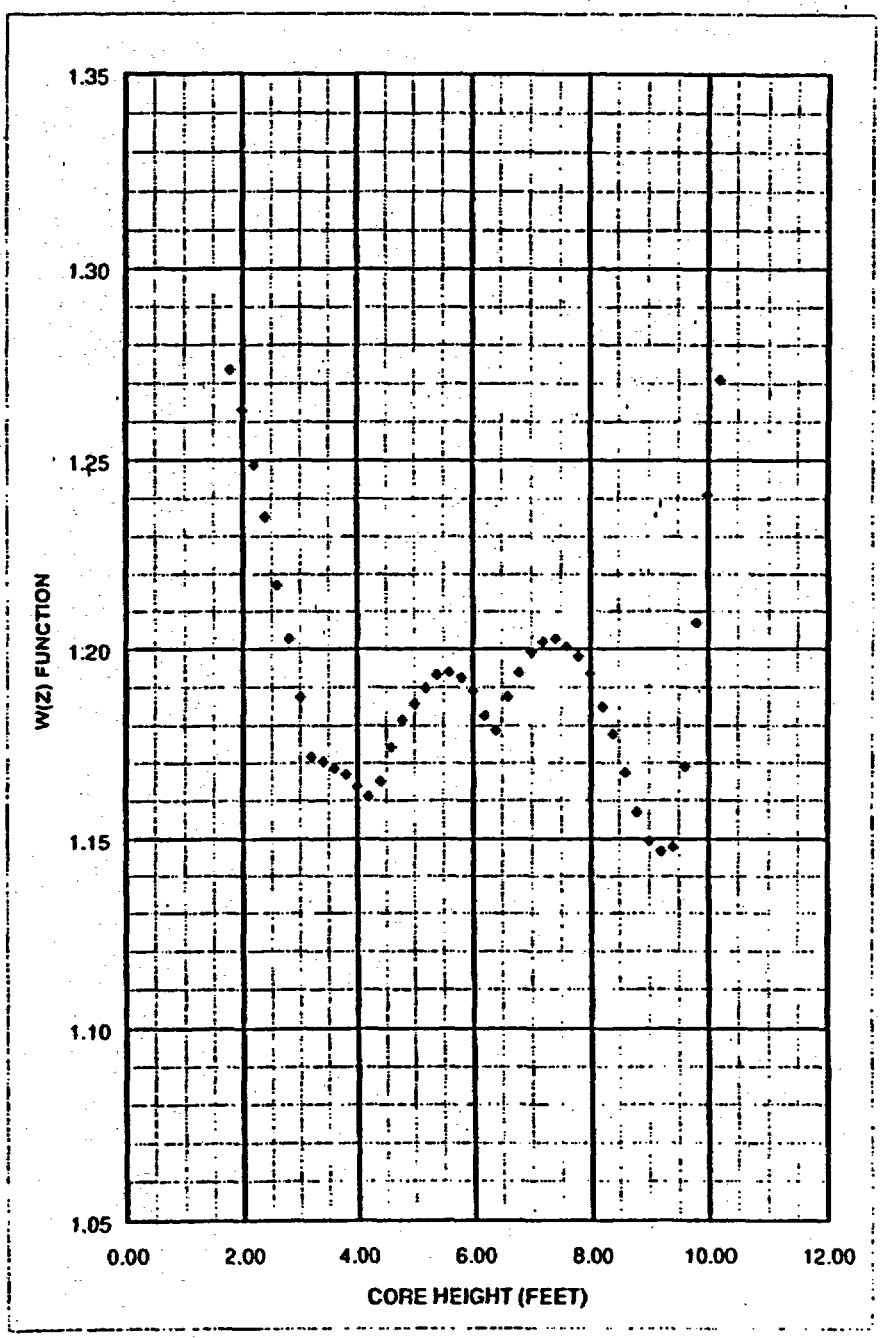
CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 11

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	1.2735
2.00	1.2630
2.20	1.2487
2.40	1.2352
2.60	1.2171
2.80	1.2027
3.00	1.1874
3.20	1.1715
3.40	1.1703
3.60	1.1686
3.80	1.1669
4.00	1.1637
4.20	1.1611
4.40	1.1651
4.60	1.1742
4.80	1.1814
5.00	1.1857
5.20	1.1898
5.40	1.1933
5.60	1.1939
5.80	1.1925
6.00	1.1890
6.20	1.1826
6.40	1.1787
6.60	1.1875
6.80	1.1938
7.00	1.1991
7.20	1.2019
7.40	1.2027
7.60	1.2007
7.80	1.1981
8.00	1.1936
8.20	1.1848
8.40	1.1777
8.60	1.1674
8.80	1.1570
9.00	1.1494
9.20	1.1467
9.40	1.1478
9.60	1.1690
9.80	1.2070
10.00	1.2410
10.20	1.2710
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 11

Figure 2.6.2.d

Summary of W(Z) Function at 20000 MWD/MTU
(Top and Bottom 15% Excluded per WCAP-10216)



CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 11

Table 2.6.2

Penalty Factors in Excess of 2% per 31 EFPD

Cycle Burnup (MWD/MTU)	Penalty Factor -$F^C_Q(z)$ (%)
322	2.00
493	2.55
665	2.74
837	2.76
1008	2.74
1866	2.58
2210	2.58
2896	2.74
3068	2.75
3239	2.72
3411	2.65
3754	2.30
4097	2.00
11821	2.00
11992	2.11
12335	2.84
12507	2.89
12679	2.87
12850	2.71
13537	2.00

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.

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 11

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)

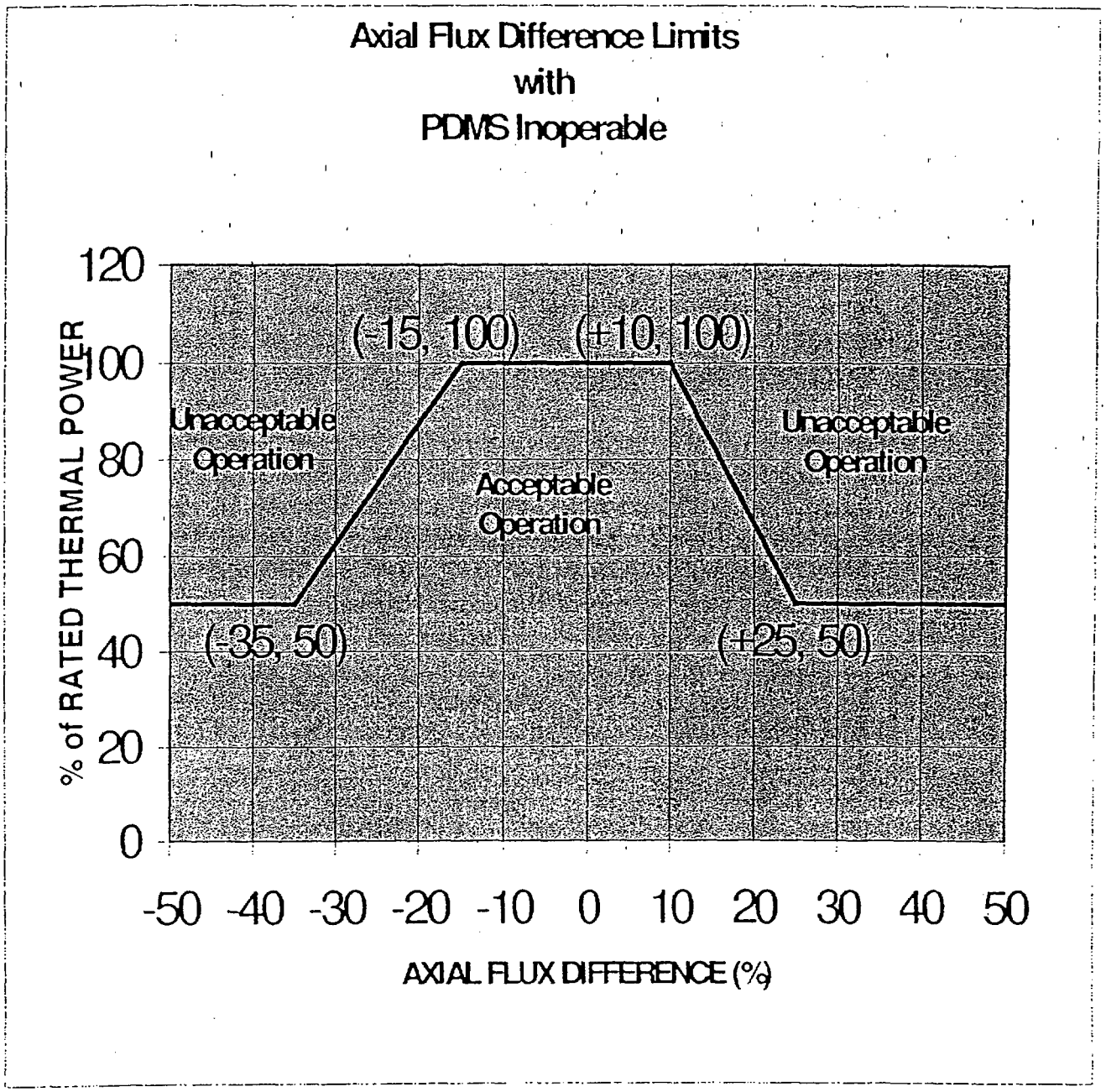
2.9.1 $DNBR_{APSL} \geq 1.536$

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



CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 11

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.

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 11

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 ≤ 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 (ΔI) "positive" breakpoint shall be 0 for all ΔI.

2.11.13 The f_2 (ΔI) "negative" breakpoint shall be 0 for all ΔI.

2.11.14 The f_2 (ΔI) "positive" slope shall be 0 for all ΔI.

2.11.15 The f_2 (ΔI) "negative" slope shall be 0 for all ΔI.

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 11

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 1753 ppm (LCO 3.9.1).

2.13.2 The Reactor Coolant System boron concentration, with all shutdown and control rods fully withdrawn, shall be greater than or equal to 1803 ppm prior to initial criticality of Cycle 11, or greater than or equal to 2048 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 (TRM TLCOs 3.1.g and 3.1.k).