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Byron Generating Station
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October 6, 2000

LTR: BYRON 2000-0148
File: 1.02.1052.194

United States Nuclear Regulatory Commission
ATTN: 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: Core Operating Limits Report for Byron Station, Unit 1 Cycle 11
Core Operating Limits Report for Byron Station, Unit 2 Cycle 9

In accordance with Technical Specification 5.6.5, "Core Operating Limits Report," we are transmitting the Core Operating Limits Report (COLR) for the upcoming cycle. Byron Station, Unit 1 has recently completed its 10th cycle of operation and is currently preparing for Cycle 11 startup. The estimated startup date is October 10, 2000. The purpose of this letter is to advise you of our review of the Unit 1 Cycle 11 reload safety evaluation under the provisions of 10 CFR 50.59.

The Byron Station, Unit 1 Cycle 11 core, which consists of NRC-approved fuel designs, was designed to operate within approved fuel design criteria and Technical Specifications such that:

- 1) core operating characteristics will be equivalent to or less limiting than those previously reviewed and accepted; or
- 2) re-analyses or re-evaluations have been performed to demonstrate that the limiting postulated Updated Final Safety Analysis Report events, which could be affected by the reload, are within allowable limits.

We have performed a detailed review of the revised reload core design documents, the associated bases, and references. Based on that review, a safety evaluation was prepared, which concluded that the reload core presents no unreviewed safety questions and requires no Technical Specification changes. The Byron Plant Review of the 10 CFR 50.59 Safety Evaluation has been completed in accordance with station procedures. Finally, further verification of the reload core design will be performed during startup testing.

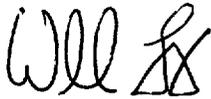
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October 6, 2000
Byron Ltr.: 2000-0148
Page 2

Additionally, an error has been identified in the COLR for Unit 2, Cycle 9. The COLR, on page 9 of 18, had an incorrect figure for the K(Z)-normalized Fq(Z) curve. There were two identical figures (Figure 2.6.1) for the >4000 MWD/MTU assembly average burnup case. There should have been one Figure 2.6.1 for the >4000 MWD/MTU case and one Figure 2.6.1.a, which represents other K(Z) limits for assembly average burnup ≤ 4000 MWD/MTU. This error occurred when the COLR was revised on June 2, 2000, to incorporate the Expanded COLR format. We are providing a revised COLR for Unit 2, Cycle 9 with the correct pages.

If there are any questions regarding this matter, please contact Ms. P. Reister, Regulatory Assurance Manager, at (815) 234-5441, extension 2280.

Respectfully,



William Levis
Site Vice President
Byron Station

WL/RC/dpk

Attachments: Core Operating Limits Report, Byron Station, Unit 1 Cycle 11
Core Operating Limits Report, Byron Station, Unit 2 Cycle 9

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

bcc: NRC Project Manager – NRR – Byron Station
Nicholas Reynolds – Winston & Strawn
Office of Nuclear Facility Safety – IDNS
Site Vice President – Byron Station
Vice President – Regulatory Services
Regulatory Assurance Manager – Byron Station
Director, Licensing and Compliance – Byron and Braidwood Stations
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Attachment

**Core Operating Limits Report, Byron Station, Unit 1, Cycle 11
(BY1C11)**

NUCLEAR FUEL MANAGEMENT DEPARTMENT
TRANSMITTAL OF DESIGN INFORMATION

- SAFETY RELATED
- NON-SAFETY RELATED
- REGULATORY RELATED

Originating Organization
 Nuclear Fuel Management
 Other (specify) _____

NFM ID # NFM0000119
 Rev. No. 2
 Page 1 of 19

Station Byron Unit 1 Cycle 11 Generic _____

To: D. B. Wozniak, Byron Site Engineering Manager

Subject Byron Unit 1 Cycle 11 Core Operating Limits Report in ITS Format and W(z) Function

R. C. Lee
 Preparer [Signature] Date 9/20/00

J. W. Gurley
 Reviewer [Signature] Date 9/20/00

E. H. Young
 NFM Supervisor [Signature] Date 9/20/00

- Status of Information:
- Verified
 - Unverified
 - Engineering Judgement

Method and Schedule of Verification for Unverified NDITs: _____

Description of Information: Attached is the Byron Unit 1 Cycle 11 Core Operating Limits Report (COLR) in the ITS format and W(z) function.

Purpose of Information: **Revision 2 of this TODI supersedes TODI NFM0000119, Rev. 1. Revision 2 incorporates the correct K(Z) curve for Assembly Burnup ≤ 4000 MWD/MTU case.** This COLR incorporates the BY1C11 cycle-specific parameters and the Expanded COLR format which includes Reactor Core Safety Limits, Reactor Trip System Instrumentation, and RCS DNB Parameters. Furthermore, the analytical limit of 224 rods out position is included. 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 (Erich Wurz) with a copy of Byron Station's completed Plant Review and COLR submittal to the NRC.

- Source of Information:
- 1) TODI NFM000112, Seq. 0. "BY1C11 Minimum Required Boron Concentration for Modes 3, 4, 5, and 6 and Control Rod Testing," dated August 4, 2000.
 - 2) Westinghouse Letter 00CB-G-0107 (CAC-00-259), "Byron 1 Cycle 11 Input for COLR," dated September 1, 2000.
 - 3) Byron Technical Specification Amendment 113, dated May 15, 2000
 - 4) TODI NFM0000099, Rev. 1. "BY1C11 Reload Design Initialization," dated August 3, 2000.
 - 5) Westinghouse Letter 00CB-G-0116 (CAC-00-280), "Byron 1 Cycle 11 Input for COLR Revision 1," dated September 18, 2000.

Supplemental Distribution: J. Bauer (DG) K. N. Kovar / R. J. Niederei (BY) P. E. Reister / J. E. Langan (BY)
 H. S. Kim / T. A. Shackelford (DG) Byron Central Files
 DG Central Files

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 11

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Byron Station Unit 1 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
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 ($F_{\Delta H}^N$)
LCO	3.2.3	Axial Flux Difference (AFD)
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.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 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 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.

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 $+3.7 \times 10^{-5} \Delta k/k/^\circ F$.

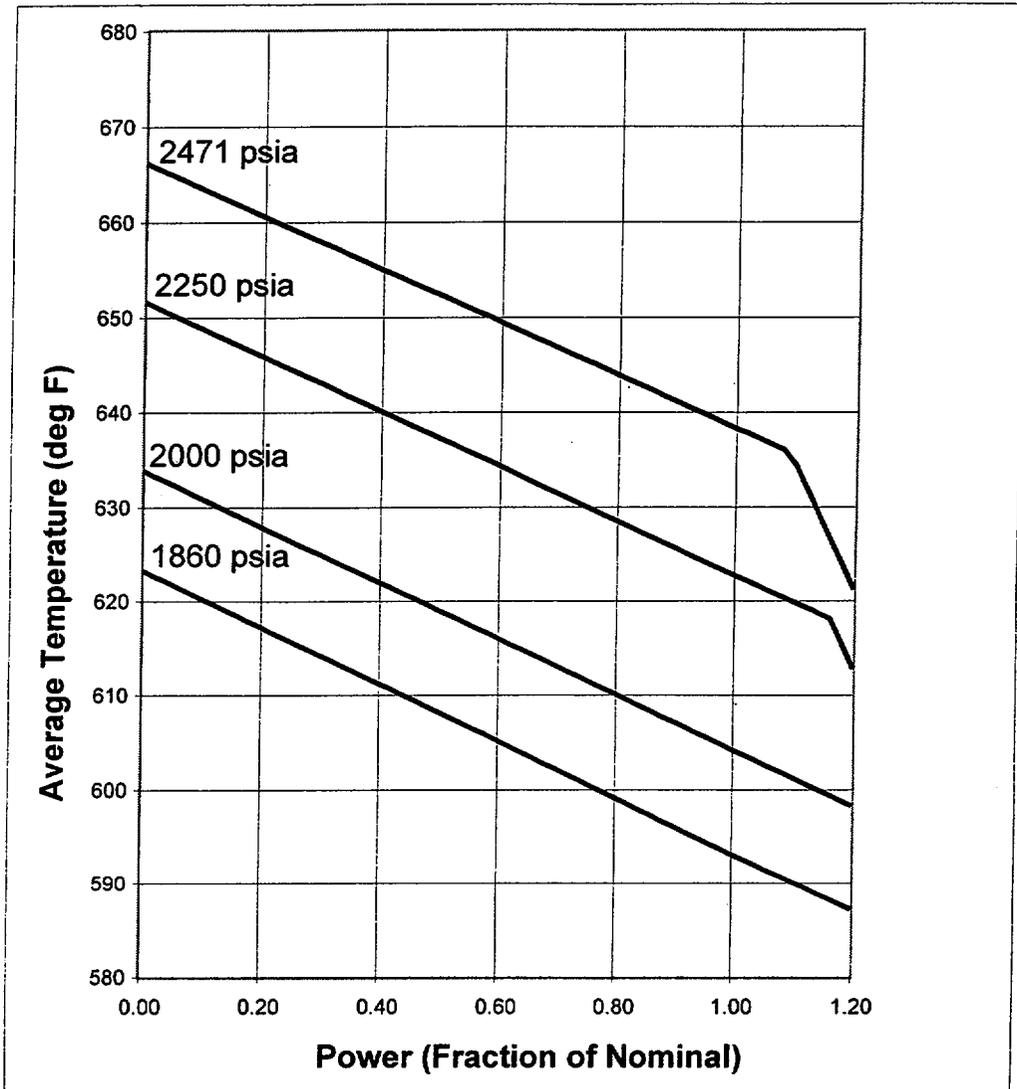
2.3.2 The EOL/ARO/HFP-MTC lower limit shall be $-4.1 \times 10^{-4} \Delta k/k/^\circ F$.

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

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

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 11

Figure 2.1.1: Reactor Core Limits



CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 11

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.

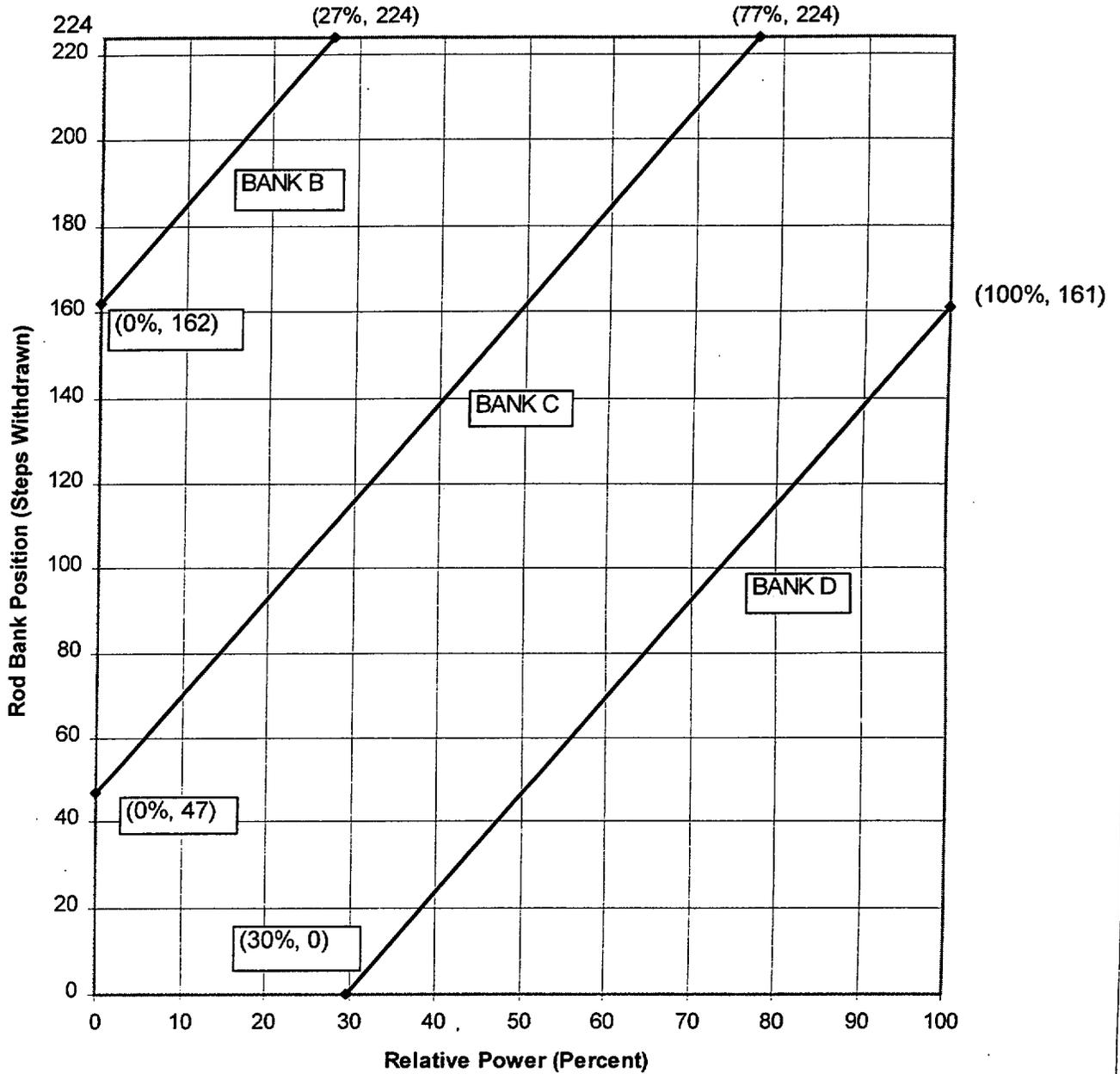
2.5.2 Each control bank shall be considered fully withdrawn from the core at greater than or equal to 224 steps.

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 113 step overlap limit.

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 11

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



CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 11

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

2.6.1

$$F_q(Z) \leq \frac{F_q^{RTP}}{0.5} \times K(Z) \text{ for } P \leq 0.5$$

$$F_q(Z) \leq \frac{F_q^{RTP}}{P} \times K(Z) \text{ for } P > 0.5$$

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 \leq 4000 MWD/MTU is provided in Figure 2.6.1.a.

2.6.2 $W(Z)$ is provided in Figures 2.6.2.a through 2.6.2.d.

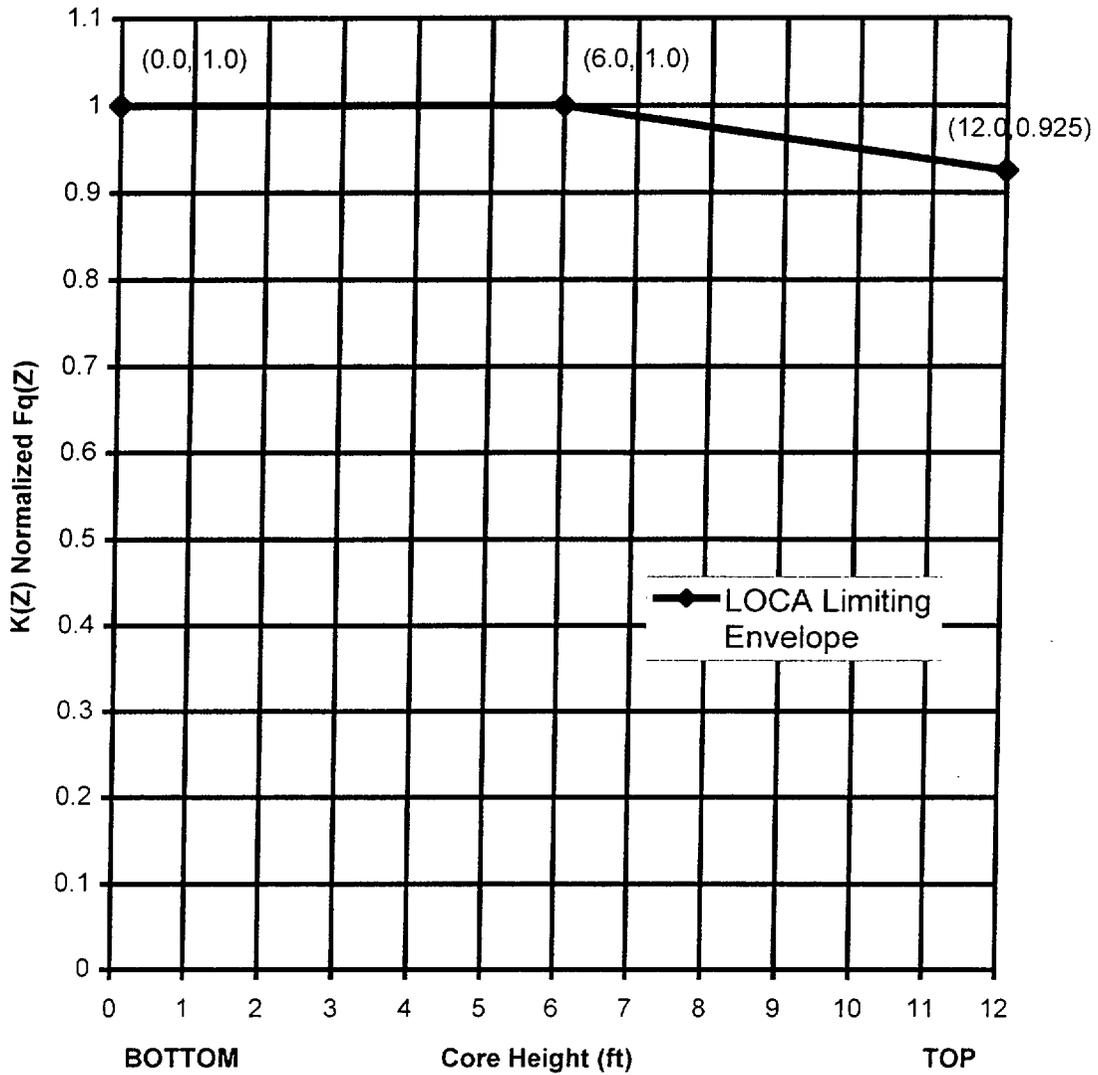
The normal operation $W(Z)$ values have been determined at burnups of 150, 4000, 10000, and 18000 MWD/MTU.

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

Multiplication Factor = 1.02

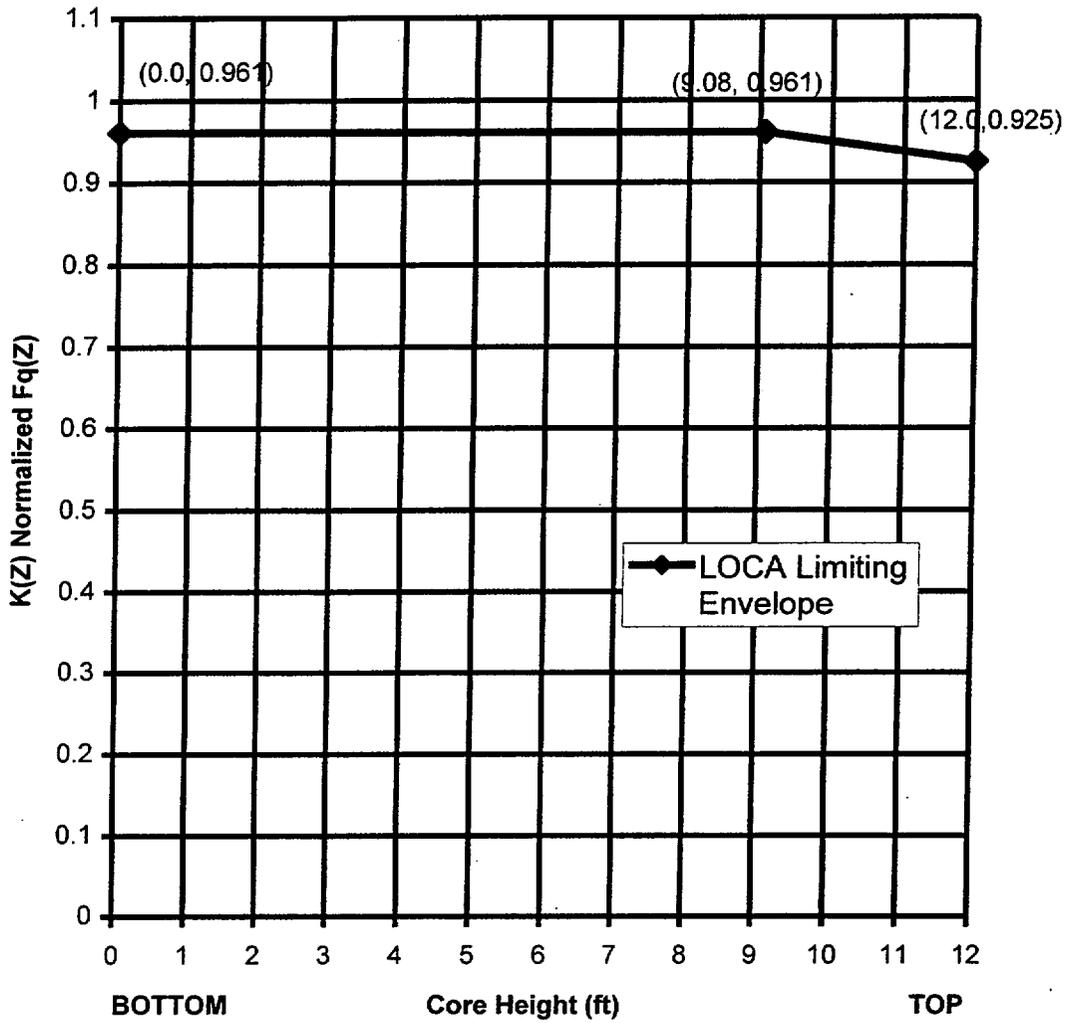
CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 11

Figure 2.6.1: K(Z) - Normalized Fq(Z) as a Function of Core Height (Assembly Average > 4000 MWD/MTU)



CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 11

Figure 2.6.1.a: K(Z) - Normalized Fq(Z) as a Function of Core Height (Assembly BU \leq 4000 MWD/MTU)



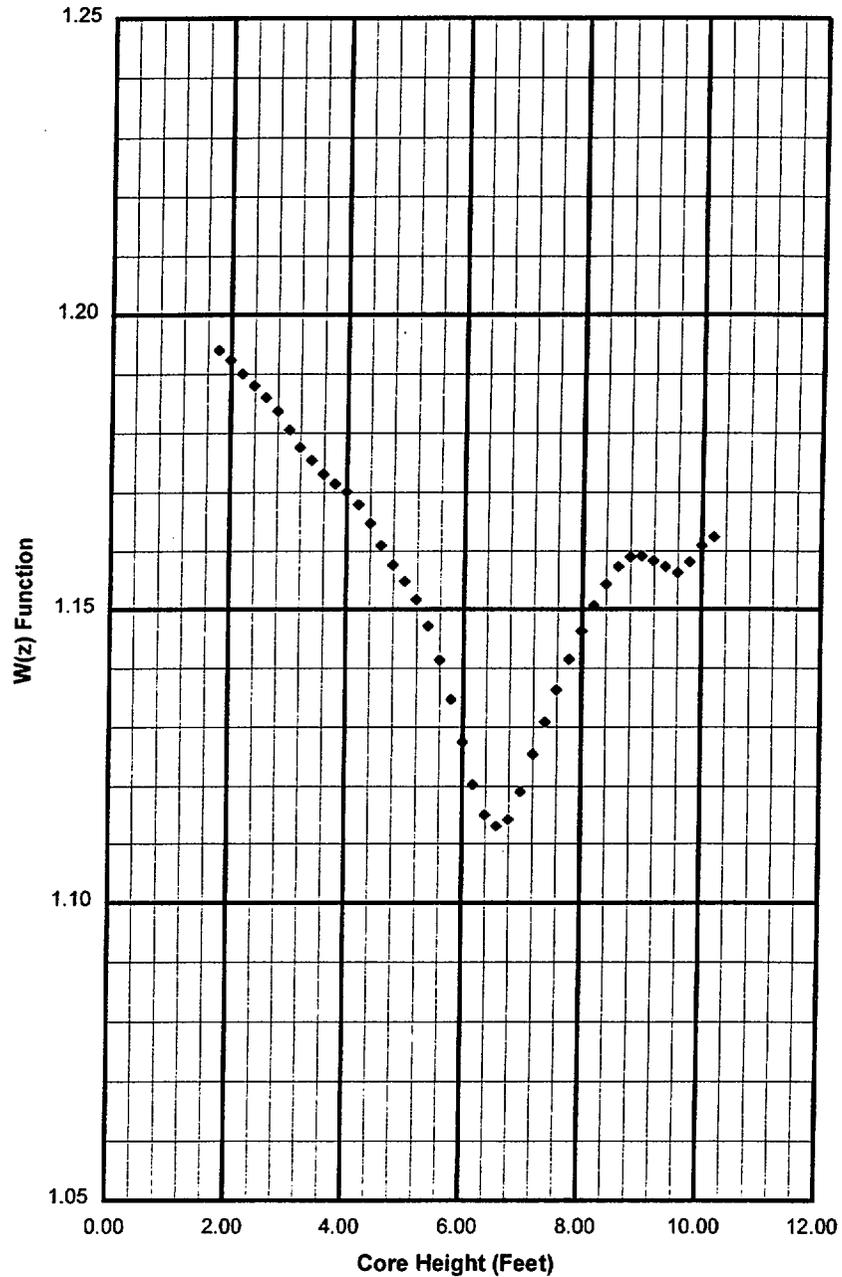
CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 11

Height (Feet)	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	1.1939
2.00	1.1922
2.20	1.1899
2.40	1.1879
2.60	1.1860
2.80	1.1836
3.00	1.1805
3.20	1.1775
3.40	1.1754
3.60	1.1730
3.80	1.1714
4.00	1.1700
4.20	1.1679
4.40	1.1647
4.60	1.1609
4.80	1.1575
5.00	1.1547
5.20	1.1516
5.40	1.1471
5.60	1.1412
5.80	1.1346
6.00	1.1273
6.20	1.1202
6.40	1.1151
6.60	1.1131
6.80	1.1143
7.00	1.1190
7.20	1.1253
7.40	1.1308
7.60	1.1363
7.80	1.1415
8.00	1.1462
8.20	1.1506
8.40	1.1543
8.60	1.1573
8.80	1.1589
9.00	1.1590
9.20	1.1583
9.40	1.1573
9.60	1.1562
9.80	1.1581
10.00	1.1609
10.20	1.1624
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 11

Figure 2.6.2.a

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



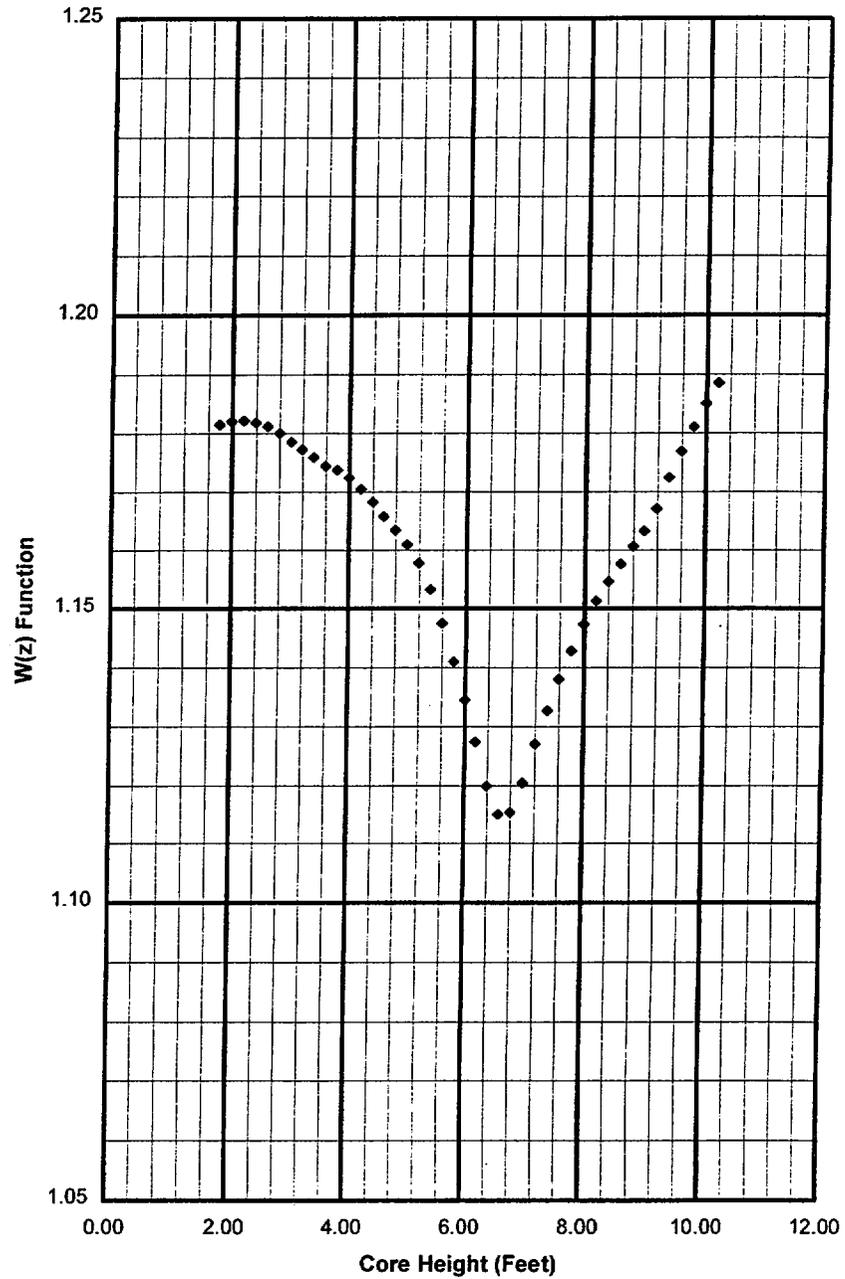
CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 11

Height (Feet)	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	1.1815
2.00	1.1820
2.20	1.1821
2.40	1.1818
2.60	1.1811
2.80	1.1799
3.00	1.1785
3.20	1.1772
3.40	1.1758
3.60	1.1744
3.80	1.1736
4.00	1.1724
4.20	1.1704
4.40	1.1681
4.60	1.1657
4.80	1.1634
5.00	1.1609
5.20	1.1578
5.40	1.1532
5.60	1.1474
5.80	1.1410
6.00	1.1345
6.20	1.1274
6.40	1.1199
6.60	1.1150
6.80	1.1153
7.00	1.1204
7.20	1.1270
7.40	1.1326
7.60	1.1379
7.80	1.1428
8.00	1.1473
8.20	1.1512
8.40	1.1545
8.60	1.1575
8.80	1.1605
9.00	1.1632
9.20	1.1671
9.40	1.1724
9.60	1.1768
9.80	1.1809
10.00	1.1849
10.20	1.1885
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 11

Figure 2.6.2.b

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



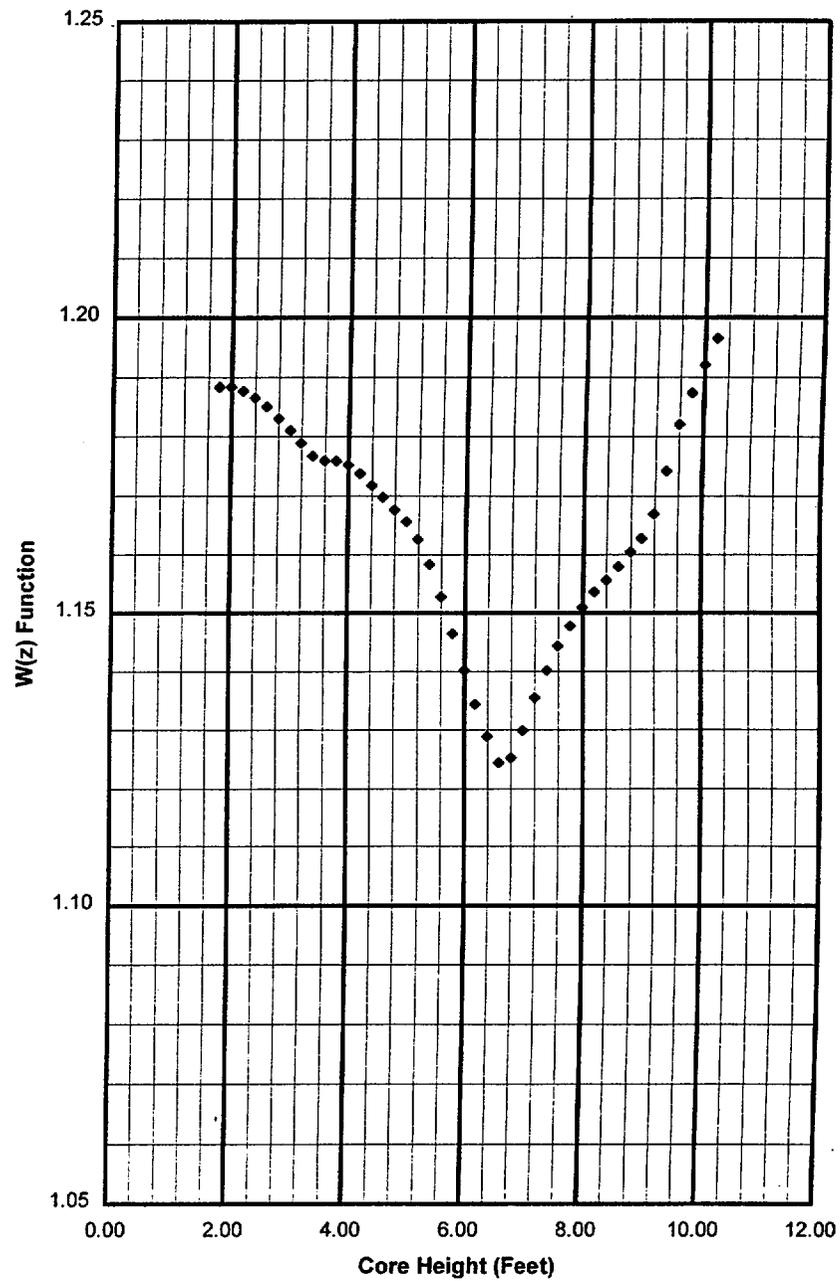
CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 11

Height (Feet)	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	1.1883
2.00	1.1882
2.20	1.1876
2.40	1.1865
2.60	1.1850
2.80	1.1830
3.00	1.1810
3.20	1.1788
3.40	1.1767
3.60	1.1759
3.80	1.1758
4.00	1.1751
4.20	1.1736
4.40	1.1717
4.60	1.1697
4.80	1.1676
5.00	1.1655
5.20	1.1626
5.40	1.1583
5.60	1.1527
5.80	1.1464
6.00	1.1402
6.20	1.1343
6.40	1.1289
6.60	1.1244
6.80	1.1252
7.00	1.1299
7.20	1.1355
7.40	1.1401
7.60	1.1442
7.80	1.1478
8.00	1.1509
8.20	1.1535
8.40	1.1556
8.60	1.1579
8.80	1.1603
9.00	1.1627
9.20	1.1669
9.40	1.1742
9.60	1.1819
9.80	1.1873
10.00	1.1919
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 11

Figure 2.6.2.c

Summary of W(z) Function at 10000 MWD/MTU
(Top and Bottom 15% Excluded per WCAP-10216)



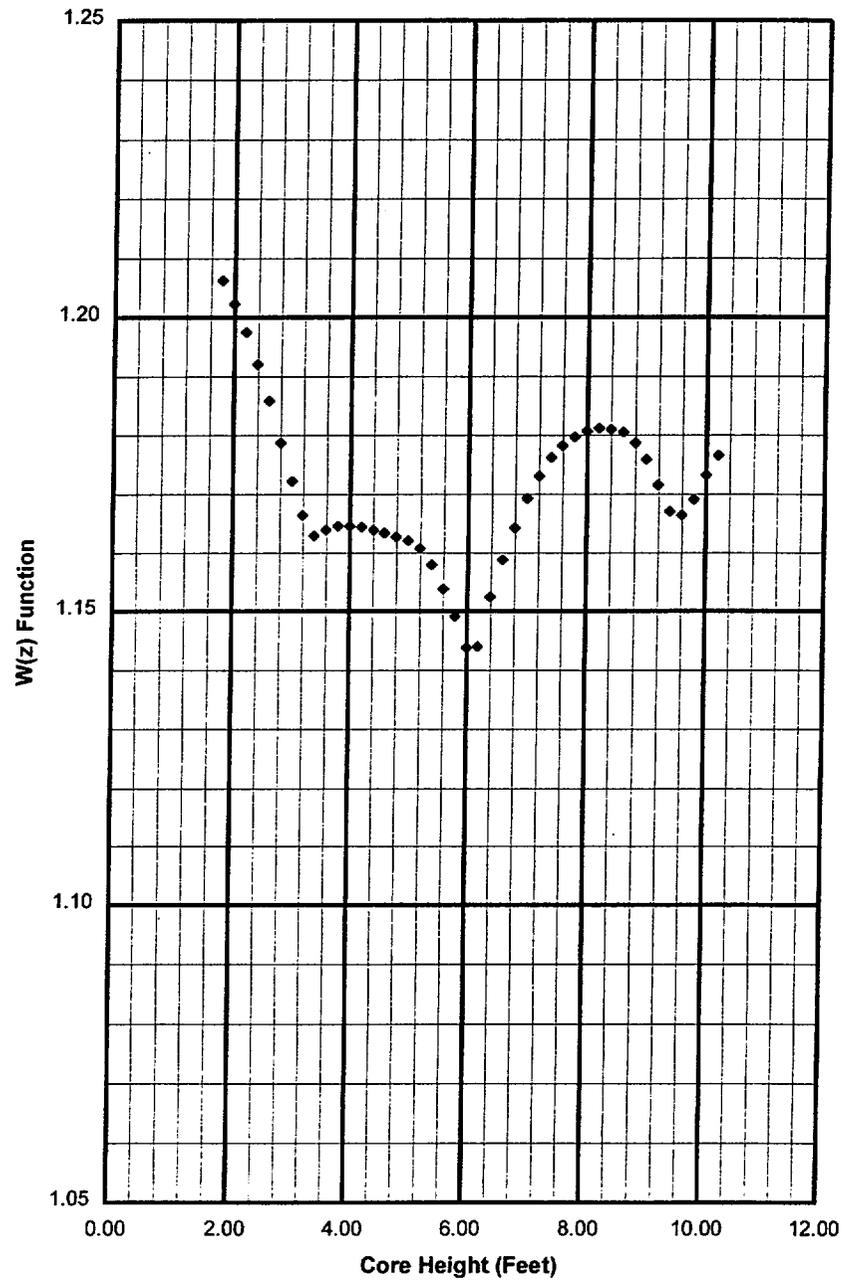
CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 11

Height (Feet)	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	1.2062
2.00	1.2022
2.20	1.1974
2.40	1.1919
2.60	1.1857
2.80	1.1787
3.00	1.1722
3.20	1.1663
3.40	1.1629
3.60	1.1638
3.80	1.1645
4.00	1.1646
4.20	1.1644
4.40	1.1639
4.60	1.1633
4.80	1.1627
5.00	1.1621
5.20	1.1607
5.40	1.1579
5.60	1.1538
5.80	1.1491
6.00	1.1437
6.20	1.1440
6.40	1.1524
6.60	1.1587
6.80	1.1642
7.00	1.1691
7.20	1.1730
7.40	1.1761
7.60	1.1782
7.80	1.1796
8.00	1.1806
8.20	1.1811
8.40	1.1810
8.60	1.1805
8.80	1.1787
9.00	1.1758
9.20	1.1715
9.40	1.1671
9.60	1.1664
9.80	1.1690
10.00	1.1731
10.20	1.1765
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 11

Figure 2.6.2.d

Summary of W(z) Function at 18000 MWD/MTU
(Top and Bottom 15% Excluded per WCAP-10216)



CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 11

Table 2.6.2	
Fq Margin Decreases in Excess of 2% per 31 EFPD	
Cycle Burnup (MWD/MTU)	Max % Decrease in Fq Margin
150	4.15
314	4.31
479	4.40
643	4.40
808	4.27
972	3.99
1137	3.59
1301	3.09
1465	2.54
≥1630	2.00

Note: All cycle burnups outside the range of the table shall use a 2% decrease in Fq margin for compliance with the 3.2.1.2 Surveillance Requirements.

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 11

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

2.7.1
$$F_{\Delta H}^N \leq F_{\Delta H}^{RTP} [1.0 + PF_{\Delta H}(1.0 - P)]$$

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

$$F_{\Delta H}^{RTP} = 1.70$$

$$PF_{\Delta H} = 0.3$$

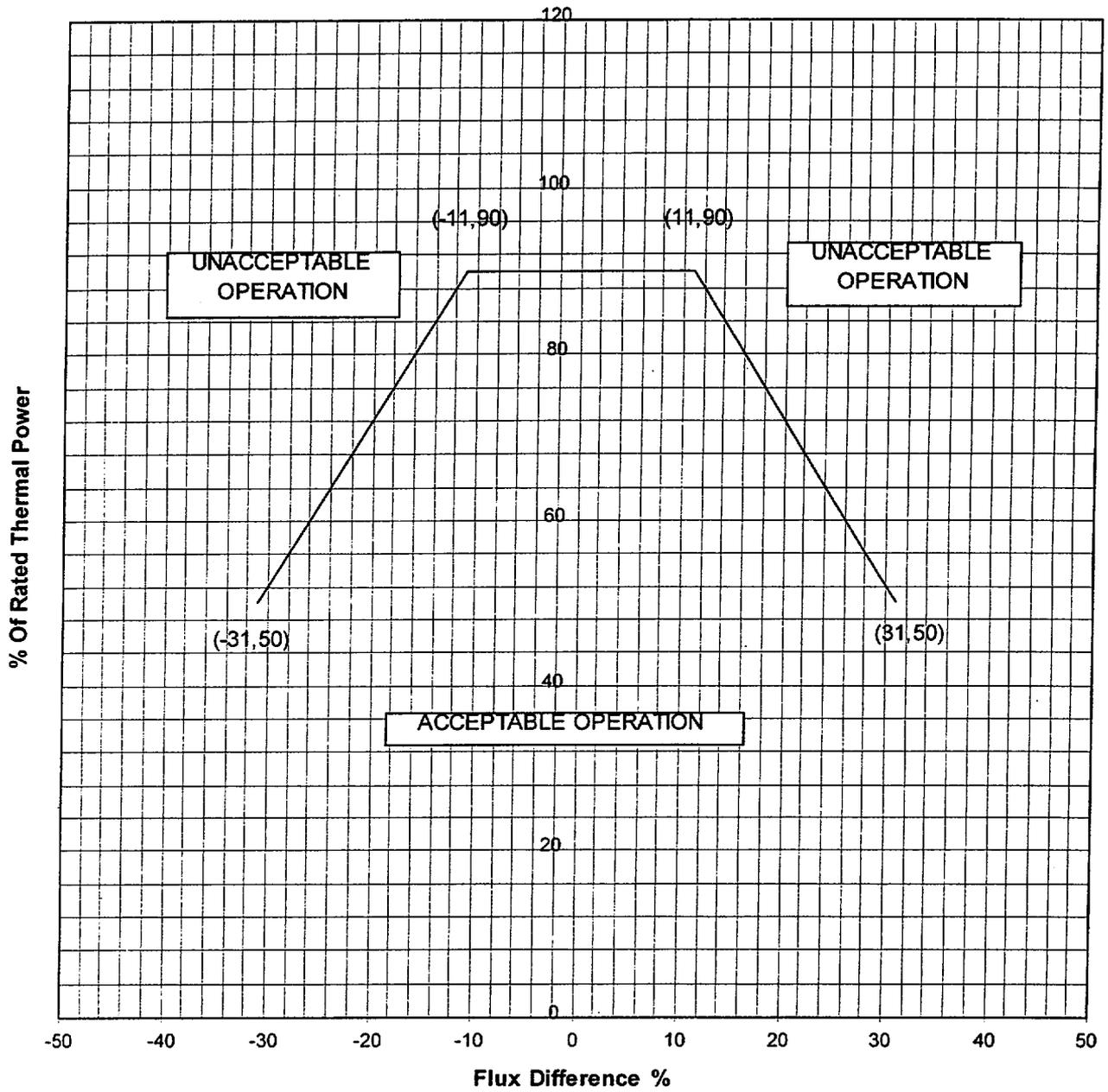
2.8 Axial Flux Difference (AFD) (LCO 3.2.3)

2.8.1 The AXIAL FLUX DIFFERENCE (AFD) target band is +5, -10% of the target flux difference.

2.8.2 The AFD Acceptable Operation Limits are provided in Figure 2.8.1.

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 11

FIGURE 2.8.1: Axial Flux Difference Limits As A Function of Rated Thermal Power



CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 11

- 2.9 Reactor Trip System Overtemperature ΔT Setpoint Parameter Values (LCO 3.3.1)
- 2.9.1 The Overtemperature ΔT reactor trip setpoint K_1 shall be equal to 1.325.
 - 2.9.2 The Overtemperature ΔT reactor trip setpoint T_{avg} coefficient K_2 shall be equal to 0.0297 / °F.
 - 2.9.3 The Overtemperature ΔT reactor trip setpoint pressure coefficient K_3 shall be equal to 0.00181 / psig.
 - 2.9.4 The nominal T_{avg} at RTP (indicated) T' shall be less than or equal to 588.4 °F.
 - 2.9.5 The nominal RCS operating pressure (indicated) P' shall be equal to 2235 psig.
 - 2.9.6 The measured reactor vessel ΔT lead/lag time constant τ_1 shall be equal to 8 sec.
 - 2.9.7 The measured reactor vessel ΔT lead/lag time constant τ_2 shall be equal to 3 sec.
 - 2.9.8 The measured reactor vessel ΔT lag time constant τ_3 shall be less than or equal to 2 sec.
 - 2.9.9 The measured reactor vessel average temperature lead/lag time constant τ_4 shall be equal to 33 sec.
 - 2.9.10 The measured reactor vessel average temperature lead/lag time constant τ_5 shall be equal to 4 sec.
 - 2.9.11 The measured reactor vessel average temperature lag time constant τ_6 shall be less than or equal to 2 sec.
 - 2.9.12 The $f_1(\Delta I)$ "positive" breakpoint shall be +10% ΔI .
 - 2.9.13 The $f_1(\Delta I)$ "negative" breakpoint shall be - 24% ΔI .
 - 2.9.14 The $f_1(\Delta I)$ "positive" slope shall be +4.11% / % ΔI .
 - 2.9.15 The $f_1(\Delta I)$ "negative" slope shall be - 3.35% / % ΔI .

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 11

- 2.10 Reactor Trip System Overpower ΔT Setpoint Parameter Values (LCO 3.3.1)
- 2.10.1 The Overpower ΔT reactor trip setpoint K_4 shall be equal to 1.072.
 - 2.10.2 The Overpower ΔT reactor trip setpoint T_{avg} rate/lag coefficient K_5 shall be equal to 0.02 / °F for increasing T_{avg} .
 - 2.10.3 The Overpower ΔT reactor trip setpoint T_{avg} rate/lag coefficient K_5 shall be equal to 0 / °F for decreasing T_{avg} .
 - 2.10.4 The Overpower ΔT reactor trip setpoint T_{avg} heatup coefficient K_6 shall be equal to 0.00245 / °F when $T > T''$.
 - 2.10.5 The Overpower ΔT reactor trip setpoint T_{avg} heatup coefficient K_6 shall be equal to 0 / °F when $T \leq T''$.
 - 2.10.6 The nominal T_{avg} at RTP (indicated) T'' shall be less than or equal to 588.4 °F.
 - 2.10.7 The measured reactor vessel ΔT lead/lag time constant τ_1 shall be equal to 8 sec.
 - 2.10.8 The measured reactor vessel ΔT lead/lag time constant τ_2 shall be equal to 3 sec.
 - 2.10.9 The measured reactor vessel ΔT lag time constant τ_3 shall be less than or equal to 2 sec.
 - 2.10.10 The measured reactor vessel average temperature lag time constant τ_6 shall be less than or equal to 2 sec.
 - 2.10.11 The measured reactor vessel average temperature rate/lag time constant τ_7 shall be equal to 10 sec.
 - 2.10.12 The $f_2(\Delta I)$ "positive" breakpoint shall be 0 for all ΔI .
 - 2.10.13 The $f_2(\Delta I)$ "negative" breakpoint shall be 0 for all ΔI .
 - 2.10.14 The $f_2(\Delta I)$ "positive" slope shall be 0 for all ΔI .
 - 2.10.15 The $f_2(\Delta I)$ "negative" slope shall be 0 for all ΔI .

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 11

2.11 Reactor Coolant System (RCS) DNB Parameter Limits (LCO 3.4.1)

- 2.11.1 The pressurizer pressure shall be greater than or equal to 2219 psig.
- 2.11.2 The RCS average temperature (T_{avg}) shall be less than or equal to 591.2 °F.
- 2.11.3 The RCS total flow rate shall be greater than or equal to 371,400 gpm.

2.12 Boron Concentration

- 2.12.1 The refueling boron concentration shall be greater than or equal to 2000 ppm (LCO 3.9.1).
- 2.12.2 The Reactor Coolant System boron concentration shall be greater than or equal to 1894 ppm prior to initial criticality of Cycle 11, or greater than or equal to 2075 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.k)

Attachment

**Core Operating Limits Report, Byron Station, Unit 2, Cycle 9
(BY2C9)**

NUCLEAR FUEL MANAGEMENT DEPARTMENT
NUCLEAR DESIGN INFORMATION TRANSMITTAL

<input checked="" type="checkbox"/> SAFETY RELATED <input type="checkbox"/> NON-SAFETY RELATED <input type="checkbox"/> REGULATORY RELATED	Originating Organization <input checked="" type="checkbox"/> Nuclear Fuel Management <input type="checkbox"/> Other (specify) _____	NDIT No. <u>NFM9900202</u> Seq. No. <u>2</u> Page 1 of 18
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Station Byron Unit 2 Cycle 9 Generic _____
 To: D. B. Wozniak, Byron Site Engineering Manager

Subject Byron Unit 2 Cycle 9 Core Operating Limits Report in ITS Format and W(z) Function

E. Wurz	<i>Erich Wurz</i>	<u>9/26/00</u>
Preparer	Preparer's Signature	Date
R. Lee	<i>Robert Lee</i>	<u>9/26/00</u>
Reviewer	Reviewer's Signature	Date
D. Redden	<i>E. Young</i>	<u>9/26/00</u>
NFM Supervisor	NFM Supervisor's Signature	Date

Status of Information: Verified
 Unverified
 Engineering Judgement

Method and Schedule of Verification for Unverified NDITs: _____

Description of Information: Attached is the Byron Unit 2 Cycle 9 Core Operating Limits Report (COLR) in the ITS format and W(z) function.

Purpose of Information: **Sequence 2 of this NDIT supersedes Sequence 1. Sequence 2 revises Page 9 to include the correct Figure 2.6.1.a for the K(z) curve with assembly average burnup \leq 4000 MWD/MTU.**

Source of Information:

- 1) PND Calculation Number PC-01, Rev. 0, "Generation of W(z) Curve," Project Byron Unit 2 Cycle 9, dated September 24, 1999.
- 2) PND Calculation Number SP-18, "Unfavorable Exposure Time (UET) Analysis," Project Byron Unit 2 Cycle 9, dated July 23, 1999.
- 3) NDIT NFM9900158, Seq. 0, "Minimum Required Boron Concentration for Control Rod Drop Testing - BY2C9," dated August 13, 1999.
- 4) PSS Calculation Number PSSCN:99-015, "Byron Unit 2 Cycle 9 Bank Insertion Limits with 116 Step Separation," dated October 15, 1999.
- 5) CAC-99-346, Rev. 3, "Safety Assessment Summary for Byron Unit 2 Cycle 9," dated October 11, 1999.
- 6) Byron Technical Specification Amendment 113, dated May 15, 2000.
- 7) PND Calculation Number PND CN:00-003, "Evaluation of SPIL Using 224 Steps Rod Withdrawn as Definition of ARO," dated May 8, 2000.

Supplemental Distribution:

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E. Young (DG)	H. S. Kim (DG)	Byron Central Files
DG Central Files	M. G. Kim (DG)	

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 9

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Byron Station Unit 2 Cycle 9 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 ($F_{\Delta H}^N$)
- LCO 3.2.3 Axial Flux Difference (AFD)
- 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.h Shutdown Margin (SDM) – MODE 1 and MODE 2 with $k_{eff} \geq 1.0$
- 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)

2.0 OPERATING LIMITS

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 9

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.

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)

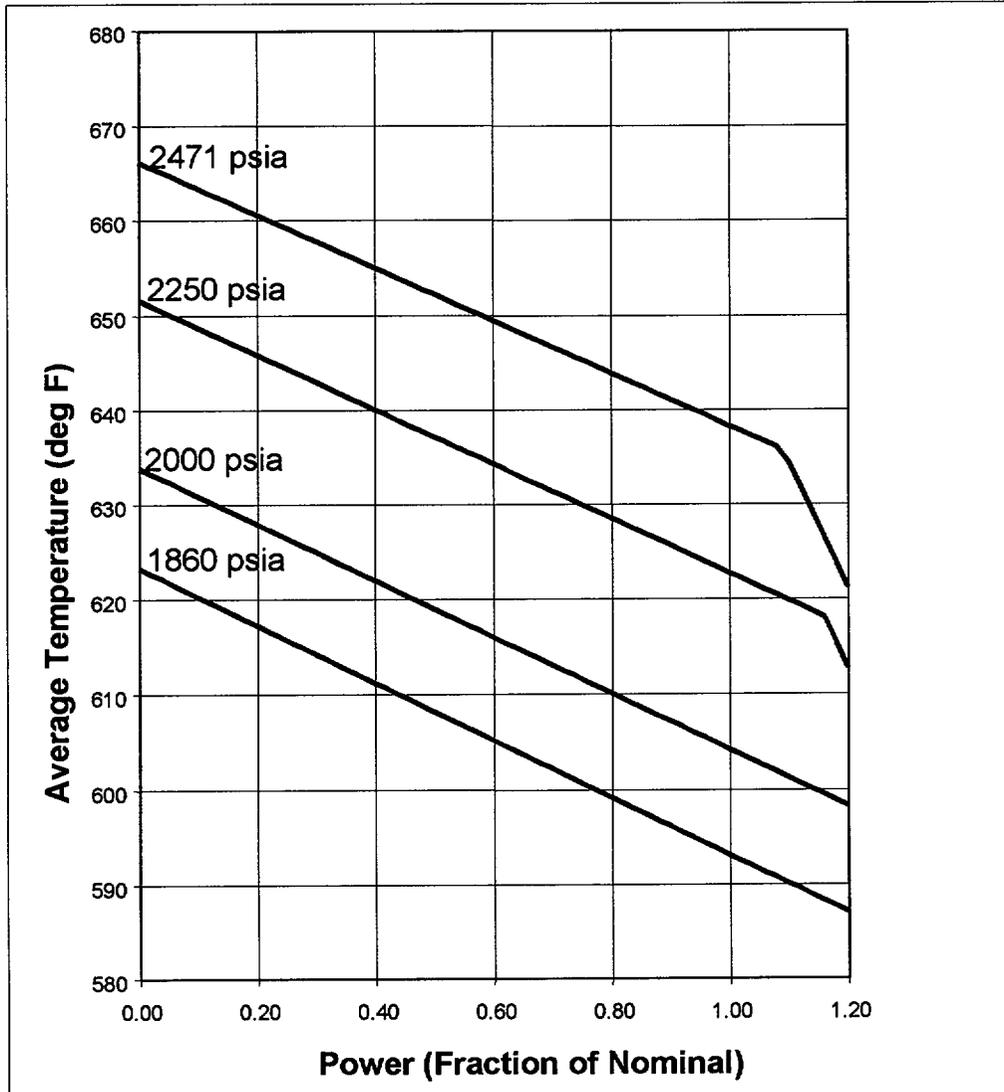
The Moderator Temperature Coefficient (MTC) limits are:

- 2.3.1 The BOL/ARO/HZP-MTC upper limit shall be $+3.3 \times 10^{-5} \Delta k/k/^\circ F$.
- 2.3.2 The EOL/ARO/HFP-MTC lower limit shall be $-4.1 \times 10^{-4} \Delta k/k/^\circ F$.
- 2.3.3 The EOL/ARO/HFP-MTC Surveillance limit at 300 ppm shall be less negative than or equal to $-3.2 \times 10^{-4} \Delta k/k/^\circ F$.

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

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 9

Figure 2.1.1: Reactor Core Limits



CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 9

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.

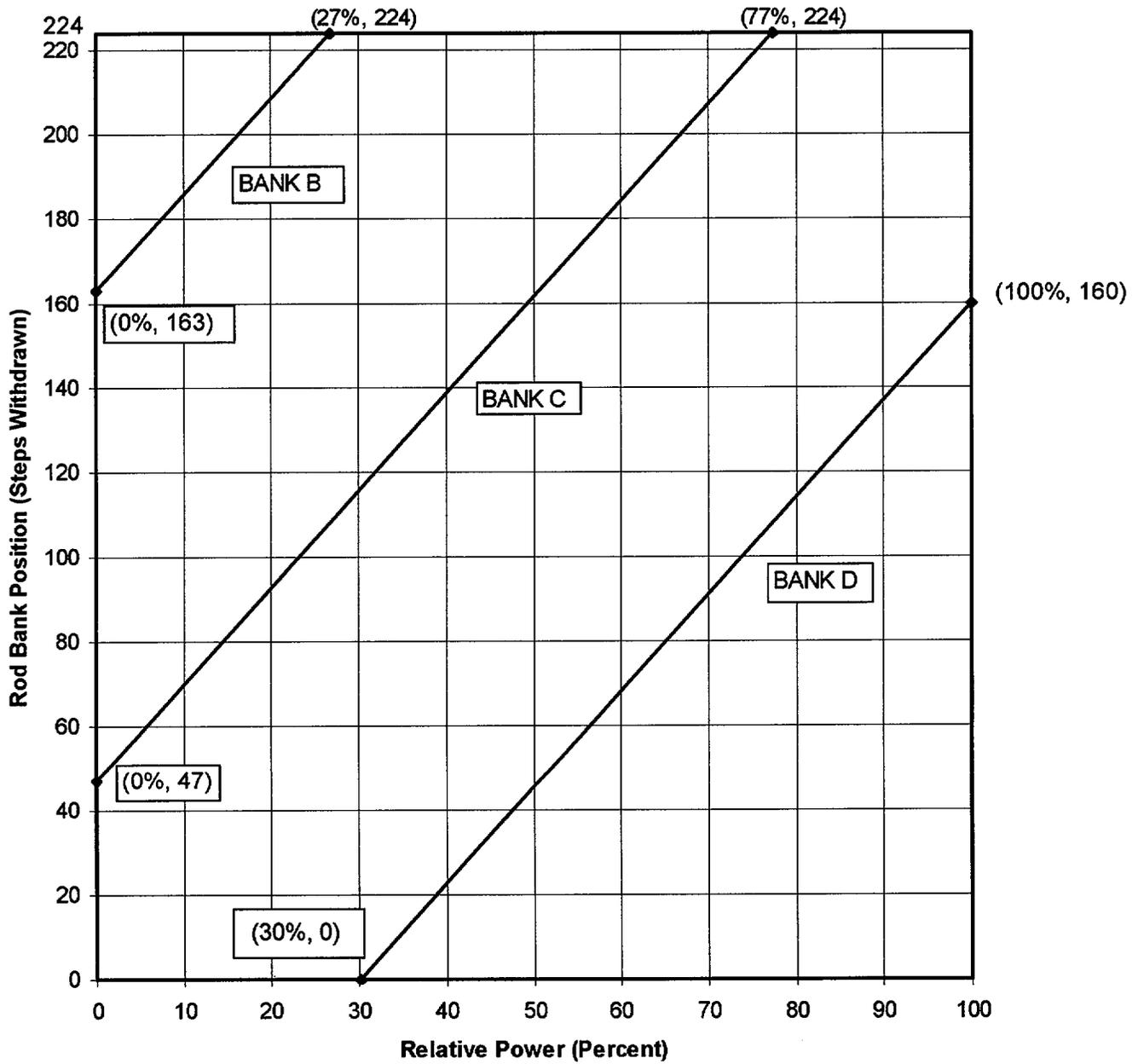
2.5.2 Each control bank shall be considered fully withdrawn from the core at greater than or equal to 224 steps.

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 115 step overlap limit.

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 9

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



CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 9

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

2.6.1

$$F_q(Z) \leq \frac{F_q^{RTP}}{0.5} \times K(Z) \text{ for } P \leq 0.5$$

$$F_q(Z) \leq \frac{F_q^{RTP}}{P} \times K(Z) \text{ for } P > 0.5$$

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 \leq 4000 MWD/MTU is provided in Figure 2.6.1.a.

2.6.2 $W(Z)$ is provided in Figures 2.6.2.a through 2.6.2.c.

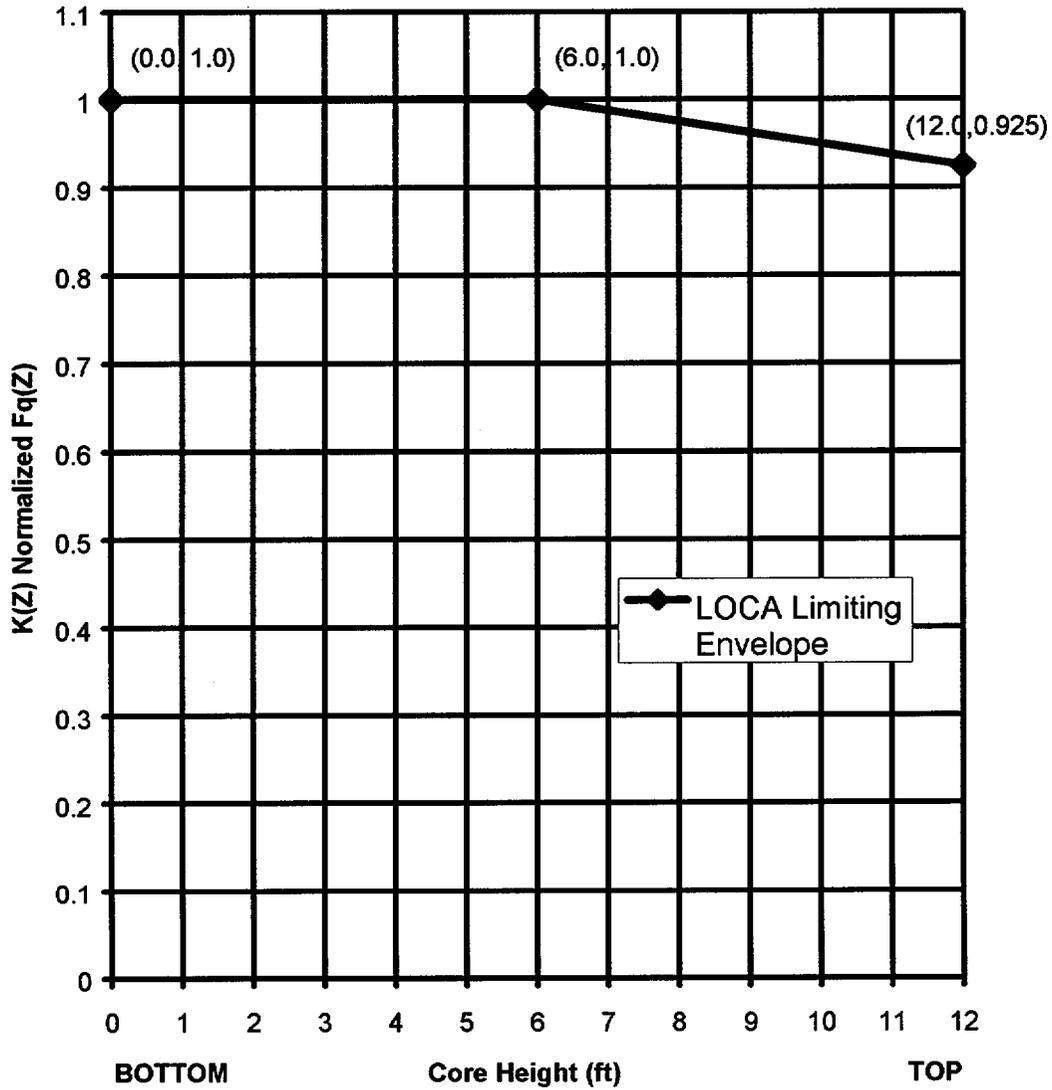
The normal operation $W(Z)$ values have been determined at burnups of 150, 8000 and 18800 MWD/MTU.

Table 2.6.2 shows the $F_{q(z)}^C$ penalty factors that are greater than 2% per 31 Effective Full Power Days. These values shall be used to increase the $F_{q(z)}^W$ 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.

$$\text{Multiplication Factor} = 1.02$$

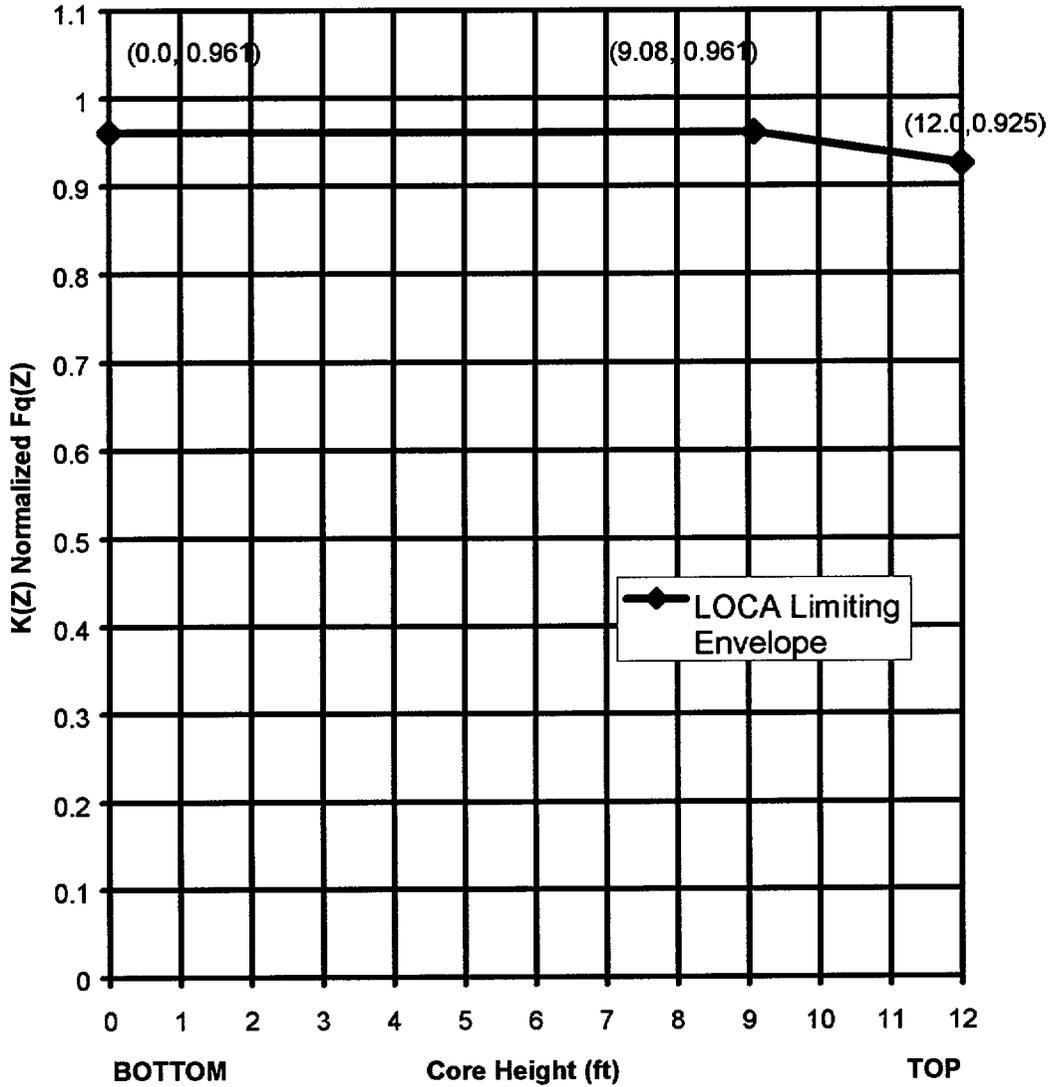
CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 9

Figure 2.6.1: K(Z) - Normalized Fq(Z) as a Function of Core Height (Assembly Average > 4000 MWD/MTU)



CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 9

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



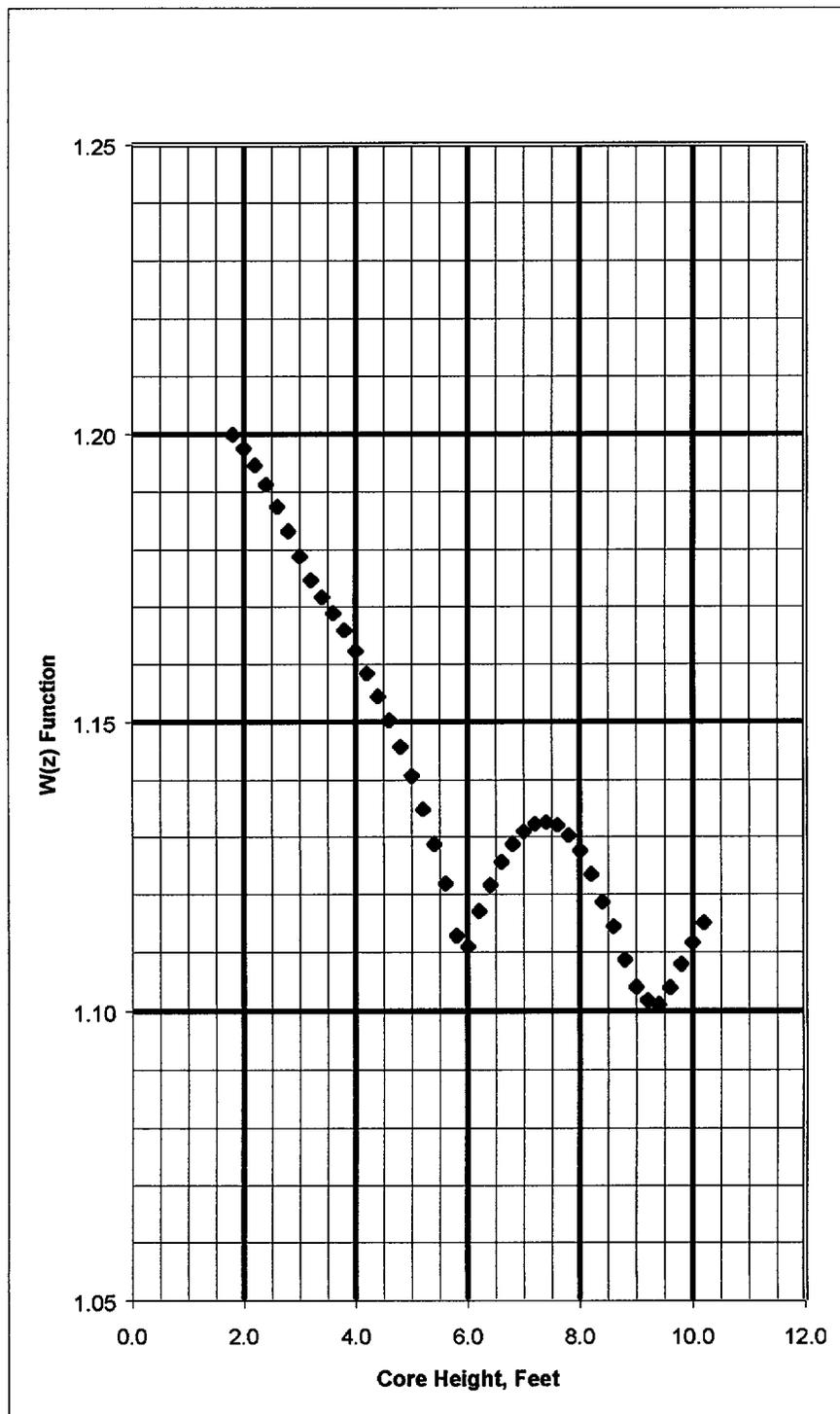
CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 9

Height Feet	Max W(z)
0.0	1.0000
0.2	1.0000
0.4	1.0000
0.6	1.0000
0.8	1.0000
1.0	1.0000
1.2	1.0000
1.4	1.0000
1.6	1.0000
1.8	1.1999
2.0	1.1975
2.2	1.1946
2.4	1.1912
2.6	1.1874
2.8	1.1832
3.0	1.1788
3.2	1.1747
3.4	1.1717
3.6	1.1689
3.8	1.1659
4.0	1.1623
4.2	1.1584
4.4	1.1544
4.6	1.1503
4.8	1.1457
5.0	1.1407
5.2	1.1349
5.4	1.1287
5.6	1.1219
5.8	1.1129
6.0	1.1110
6.2	1.1171
6.4	1.1216
6.6	1.1256
6.8	1.1287
7.0	1.1309
7.2	1.1323
7.4	1.1326
7.6	1.1320
7.8	1.1302
8.0	1.1276
8.2	1.1235
8.4	1.1187
8.6	1.1145
8.8	1.1087
9.0	1.1041
9.2	1.1018
9.4	1.1011
9.6	1.1040
9.8	1.1080
10.0	1.1117
10.2	1.1151
10.4	1.0000
10.6	1.0000
10.8	1.0000
11.0	1.0000
11.2	1.0000
11.4	1.0000
11.6	1.0000
11.8	1.0000
12.0	1.0000

Byron Unit 2 Cycle 9

Figure 2.6.2.a

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



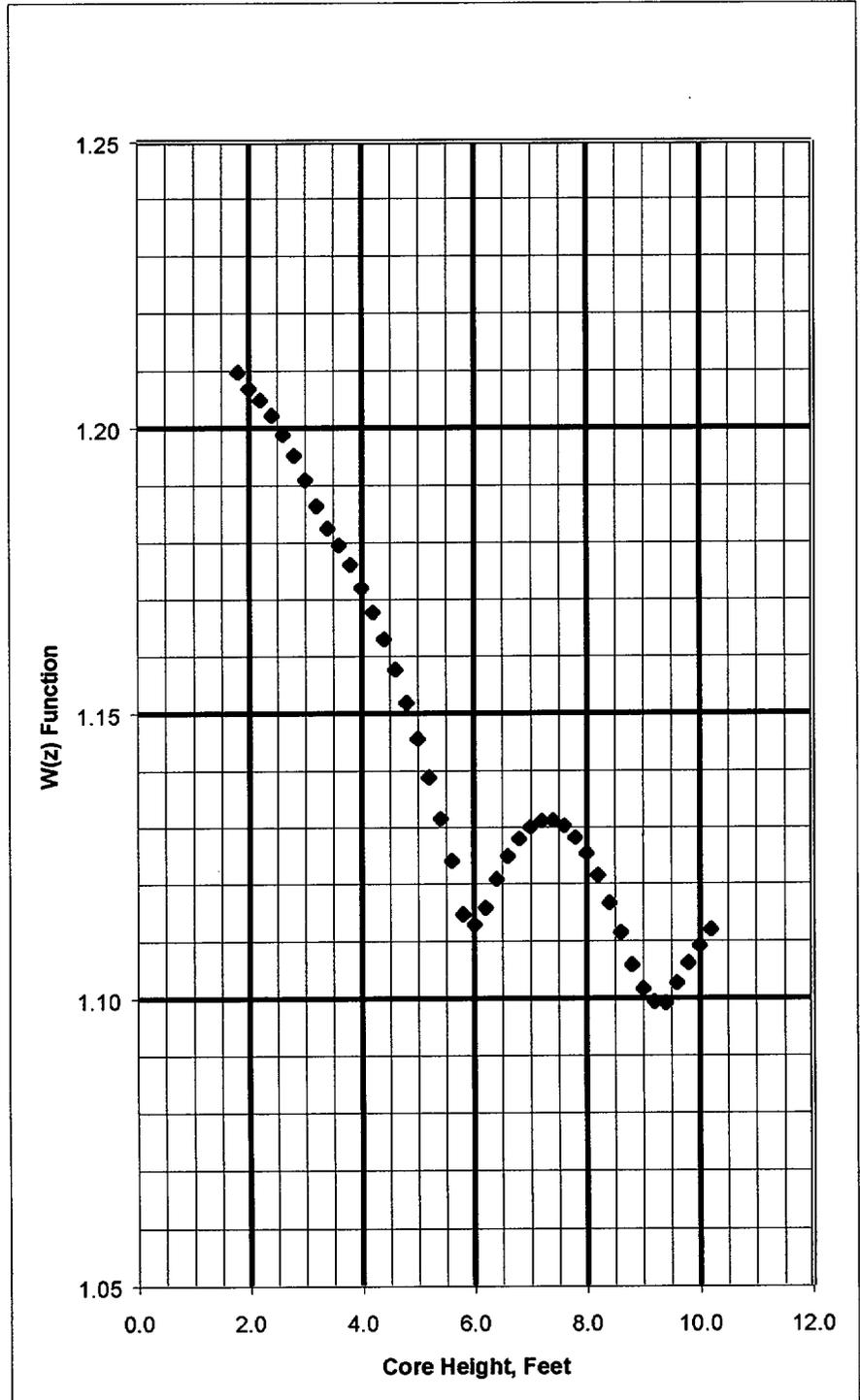
CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 9

Height Feet	Max W(z)
0.0	1.0000
0.2	1.0000
0.4	1.0000
0.6	1.0000
0.8	1.0000
1.0	1.0000
1.2	1.0000
1.4	1.0000
1.6	1.0000
1.8	1.2097
2.0	1.2069
2.2	1.2049
2.4	1.2022
2.6	1.1989
2.8	1.1952
3.0	1.1909
3.2	1.1864
3.4	1.1825
3.6	1.1795
3.8	1.1761
4.0	1.1720
4.2	1.1677
4.4	1.1630
4.6	1.1577
4.8	1.1519
5.0	1.1456
5.2	1.1388
5.4	1.1316
5.6	1.1240
5.8	1.1147
6.0	1.1129
6.2	1.1158
6.4	1.1208
6.6	1.1248
6.8	1.1279
7.0	1.1300
7.2	1.1311
7.4	1.1312
7.6	1.1303
7.8	1.1281
8.0	1.1253
8.2	1.1215
8.4	1.1166
8.6	1.1115
8.8	1.1059
9.0	1.1017
9.2	1.0994
9.4	1.0992
9.6	1.1027
9.8	1.1062
10.0	1.1092
10.2	1.1120
10.4	1.0000
10.6	1.0000
10.8	1.0000
11.0	1.0000
11.2	1.0000
11.4	1.0000
11.6	1.0000
11.8	1.0000
12.0	1.0000

Byron Unit 2 Cycle 9

Figure 2.6.2.b

Summary of W(z) Function at 8000 MWD/MTU
(Top and Bottom 15% Excluded per WCAP-10216)



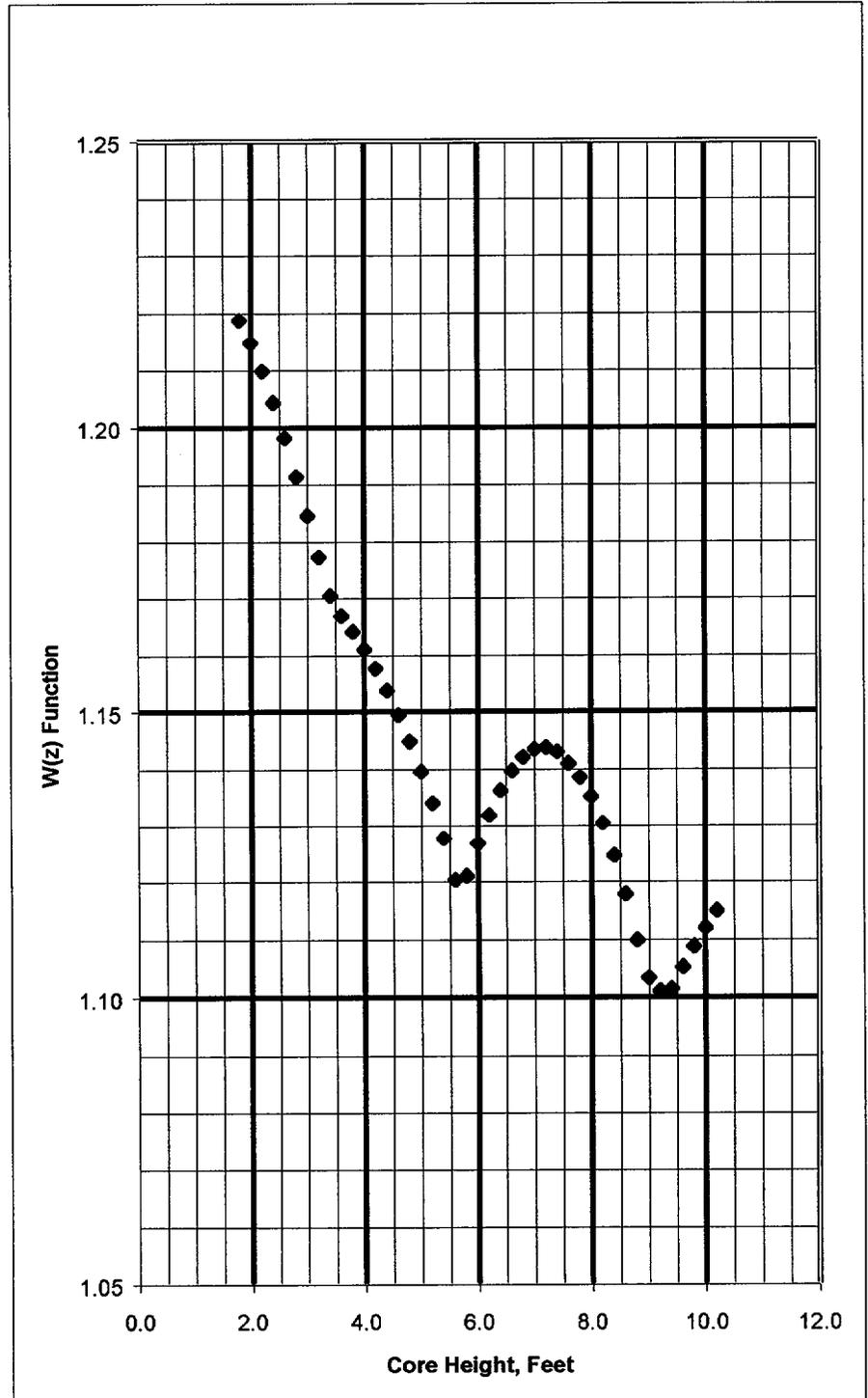
CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 9

Height Feet	Max W(z)
0.0	1.0000
0.2	1.0000
0.4	1.0000
0.6	1.0000
0.8	1.0000
1.0	1.0000
1.2	1.0000
1.4	1.0000
1.6	1.0000
1.8	1.2188
2.0	1.2148
2.2	1.2099
2.4	1.2044
2.6	1.1982
2.8	1.1914
3.0	1.1846
3.2	1.1773
3.4	1.1705
3.6	1.1670
3.8	1.1642
4.0	1.1611
4.2	1.1577
4.4	1.1538
4.6	1.1495
4.8	1.1449
5.0	1.1396
5.2	1.1341
5.4	1.1276
5.6	1.1203
5.8	1.1210
6.0	1.1267
6.2	1.1319
6.4	1.1363
6.6	1.1397
6.8	1.1421
7.0	1.1435
7.2	1.1438
7.4	1.1430
7.6	1.1410
7.8	1.1386
8.0	1.1352
8.2	1.1304
8.4	1.1245
8.6	1.1178
8.8	1.1099
9.0	1.1034
9.2	1.1011
9.4	1.1015
9.6	1.1053
9.8	1.1088
10.0	1.1120
10.2	1.1149
10.4	1.0000
10.6	1.0000
10.8	1.0000
11.0	1.0000
11.2	1.0000
11.4	1.0000
11.6	1.0000
11.8	1.0000
12.0	1.0000

Byron Unit 2 Cycle 9

Figure 2.6.2.c

Summary of W(z) Function at 18800 MWD/MTU
(Top and Bottom 15% Excluded per WCAP-10216)



CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 9

Table 2.6.2	
Fq Margin Decreases in Excess of 2% per 31 EFPD	
Cycle Burnup (MWD/MTU)	Max % Decrease in Fq Margin
150	3.54
275	3.50
400	3.48
525	3.44
650	3.38
775	3.29
900	3.15
1025	2.96
1150	2.69
1275	2.37
1400	2.01
1525	2.00

Note: All cycle burnups outside the range of the table shall use a 2% decrease in Fq margin for compliance with the 3.2.1.2 Surveillance Requirements.

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 9

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

$$2.7.1 \quad F_{\Delta H}^N \leq F_{\Delta H}^{RTP} [1.0 + PF_{\Delta H}(1.0 - P)]$$

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

$$F_{\Delta H}^{RTP} = 1.70$$

$$PF_{\Delta H} = 0.3$$

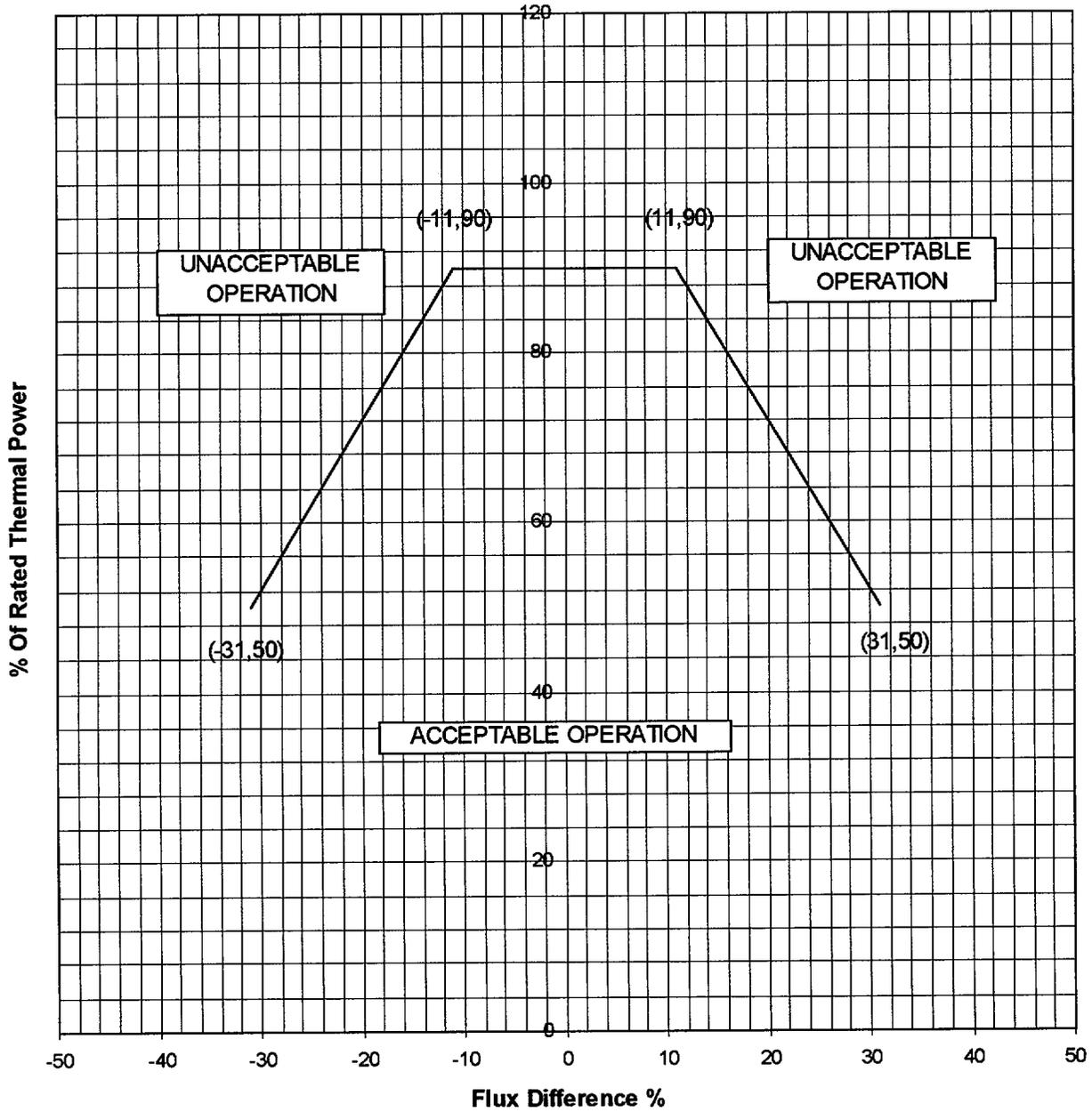
2.8 Axial Flux Difference (AFD) (LCO 3.2.3)

2.8.1 The AXIAL FLUX DIFFERENCE (AFD) target band is +3, -12% of the target flux difference.

2.8.2 The AFD Acceptable Operation Limits are provided in Figure 2.8.1.

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 9

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 9

2.9 Reactor Trip System Overtemperature ΔT Setpoint Parameter Values (LCO 3.3.1)

- 2.9.1 The Overtemperature ΔT reactor trip setpoint K_1 shall be equal to 1.325.
- 2.9.2 The Overtemperature ΔT reactor trip setpoint T_{avg} coefficient K_2 shall be equal to 0.0297 / °F.
- 2.9.3 The Overtemperature ΔT reactor trip setpoint pressure coefficient K_3 shall be equal to 0.00181 / psig.
- 2.9.4 The nominal T_{avg} at RTP (indicated) T' shall be less than or equal to 588.4 °F.
- 2.9.5 The nominal RCS operating pressure (indicated) P' shall be equal to 2235 psig.
- 2.9.6 The measured reactor vessel ΔT lead/lag time constant τ_1 shall be equal to 8 sec.
- 2.9.7 The measured reactor vessel ΔT lead/lag time constant τ_2 shall be equal to 3 sec.
- 2.9.8 The measured reactor vessel ΔT lag time constant τ_3 shall be less than or equal to 2 sec.
- 2.9.9 The measured reactor vessel average temperature lead/lag time constant τ_4 shall be equal to 33 sec.
- 2.9.10 The measured reactor vessel average temperature lead/lag time constant τ_5 shall be equal to 4 sec.
- 2.9.11 The measured reactor vessel average temperature lag time constant τ_6 shall be less than or equal to 2 sec.
- 2.9.12 The $f_1(\Delta I)$ "positive" breakpoint shall be +10% ΔI .
- 2.9.13 The $f_1(\Delta I)$ "negative" breakpoint shall be - 24% ΔI .
- 2.9.14 The $f_1(\Delta I)$ "positive" slope shall be +4.11% / % ΔI .
- 2.9.15 The $f_1(\Delta I)$ "negative" slope shall be - 3.35% / % ΔI .

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 9

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

- 2.10.1 The Overpower ΔT reactor trip setpoint K_4 shall be equal to 1.072.
- 2.10.2 The Overpower ΔT reactor trip setpoint T_{avg} rate/lag coefficient K_5 shall be equal to 0.02 / °F for increasing T_{avg} .
- 2.10.3 The Overpower ΔT reactor trip setpoint T_{avg} rate/lag coefficient K_5 shall be equal to 0 / °F for decreasing T_{avg} .
- 2.10.4 The Overpower ΔT reactor trip setpoint T_{avg} heatup coefficient K_6 shall be equal to 0.00245 / °F when $T > T''$.
- 2.10.5 The Overpower ΔT reactor trip setpoint T_{avg} heatup coefficient K_6 shall be equal to 0 / °F when $T \leq T''$.
- 2.10.6 The nominal T_{avg} at RTP (indicated) T'' shall be less than or equal to 588.4 °F.
- 2.10.7 The measured reactor vessel ΔT lead/lag time constant τ_1 shall be equal to 8 sec.
- 2.10.8 The measured reactor vessel ΔT lead/lag time constant τ_2 shall be equal to 3 sec.
- 2.10.9 The measured reactor vessel ΔT lag time constant τ_3 shall be less than or equal to 2 sec.
- 2.10.10 The measured reactor vessel average temperature lag time constant τ_6 shall be less than or equal to 2 sec.
- 2.10.11 The measured reactor vessel average temperature rate/lag time constant τ_7 shall be equal to 10 sec.
- 2.10.12 The $f_2(\Delta I)$ "positive" breakpoint shall be 0 for all ΔI .
- 2.10.13 The $f_2(\Delta I)$ "negative" breakpoint shall be 0 for all ΔI .
- 2.10.14 The $f_2(\Delta I)$ "positive" slope shall be 0 for all ΔI .
- 2.10.15 The $f_2(\Delta I)$ "negative" slope shall be 0 for all ΔI .

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 9

2.11 Reactor Coolant System (RCS) DNB Parameter Limits (LCO 3.4.1)

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

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

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

2.12 Boron Concentration

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

2.12.2 The Reactor Coolant System boron concentration shall be greater than or equal to 1919 ppm 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.k)