



RS-00-43

July 18, 2000

United States Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555-0001

Braidwood Station, Units 1 and 2
Facility Operating License Nos. NPF-72 and NPF-77
NRC Docket Nos. STN 50-456 and STN 50-457

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: Braidwood Station, Unit 1 Cycle 9 and Unit 2 Cycle 8, and Byron Station,
Unit 1 Cycle 10 and Unit 2 Cycle 9, Core Operating Limits Reports

Reference: Letter from G. F. Dick (U.S. NRC) to O. D. Kingsley (Commonwealth Edison
Company), "Byron and Braidwood - Issuance of Amendments Regarding
Relocation of Reactor Coolant System Limits," dated May 15, 2000.

In accordance with Technical Specification 5.6.5, "Core Operating Limits Report (COLR)," the COLR shall be provided to the NRC upon issuance for each reload cycle, including midcycle revisions or supplements. We are providing the revised COLRs for Braidwood Station, Units 1 and 2, and Byron Station, Units 1 and 2, respectively, in the attachments to this letter. The COLRs were revised to support the implementation of the license amendments issued in the Reference letter.

Should you have any questions relative to this letter, please contact Ms. Kelly M. Root at (630) 663-7292.

Respectfully,

A handwritten signature in cursive script that reads "K. A. Ringer for".

R. M. Krich
Vice President – Regulatory Services

A001

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Attachments: Attachment A-1, Braidwood Station, Unit 1 Cycle 9
Attachment A-2, Braidwood Station, Unit 2 Cycle 8
Attachment A-3, Byron Station, Unit 1 Cycle 10
Attachment A-4, Byron Station, Unit 2 Cycle 9

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

Attachment A-1

Braidwood Station, Unit 1 Cycle 9

NUCLEAR FUEL MANAGEMENT DEPARTMENT
NUCLEAR DESIGN INFORMATION TRANSMITTAL

☒ SAFETY RELATED
☐ NON-SAFETY RELATED
☐ REGULATORY RELATED

Originating Organization
☒ Nuclear Fuel Management
☐ Other (specify) _____

NDIT No. NFM0000014
Seq. No. 1
Page 1 of 18

Station Braidwood Unit 1 Cycle 9 Generic _____

To: Tom Luke, Braidwood Site Engineering Manager

Subject Braidwood Unit 1 Cycle 9 Core Operating Limits Report

R. Lee

Preparer

Robert Lee
Preparer's Signature

6/2/00
Date

E. Wurz

Reviewer

Erich Wurz
Reviewer's Signature

6/2/00
Date

D. Redden

NFM Supervisor

[Signature]
NFM Supervisor's Signature

6/2/00
Date

Status of Information:

☒ Verified
☐ Unverified
☐ Engineering Judgement

Method and Schedule of Verification for Unverified NDITs:

Description of Information: Attached is the Braidwood Unit 1 Cycle 9 Core Operating Limits Report (COLR) in the ITS format and W(z) function.

Purpose of Information: **The Sequence 1 of this NDIT supersedes Sequence 0.** This sequence incorporates the Expanded COLR format and other administrative changes. Braidwood Station is requested to perform a plant review of this document. Upon completion of the plant review, Braidwood Station is to transmit the COLR portion to the Nuclear Regulatory Commission pursuant to Technical Specification 5.6.5. Please provide NFM (Rob Lee) with a copy of Braidwood Station's completed plant review and COLR submittal to the NRC.

Please note that Regulatory Assurance/Regulatory Services will be responsible for the distribution of TRM changes.

Source of Information: 1) PND Calculation Number SP-03, "BRIC9 SPIL - CAOC Analysis," Project BRIC9, File NDN 10.6, dated 9/22/99.
2) PND Calculation Number SP-15, "BRIC9 SPIL - UET," Project BRIC9, File NDN 10.6, dated 11/8/99.
3) PND Calculation Number SP-27, "BRIC9 SPIL - Minimum Required Boron Concentration for Rod Drop Testing," Project BRIC9, File NDN 10.6, dated 12/13/99.
4) Letter from M. Lesniak to U. S. Nuclear Regulatory Commission, "Application for Amendment to Facility Operating Licenses-Reactivity Control Systems; Byron Station Units 1 and 2, NPF -37/66; Docket Nos. 50-454/455; Braidwood Units 1 and 2 NPF-72/77 Docket Nos. 50-456/457," dated December 21, 1995.

Supplemental Distribution: J. Bauer (DG)
E. H. Young (DG)
Braidwood Central File
DG Central Files

L. Kepley (BW)
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P. Boyle (BW)
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K. Sahadewan (BW)
M. G. Needham (BW)

CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 1 CYCLE 9

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Braidwood Station Unit 1 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)

CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 1 CYCLE 9

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.

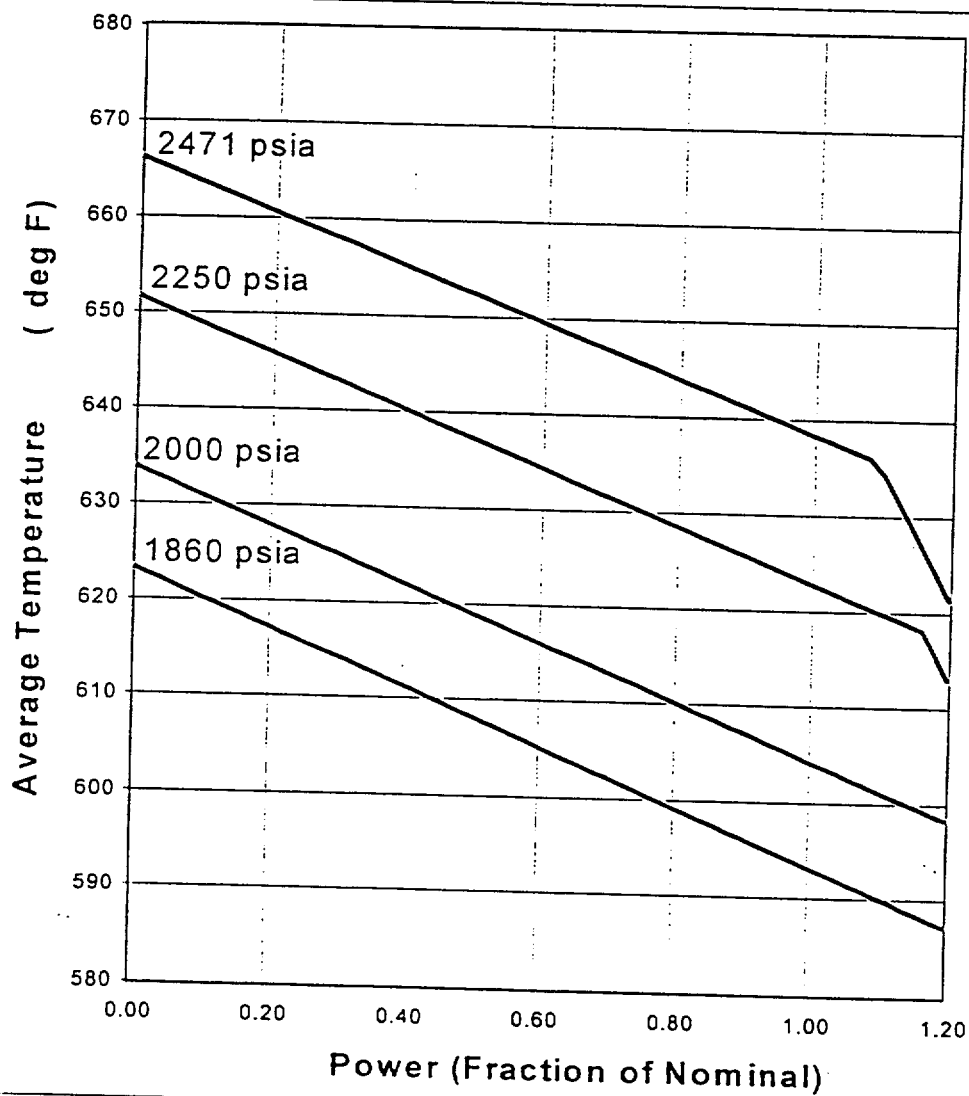


Figure 2.1.1: Reactor Core Limits

CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 1 CYCLE 9

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 $+3.4 \times 10^{-5} \Delta k/k/^{\circ}F$.
- 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

2.4 Shutdown Bank Insertion Limit (LCO 3.1.5)

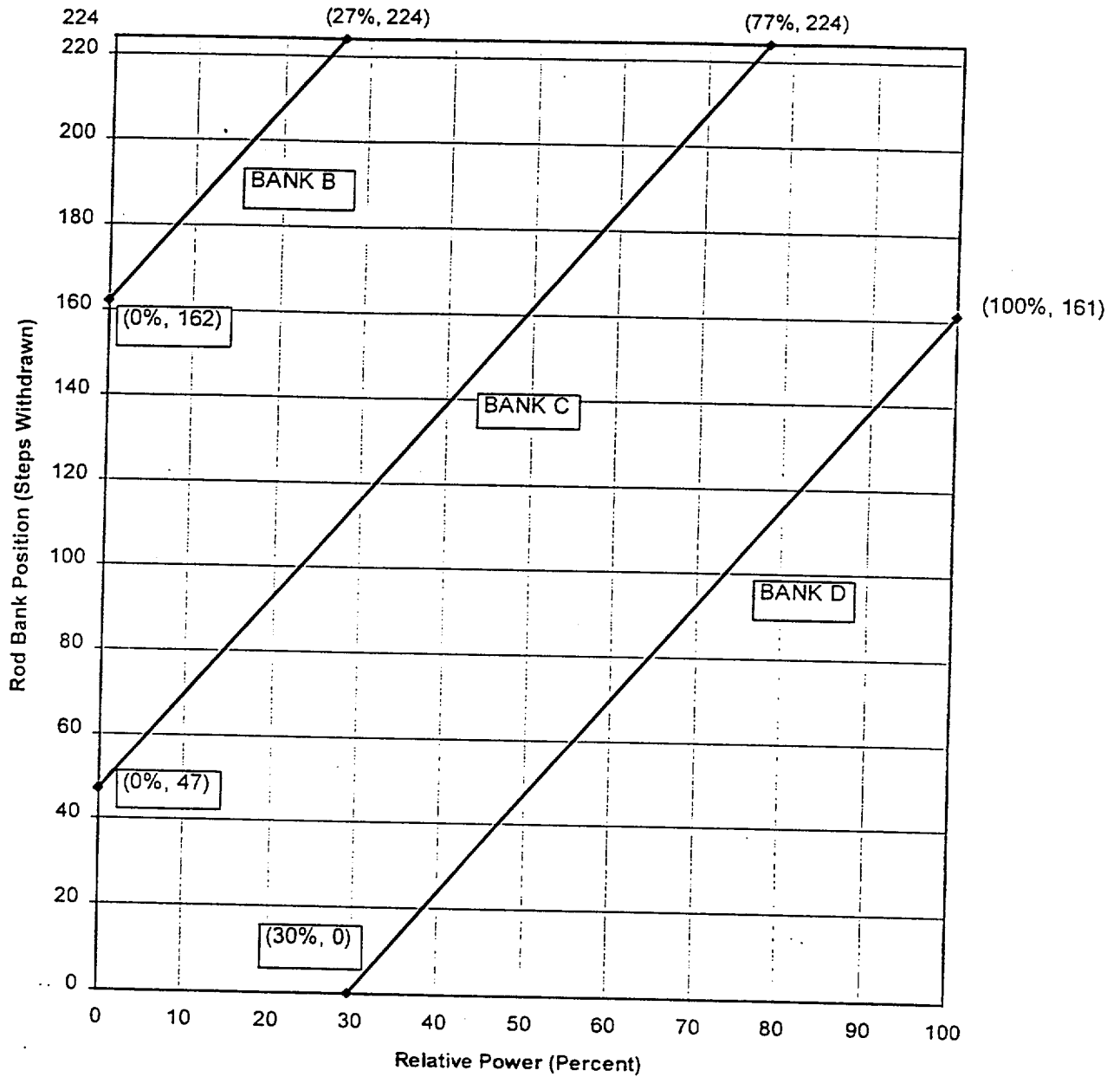
- 2.4.1 All shutdown banks shall be fully withdrawn to at least 224 steps.

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 BRAIDWOOD UNIT 1 CYCLE 9

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



CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 1 CYCLE 9

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

2.6.1

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

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

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 2.5.1.a.

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

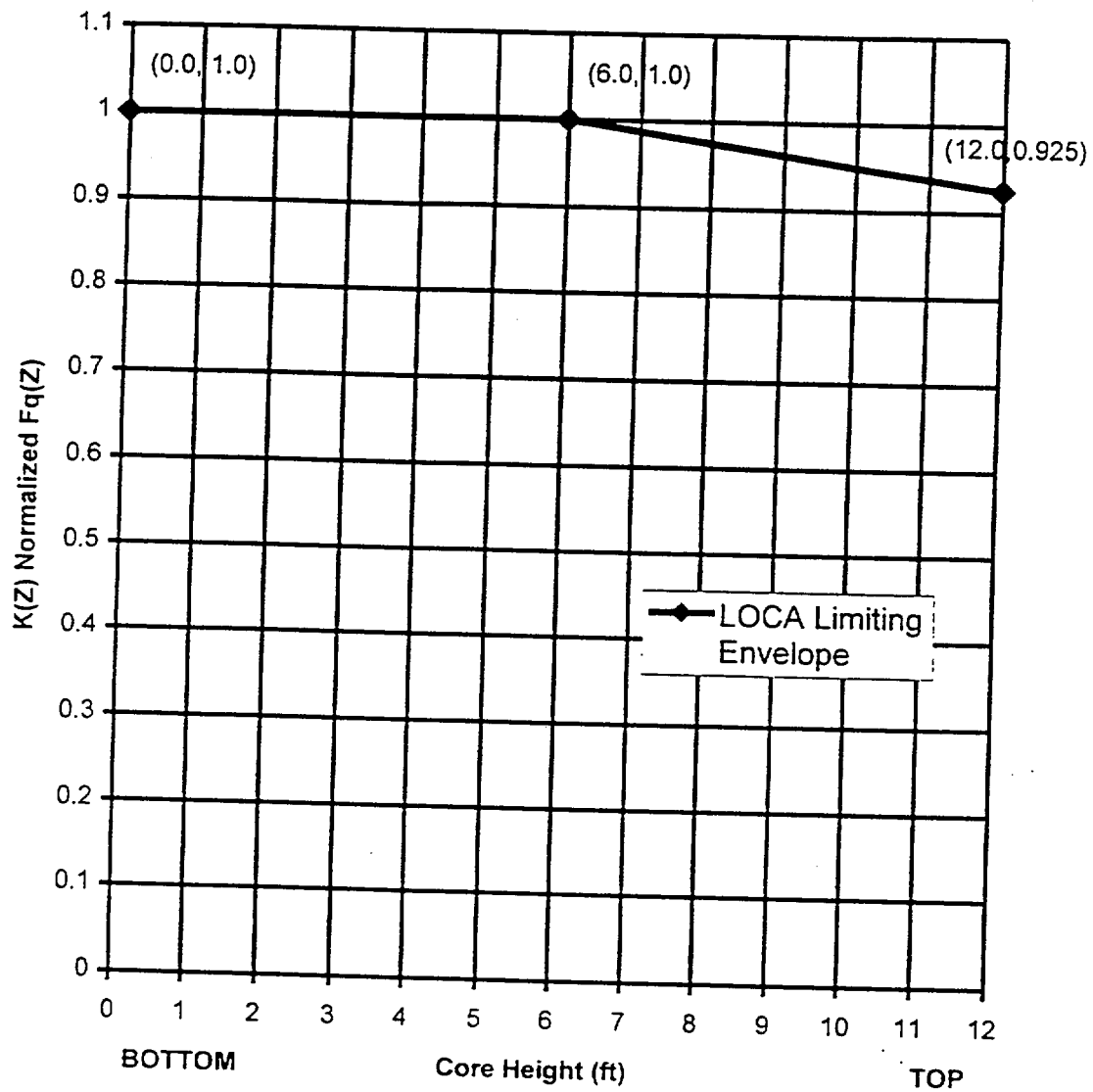
The normal operation $W(Z)$ values have been determined at burnups of 150, 4000, 10000 and 20000 MWD/MTU.

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

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

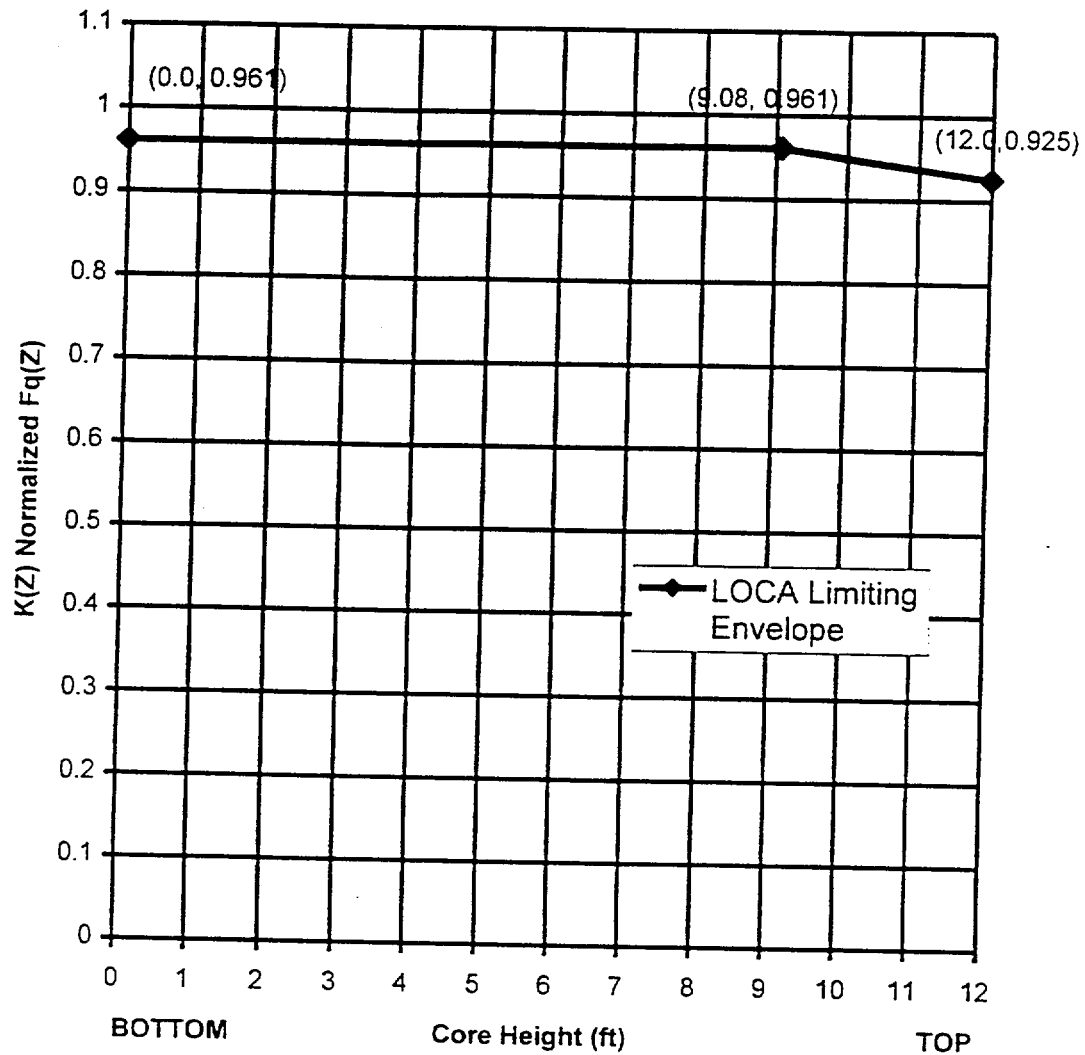
CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 1 CYCLE 9

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



CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 1 CYCLE 9

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



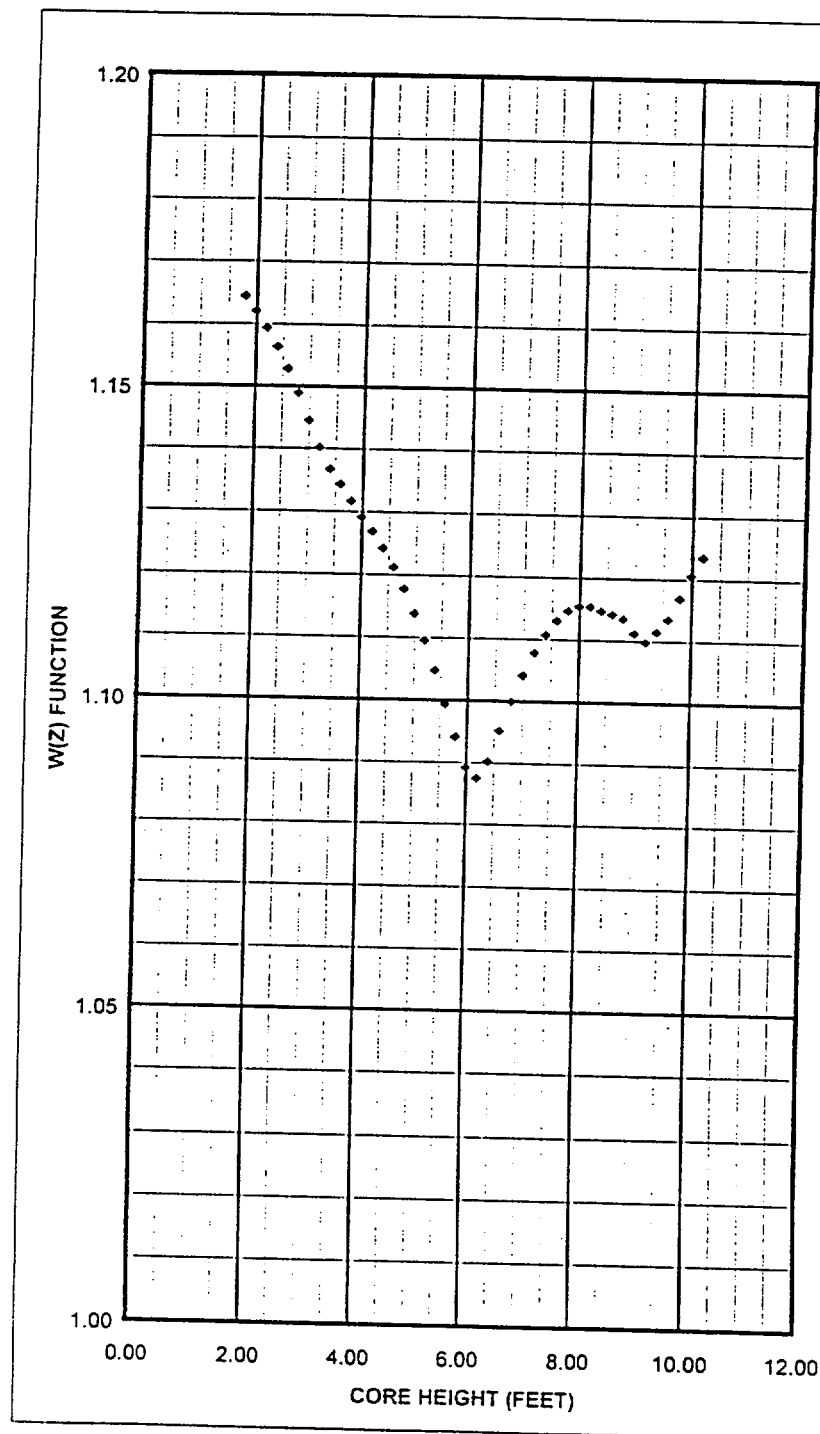
CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 1 CYCLE 9

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	1.1643
2.00	1.1620
2.20	1.1593
2.40	1.1563
2.60	1.1528
2.80	1.1489
3.00	1.1445
3.20	1.1402
3.40	1.1367
3.60	1.1343
3.80	1.1316
4.00	1.1291
4.20	1.1268
4.40	1.1241
4.60	1.1211
4.80	1.1177
5.00	1.1138
5.20	1.1095
5.40	1.1047
5.60	1.0993
5.80	1.0941
6.00	1.0892
6.20	1.0875
6.40	1.0902
6.60	1.0952
6.80	1.0999
7.00	1.1041
7.20	1.1078
7.40	1.1107
7.60	1.1130
7.80	1.1146
8.00	1.1154
8.20	1.1154
8.40	1.1147
8.60	1.1142
8.80	1.1135
9.00	1.1112
9.20	1.1098
9.40	1.1115
9.60	1.1135
9.80	1.1169
10.00	1.1206
10.20	1.1235
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

Braidwood Unit 1 Cycle 9

Figure 2.6.2.a

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



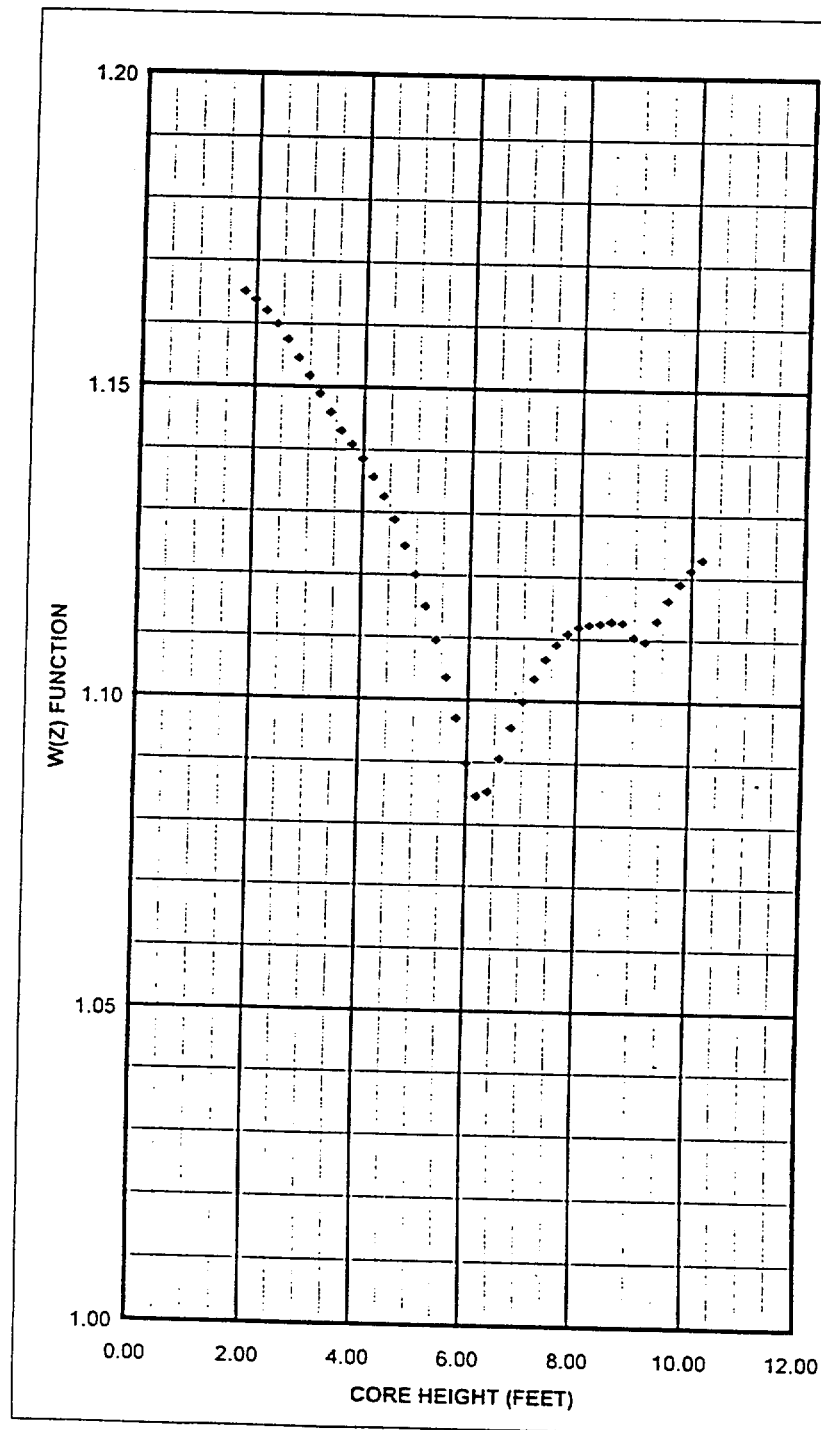
CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 1 CYCLE 9

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	1.1650
2.00	1.1637
2.20	1.1620
2.40	1.1599
2.60	1.1574
2.80	1.1545
3.00	1.1517
3.20	1.1489
3.40	1.1459
3.60	1.1430
3.80	1.1408
4.00	1.1385
4.20	1.1356
4.40	1.1325
4.60	1.1288
4.80	1.1246
5.00	1.1200
5.20	1.1149
5.40	1.1095
5.60	1.1035
5.80	1.0970
6.00	1.0898
6.20	1.0845
6.40	1.0853
6.60	1.0906
6.80	1.0956
7.00	1.0998
7.20	1.1035
7.40	1.1066
7.60	1.1090
7.80	1.1108
8.00	1.1118
8.20	1.1122
8.40	1.1124
8.60	1.1128
8.80	1.1126
9.00	1.1104
9.20	1.1097
9.40	1.1130
9.60	1.1163
9.80	1.1190
10.00	1.1212
10.20	1.1229
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

Braidwood Unit 1 Cycle 9

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 BRAIDWOOD UNIT 1 CYCLE 9

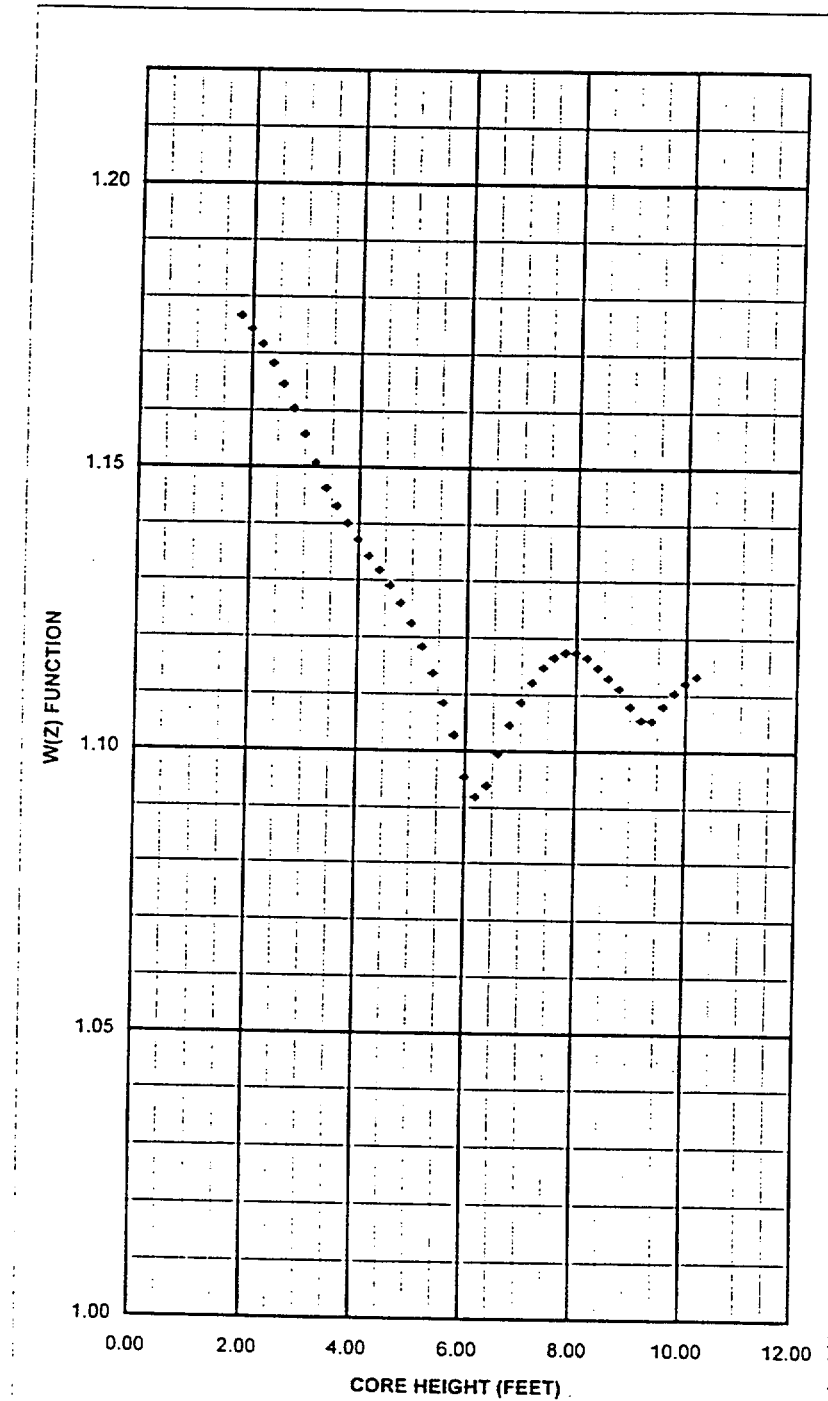
Height MAX W(Z)

Feet	
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	1.1765
2.00	1.1742
2.20	1.1715
2.40	1.1682
2.60	1.1645
2.80	1.1603
3.00	1.1557
3.20	1.1507
3.40	1.1462
3.60	1.1430
3.80	1.1400
4.00	1.1371
4.20	1.1342
4.40	1.1317
4.60	1.1290
4.80	1.1259
5.00	1.1224
5.20	1.1183
5.40	1.1136
5.60	1.1084
5.80	1.1027
6.00	1.0953
6.20	1.0918
6.40	1.0938
6.60	1.0994
6.80	1.1045
7.00	1.1086
7.20	1.1121
7.40	1.1147
7.60	1.1165
7.80	1.1174
8.00	1.1174
8.20	1.1165
8.40	1.1147
8.60	1.1129
8.80	1.1111
9.00	1.1079
9.20	1.1055
9.40	1.1054
9.60	1.1080
9.80	1.1104
10.00	1.1121
10.20	1.1133
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

Braidwood Unit 1 Cycle 9

Figure 2.6.2.c

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



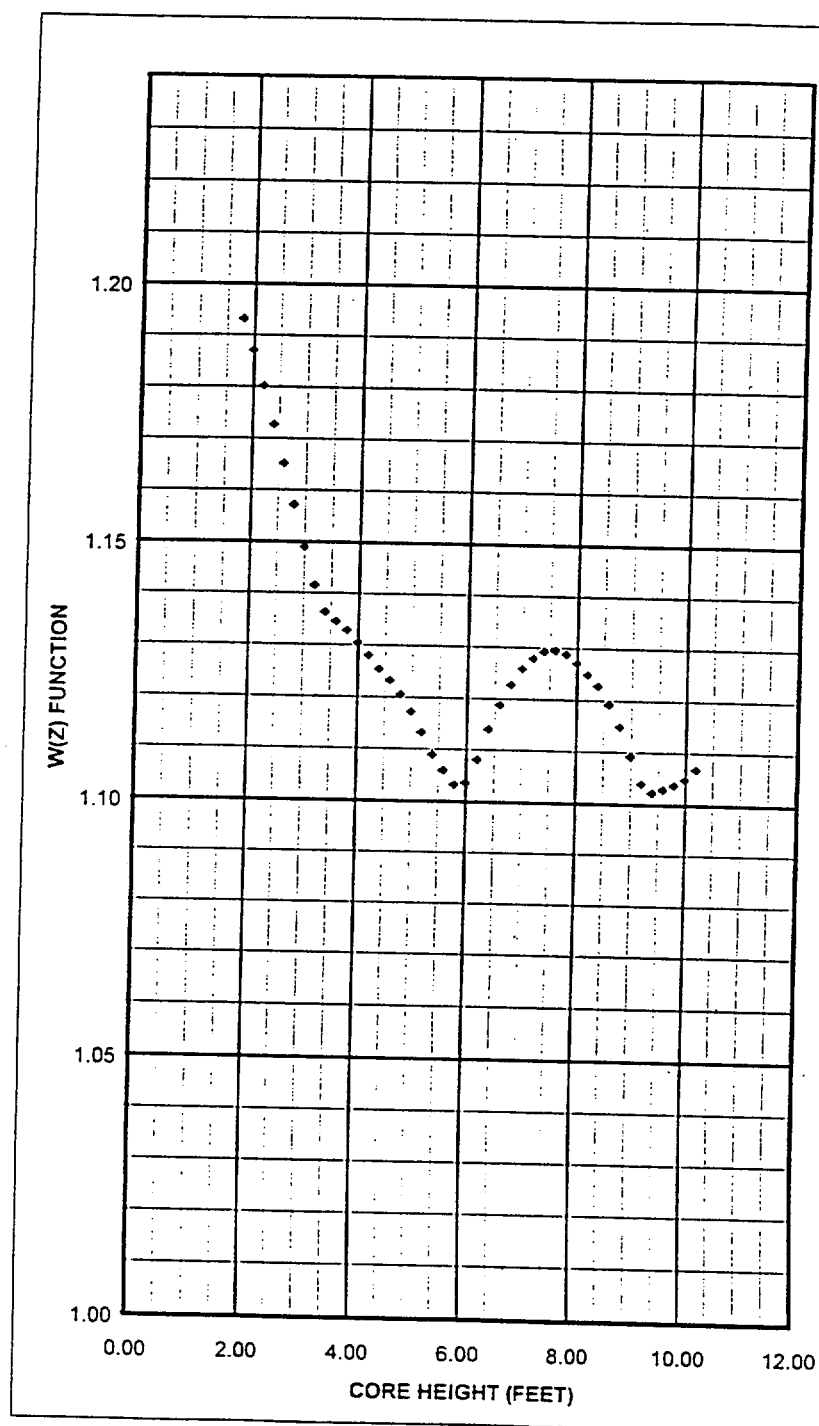
CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 1 CYCLE 9

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	1.1931
2.00	1.1870
2.20	1.1801
2.40	1.1726
2.60	1.1651
2.80	1.1571
3.00	1.1489
3.20	1.1415
3.40	1.1363
3.60	1.1345
3.80	1.1328
4.00	1.1305
4.20	1.1280
4.40	1.1253
4.60	1.1232
4.80	1.1205
5.00	1.1172
5.20	1.1132
5.40	1.1089
5.60	1.1060
5.80	1.1032
6.00	1.1036
6.20	1.1081
6.40	1.1140
6.60	1.1188
6.80	1.1227
7.00	1.1258
7.20	1.1279
7.40	1.1292
7.60	1.1295
7.80	1.1288
8.00	1.1271
8.20	1.1249
8.40	1.1227
8.60	1.1192
8.80	1.1149
9.00	1.1092
9.20	1.1040
9.40	1.1022
9.60	1.1029
9.80	1.1038
10.00	1.1049
10.20	1.1069
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

Braidwood Unit 1 Cycle 9

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 BRAIDWOOD UNIT 1 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	3.79
313	5.42
477	6.83
640	7.95
804	8.65
967	8.89
1131	8.64
1294	8.03
1458	7.17
1621	6.21
1784	5.51
1948	4.82
2111	4.18
2275	3.59
2438	3.07
2602	2.61
2765	2.21

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. Linear interpolation is adequate for intermediate cycle burnups.

CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 1 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

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

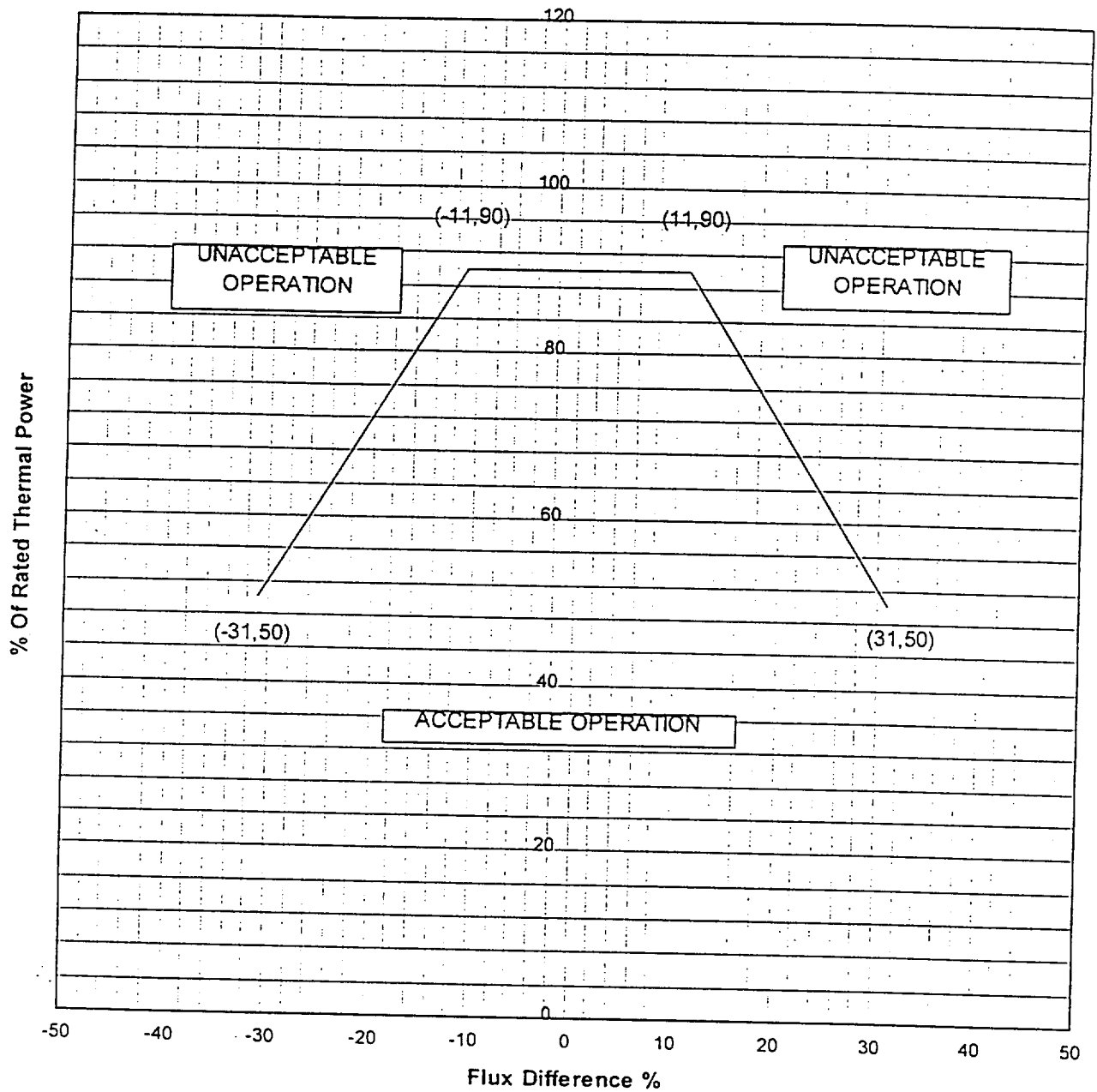
$$PF_{\Delta H} = 0.3$$

2.8 Axial Flux Difference (AFD) (LCO 3.2.3)

2.8.1 The AXIAL FLUX DIFFERENCE (AFD) target band is +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 BRAIDWOOD UNIT 1 CYCLE 9

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

CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 1 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 BRAIDWOOD UNIT 1 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 BRAIDWOOD UNIT 1 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 1969 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).

Attachment A-2

Braidwood Station, Unit 2 Cycle 8

NUCLEAR FUEL MANAGEMENT DEPARTMENT
NUCLEAR DESIGN INFORMATION TRANSMITTAL

- ☒ SAFETY RELATED
☐ NON-SAFETY RELATED
☐ REGULATORY RELATED

Originating Organization
☒ Nuclear Fuel Management
☐ Other (specify) _____

NDIT No. NFM9900022
Seq. No. 2
Page 1 of 15

Station Braidwood Unit 2 Cycle 8 Generic _____

To: Lonnie K. Kepley

Subject Braidwood Unit 2 Cycle 8 Core Operating Limits Report in ITS Format and W(z) Function

R. Lee

Preparer

Robert Lee
Preparer's Signature

6/2/00
Date

E. Wurz

Reviewer

Erich Wurz
Reviewer's Signature

6/2/00
Date

D. Redden

NFM Supervisor

[Signature]
Supervisor's Signature

6/2/00
Date

Status of Information:

- ☒ Verified
☐ Unverified
☐ Engineering Judgement

Method and Schedule of Verification for Unverified
NDITs: _____

Description of Information: Attached is the Braidwood Unit 2 Cycle 8 Core Operating Limits Report (COLR) in the ITS format and W(z) function.

Purpose of Information: . Sequence 2 of this NDIT supersedes NDIT NFM9900022, Seq. 1. This sequence incorporates the Expanded COLR format and other administrative changes. Sequence 1 incorporated a revised K(Z) curve for assembly average burnup ≤ 4000 MWD/MTU due to the recent issue on the LOCBART code discrepancy affecting LBLOCA analysis. Braidwood Station is requested to perform a Plant Review of this document. Upon completion of the Plant Review, Braidwood Station is to transmit the COLR portion to the Nuclear Regulatory Commission. Please provide NFM (Rob Lee) with a copy of Braidwood Station's completed ITR and COLR submittal to the NRC.

Please note that Regulatory Assurance/Regulatory Services will be responsible for the distribution of the TRM changes.

- Source of Information: 1) PND Calculation Number PC-01, "BR2C8 W(z) Curve Generation," File NDN 10.6, dated 3/8/99
2) PND Calculation Number SP-14, "BR2C8 SPIL - UET," File NDN 10.6, dated 1/21/99.
3) Westinghouse letter CAE-99-058 / CCE-99-063, "K(z) Curve Ramifications to LOCBART Code Non-Conformance Fq Reductions," dated July 2, 1999
4) PSS Calculation Number PSSCN:99-008, "BR2C8 BEACON Model Development," Rev. 1, dated 7/8/99

Supplemental Distribution: J. Bauer (DG)
E. Young/B. Manges (DG)
Braidwood Central File

M. G. Needham (BW)
H. S. Kim/J. Dunlap (DG)
D. G. Central Files

P. Boyle (BW)
D. R. Redden
T. Simpkin (BW)

CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 2 CYCLE 8

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Braidwood Station Unit 2 Cycle 8 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)

CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 2 CYCLE 8

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.

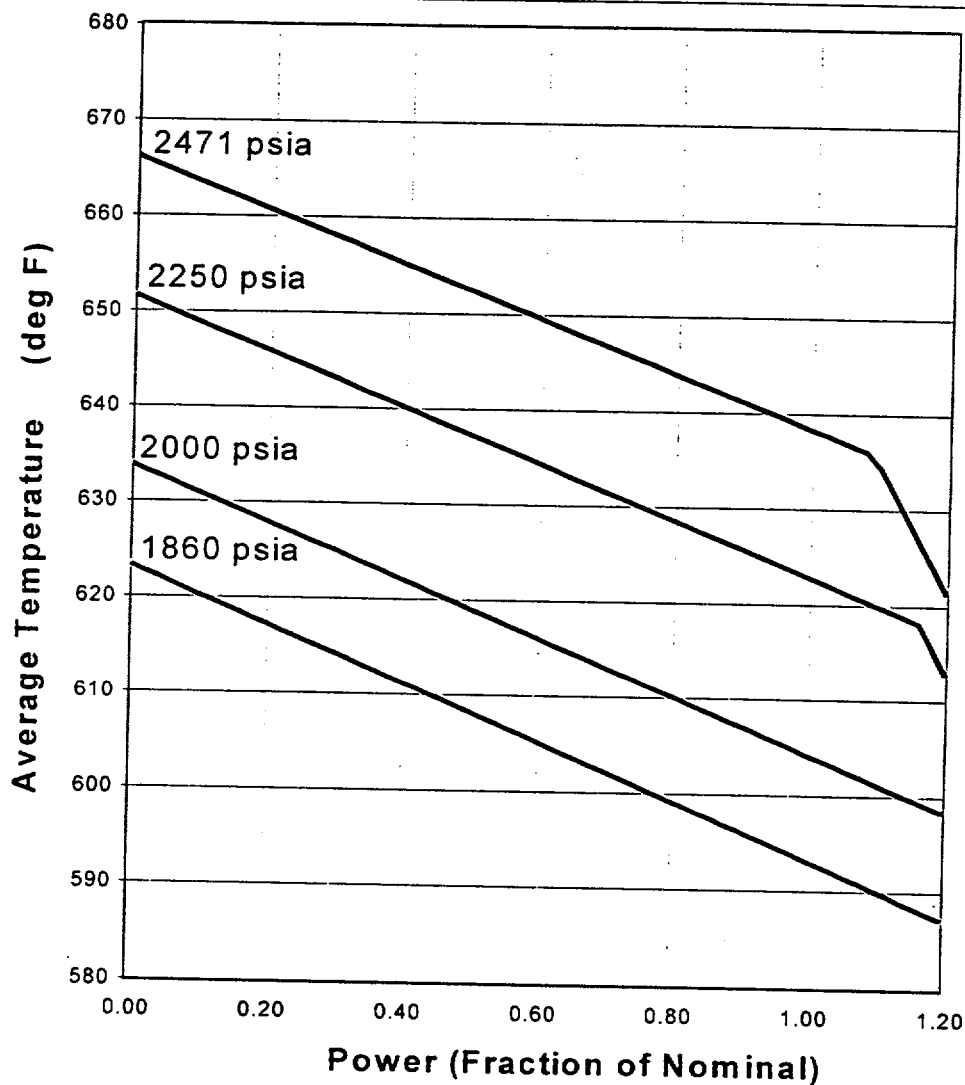


Figure 2.1.1: Reactor Core Limits

CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 2 CYCLE 8

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, and 3.9.1; 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

2.4 Shutdown Bank Insertion Limit (LCO 3.1.5)

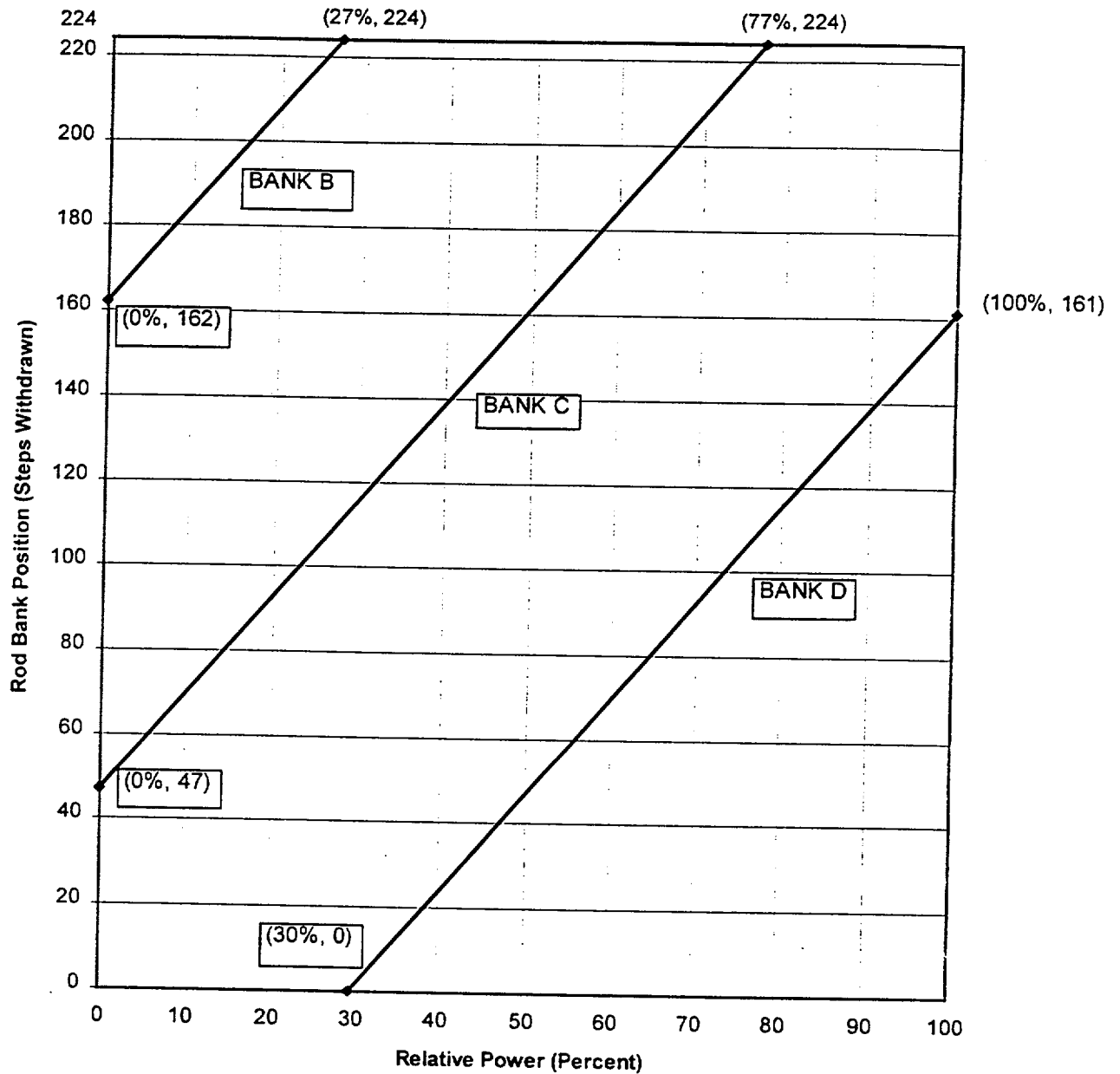
- 2.4.1 All shutdown banks shall be fully withdrawn to at least 224 steps.

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 BRAIDWOOD UNIT 2 CYCLE 8

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



CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 2 CYCLE 8

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.

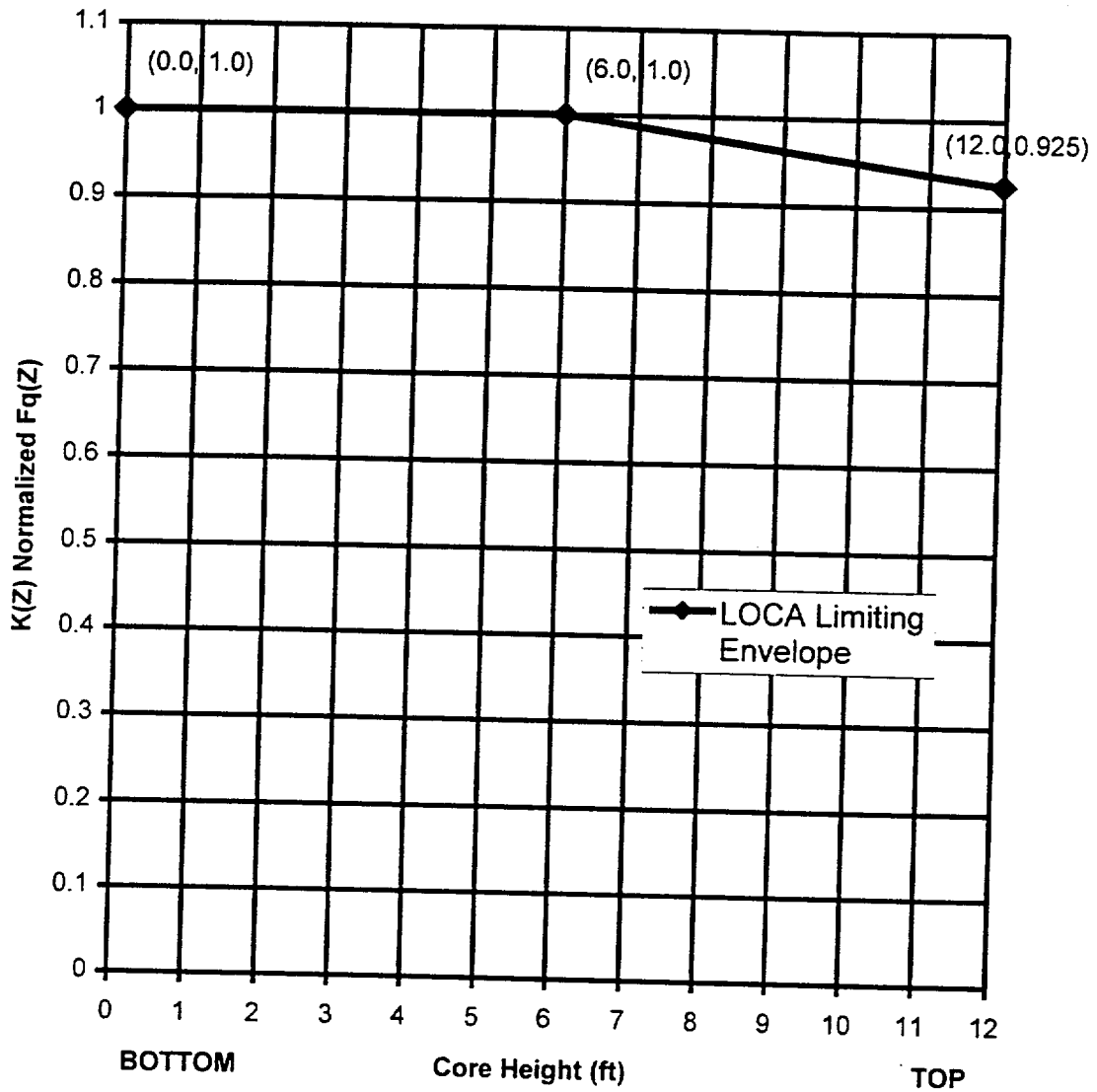
The normal operation $W(Z)$ values have been determined at burnups of 150, 4000, 10000, and 19600 MWD/MTU.

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.

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

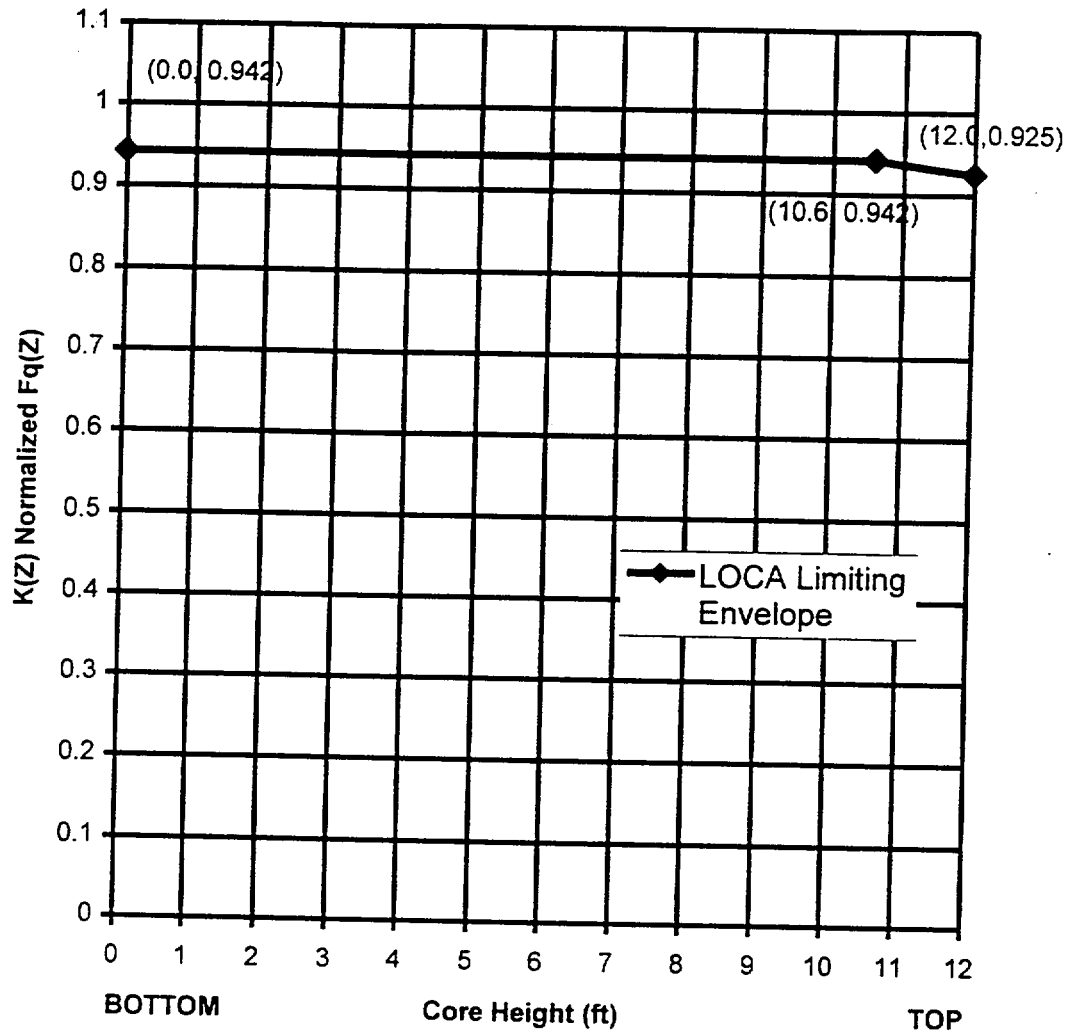
CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 2 CYCLE 8

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



CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 2 CYCLE 8

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



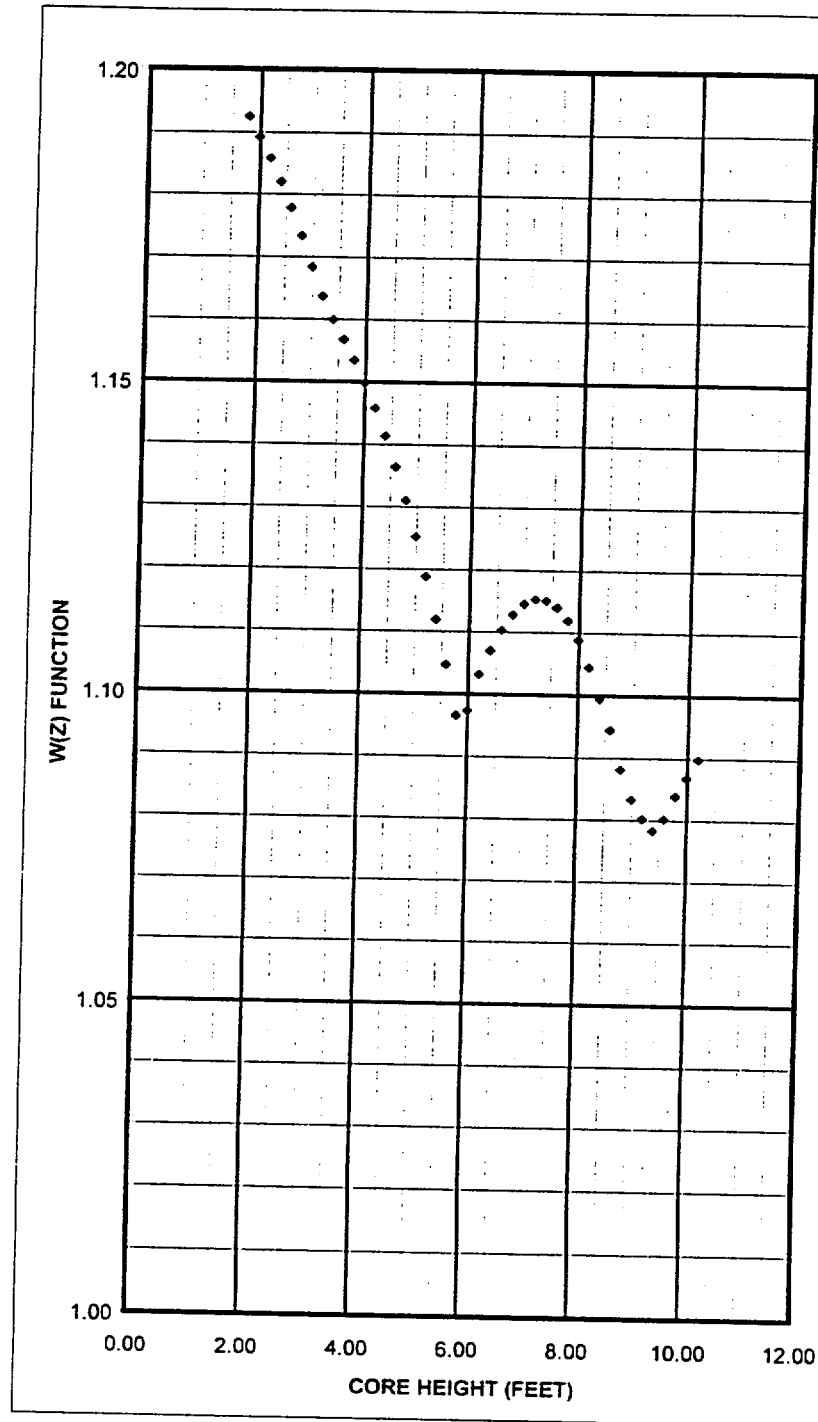
CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 2 CYCLE 8

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	1.1925
2.00	1.1892
2.20	1.1858
2.40	1.1820
2.60	1.1778
2.80	1.1733
3.00	1.1683
3.20	1.1636
3.40	1.1599
3.60	1.1567
3.80	1.1534
4.00	1.1498
4.20	1.1458
4.40	1.1413
4.60	1.1364
4.80	1.1310
5.00	1.1252
5.20	1.1188
5.40	1.1119
5.60	1.1047
5.80	1.0965
6.00	1.0973
6.20	1.1032
6.40	1.1070
6.60	1.1103
6.80	1.1128
7.00	1.1145
7.20	1.1153
7.40	1.1151
7.60	1.1140
7.80	1.1119
8.00	1.1088
8.20	1.1045
8.40	1.0994
8.60	1.0945
8.80	1.0881
9.00	1.0833
9.20	1.0802
9.40	1.0783
9.60	1.0802
9.80	1.0839
10.00	1.0868
10.20	1.0898
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

Braidwood Unit 2 Cycle 8

Figure 2.6.2.a

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



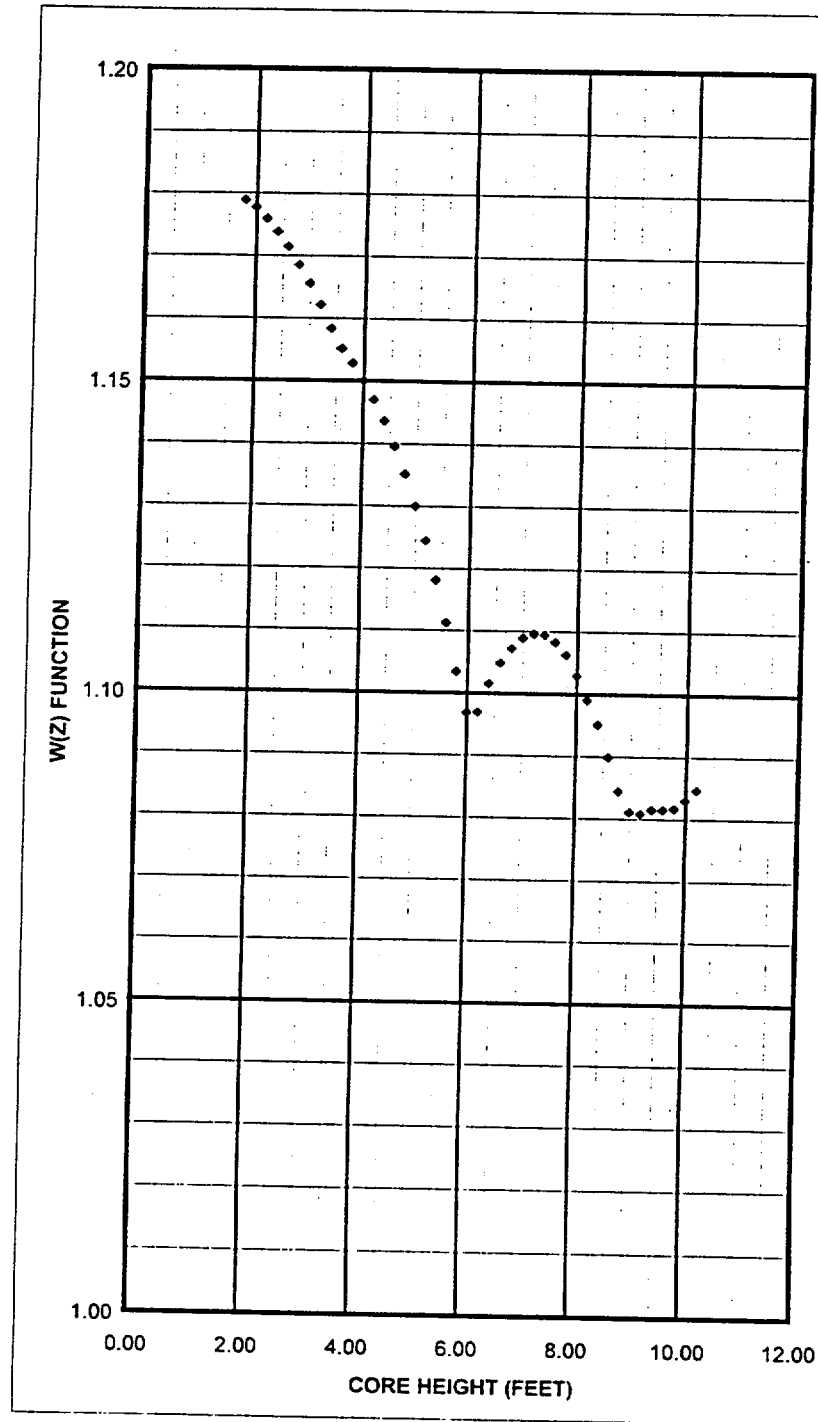
CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 2 CYCLE 8

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	1.1789
2.00	1.1777
2.20	1.1759
2.40	1.1738
2.60	1.1714
2.80	1.1685
3.00	1.1655
3.20	1.1621
3.40	1.1583
3.60	1.1551
3.80	1.1528
4.00	1.1500
4.20	1.1470
4.40	1.1436
4.60	1.1396
4.80	1.1351
5.00	1.1300
5.20	1.1244
5.40	1.1181
5.60	1.1112
5.80	1.1034
6.00	1.0968
6.20	1.0969
6.40	1.1015
6.60	1.1048
6.80	1.1072
7.00	1.1089
7.20	1.1096
7.40	1.1094
7.60	1.1083
7.80	1.1062
8.00	1.1029
8.20	1.0990
8.40	1.0951
8.60	1.0899
8.80	1.0844
9.00	1.0811
9.20	1.0808
9.40	1.0815
9.60	1.0815
9.80	1.0817
10.00	1.0830
10.20	1.0847
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

Braidwood Unit 2 Cycle 8

Figure 2.6.2.b

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



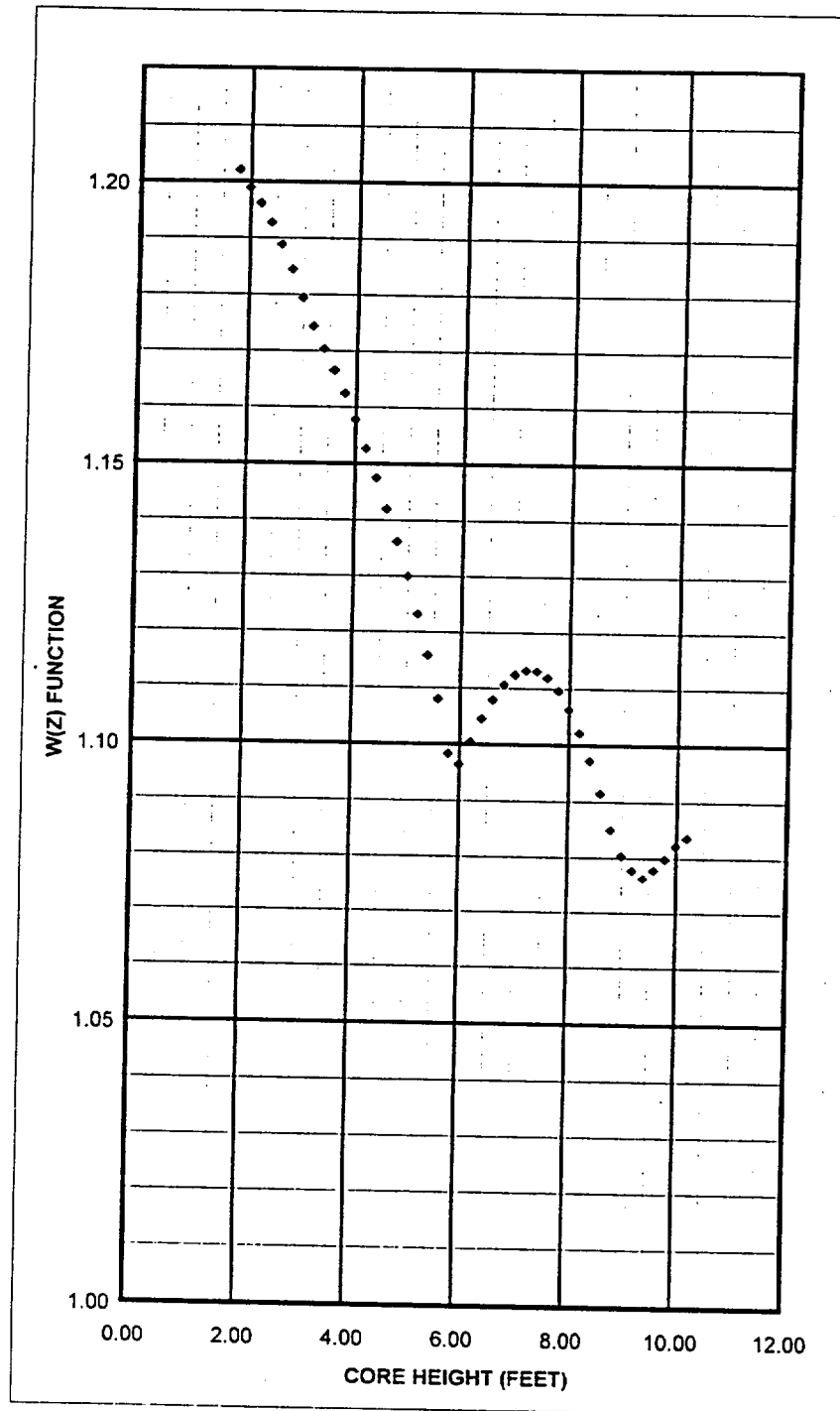
CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 2 CYCLE 8

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	1.2020
2.00	1.1988
2.20	1.1961
2.40	1.1927
2.60	1.1888
2.80	1.1844
3.00	1.1794
3.20	1.1743
3.40	1.1703
3.60	1.1665
3.80	1.1624
4.00	1.1577
4.20	1.1526
4.40	1.1474
4.60	1.1419
4.80	1.1361
5.00	1.1299
5.20	1.1231
5.40	1.1158
5.60	1.1080
5.80	1.0983
6.00	1.0964
6.20	1.1004
6.40	1.1045
6.60	1.1079
6.80	1.1106
7.00	1.1124
7.20	1.1132
7.40	1.1131
7.60	1.1119
7.80	1.1096
8.00	1.1063
8.20	1.1021
8.40	1.0972
8.60	1.0915
8.80	1.0850
9.00	1.0804
9.20	1.0778
9.40	1.0764
9.60	1.0779
9.80	1.0799
10.00	1.0822
10.20	1.0836
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

Braidwood Unit 2 Cycle 8

Figure 2.6.2.c

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



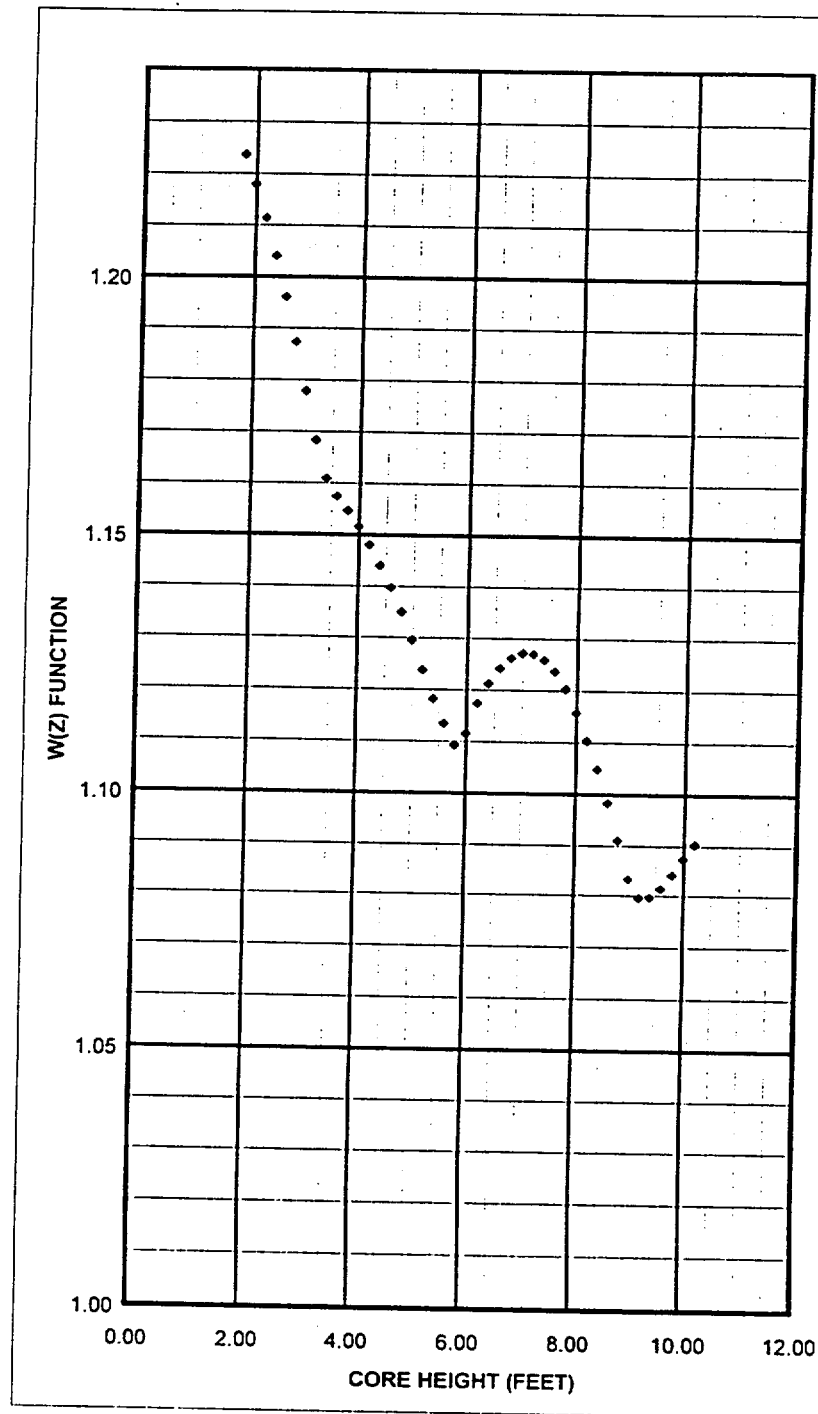
CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 2 CYCLE 8

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	1.2236
2.00	1.2179
2.20	1.2114
2.40	1.2040
2.60	1.1960
2.80	1.1873
3.00	1.1778
3.20	1.1683
3.40	1.1609
3.60	1.1574
3.80	1.1546
4.00	1.1515
4.20	1.1480
4.40	1.1440
4.60	1.1397
4.80	1.1349
5.00	1.1295
5.20	1.1238
5.40	1.1182
5.60	1.1134
5.80	1.1093
6.00	1.1115
6.20	1.1174
6.40	1.1212
6.60	1.1242
6.80	1.1262
7.00	1.1272
7.20	1.1271
7.40	1.1259
7.60	1.1237
7.80	1.1203
8.00	1.1157
8.20	1.1103
8.40	1.1048
8.60	1.0983
8.80	1.0910
9.00	1.0834
9.20	1.0795
9.40	1.0796
9.60	1.0814
9.80	1.0843
10.00	1.0875
10.20	1.0903
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

Braidwood Unit 2 Cycle 8

Figure 2.6.2.d

Summary of W(Z) Function at 19600 MWD/MTU
(Top and Bottom 15% Excluded per WCAP-10216)



CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 2 CYCLE 8

Table 2.6.2

Fq Margin Decreases in Excess of 2% per 31 EFPD

Cycle Burnup (MWD/MTU)	Max % Decrease in Fq Margin
150	5.27
314	5.21
478	5.10
642	4.95
806	4.75
970	4.39
1134	3.94
1298	3.44
1462	2.98
1626	2.55
1790	2.18
1954	2.00
11301	2.00
11465	2.09
11629	2.39
11793	2.66
11957	2.89
12121	3.09
12285	3.26
12449	3.37
12613	3.36
12777	3.28
12941	3.14
13105	3.00
13269	2.83
13433	2.59
13597	2.31
13761	2.02
13925	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 BRAIDWOOD UNIT 2 CYCLE 8

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

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

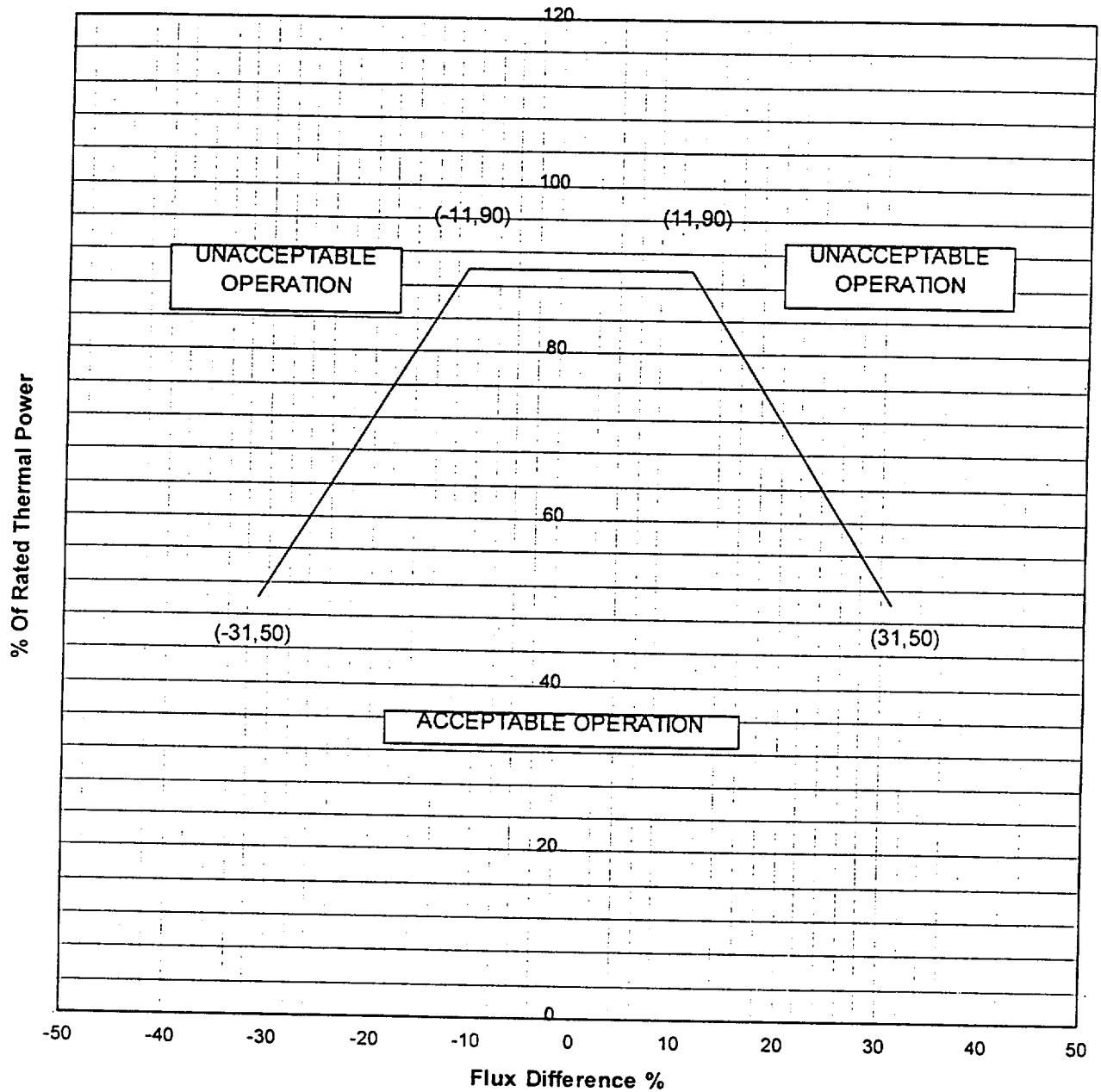
$$PF_{\Delta H} = 0.3$$

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 BRAIDWOOD UNIT 2 CYCLE 8

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

CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 2 CYCLE 8

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 BRAIDWOOD UNIT 2 CYCLE 8

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 BRAIDWOOD UNIT 2 CYCLE 8

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 (LCO 3.9.1)

2.12.1 The refueling boron concentration shall be greater than or equal to 2000 ppm.

Attachment A-3

Byron Station, Unit 1 Cycle 10

NUCLEAR FUEL MANAGEMENT DEPARTMENT
NUCLEAR DESIGN INFORMATION TRANSMITTAL

☒ SAFETY RELATED
☐ NON-SAFETY RELATED
☐ REGULATORY RELATED

Originating Organization
☒ Nuclear Fuel Management
☐ Other (specify) _____

NDIT No. NFM9900043
Seq. No. 2
Page 1 of 18

Station Byron Unit 1 Cycle 10 Generic _____

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

Subject Byron Unit 1 Cycle 10 Core Operating Limits Report in ITS Format and W(z) Function

E. Wurz

Preparer

Erich Wurz
Preparer's Signature

6/2/00
Date

R. C. Lee

Reviewer

Robert Lee
Reviewer's Signature

6/2/00
Date

D. Redden

NFM Supervisor

[Signature]
NFM Supervisor's Signature

6/2/00
Date

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 10 Core Operating Limits Report (COLR) in the ITS format and W(z) function.

Purpose of Information: Sequence 2 of this NDIT supersedes NDIT NFM9900043, Seq. 1. Sequence 2 incorporates 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.

Please note Regulatory Assurance/Regulatory Services will be responsible for the distribution of TRM changes.

Source of Information: 1) PND Calculation Number PC-01, Rev. 0, "BYIC10 W(z) Curve Generation and Burnup Dependent Penalties," Project BYIC10, dated March 3, 1999.
2) PND Calculation Number SP-01, "UET Determination," Project BYIC10, dated October 29, 1998.
3) Westinghouse letter CAE-99-058 / CCE-99-063, "K(z) Curve Ramifications to LOCBART Code Non-Conformance Fq Reductions," dated July 2, 1999.
4) PSS Calculation Number PSS-CN:99-003, "BYIC10 BEACON Model Development," dated July 6, 1999.
5) Byron Technical Specification Amendment 113, dated May 15, 2000
6) 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: J. Bauer (DG)
E. Young (DG)
DG Central Files

K. N. Kovar / R. J. Niederer (BY)
H. S. Kim / T. Stevens (DG)

B. J. Adams / K. Moser (BY)
Byron Central Files

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 10

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Byron Station Unit 1 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 ($F_o(Z)$)
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 10

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 $+3.8 \times 10^{-5} \Delta k/k/^{\circ}F$.

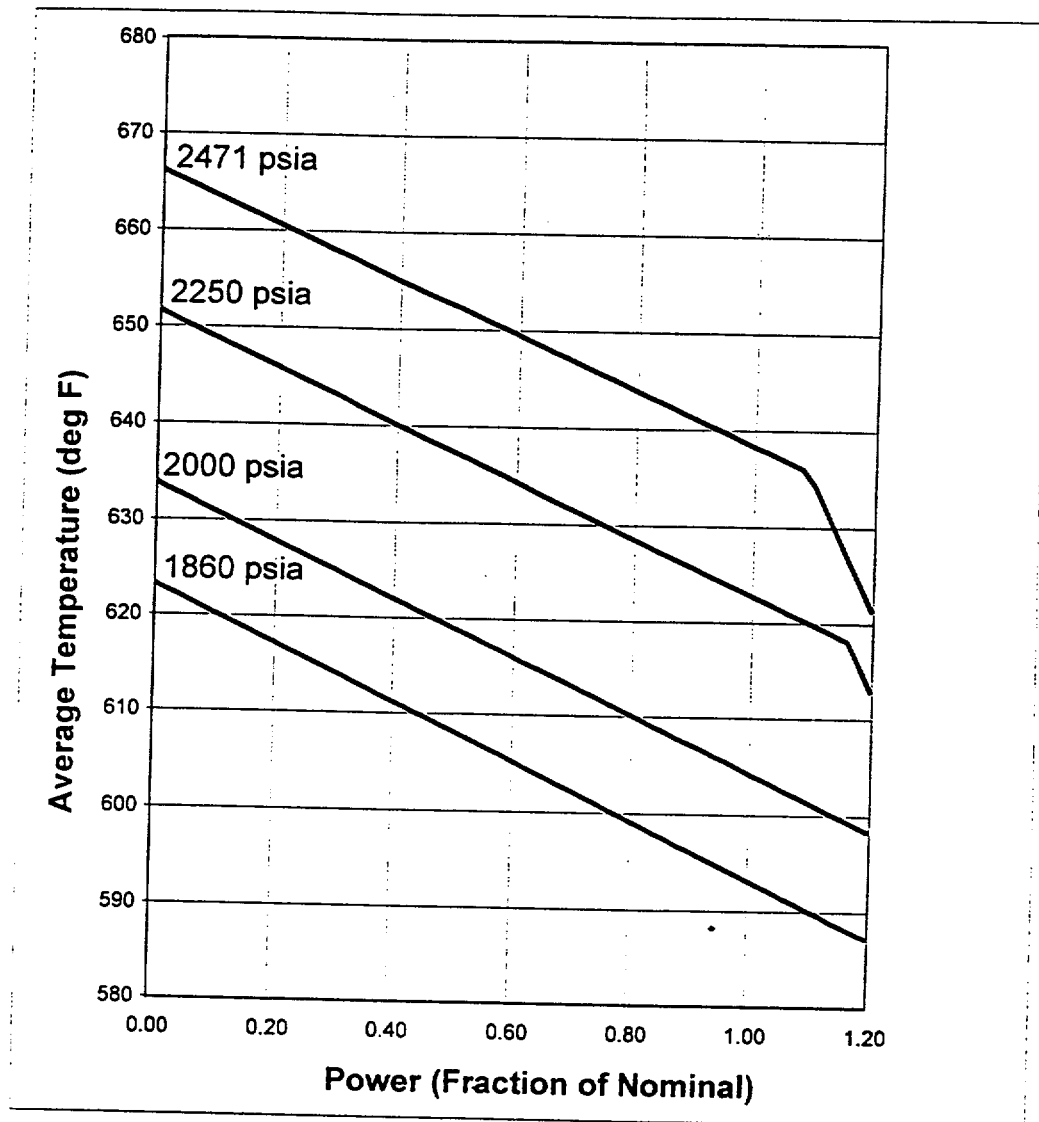
- 2.3.2 The EOL/ARO/HFP-MTC lower limit shall be $-4.1 \times 10^{-4} \Delta k/k/^{\circ}F$.

- 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 10

Figure 2.1.1: Reactor Core Limits



CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 10

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.

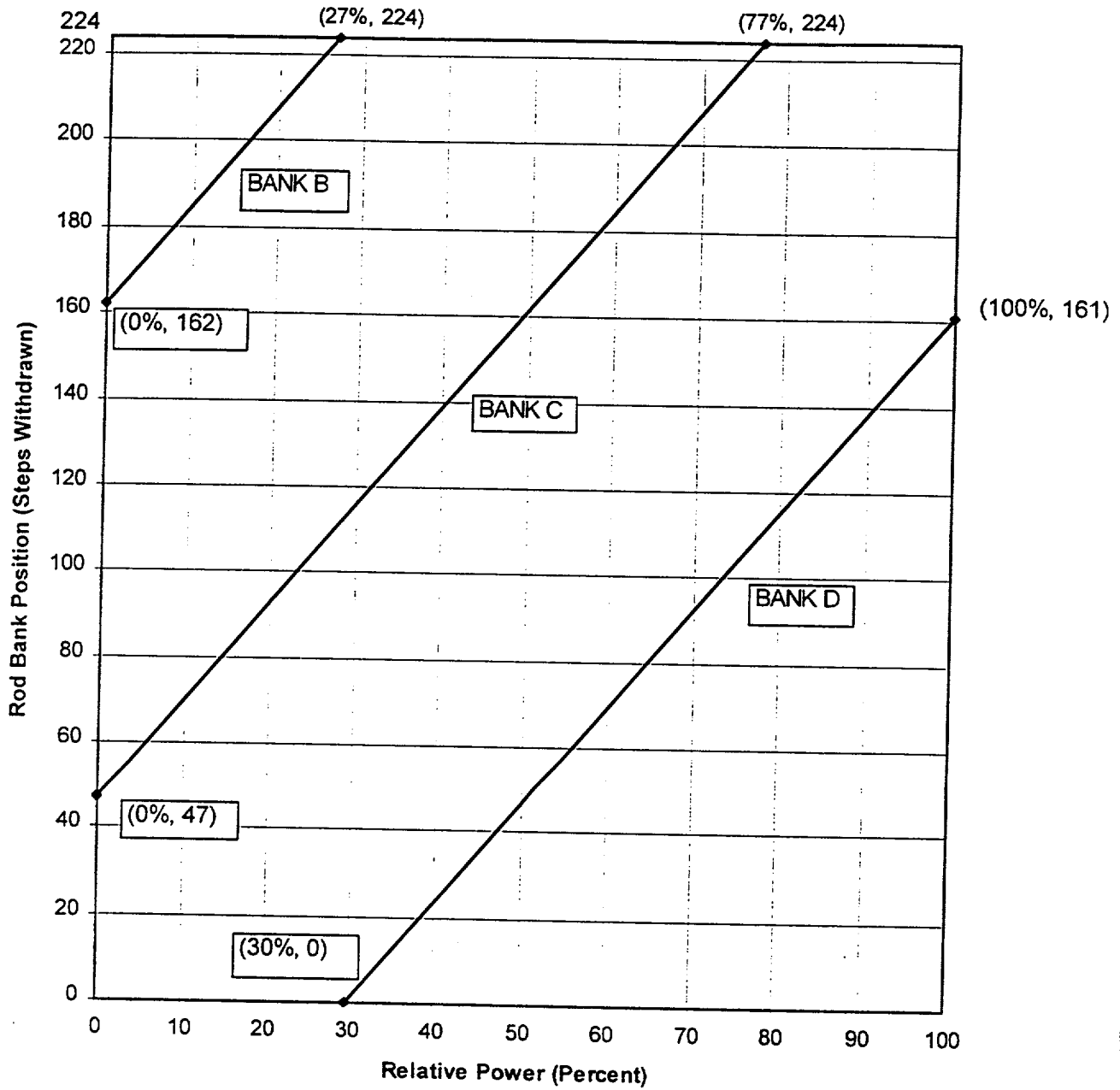
2.5.2 Each control bank shall be considered fully withdrawn from the core at greater than or equal to 224 steps.

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.

CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 10

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



CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 10

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 ≤ 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.

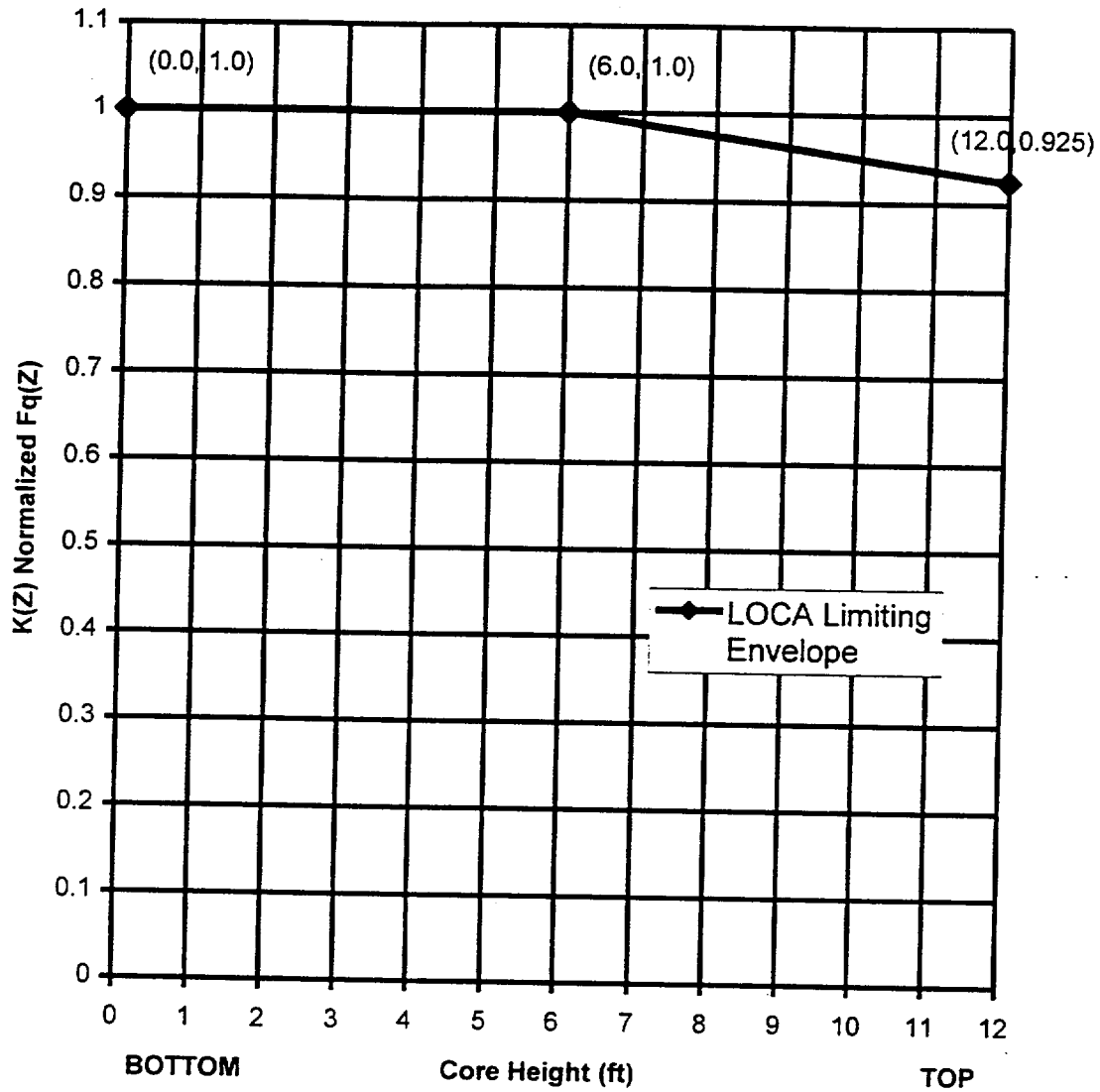
The normal operation $W(Z)$ values have been determined at burnups of 150, 8000 and 18600 MWD/MTU.

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.

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

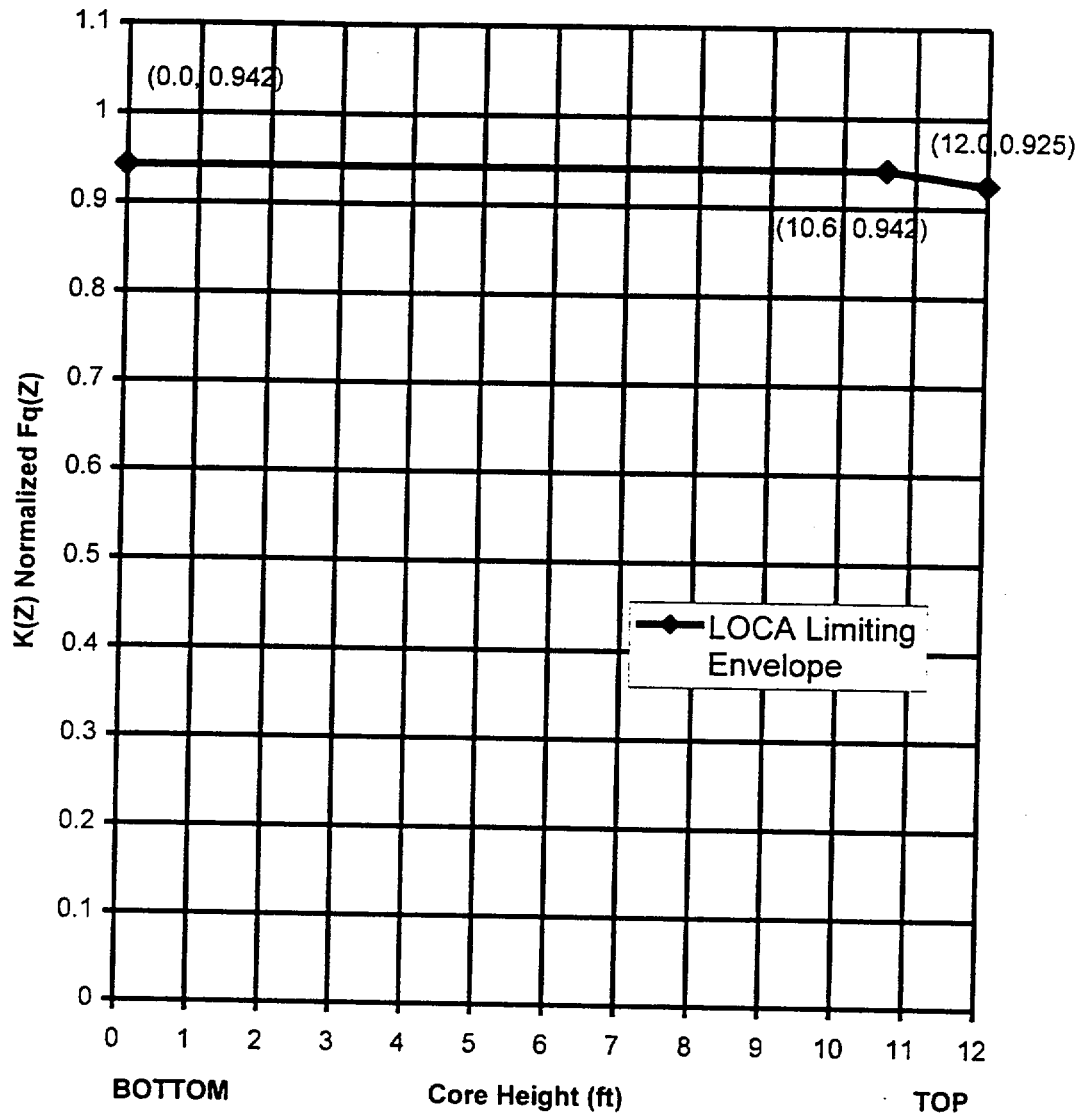
CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 10

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



CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 10

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



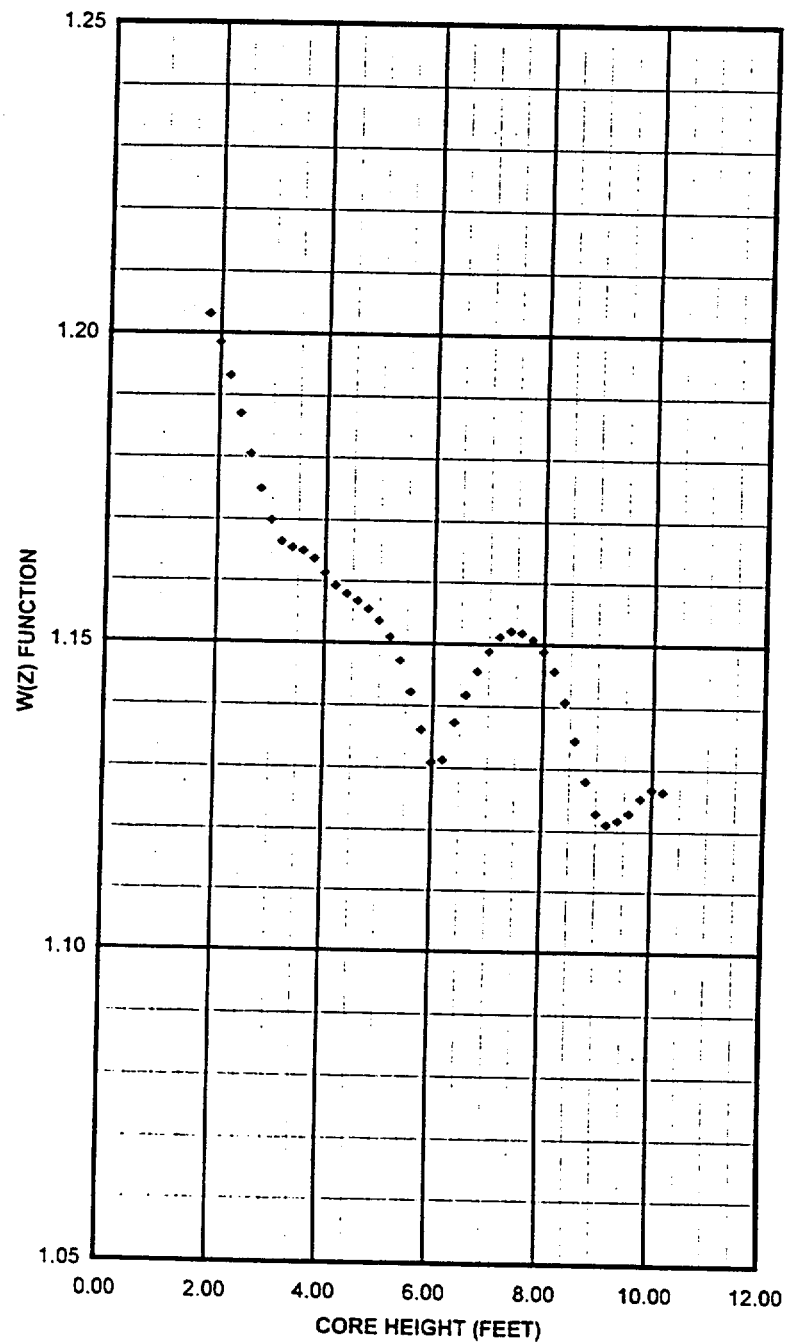
CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 10

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	1.2031
2.00	1.1985
2.20	1.1931
2.40	1.1870
2.60	1.1805
2.80	1.1749
3.00	1.1698
3.20	1.1664
3.40	1.1654
3.60	1.1649
3.80	1.1636
4.00	1.1613
4.20	1.1592
4.40	1.1579
4.60	1.1568
4.80	1.1554
5.00	1.1536
5.20	1.1510
5.40	1.1471
5.60	1.1421
5.80	1.1360
6.00	1.1308
6.20	1.1312
6.40	1.1372
6.60	1.1417
6.80	1.1455
7.00	1.1488
7.20	1.1511
7.40	1.1521
7.60	1.1518
7.80	1.1507
8.00	1.1488
8.20	1.1456
8.40	1.1407
8.60	1.1345
8.80	1.1280
9.00	1.1228
9.20	1.1211
9.40	1.1217
9.60	1.1229
9.80	1.1254
10.00	1.1268
10.20	1.1264
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 10

Figure 2.6.2.a

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



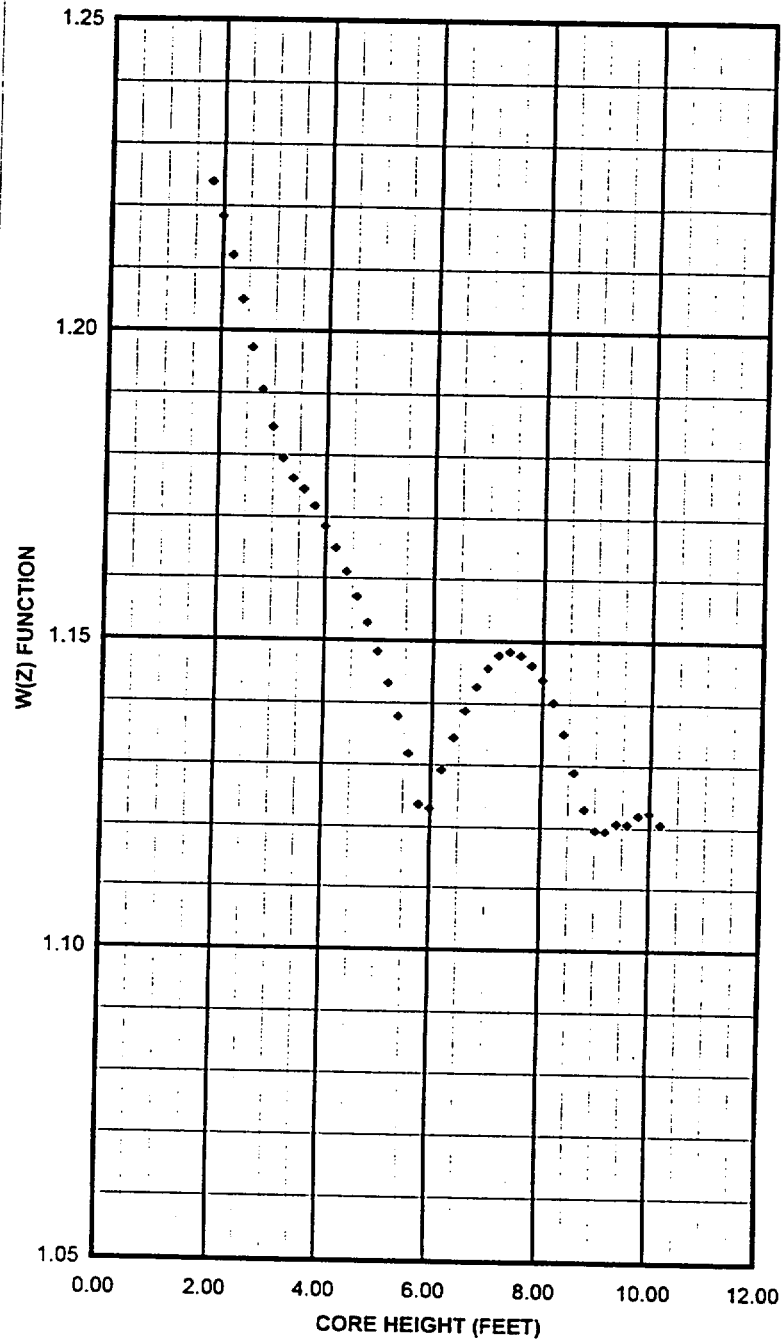
CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 10

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	1.2239
2.00	1.2183
2.20	1.2120
2.40	1.2049
2.60	1.1973
2.80	1.1905
3.00	1.1845
3.20	1.1794
3.40	1.1762
3.60	1.1744
3.80	1.1717
4.00	1.1684
4.20	1.1649
4.40	1.1610
4.60	1.1570
4.80	1.1528
5.00	1.1482
5.20	1.1431
5.40	1.1378
5.60	1.1318
5.80	1.1236
6.00	1.1230
6.20	1.1292
6.40	1.1344
6.60	1.1388
6.80	1.1426
7.00	1.1456
7.20	1.1477
7.40	1.1483
7.60	1.1477
7.80	1.1461
8.00	1.1438
8.20	1.1402
8.40	1.1351
8.60	1.1289
8.80	1.1230
9.00	1.1195
9.20	1.1194
9.40	1.1207
9.60	1.1206
9.80	1.1220
10.00	1.1224
10.20	1.1206
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 10

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 1 CYCLE 10

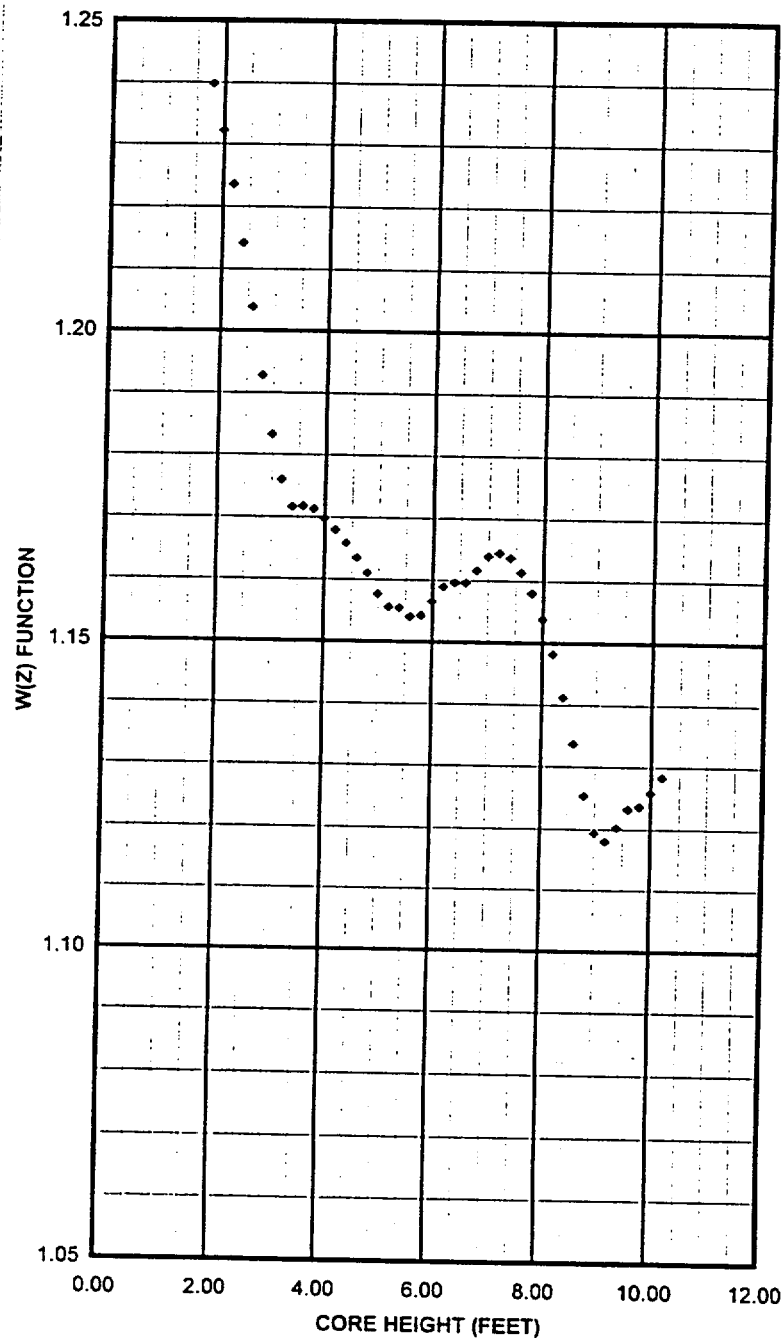
Height
Feet

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	1.2398
2.00	1.2322
2.20	1.2236
2.40	1.2141
2.60	1.2038
2.80	1.1928
3.00	1.1832
3.20	1.1759
3.40	1.1715
3.60	1.1717
3.80	1.1712
4.00	1.1697
4.20	1.1679
4.40	1.1658
4.60	1.1634
4.80	1.1610
5.00	1.1576
5.20	1.1556
5.40	1.1554
5.60	1.1540
5.80	1.1542
6.00	1.1565
6.20	1.1589
6.40	1.1596
6.60	1.1596
6.80	1.1616
7.00	1.1638
7.20	1.1644
7.40	1.1636
7.60	1.1613
7.80	1.1580
8.00	1.1538
8.20	1.1482
8.40	1.1412
8.60	1.1337
8.80	1.1253
9.00	1.1193
9.20	1.1179
9.40	1.1202
9.60	1.1232
9.80	1.1236
10.00	1.1258
10.20	1.1283
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 10

Figure 2.6.2.c

Summary of W(Z) Function at 18600 MWD/MTU
(Top and Bottom 15% Excluded per WCAP-10216)



CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 1 CYCLE 10

Table 2.6.2

Fq Margin Decreases in Excess of 2% per 31 EFPD

Cycle Burnup (MWD/MTU)	Max % Decrease in Fq Margin
807	2.00
972	2.19
1136	2.92
1301	3.56
1465	4.04
1629	4.37
1794	4.46
1958	4.42
2122	4.33
2287	4.26
2451	4.19
2615	4.09
2780	3.93
2944	3.71
3108	3.42
3273	3.06
3437	2.74
3602	2.39
3766	2.04
3930	2.00
9683	2.00
9847	2.07
10011	2.39
10176	2.64
10340	2.80
10505	2.88
10669	2.90
10833	2.86
10998	2.77
11162	2.64
11326	2.47
11491	2.27
11655	2.07
11819	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 10

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

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

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

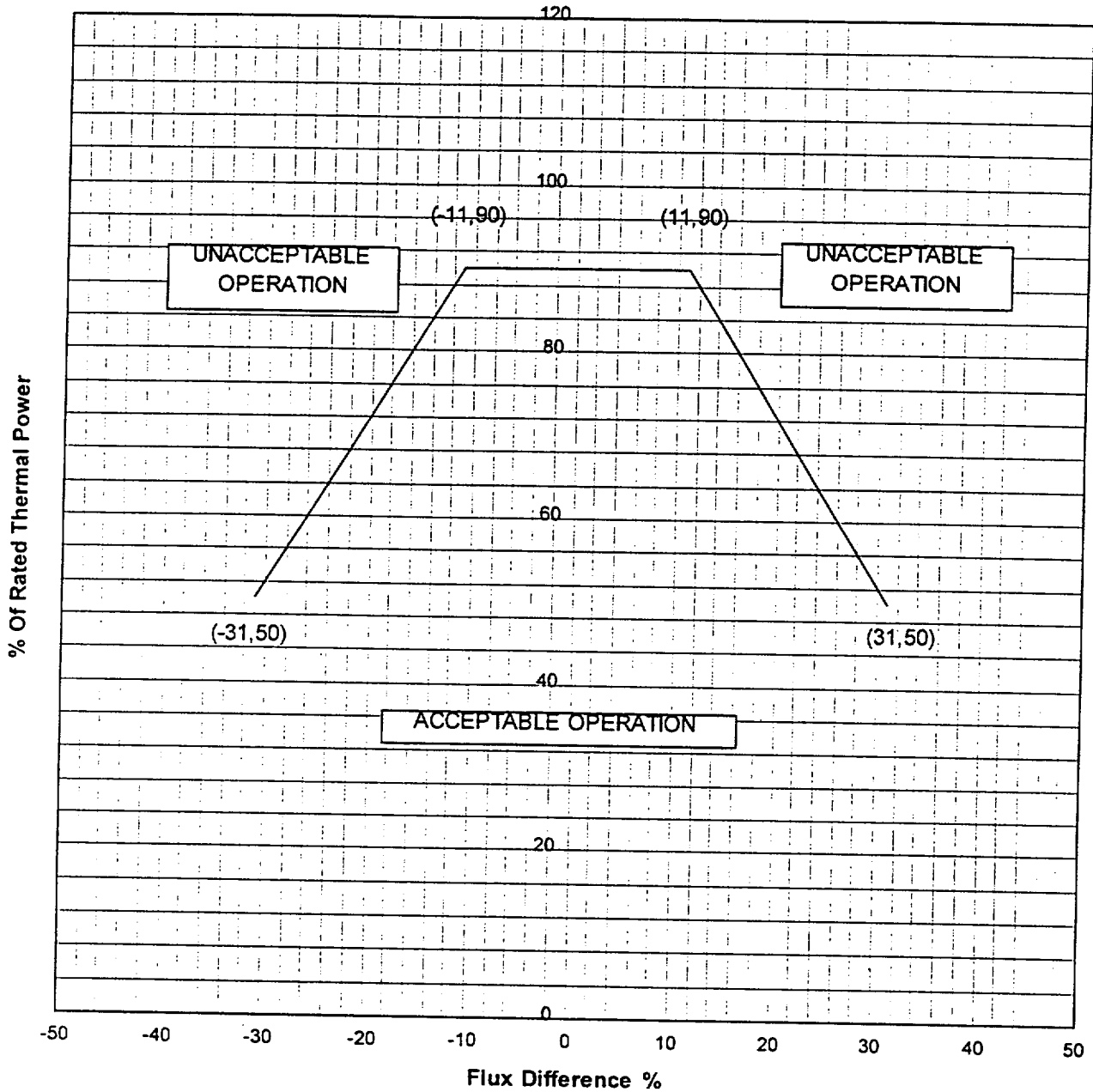
2.8 Axial Flux Difference (AFD) (LCO 3.2.3)

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 1 CYCLE 10

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 10

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 10

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 10

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 (LCO 3.9.1)

2.12.1 The refueling boron concentration shall be greater than or equal to 2000 ppm.

Attachment A-4

Byron Station, Unit 2 Cycle 9

NUCLEAR FUEL MANAGEMENT DEPARTMENT
NUCLEAR DESIGN INFORMATION TRANSMITTAL

☒ SAFETY RELATED
☐ NON-SAFETY RELATED
☐ REGULATORY RELATED

Originating Organization
☒ Nuclear Fuel Management
☐ Other (specify) _____

NDIT No. NFM9900202
Seq. No. 1
Page 1 of 18

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

Preparer

Erich Wurz
Preparer's Signature

6/2/00
Date

R. Lee

Reviewer

Robert Lee
Reviewer's Signature

6/2/00
Date

D. Redden

NFM Supervisor

[Signature]
NFM Supervisor's Signature

6/2/00
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 1 of this NDIT supersedes Sequence 0. Sequence 1 adds further clarification for the minimum boron concentration for TLCO 3.1.k to include DRPI operability surveillance and it incorporates the Expanded COLR format which includes Reactor Core Safety Limits, Reactor Trip System Instrumentation, and RCS DNB Parameters. Furthermore, the analytical 224 position limit for rods out 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. Please note Regulatory Assurance/Regulatory Services will be responsible for the distribution of TRM changes.

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 PNDN:00-003, "Evaluation of SPIL Using 224 Steps Rod Withdrawn as Definition of ARO," dated May 8, 2000.

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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)

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

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)

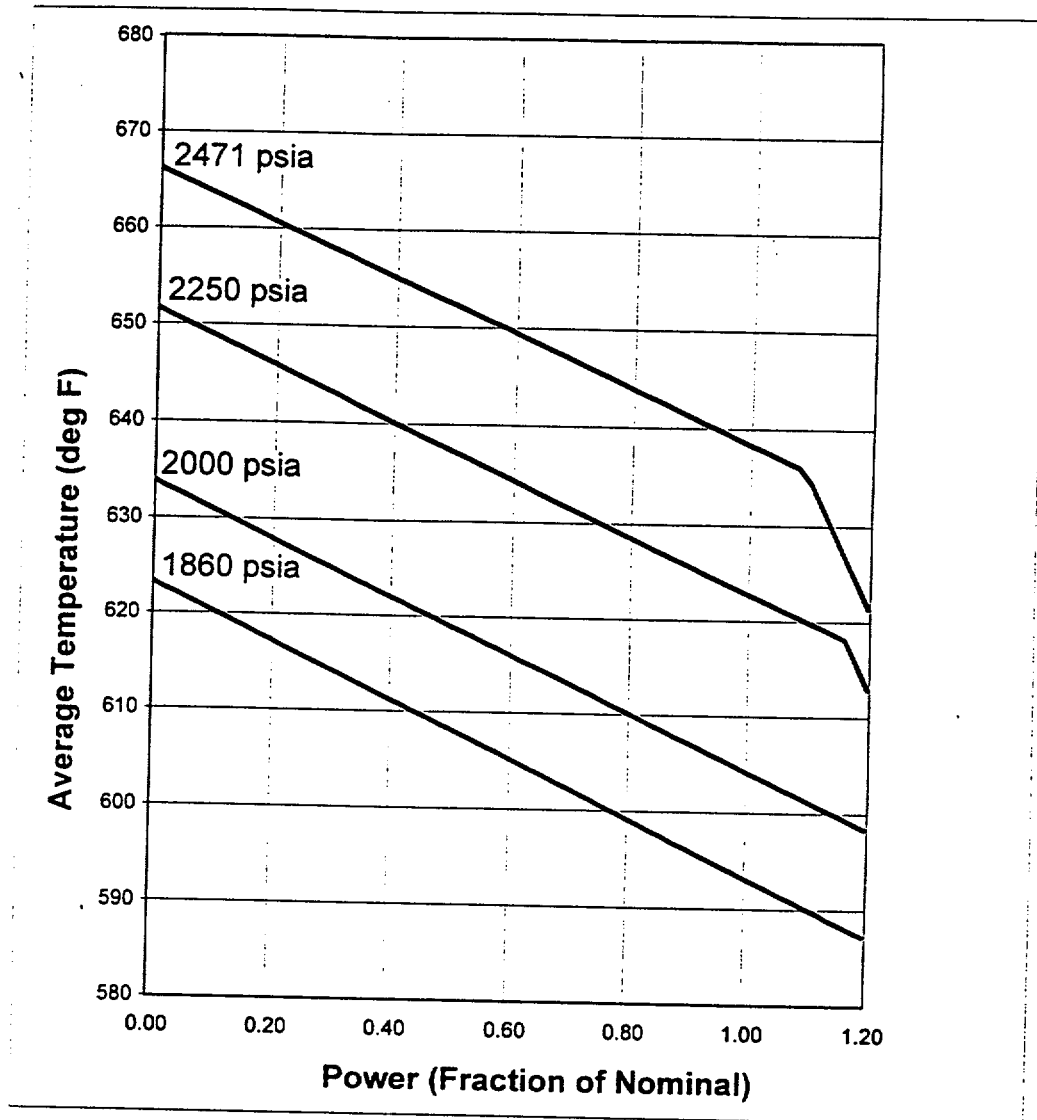
The Moderator Temperature Coefficient (MTC) limits are:

- 2.3.1 The BOL/ARO/HZP-MTC upper limit shall be $+3.3 \times 10^{-5} \Delta k/k/^\circ F$.
- 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.

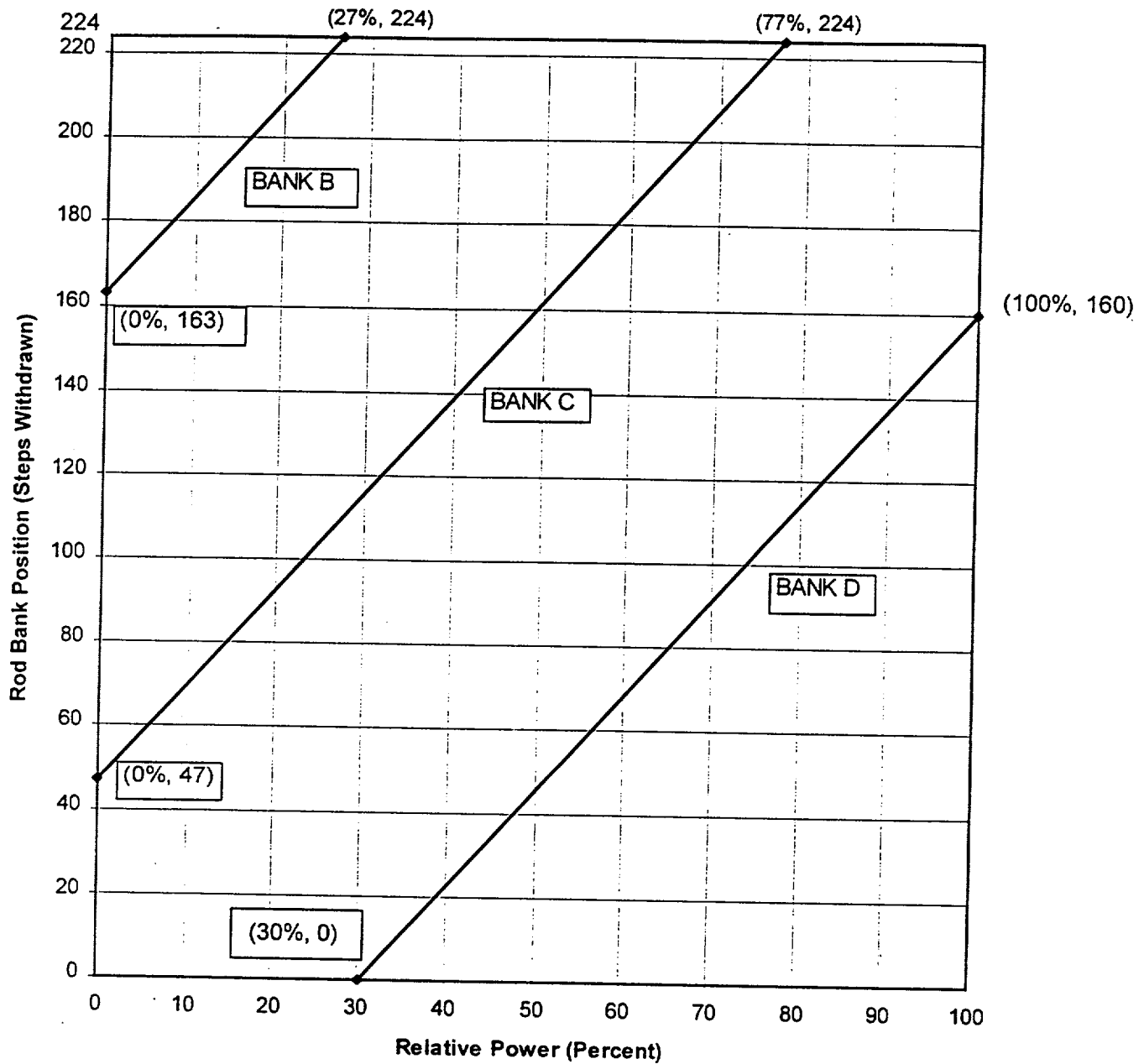
2.5.2 Each control bank shall be considered fully withdrawn from the core at greater than or equal to 224 steps.

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 ≤ 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.

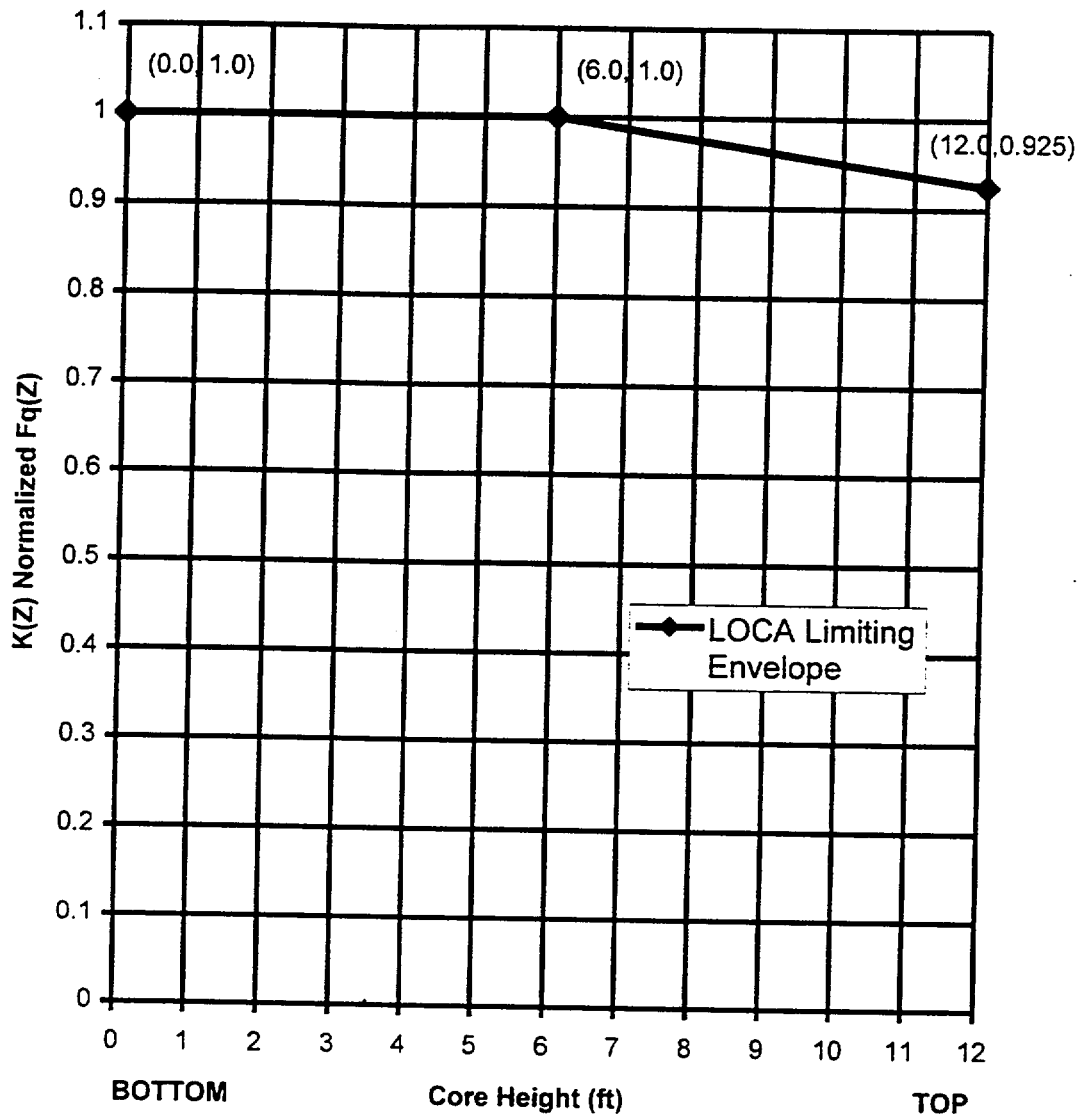
The normal operation $W(Z)$ values have been determined at burnups of 150, 8000 and 18800 MWD/MTU.

Table 2.6.2 shows the $F_q^C(z)$ 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.

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

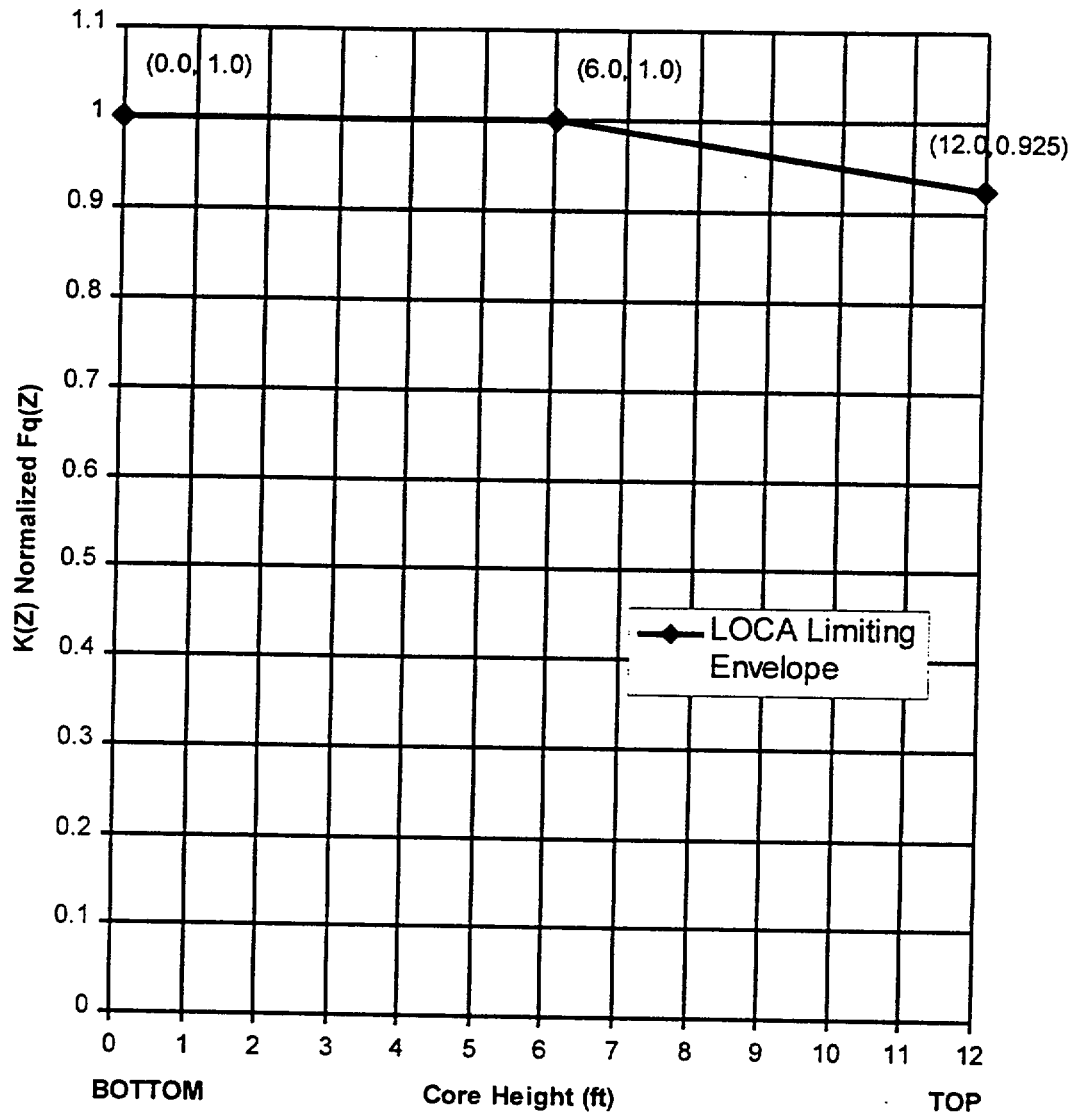
CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 9

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



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

Height
Feet

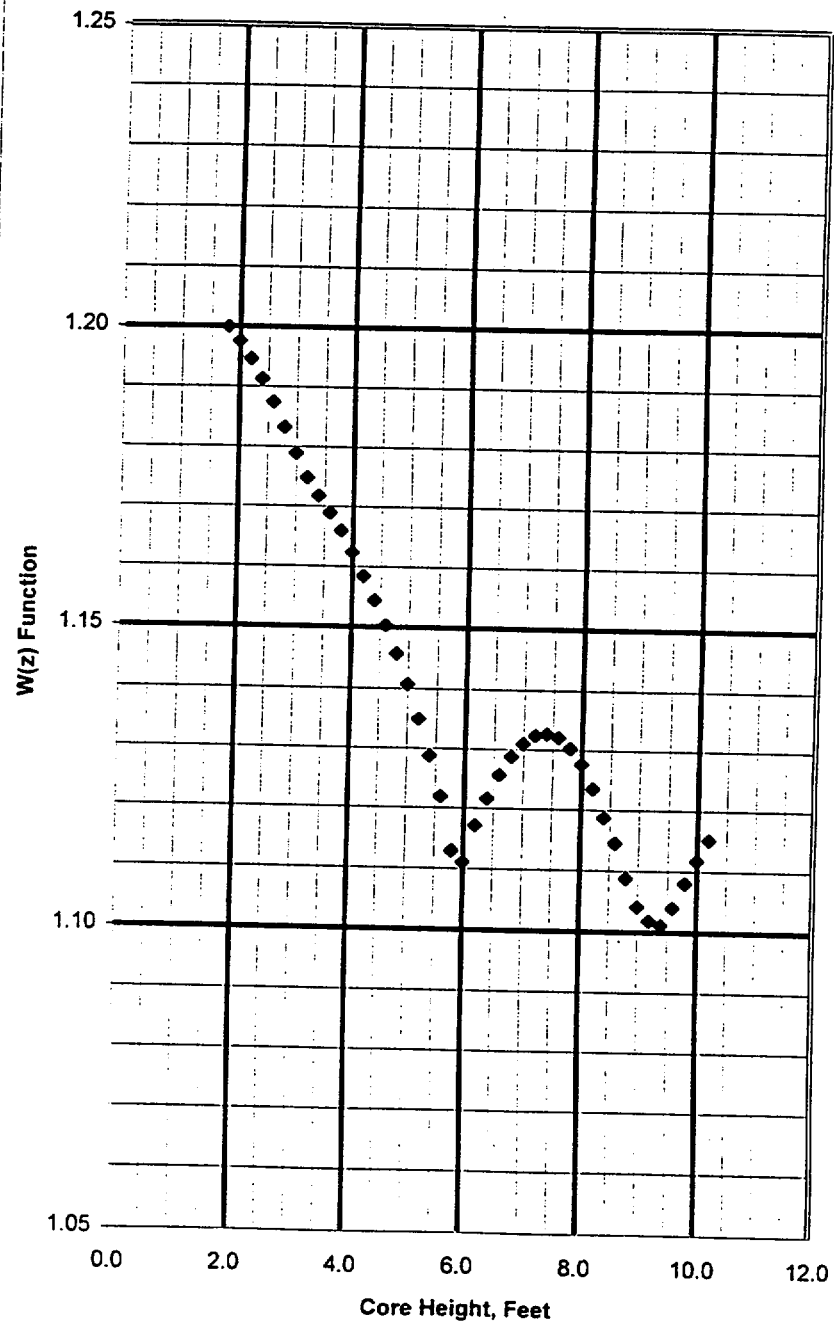
Max W(z)

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)

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



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

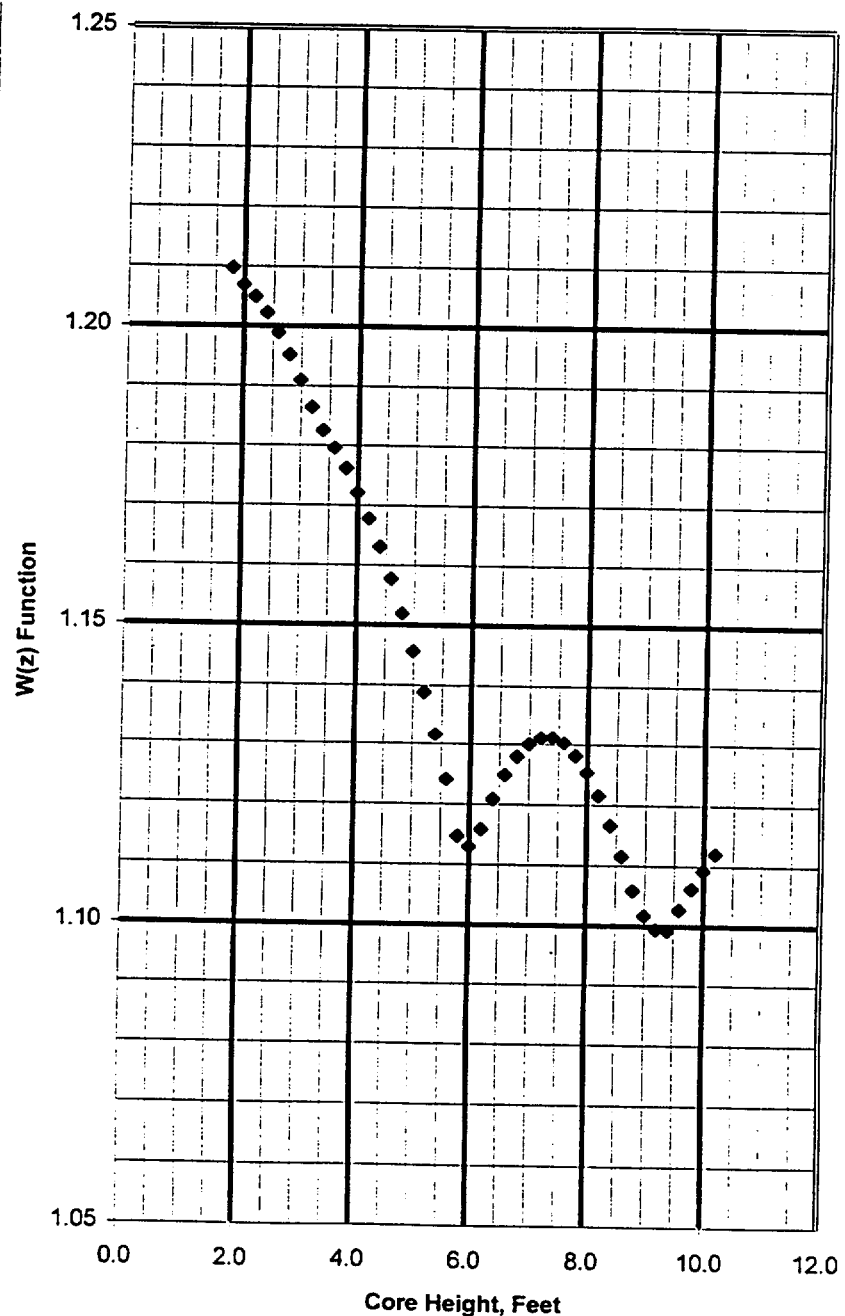
Height
Feet

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)

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



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

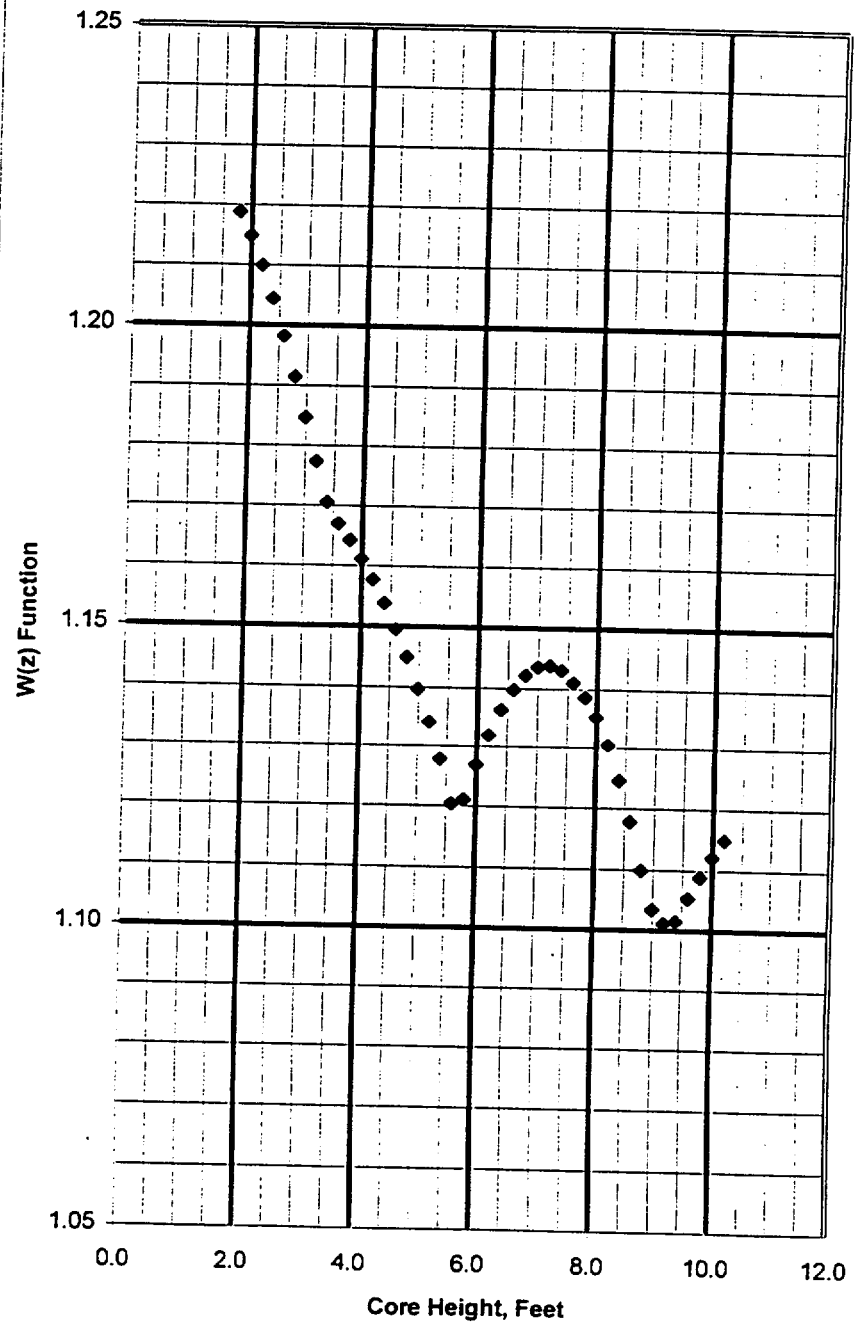
Height
Feet

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)

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



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

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

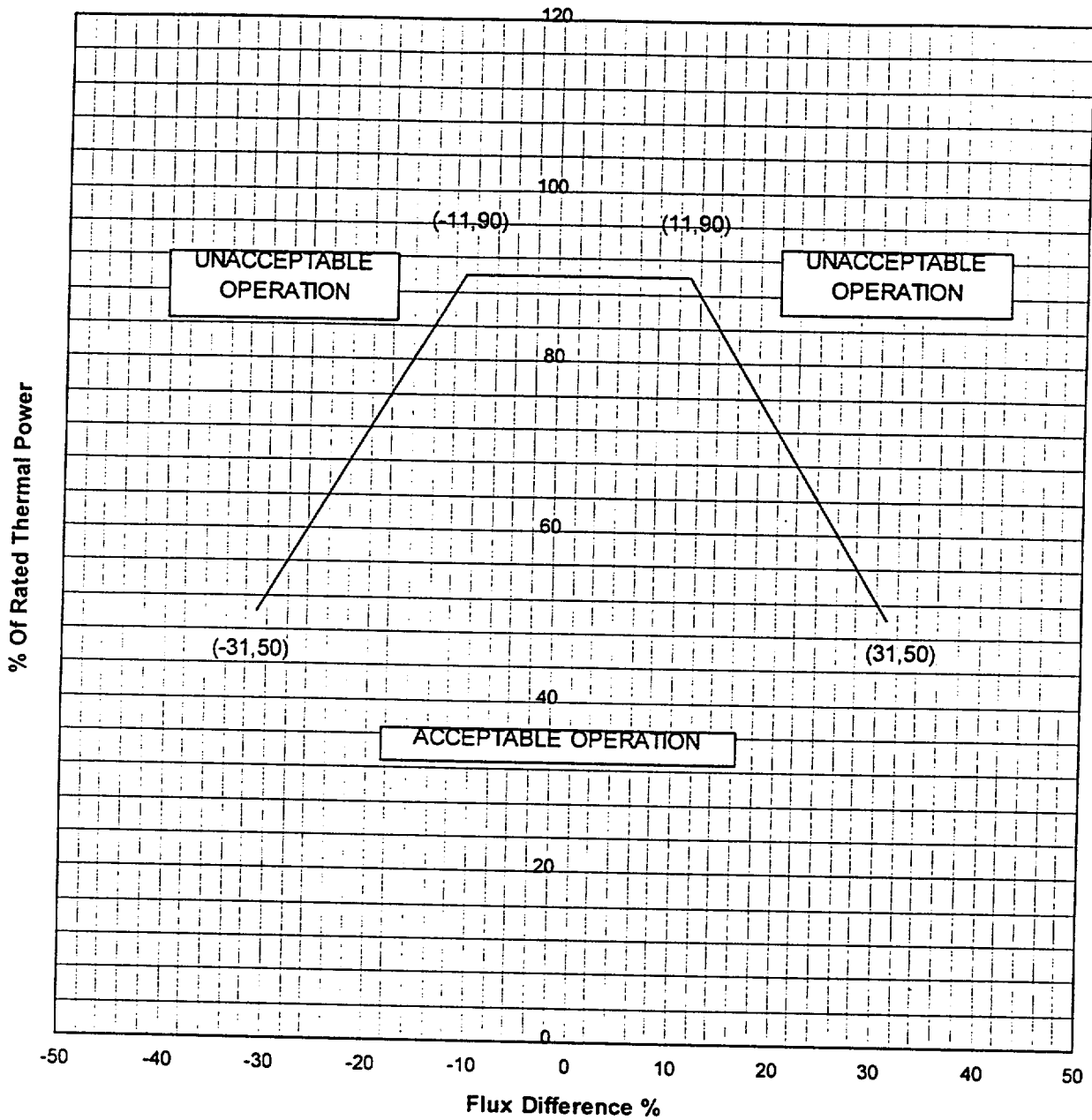
$$PF_{\Delta H} = 0.3$$

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)