

Commonwealth Edison Company  
Braidwood Generating Station  
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Braceville, IL 60407-9619  
Tel 815-458-2801



March 22, 2000  
BW000032

U.S. Nuclear Regulatory Commission  
ATTN: Document Control Desk  
Washington, DC 20555-0001

Braidwood Station, Unit 1  
Facility Operating License No. NPF-72  
NRC Docket No. STN 50-456

Subject: Braidwood Station Unit 1 Cycle 9 Core Operating Limits Report

Braidwood Station Unit 1 has recently completed its eighth cycle of operation. The purpose of this letter is to advise you of ComEd's review of the Cycle 9 reload under the provisions of 10CFR50.59 and transmit the Core Operation Limits Report (COLR) for the upcoming cycle consistent with Generic Letter 88-16.

The Braidwood Station Unit 1 core, which consists of NRC approved fuel designs, was designed to operate within approved fuel design criteria, Technical Specifications and related bases 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 UFSAR events which could be affected by the reload are within allowable limits.

Consistent with past reloads, the reload licensing analyses performed for Cycle 9 utilized NRC approved methodologies. The fresh fuel loaded in Cycle 9 consists of 88 VANTAGE 5 fuel assemblies. There are 36 Region 11A assemblies with 4.80 without enrichment and 52 Region 11B assemblies with 4.60 without enrichment. The cycle specific power distribution limits for Cycle 9 are presented in the attached COLR.

ComEd has performed a detail review of the relevant reload licensing documents, the associated bases, and references. Based on that review, a safety evaluation was prepared, as required by 10CFR50.59, which concluded that the reload presents no unreviewed safety questions and required no Technical Specification changes. The Braidwood Independent Technical Review (ITR) review of the reload of the 10CFR50.59 has been completed.

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Finally, further verification of the reload core design is performed during startup testing. The start up tests are consistent with Technical Specifications and meet the intent of the testing recommended in ANSI 19.6.1.

If there are any questions regarding this matter please contact T. W. Simpkin at (815) 458-2801 extension 2980.

Respectfully,



T. J. Tulon  
Site Vice President  
Braidwood Station

Attachment

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

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>NFM0000014</u> Seq. No. <u>0</u> Page 1 of 15
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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		<u>1/21/00</u>
Preparer	Preparer's Signature	Date
E. Wurz		<u>1/21/00</u>
Reviewer	Reviewer's Signature	Date
R. Ng		<u>1/21/2000</u>
Reviewer	Reviewer's Signature	Date
D. Redden		<u>1/25/00</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 Braidwood Unit 1 Cycle 9 Core Operating Limits Report (COLR) in the ITS format and W(z) function.

Purpose of Information: This COLR incorporates the ITS format and W(Z) function. 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.

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) L. Kopley / G. Gosbee (BW) P. Boyle (BW)  
 E. H. Young (DG) R. M. Ng (DG) H. S. Kim/J. Dunlap (DG)  
 Braidwood Central File T. Simpkin (BW)  
 DG Central Files

**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:

- 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 3.3.9 Boron Dilution Protection System (BDPS)
- 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 Shutdown Margin (SDM)

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

- 2.1.1 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:

- 2.1.2.1 SDM shall be greater than or equal to 1.0%  $\Delta k/k$  (LCO 3.1.1).
- 2.1.2.2 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).

### 2.2 Moderator Temperature Coefficient (LCO 3.1.3)

The Moderator Temperature Coefficient (MTC) limits are:

- 2.2.1 The BOL/ARO/HZP-MTC shall be less positive than  $+3.4 \times 10^{-5} \Delta k/k/^\circ F$ .
- 2.2.2 The EOL/ARO/HFP-MTC shall be less negative than  $-4.1 \times 10^{-4} \Delta k/k/^\circ F$ .
- 2.2.3 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 BRAIDWOOD UNIT 1 CYCLE 9

2.3 Shutdown Bank Insertion Limit (LCO 3.1.5)

2.3.1 All shutdown banks shall be withdrawn to at least 228 steps.

2.4 Control Bank Insertion Limits (LCO 3.1.6)

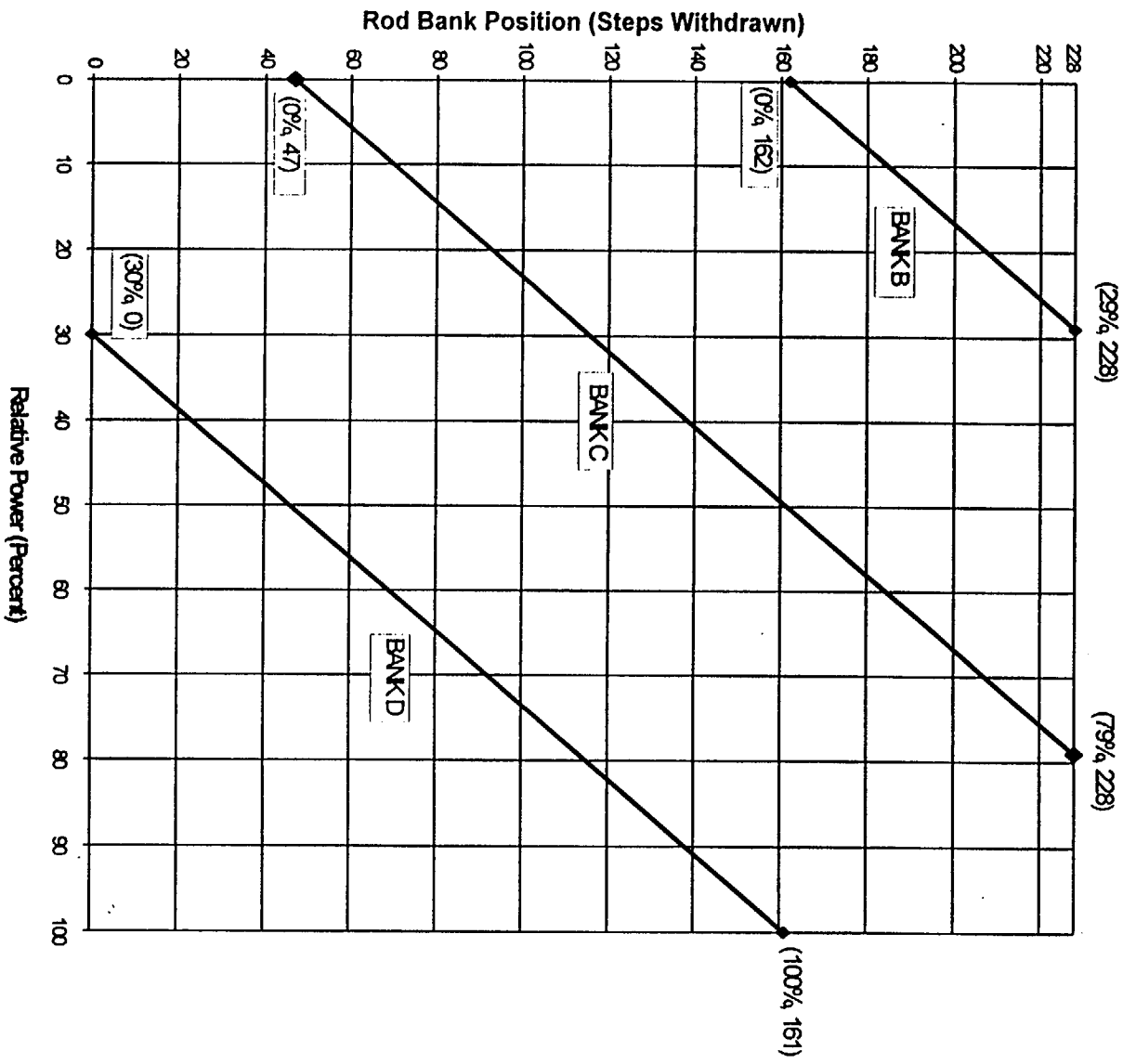
2.4.1 The control banks shall be limited in physical insertion as shown in Figure 2.4.1.

2.4.2 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.

2.4.3 The control banks shall be operated with a 113 step overlap.

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

Figure 2.4.1:  
Control Bank Insertion Limits Versus Percent Rated Thermal Power



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

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

## 2.5.1

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

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

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 2.5.1.  
 $K(Z)$  for assembly average burnup  $\leq$  4000 MWD/MTU is provided in Figure 2.5.1.a.

2.5.2  $W(Z)$  is provided in Figures 2.5.2.a through 2.5.2.d.

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

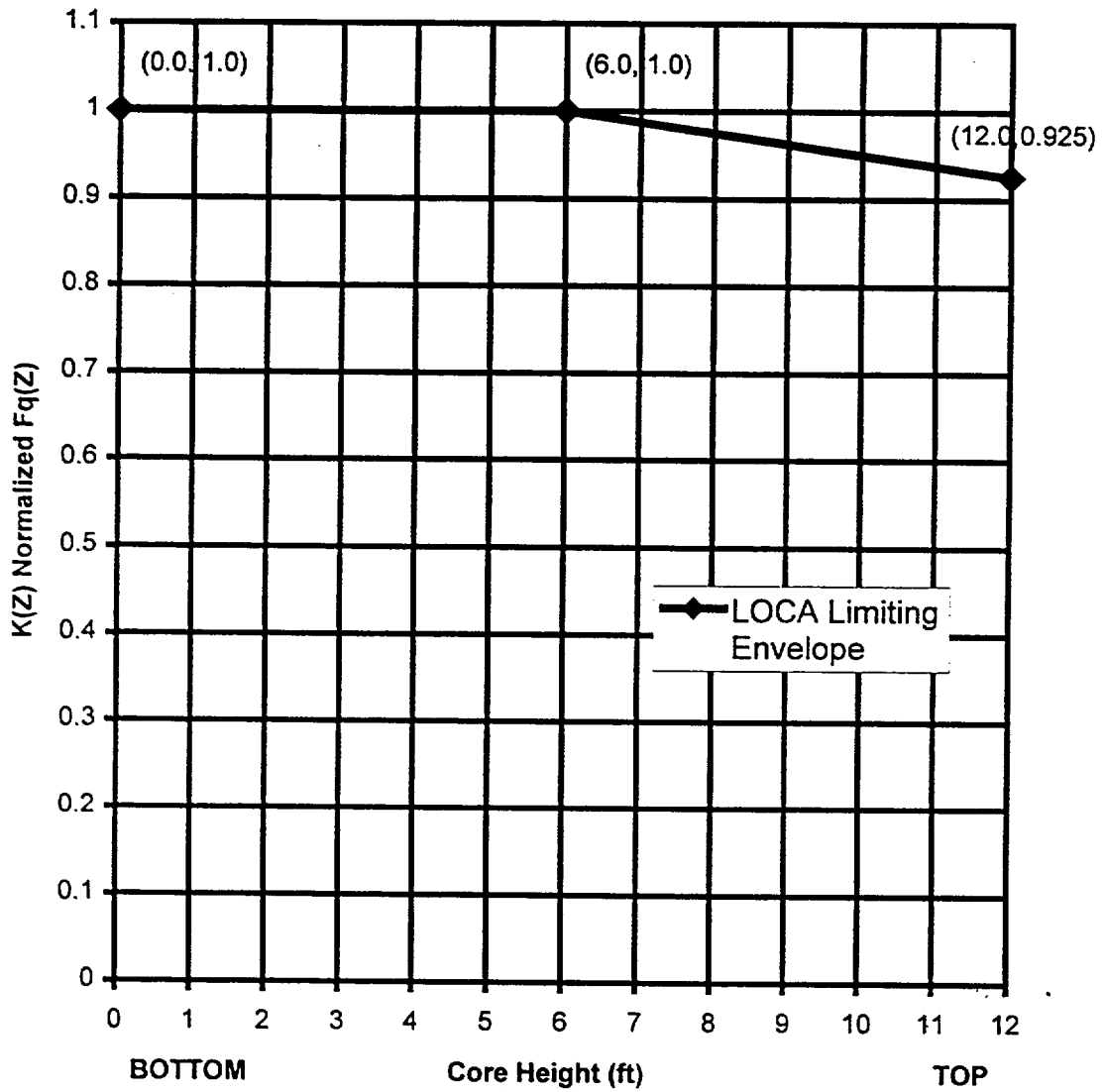
Table 2.5.2 shows the  $F_{o(z)}^C$  penalty factors that are greater than 2% per 31 Effective Full Power Days. These values shall be used to increase the  $F_{o(z)}^W$  as per Surveillance Requirement 3.2.1.2. A 2% penalty factor shall be used at all cycle burnups that are outside the range of Table 2.5.2.

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



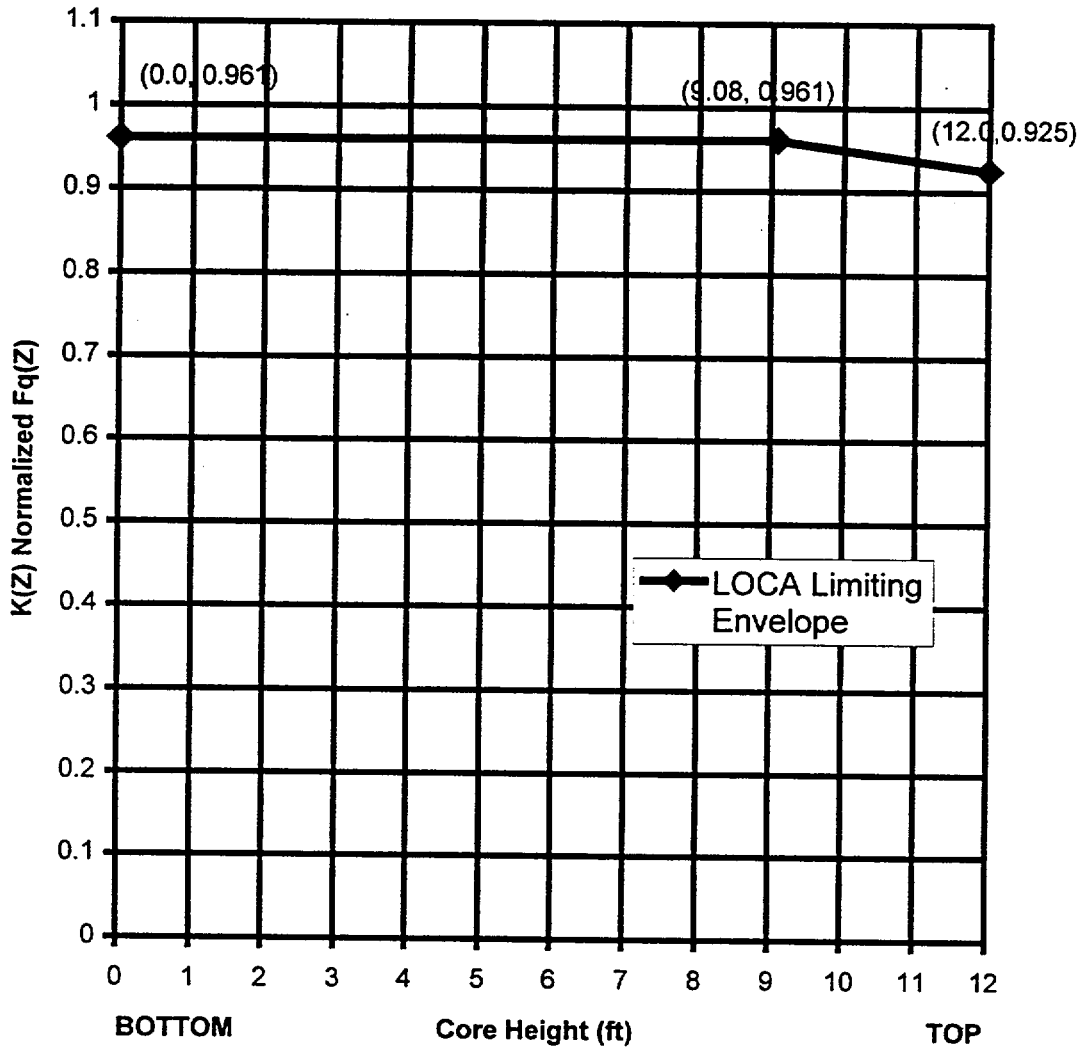
CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 1 CYCLE 9

Figure 2.5.1:  $K(Z)$  - Normalized  $Fq(Z)$  as a Function of Core Height (Assembly BU > 4000 MWD/MTU)



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

Figure 2.5.1.a: K(Z) - Normalized Fq(Z) as a Function of Core Height (Assembly BU ≤ 4000 MWD/MTU)



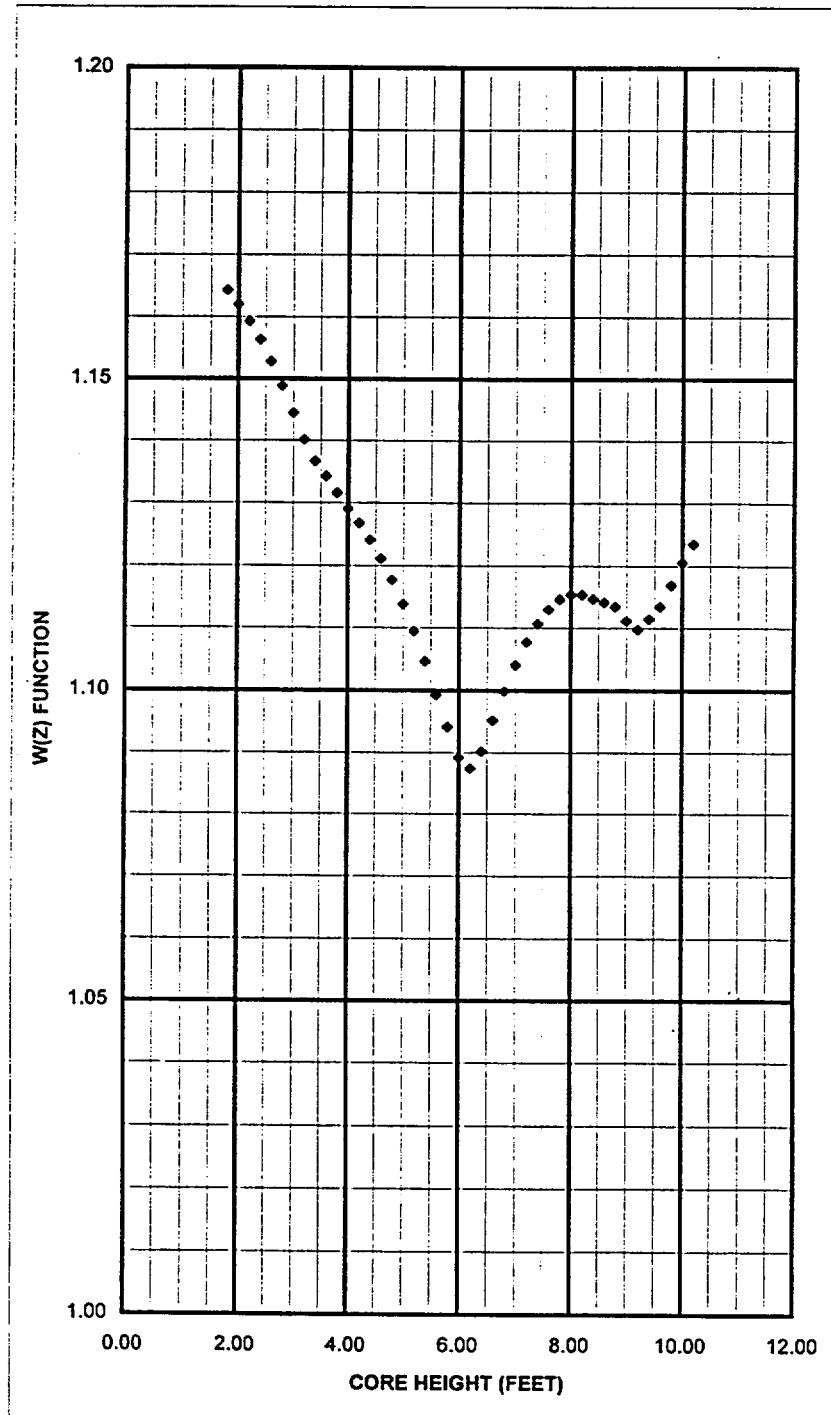
CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 1 CYCLE 9

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 2.5.2.a

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



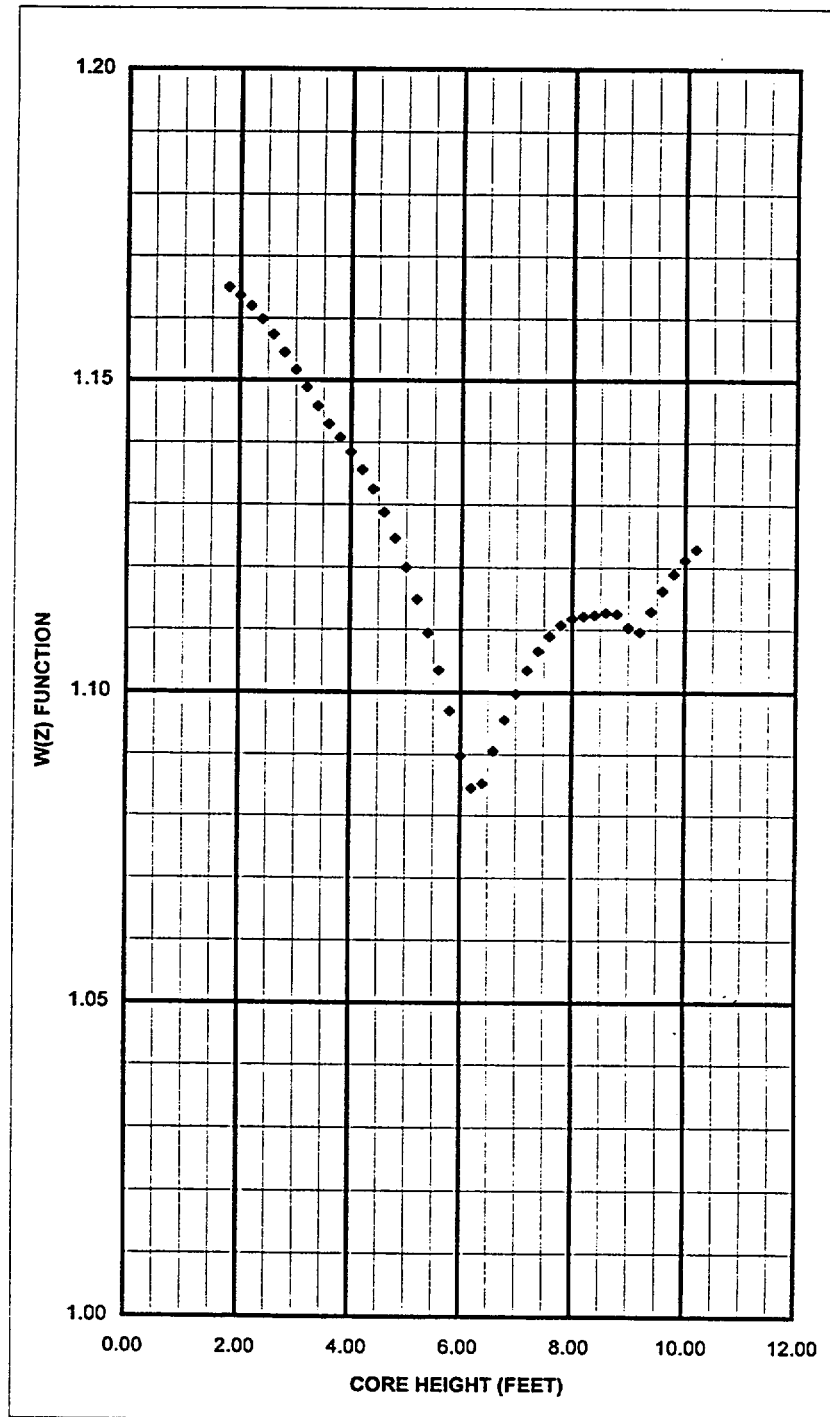
CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 1 CYCLE 9

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 2.5.2.b

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



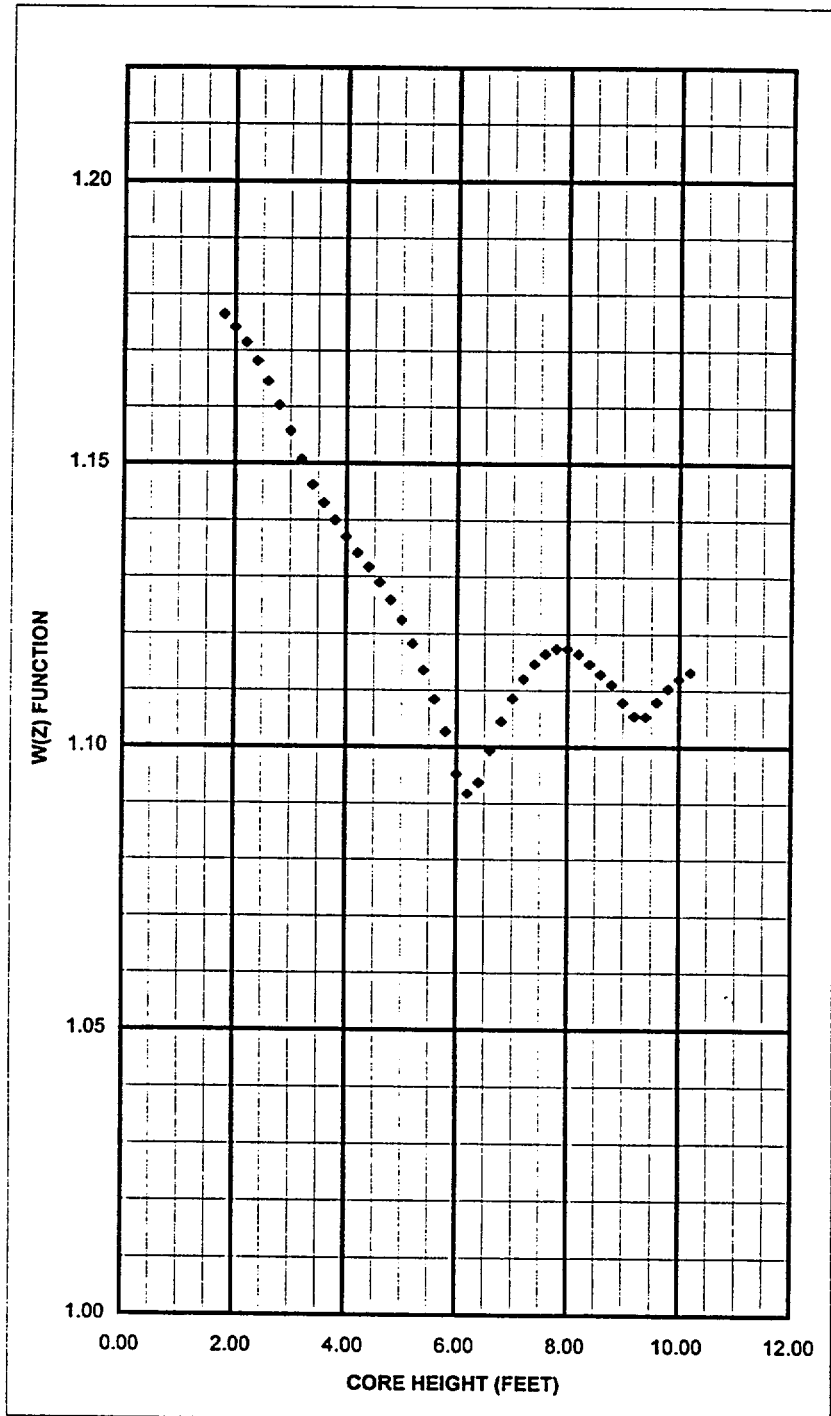
CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 1 CYCLE 9

Height 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	1.1765
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 2.5.2.c

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



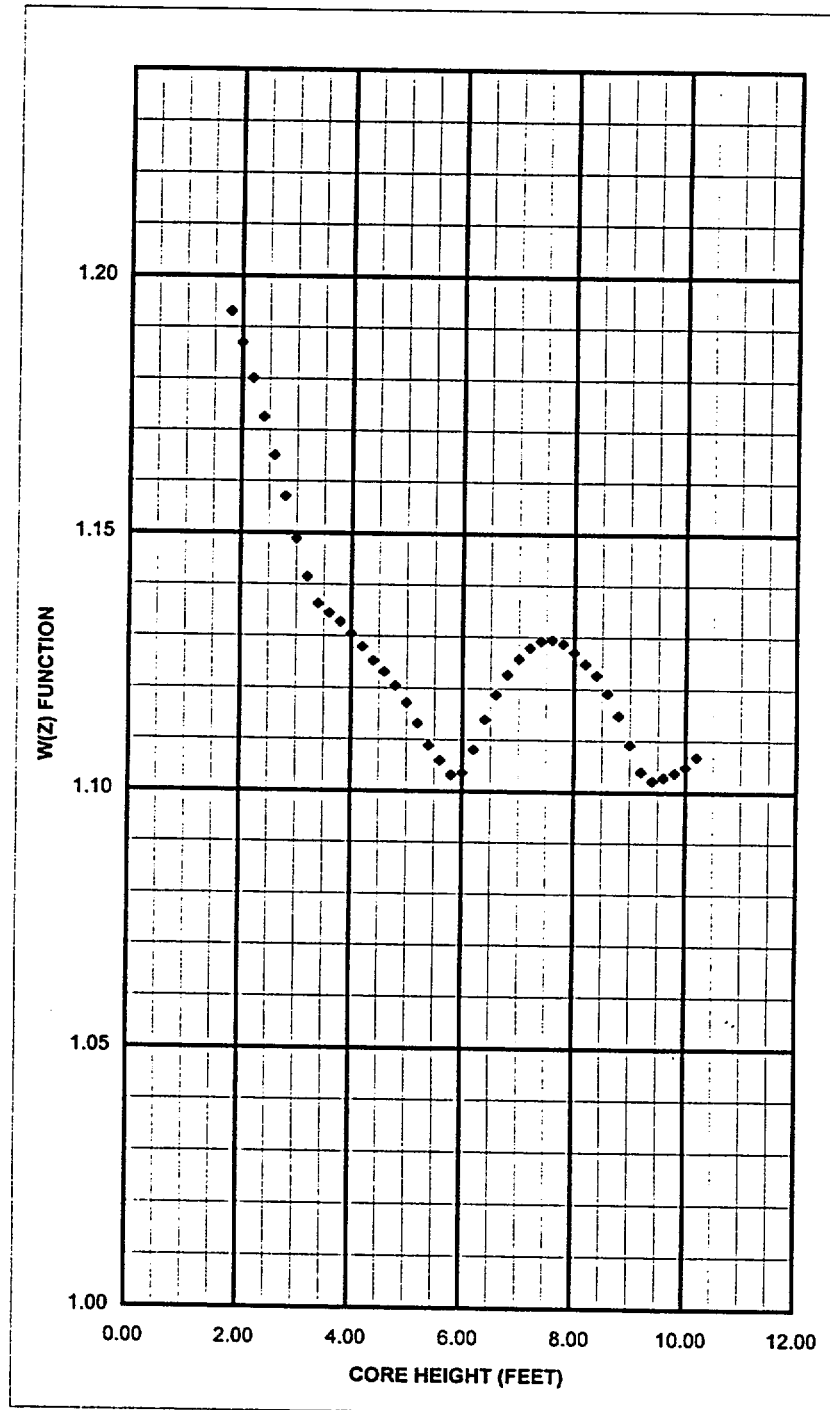
CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 1 CYCLE 9

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 2.5.2.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 2.5.2 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

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

$$2.6.1 \quad F_{\Delta H}^N \leq F_{\Delta H}^{RTP} [1.0 + PF_{\Delta H}(1.0 - P)]$$

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

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

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

2.7 Axial Flux Difference (AFD) (LCO 3.2.3)

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

2.7.2 The AFD Acceptable Operation Limits are provided in Figure 2.7.1.

2.8 Boron Concentration

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

2.8.2 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)



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

FIGURE 2.7.1: Axial Flux Difference Limits As A Function of Rated Thermal Power

