



Tennessee Valley Authority, Post Office Box 2000, Spring City, Tennessee 37381-2000

August 20, 2018

10 CFR 50.4

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

Watts Bar Nuclear Plant, Units 1 and 2
Facility Operating License Nos. NPF-90 and NPF-96
NRC Docket Nos. 50-390 and 50-391

Subject: **UNIT 1 REVISION 1 OF THE CYCLE 15 CORE OPERATING LIMITS REPORT (COLR) and UNIT 2 REVISION 1 OF THE CYCLE 2 CORE OPERATING LIMITS REPORT (COLR)**

Pursuant to Watts Bar Nuclear Plant Technical Specifications (Tech Spec) Section 5.9.5.d, Tennessee Valley Authority (TVA) has enclosed Revision 1 of the Unit 1 Cycle 15 COLR and Revision 1 of the Unit 2 Cycle 2 COLR. This revision added shutdown margin limits for Tech Spec 3.1.5, 3.1.6, and 3.1.7 per a NRC Commitment. The analytical methods used to determine the core operating limits were previously reviewed and approved by the NRC.

There are no regulatory commitments contained in this letter or the enclosure. Should you have questions regarding this submittal, please contact Kim Hulvey at (423) 365-7720.

Respectfully,

A handwritten signature in black ink, appearing to read 'Paul Simmons', written over a horizontal line.

Paul Simmons
Site Vice President
Watts Bar Nuclear Plant

U.S. Regulatory Commission
Page 2
August 20, 2018

Enclosures: Watts Bar Nuclear Plant, Unit 1, Cycle 15 Core Operating Limits Report,
Revision 1, January 2018
Watts Bar Nuclear Plant, Unit 2, Cycle 2 Core Operating Limits Report,
Revision 1, January 2018

cc (Enclosure):

NRC Regional Administrator - Region II
NRR Project Manager
NRC Senior Resident Inspector

ENCLOSURE 1

**Watts Bar Nuclear Plant, Unit 1, Cycle 15
Core Operating Limits Report
Revision 1
January 2018**

QA Record
L38 180118 800

WATTS BAR NUCLEAR PLANT, UNIT 1, CYCLE 15

CORE OPERATING LIMITS REPORT

Revision 1

January 2018

Prepared by:

W. Andrew Whitener / 1/19/2018
W. Andrew Whitener, Nuclear Fuel Programs & Oversight Date

Verified by:

John A. Ritchie / 1/19/2018
John A. Ritchie, PWR Fuel Engineering Date

Reviewed by:

Christine A. Setter / 1/19/2018
Christine A. Setter, Manager, PWR Fuel Engineering Date

Bryan T. Mack / 1/22/2018
Bryan T. Mack, Manager, Reactor Engineering Date

Approved by:

J. M. [Signature] / 1/26/18
PORC Chairman Date

[Signature] / 1/26/18
Plant Manager Date

Revision	Date of PORC Approval	Affected Pages	Reason for Revision
0	03/23/2017	All	Initial issue
1	See above	1 - 5	Added Shutdown Margin limits for TS 3.1.5, 3.1.6, and 3.1.7 per NRC Commitment 119190730 (L44 171118 001). Renumbered as appropriate.

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Watts Bar Unit 1 Cycle 15 has been prepared in accordance with the requirements of the Technical Specification (TS) 5.9.5.

The Technical Specifications affected by this report are listed below:

- 3.1.4 Moderator Temperature Coefficient (MTC)
- 3.1.5 Rod Group Alignment Limits
- 3.1.6 Shutdown Bank Insertion Limits
- 3.1.7 Control Bank Insertion Limits
- 3.2.1 Heat Flux Hot Channel Factor ($F_Q(Z)$)
- 3.2.2 Nuclear Enthalpy Rise Hot Channel Factor ($F_{\Delta H}^N$)
- 3.2.3 Axial Flux Difference (AFD)
- 3.9.1 Boron Concentration

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 have been developed using the NRC approved methodologies specified in the Technical Specifications Section 5.9.5.

The following abbreviations are used in this section:

- BOL -- Beginning of Cycle Life
- ARO -- All Rods Out
- HZP -- Hot Zero Thermal Power
- EOL -- End of Cycle Life
- RTP -- Rated Thermal Power

2.1 MODERATOR TEMPERATURE COEFFICIENT - MTC (LCO 3.1.4)

2.1.1 The MTC limits are:

The ARO/HZP - MTC shall be less positive than or equal to $0 \Delta k/k/^\circ F$ (upper limit). With the measured BOL/ARO/HZP - MTC more positive than $-1.30 \times 10^{-5} \Delta k/k/^\circ F$ (as-measured MTC limit), establish control rod withdrawal limits to ensure the MTC remains less positive than or equal to $0 \Delta k/k/^\circ F$ (upper limit) for all times in core life.

The EOL/ARO/RTP - MTC shall be less negative than or equal to $-4.5 \times 10^{-4} \Delta k/k/^\circ F$ (lower limit).

2.1.2 The 300 ppm surveillance limit is:

The measured 300 ppm /ARO/RTP-MTC should be less negative than or equal to $-3.75 \times 10^{-4} \Delta k/k/^\circ F$.

2.1.3 The 60 ppm surveillance limit is:

The measured 60 ppm /ARO/RTP-MTC should be less negative than or equal to $-4.28 \times 10^{-4} \Delta k/k/^\circ F$.

2.2 SHUTDOWN MARGIN – SDM (LCO 3.1.5, 3.1.6, 3.1.7)

2.2.1 For TS 3.1.5, SDM shall be $\geq 1.6\% \Delta k/k$ in MODE 1 and MODE 2.

2.2.2 For TS 3.1.6, SDM shall be $\geq 1.6\% \Delta k/k$ in MODE 1 and MODE 2.

2.2.3 For TS 3.1.7, SDM shall be $\geq 1.6\% \Delta k/k$ in MODE 1 and MODE 2 with $k_{eff} \geq 1.0$.

2.3 SHUTDOWN BANK INSERTION LIMITS (LCO 3.1.6)

2.3.1 The shutdown banks shall be withdrawn to a position greater than or equal to 225 steps withdrawn.

2.4 CONTROL BANK INSERTION LIMITS (LCO 3.1.7)

2.4.1 The control banks are fully withdrawn or shall be limited in physical insertion as shown in Figure 1.

2.4.2 Each control bank shall be considered fully withdrawn from the core at greater than or equal to 225 steps.

2.4.3 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.

2.4.4 Each control bank not fully withdrawn from the core shall be operated with the following overlap as a function of park position.

Park Position (steps)	Bank Overlap (steps)	Bank Difference (steps)
225	109	116
226	110	116
227	111	116
228	112	116
229	113	116
230	114	116
231	115	116

2.5 HEAT FLUX HOT CHANNEL FACTOR - $F_Q(Z)$ (LCO 3.2.1)

$$F_Q(Z) \leq [CFQ / P] * K(Z) \quad \text{for } P > 0.5$$

$$F_Q(Z) \leq [CFQ / 0.5] * K(Z) \quad \text{for } P \leq 0.5$$

Where P = Thermal Power / Rated Thermal Power

2.5.1 CFQ = 2.50

2.5.2 K(Z) is provided in Figure 2.

2.5.3 $F_Q^W(Z) = F_Q^c(Z) * W(Z)/P$ for $P > 0.5$

$F_Q^W(Z) = F_Q^c(Z) * W(Z)/0.5$ for $P \leq 0.5$

where: W(Z) values are provided in Table A.1. The table provides sufficient information to determine W(Z) versus core height for all cycle burnups.

2.5.4 Part power W(Z) values are only required to be used when the part power surveillance is performed using the moveable incore detector system.

2.5.5 $F_Q^W(Z)$ Penalty Factor

The $F_Q^W(Z)$ penalty factor is provided in Table A.2.

2.6 NUCLEAR ENTHALPY RISE HOT CHANNEL FACTOR – $F_{\Delta H}^N$ (LCO 3.2.2)

$$F_{\Delta H}^N \leq F_{\Delta H}^{RTP} * (1 + PF * (1-P))$$

where P = Thermal Power / Rated Thermal Power

$$F_{\Delta H}^{RTP} = 1.65 \text{ for RFA-2 fuel, and}$$

$$PF = 0.3$$

2.7 AXIAL FLUX DIFFERENCE - AFD (LCO 3.2.3)

2.7.1 The AFD limits for Cycle 15 are provided in Figure 3.

2.8 REFUELING BORON CONCENTRATION (LCO 3.9.1)

2.8.1 The refueling boron concentration shall be ≥ 2000 ppm.

3.0 NUMBER OF TPBARS IN REACTOR CORE (TS 4.2.1)

3.0.1 There are 1104 tritium producing burnable absorber rods (TPBARs) in the reactor core for Cycle 15.

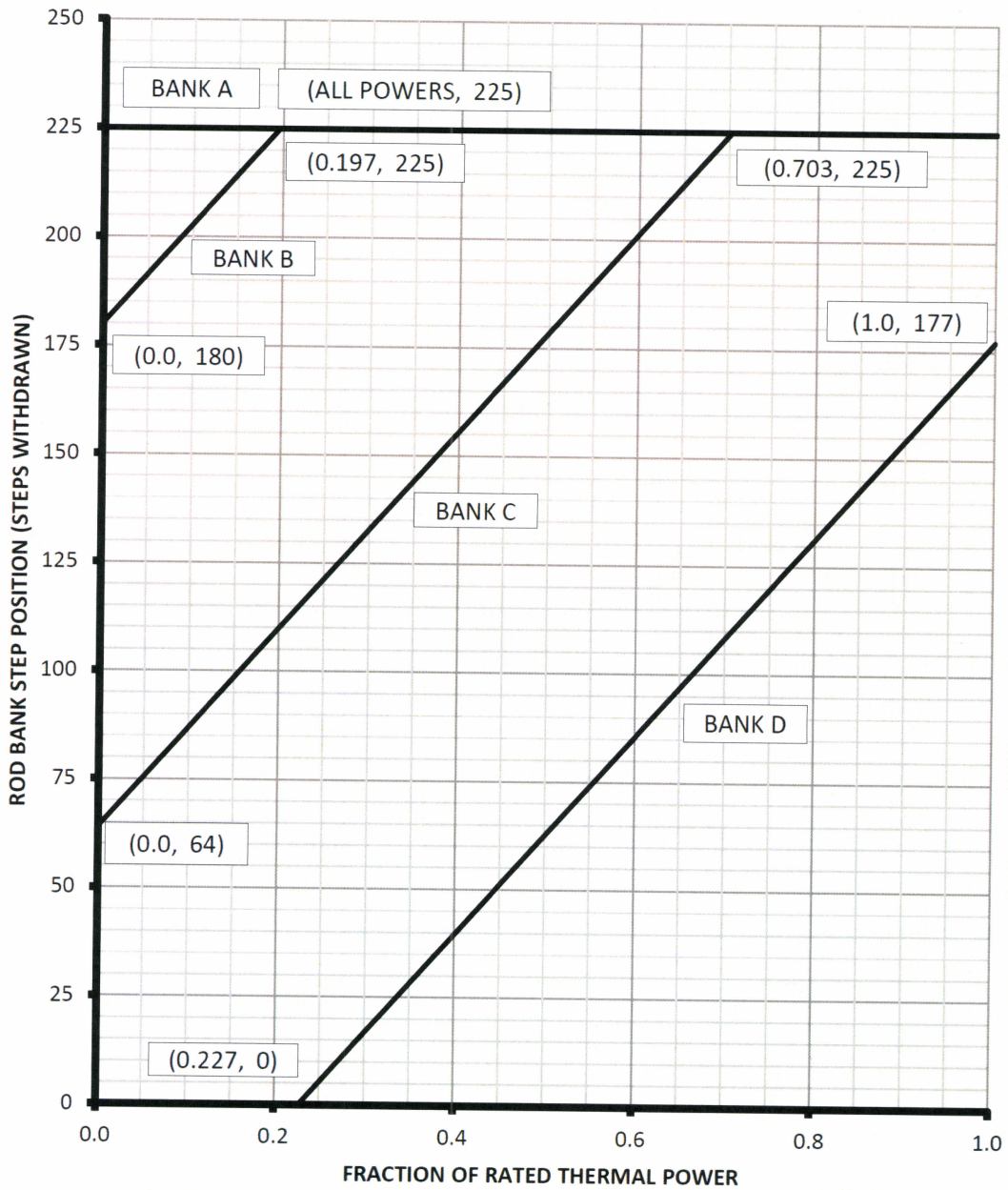


Figure 1
Control Bank Insertion Limits Versus Thermal Power
Four Loop Operation

Note: Fully withdrawn region shall be the condition where shutdown and control banks are at a position within the interval of ≥ 225 and ≤ 231 steps withdrawn.

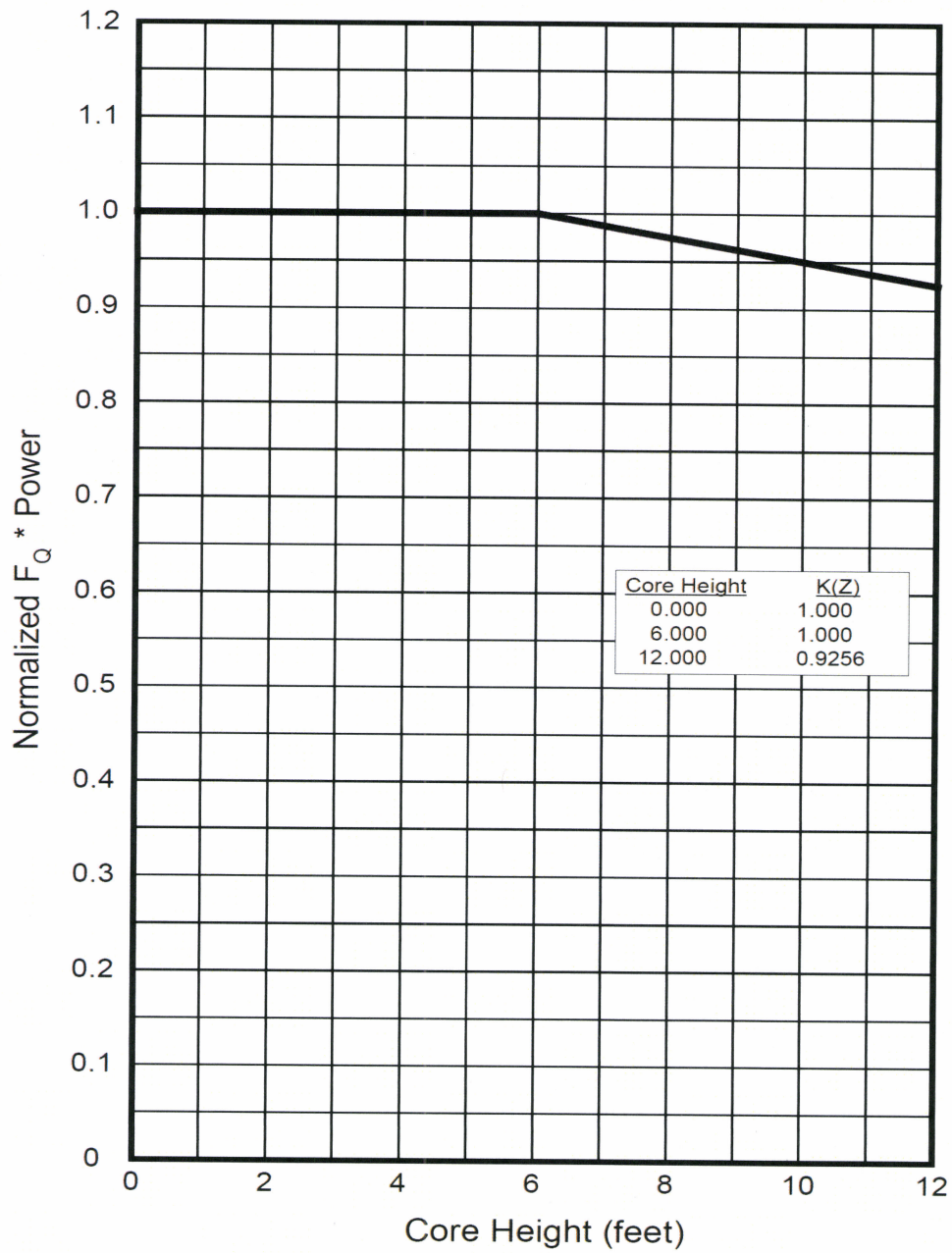


Figure 2
K(Z) - Normalized $F_Q(Z)$ as a Function of Core Height

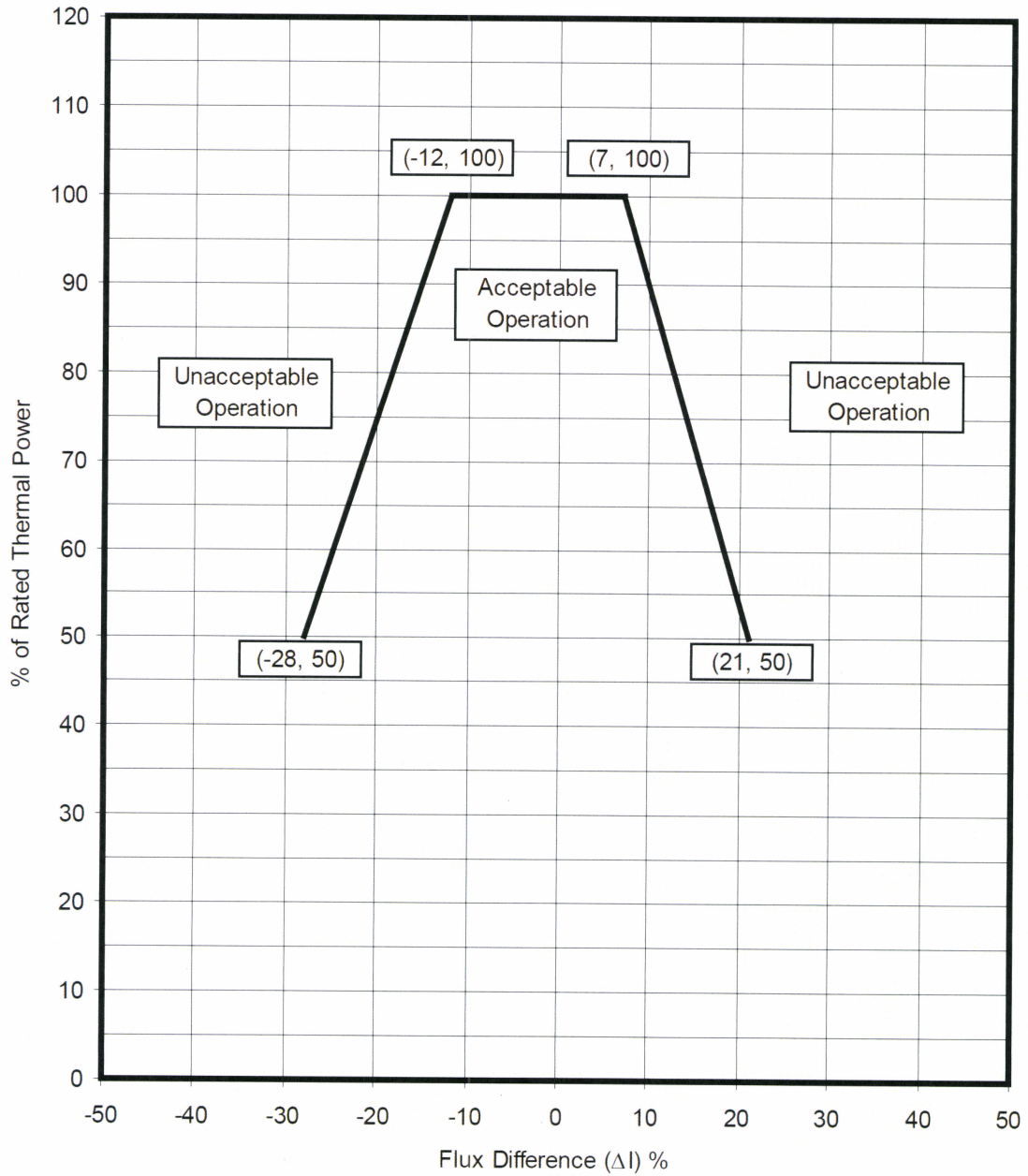


Figure 3
Axial Flux Difference Acceptable Operation Limits as a function of Rated Thermal Power (RAOC)

**Table A.1
RAOC W(Z) Surveillance Factors**

Height (ft)	Max W(z) at 150 MWD/MTU (30% Power)	Max W(z) at 150 MWD/MTU (75% Power)	Max W(z) at 150 MWD/MTU (100% Power)	Max W(z) at 2000 MWD/MTU (100% Power)	Max W(z) at 4000 MWD/MTU (100% Power)	Max W(z) at 8000 MWD/MTU (100% Power)	Max W(z) at 12000 MWD/MTU (100% Power)	Max W(z) at 16000 MWD/MTU (100% Power)	Max W(z) at 18000 MWD/MTU (100% Power)
12.0745	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11.8733	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11.6720	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11.4708	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11.2695	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11.0683	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
10.8671	1.3729	1.3564	1.2162	1.2531	1.2186	1.2040	1.1924	1.1753	1.1736
10.6658	1.3606	1.3342	1.2134	1.2489	1.2179	1.2013	1.1917	1.1714	1.1654
10.4646	1.3427	1.3152	1.2081	1.2427	1.2140	1.1961	1.1877	1.1708	1.1598
10.2633	1.3207	1.2945	1.2007	1.2378	1.2094	1.1892	1.1833	1.1619	1.1547
10.0621	1.3022	1.2699	1.1943	1.2317	1.2036	1.1816	1.1777	1.1563	1.1483
9.8608	1.2879	1.2469	1.1917	1.2237	1.1952	1.1720	1.1705	1.1517	1.1473
9.6596	1.2725	1.2237	1.1912	1.2180	1.1876	1.1645	1.1623	1.1509	1.1558
9.4584	1.2525	1.1971	1.1895	1.2168	1.1867	1.1652	1.1556	1.1590	1.1660
9.2571	1.2362	1.1777	1.1932	1.2139	1.1876	1.1659	1.1573	1.1637	1.1721
9.0559	1.2186	1.1667	1.1970	1.2087	1.1872	1.1654	1.1585	1.1664	1.1785
8.8546	1.1947	1.1537	1.1960	1.1998	1.1846	1.1659	1.1591	1.1723	1.1830
8.6534	1.1724	1.1439	1.1954	1.1936	1.1834	1.1704	1.1644	1.1821	1.1881
8.4522	1.1579	1.1436	1.2020	1.1983	1.1878	1.1772	1.1749	1.1949	1.2052
8.2509	1.1433	1.1451	1.2083	1.2025	1.1898	1.1820	1.1868	1.2085	1.2207
8.0497	1.1271	1.1450	1.2125	1.2042	1.1898	1.1847	1.1969	1.2204	1.2332
7.8484	1.1095	1.1445	1.2149	1.2046	1.1873	1.1857	1.2046	1.2297	1.2436
7.6472	1.0936	1.1432	1.2153	1.2032	1.1848	1.1850	1.2102	1.2366	1.2514
7.4459	1.0795	1.1412	1.2138	1.2001	1.1866	1.1825	1.2135	1.2410	1.2565
7.2447	1.0666	1.1385	1.2106	1.1953	1.1869	1.1776	1.2147	1.2430	1.2591
7.0435	1.0562	1.1339	1.2052	1.1894	1.1849	1.1756	1.2137	1.2426	1.2591
6.8422	1.0497	1.1308	1.2009	1.1848	1.1817	1.1751	1.2108	1.2399	1.2567
6.6410	1.0472	1.1305	1.1990	1.1817	1.1772	1.1727	1.2063	1.2352	1.2520
6.4397	1.0444	1.1285	1.1949	1.1766	1.1712	1.1692	1.2003	1.2290	1.2456
6.2385	1.0422	1.1258	1.1893	1.1696	1.1642	1.1640	1.1925	1.2207	1.2371
6.0373	1.0396	1.1219	1.1816	1.1634	1.1587	1.1581	1.1832	1.2105	1.2264
5.8360	1.0388	1.1190	1.1740	1.1578	1.1532	1.1529	1.1718	1.1982	1.2137
5.6348	1.0400	1.1175	1.1684	1.1520	1.1466	1.1494	1.1601	1.1846	1.1993
5.4335	1.0417	1.1161	1.1633	1.1474	1.1431	1.1469	1.1534	1.1719	1.1847
5.2323	1.0453	1.1158	1.1595	1.1446	1.1428	1.1449	1.1515	1.1629	1.1749
5.0310	1.0507	1.1171	1.1564	1.1431	1.1432	1.1456	1.1510	1.1612	1.1720
4.8298	1.0573	1.1189	1.1535	1.1418	1.1435	1.1476	1.1504	1.1610	1.1714
4.6286	1.0638	1.1199	1.1500	1.1399	1.1431	1.1485	1.1500	1.1594	1.1688
4.4273	1.0702	1.1203	1.1459	1.1373	1.1420	1.1489	1.1488	1.1573	1.1654
4.2261	1.0766	1.1199	1.1411	1.1342	1.1403	1.1487	1.1470	1.1544	1.1611
4.0248	1.0828	1.1193	1.1360	1.1306	1.1383	1.1482	1.1459	1.1511	1.1563
3.8236	1.0886	1.1177	1.1300	1.1268	1.1354	1.1468	1.1463	1.1468	1.1504
3.6224	1.0952	1.1170	1.1247	1.1227	1.1335	1.1461	1.1507	1.1437	1.1456
3.4211	1.1060	1.1203	1.1233	1.1184	1.1349	1.1496	1.1564	1.1449	1.1448
3.2199	1.1192	1.1258	1.1241	1.1193	1.1385	1.1550	1.1620	1.1469	1.1454
3.0186	1.1395	1.1382	1.1321	1.1281	1.1475	1.1637	1.1685	1.1522	1.1504
2.8174	1.1699	1.1599	1.1497	1.1469	1.1641	1.1795	1.1802	1.1653	1.1636
2.6161	1.2017	1.1826	1.1682	1.1669	1.1853	1.2012	1.1971	1.1843	1.1828
2.4149	1.2342	1.2067	1.1870	1.1873	1.2060	1.2220	1.2128	1.2023	1.2008
2.2137	1.2675	1.2308	1.2057	1.2077	1.2264	1.2424	1.2281	1.2198	1.2184
2.0124	1.3022	1.2547	1.2240	1.2277	1.2461	1.2622	1.2427	1.2367	1.2354
1.8112	1.3379	1.2781	1.2417	1.2469	1.2649	1.2809	1.2563	1.2528	1.2516
1.6099	1.3743	1.3004	1.2582	1.2650	1.2823	1.2981	1.2692	1.2677	1.2666
1.4087	1.4110	1.3210	1.2726	1.2808	1.2974	1.3130	1.2816	1.2805	1.2795
1.2075	1.4466	1.3383	1.2834	1.2933	1.3087	1.3239	1.2904	1.2894	1.2885
1.0062	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.8050	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.6037	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.4025	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.2012	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table A.2
 $F_Q^W(Z)$ Penalty Factor

Core Burnup (MWD/MTU)	$F_Q^W(Z)$ Penalty Factor
All Burnups	1.0200

Note:

1. The Penalty Factor, which is applied to $F_Q^W(Z)$ for compliance with Surveillance Requirement 3.2.1.2, is the maximum factor by which $F_Q^W(Z)$ is expected to increase per 31 Effective Full Power Days (EFPD) starting from the burnup at which the $F_Q^W(Z)$ was determined.

ENCLOSURE 2

**Watts Bar Nuclear Plant, Unit 2, Cycle 2
Core Operating Limits Report
Revision 1
January 2018**

QA Record
L36 180118 801

WATTS BAR NUCLEAR PLANT, UNIT 2, CYCLE 2

CORE OPERATING LIMITS REPORT

Revision 1

January 2018

Prepared by:

W. Andrew Whitener / 1/19/2018
W. Andrew Whitener, Nuclear Fuel Programs & Oversight Date

Verified by:

John A. Ritchie / 1/19/2018
John A. Ritchie, PWR Fuel Engineering Date

Reviewed by:

Christine A. Setter / 1/19/2018
Christine A. Setter, Manager, PWR Fuel Engineering Date

Bryan T. Mack / 1/22/2018
Bryan T. Mack, Manager, Reactor Engineering Date

Approved by:

[Signature] / 1/26/18
PORC Chairman Date

[Signature] / 1/26/18
Plant Manager Date

Revision	Date of PORC Approval	Affected Pages	Reason for Revision
0	11/15/2017	All	Initial issue
1	See above	1 - 5	Added Shutdown Margin limits for TS 3.1.5, 3.1.6, and 3.1.7 per NRC Commitment 119180730 (L44 171116 001). Renumbered as appropriate.

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Watts Bar Unit 2 Cycle 2 has been prepared in accordance with the requirements of the Technical Specification (TS) 5.9.5.

The Technical Specifications affected by this report are listed below:

- 3.1.4 Moderator Temperature Coefficient (MTC)
- 3.1.5 Rod Group Alignment Limits
- 3.1.6 Shutdown Bank Insertion Limits
- 3.1.7 Control Bank Insertion Limits
- 3.2.1 Heat Flux Hot Channel Factor ($F_Q(Z)$)
- 3.2.2 Nuclear Enthalpy Rise Hot Channel Factor ($F_{\Delta H}^N$)
- 3.2.3 Axial Flux Difference (AFD)
- 3.9.1 Boron Concentration

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 have been developed using the NRC approved methodologies specified in the Technical Specifications Section 5.9.5.

The following abbreviations are used in this section:

BOL	--	Beginning of Cycle Life
ARO	--	All Rods Out
HZP	--	Hot Zero Thermal Power
EOL	--	End of Cycle Life
RTP	--	Rated Thermal Power

2.1 MODERATOR TEMPERATURE COEFFICIENT - MTC (LCO 3.1.4)

2.1.1 The MTC limits are:

The ARO/HZP - MTC shall be less positive than or equal to $0 \Delta k/k/^\circ F$ (upper limit). With the measured BOL/ARO/HZP - MTC more positive than $-2.25 \times 10^{-5} \Delta k/k/^\circ F$ (as-measured MTC limit), establish control rod withdrawal limits to ensure the MTC remains less positive than or equal to $0 \Delta k/k/^\circ F$ (upper limit) for all times in core life.

The EOL/ARO/RTP - MTC shall be less negative than or equal to $-4.50 \times 10^{-4} \Delta k/k/^\circ F$ (lower limit).

2.1.2 The 300 ppm surveillance limit is:

The measured 300 ppm /ARO/RTP-MTC should be less negative than or equal to $-3.65 \times 10^{-4} \Delta k/k/^\circ F$.

2.1.3 The 60 ppm surveillance limit is:

The measured 60 ppm /ARO/RTP-MTC should be less negative than or equal to $-4.18 \times 10^{-4} \Delta k/k/^\circ F$.

2.2 SHUTDOWN MARGIN – SDM (LCO 3.1.5, 3.1.6, 3.1.7)

2.2.1 For TS 3.1.5, SDM shall be $\geq 1.6\% \Delta k/k$ in MODE 1 and MODE 2.

2.2.2 For TS 3.1.6, SDM shall be $\geq 1.6\% \Delta k/k$ in MODE 1 and MODE 2.

2.2.3 For TS 3.1.7, SDM shall be $\geq 1.6\% \Delta k/k$ in MODE 1 and MODE 2 with $k_{\text{eff}} \geq 1.0$.

2.3 SHUTDOWN BANK INSERTION LIMITS (LCO 3.1.6)

2.3.1 The shutdown banks shall be withdrawn to a position greater than or equal to 225 steps withdrawn.

2.4 CONTROL BANK INSERTION LIMITS (LCO 3.1.7)

2.4.1 The control banks are fully withdrawn or shall be limited in physical insertion as shown in Figure 1.

2.4.2 Each control bank shall be considered fully withdrawn from the core at greater than or equal to 225 steps.

2.4.3 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.

2.4.4 Each control bank not fully withdrawn from the core shall be operated with the following overlap as a function of park position.

Park Position (steps)	Bank Overlap (steps)	Bank Difference (steps)
225	109	116
226	110	116
227	111	116
228	112	116
229	113	116
230	114	116
231	115	116

2.5 HEAT FLUX HOT CHANNEL FACTOR - $F_Q(Z)$ (LCO 3.2.1)

$$F_Q(Z) \leq [CFQ / P] * K(Z) \quad \text{for } P > 0.5$$

$$F_Q(Z) \leq [CFQ / 0.5] * K(Z) \quad \text{for } P \leq 0.5$$

Where P = Thermal Power / Rated Thermal Power

2.5.1 CFQ = 2.50

2.5.2 K(Z) is provided in Figure 2.

$$2.5.3 F_Q^W(Z) = F_Q^C(Z) * W(Z)/P \quad \text{for } P > 0.5$$

$$F_Q^W(Z) = F_Q^C(Z) * W(Z)/0.5 \quad \text{for } P \leq 0.5$$

where: W(Z) values are provided in Table A.1. The table provides sufficient information to determine W(Z) versus core height for all cycle burnups.

2.5.4 Part power W(Z) values are only required to be used when the part power surveillance is performed using the fixed incore detector system.

2.5.5 $F_Q^W(Z)$ Penalty Factor

The $F_Q^W(Z)$ penalty factor is provided in Table A.2.

2.6 NUCLEAR ENTHALPY RISE HOT CHANNEL FACTOR – $F_{\Delta H}^N$ (LCO 3.2.2)

$$F_{\Delta H}^N \leq F_{\Delta H}^{RTP} * (1 + PF * (1-P))$$

where P = Thermal Power / Rated Thermal Power

$F_{\Delta H}^{RTP} = 1.65$ for RFA-2 fuel, and

PF = 0.3

2.7 AXIAL FLUX DIFFERENCE - AFD (LCO 3.2.3)

2.7.1 The AFD limits for Cycle 2 are provided in Figure 3.

2.8 REFUELING BORON CONCENTRATION (LCO 3.9.1)

2.8.1 The refueling boron concentration shall be ≥ 2000 ppm.

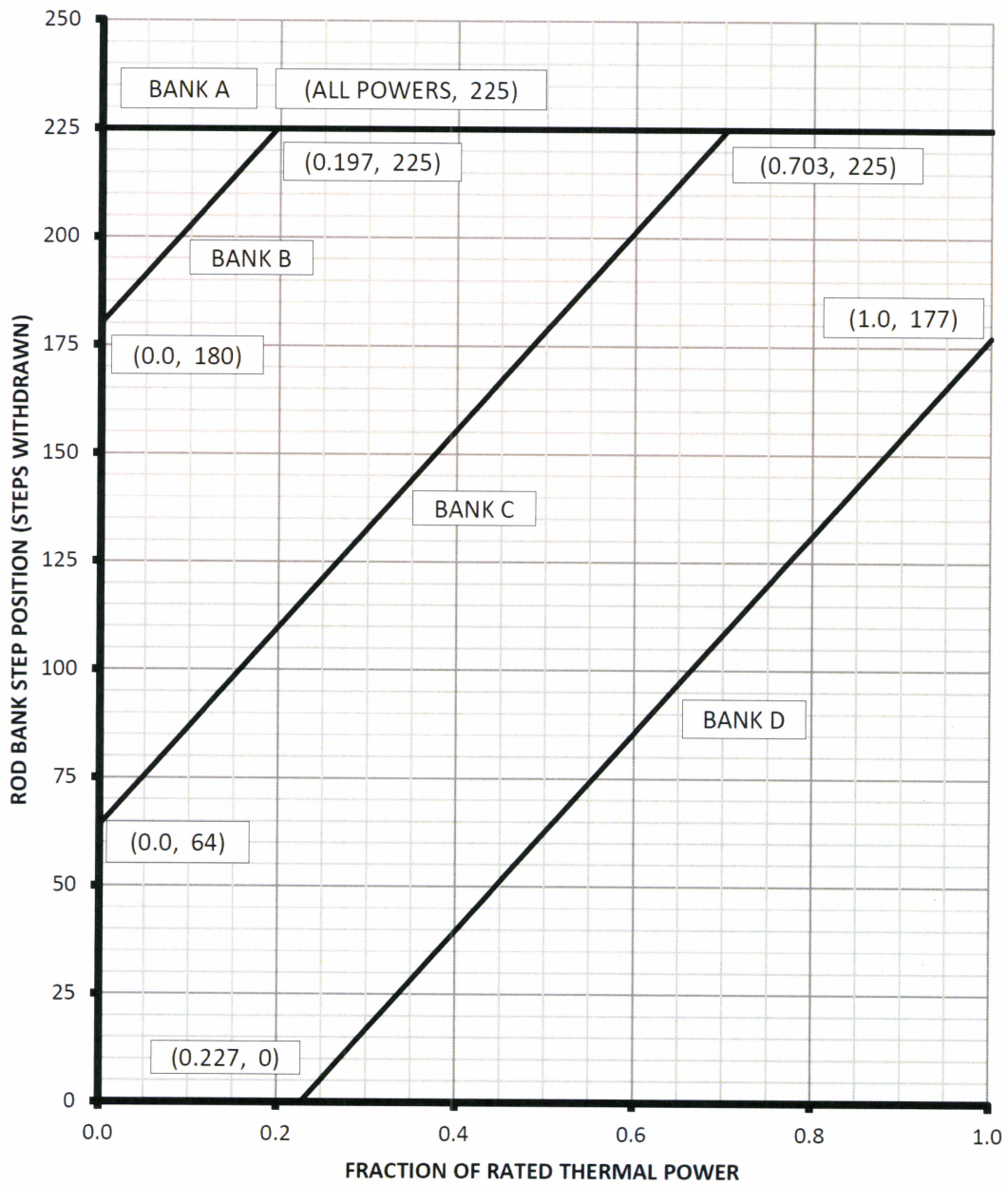


Figure 1
Control Bank Insertion Limits Versus Thermal Power
Four Loop Operation

* Fully withdrawn region shall be the condition where shutdown and control banks are at a position within the interval of ≥ 225 and ≤ 231 steps withdrawn.

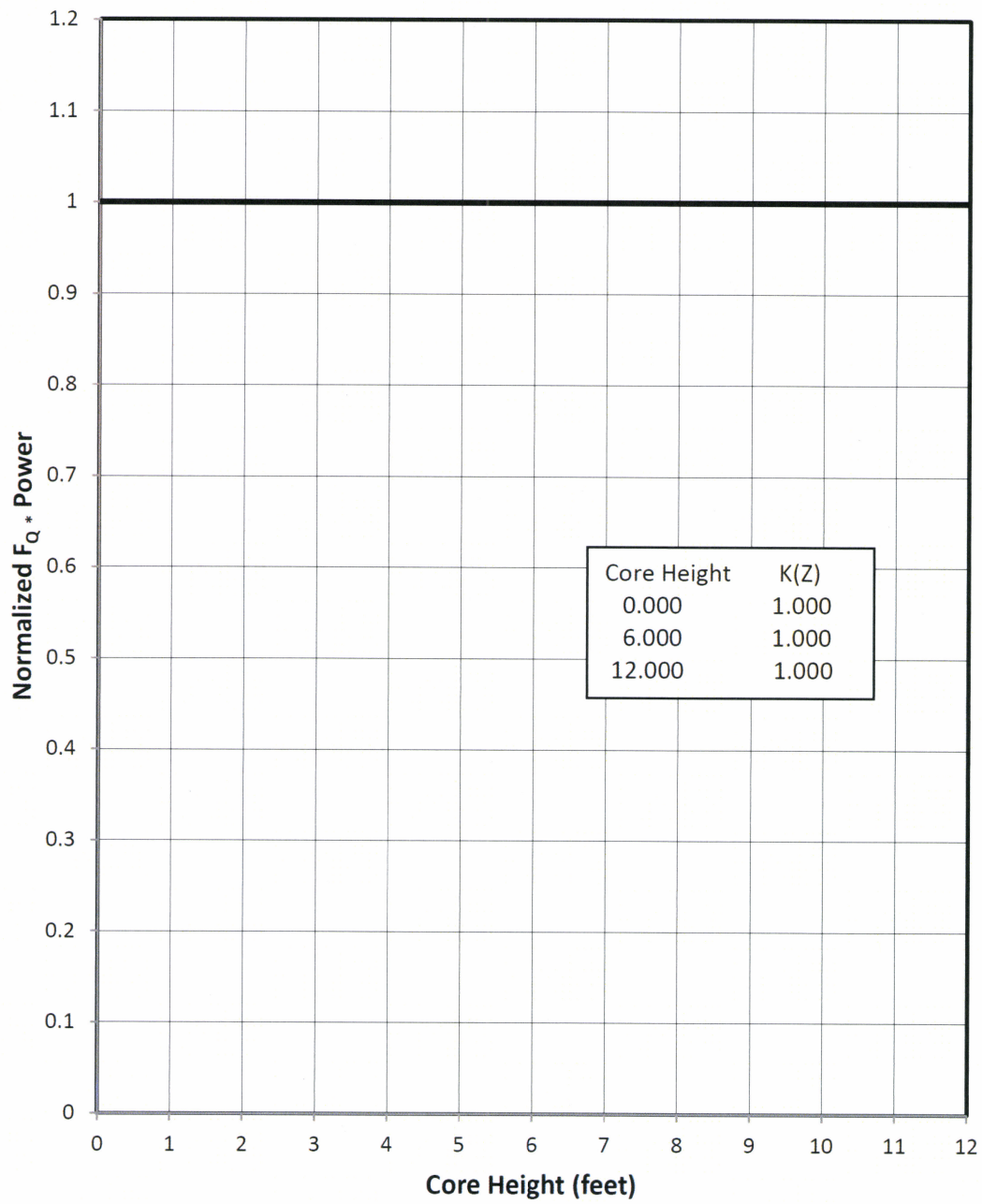


Figure 2
 $K(Z)$ - Normalized $F_Q(Z)$ as a Function of Core Height

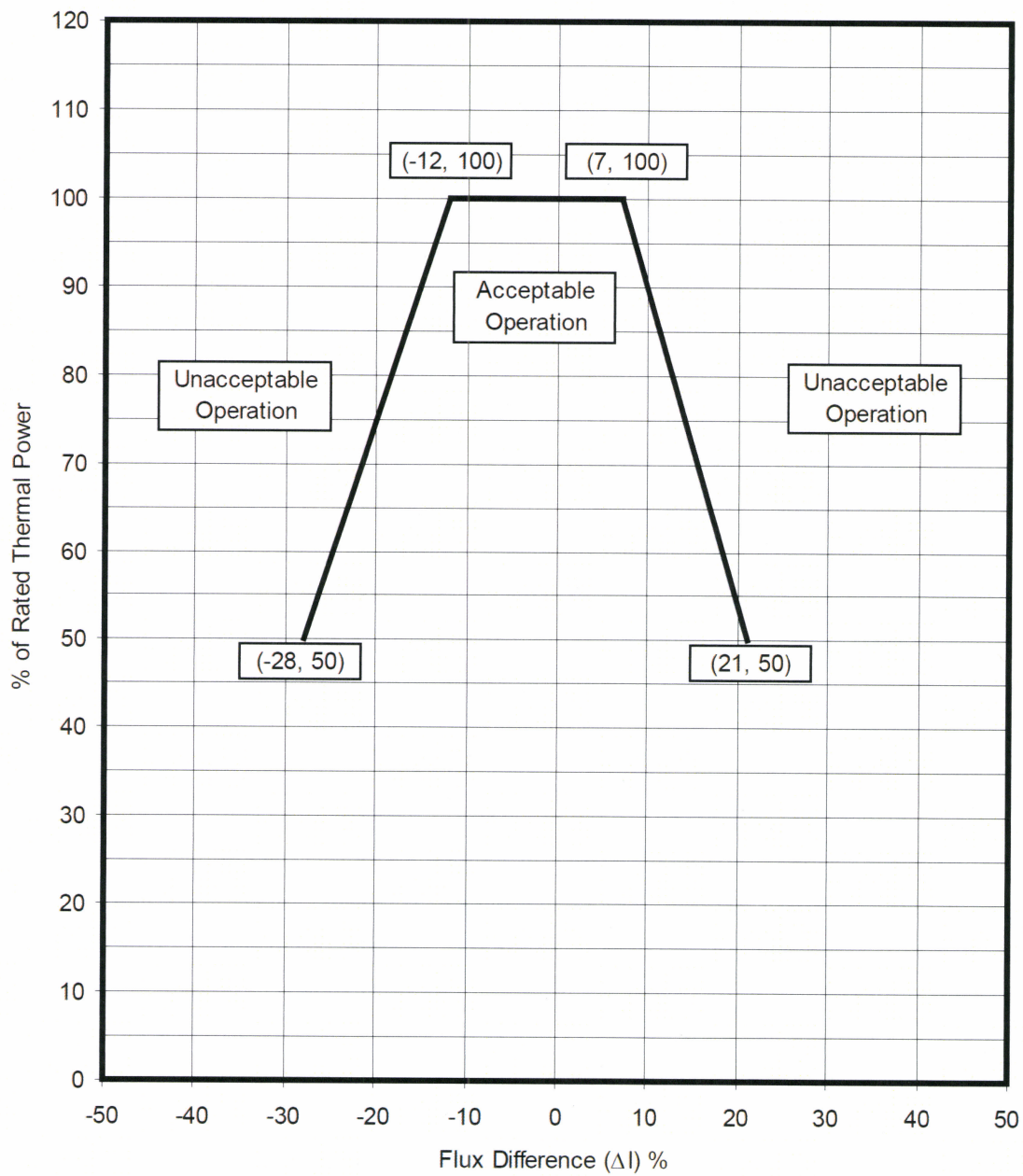


Figure 3
Axial Flux Difference Acceptable Operation Limits as a function of Rated Thermal Power (RAOC)

Table A.1
RAOC W(Z) Surveillance Factors

Height (ft)	Max W(z) at 150	Max W(z) at 150	Max W(z) at 150	Max W(z) at 2000	Max W(z) at 6000	Max W(z) at 10000	Max W(z) at 14000	Max W(z) at 16000
	MWD/MTU (30% Power)	MWD/MTU (75% Power)	MWD/MTU (100% Power)	MWD/MTU (100% Power)	MWD/MTU (100% Power)	MWD/MTU (100% Power)	MWD/MTU (100% Power)	MWD/MTU (100% Power)
12.0720	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11.8708	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11.6696	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11.4684	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11.2672	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11.0660	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
10.8648	1.4084	1.4573	1.3286	1.3235	1.3275	1.1820	1.1574	1.1531
10.6636	1.3886	1.4287	1.3221	1.3185	1.3127	1.1773	1.1526	1.1487
10.4624	1.3626	1.3906	1.3150	1.3166	1.2897	1.1718	1.1469	1.1435
10.2612	1.3419	1.3633	1.3060	1.3114	1.2662	1.1651	1.1405	1.1378
10.0600	1.3171	1.3310	1.2952	1.3032	1.2594	1.1574	1.1332	1.1363
9.8588	1.2934	1.3014	1.2879	1.2941	1.2318	1.1495	1.1255	1.1340
9.6576	1.2774	1.2876	1.2822	1.2843	1.2230	1.1417	1.1173	1.1311
9.4564	1.2529	1.2636	1.2746	1.2728	1.2229	1.1387	1.1180	1.1292
9.2552	1.2254	1.2344	1.2653	1.2599	1.2213	1.1456	1.1264	1.1386
9.0540	1.2019	1.2085	1.2586	1.2507	1.2188	1.1508	1.1370	1.1465
8.8528	1.1866	1.2133	1.2640	1.2580	1.2126	1.1532	1.1444	1.1529
8.6516	1.1766	1.2171	1.2719	1.2614	1.2131	1.1557	1.1584	1.1655
8.4504	1.1639	1.2139	1.2763	1.2628	1.2261	1.1621	1.1803	1.1847
8.2492	1.1554	1.1989	1.2784	1.2662	1.2377	1.1704	1.1991	1.2052
8.0480	1.1440	1.2113	1.2858	1.2751	1.2464	1.1778	1.2156	1.2244
7.8468	1.1366	1.2222	1.2939	1.2809	1.2525	1.1881	1.2297	1.2410
7.6456	1.1296	1.2185	1.2967	1.2824	1.2547	1.1955	1.2405	1.2542
7.4444	1.1238	1.2126	1.2968	1.2813	1.2548	1.2012	1.2494	1.2654
7.2432	1.1152	1.2074	1.2936	1.2770	1.2517	1.2042	1.2549	1.2729
7.0420	1.1046	1.2055	1.2883	1.2706	1.2465	1.2053	1.2577	1.2775
6.8408	1.0953	1.1977	1.2801	1.2616	1.2392	1.2043	1.2581	1.2794
6.6396	1.0883	1.1873	1.2687	1.2500	1.2298	1.2015	1.2561	1.2785
6.4384	1.0843	1.1782	1.2561	1.2370	1.2189	1.1976	1.2523	1.2760
6.2372	1.0678	1.1667	1.2420	1.2227	1.2065	1.1922	1.2464	1.2709
6.0360	1.0577	1.1543	1.2259	1.2066	1.1924	1.1851	1.2383	1.2634
5.8348	1.0505	1.1407	1.2075	1.1885	1.1768	1.1765	1.2280	1.2535
5.6336	1.0458	1.1274	1.1880	1.1695	1.1602	1.1667	1.2157	1.2414
5.4324	1.0318	1.1132	1.1695	1.1537	1.1485	1.1599	1.2051	1.2294
5.2312	1.0266	1.1062	1.1585	1.1462	1.1413	1.1591	1.2067	1.2304
5.0300	1.0316	1.1052	1.1528	1.1403	1.1382	1.1599	1.2081	1.2301
4.8288	1.0351	1.1029	1.1455	1.1334	1.1372	1.1636	1.2083	1.2281
4.6276	1.0375	1.1001	1.1376	1.1257	1.1354	1.1660	1.2079	1.2244
4.4264	1.0391	1.0962	1.1288	1.1173	1.1329	1.1677	1.2064	1.2189
4.2252	1.0397	1.0907	1.1190	1.1081	1.1297	1.1684	1.2035	1.2127
4.0240	1.0455	1.0861	1.1084	1.0982	1.1257	1.1683	1.1993	1.2060
3.8228	1.0506	1.0811	1.0973	1.0875	1.1210	1.1674	1.1936	1.1975
3.6216	1.0439	1.0727	1.0860	1.0789	1.1159	1.1651	1.1862	1.1870
3.4204	1.0456	1.0669	1.0758	1.0775	1.1109	1.1682	1.1844	1.1797
3.2192	1.0556	1.0661	1.0698	1.0774	1.1111	1.1714	1.1851	1.1760
3.0180	1.0666	1.0694	1.0685	1.0799	1.1150	1.1777	1.1882	1.1773
2.8168	1.0865	1.0820	1.0766	1.0958	1.1296	1.1880	1.2031	1.1943
2.6156	1.1158	1.1038	1.0937	1.1178	1.1542	1.2035	1.2225	1.2124
2.4144	1.1444	1.1246	1.1097	1.1387	1.1777	1.2252	1.2405	1.2303
2.2132	1.1803	1.1476	1.1261	1.1604	1.2020	1.2484	1.2586	1.2482
2.0120	1.2165	1.1715	1.1429	1.1824	1.2265	1.2710	1.2758	1.2652
1.8108	1.2460	1.1940	1.1596	1.2043	1.2505	1.2927	1.2919	1.2811
1.6096	1.2780	1.2149	1.1752	1.2249	1.2732	1.3130	1.3072	1.2962
1.4084	1.3122	1.2344	1.1897	1.2439	1.2941	1.3318	1.3219	1.3108
1.2072	1.3431	1.2528	1.2030	1.2614	1.3132	1.3488	1.3355	1.3246
1.0060	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.8048	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.6036	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.4024	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.2012	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table A.2
 $F_Q^W(Z)$ Penalty Factor

Burnup (MWD/MTU)	Penalty Factor
150	1.0237
300	1.0244
451	1.0250
601	1.0254
751	1.0253
902	1.0248
1052	1.0237
1203	1.0221
1353	1.0201
1503	1.0200
11715	1.0200
11863	1.0203
12012	1.0206
12160	1.0210
12308	1.0209
12456	1.0205
12605	1.0201
12753	1.0200

Note:

1. The Penalty Factor, which is applied to $F_Q^W(Z)$ for compliance with Surveillance Requirement 3.2.1.2, is the maximum factor by which $F_Q^W(Z)$ is expected to increase per 31 Effective Full Power Days (EFPD) starting from the burnup at which the $F_Q^W(Z)$ was determined.