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

WBL-20-022

May 20, 2020

10 CFR 50.4

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

Watts Bar Nuclear Plant, Unit 1
Facility Operating License No. NPF-90
NRC Docket No. 50-390

Subject: **UNIT 1 REVISION 0 OF THE CYCLE 17 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 0 of the Unit 1 Cycle 17 CORE OPERATING LIMITS REPORT (COLR). 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 Tony Brown, Site Licensing Manager at (423) 365-7720.

Respectfully,

Anthony L. Williams, IV
Site Vice President
Watts Bar Nuclear Plant

Enclosures: Watts Bar Nuclear Plant, Unit 1, Cycle 17 Core Operating Limits Report, Revision 0, March 2020

cc (Enclosure):

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

ENCLOSURE 1

Watts Bar Nuclear Plant, Unit 1, Cycle 17
Core Operating Limits Report
Revision 0
March 2020

QA Record
L36 200324 801

WATTS BAR NUCLEAR PLANT, UNIT 1, CYCLE 17

CORE OPERATING LIMITS REPORT

Revision 0

March 2020

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T.B. Marshall, Plant Manager / 04/23/20 Date

Revision	Date of PORC Approval	Affected Pages	Reason for Revision
0	See Above	All	Initial Issue

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Watts Bar Unit 1 Cycle 17 has been prepared in accordance with the requirements of the Technical Specifications 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 Δk/k/°F (upper limit). With the measured BOL/ARO/HZP - MTC more positive than -3.553 x 10-5 Δk/k/°F (as-measured MTC limit), establish control rod withdrawal limits to ensure the MTC remains less positive than or equal to 0 Δk/k/°F (upper limit) for all times in core life.

The EOL/ARO/RTP - MTC shall be less negative than or equal to -4.5 x 10-4 Δk/k/°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 x 10-4 Δk/k/°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 x 10-4 Δk/k/°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 ≥ 1.6% Δk/k in MODE 1 and MODE 2.

2.2.2 For TS 3.1.6, SDM shall be ≥ 1.6% Δk/k in MODE 1 and MODE 2.

2.2.3 For TS 3.1.7, SDM shall be ≥ 1.6% Δk/k in MODE 1 and MODE 2 with keff ≥ 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)

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

$F_Q(Z) \leq [CFQ / 0.5] * K(Z)$ 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 Tables A.1 and A.3. Table A.1 contains normal W(Z) factors based on the non-perturbed model. Table A.3 contains W(Z) factors based on the perturbed model.

The data in Tables A.1 and A.3 should be used independently; cross interpolation or extrapolation between W(Z) sets is prohibited.

Table A.1 values should be used when D-AO is in the range of $\geq$-3% and $\leq$ +3%.
Table A.3 values should be used when D-AO is in the range of $\geq$ 0% and $\leq$ +6%.

These tables provide 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 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 17 are provided in Figure 3.

2.8 REFUELING BORON CONCENTRATION (LCO 3.9.1)

2.8.1 The refueling boron concentration shall be $\geq$ 2000 ppm.

3.0 NUMBER OF TPBARS IN REACTOR CORE (TS 4.2.1)

3.0.1 There are 1792 tritium producing burnable absorber rods (TPBARs) in the reactor core for Cycle 17.

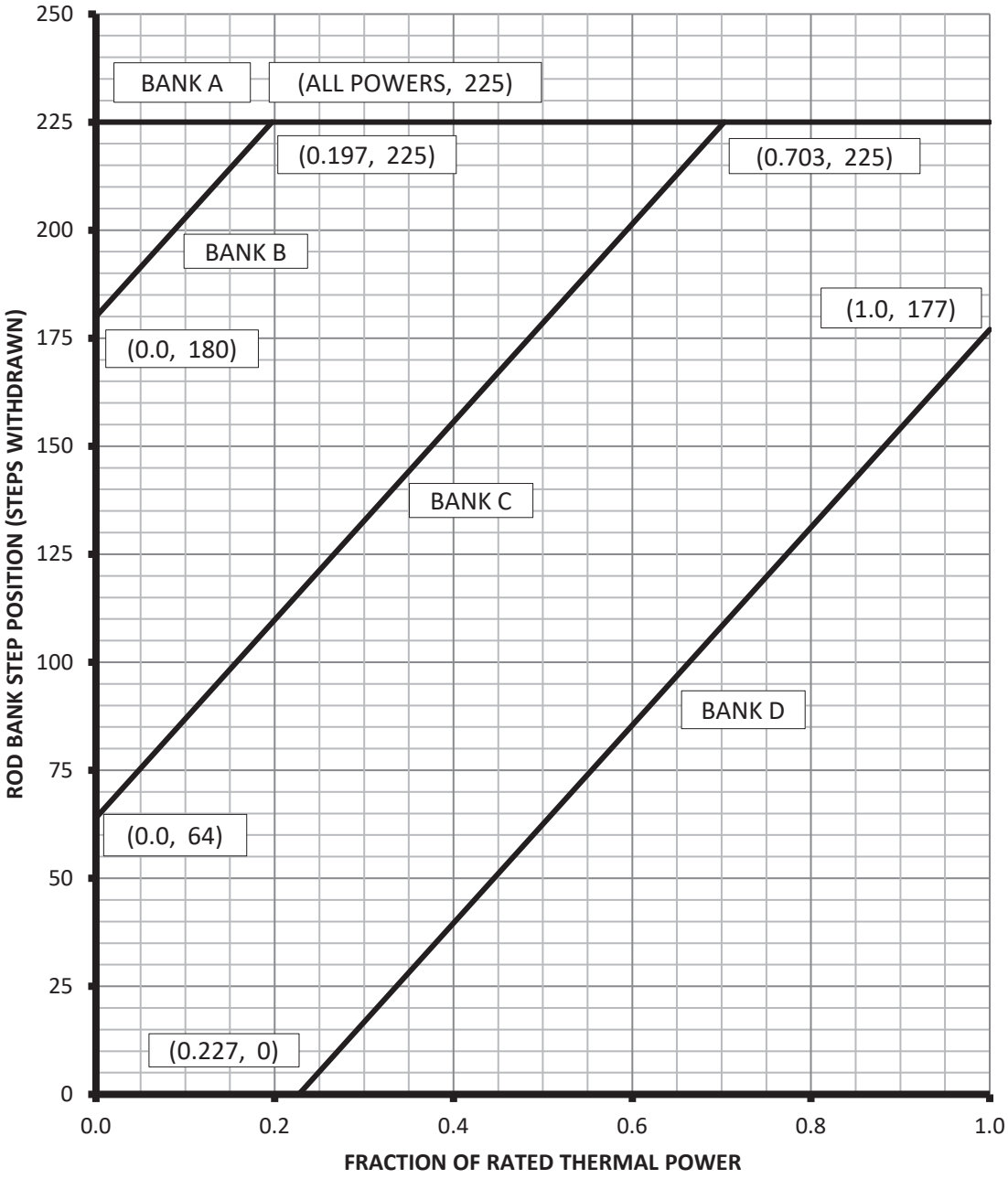

Figure 1
Control Bank Insertion Limits Versus Thermal Power
Four Loop Operation

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.

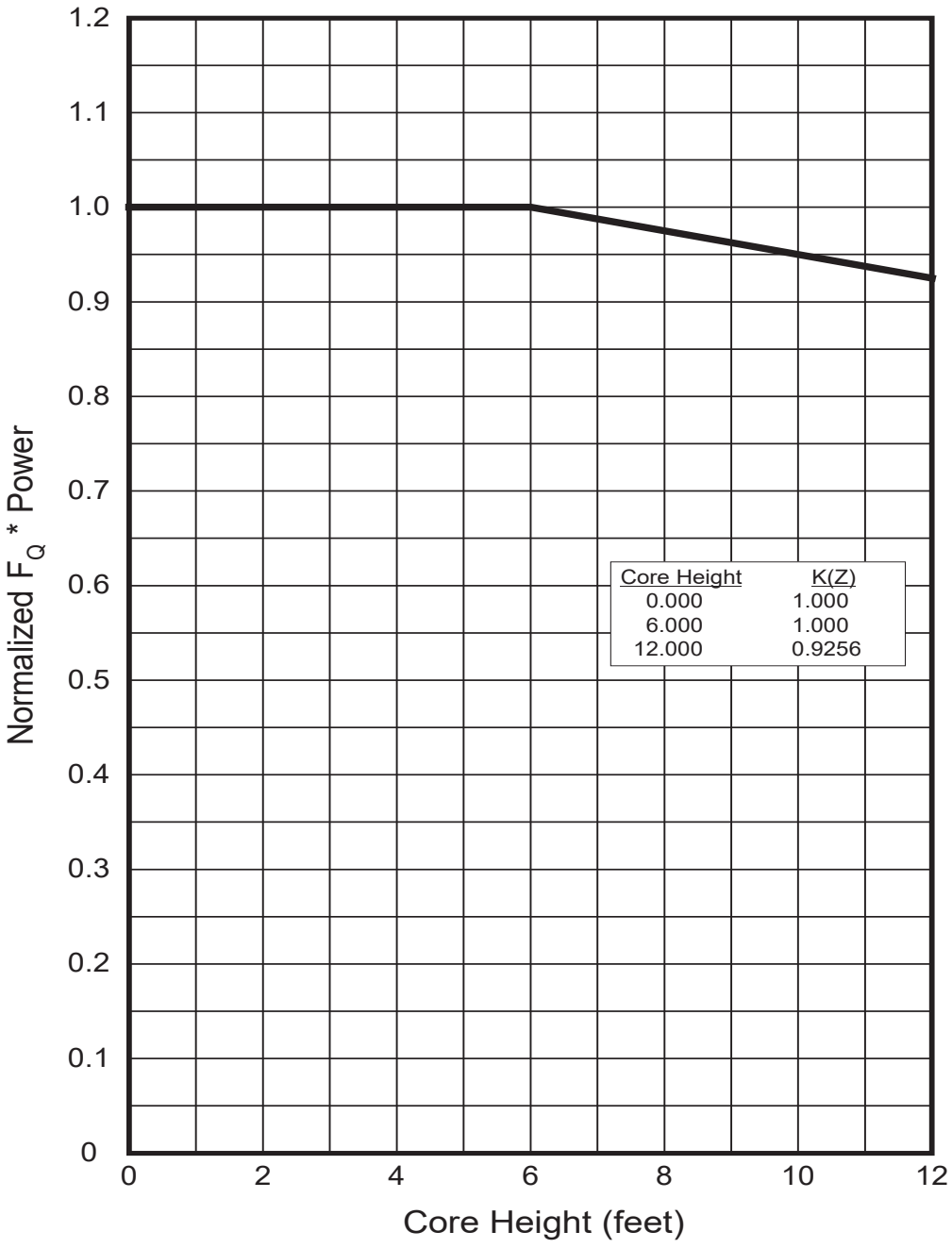

Figure 2
K(Z) - Normalized $F_Q(Z)$ as a Function of Core Height

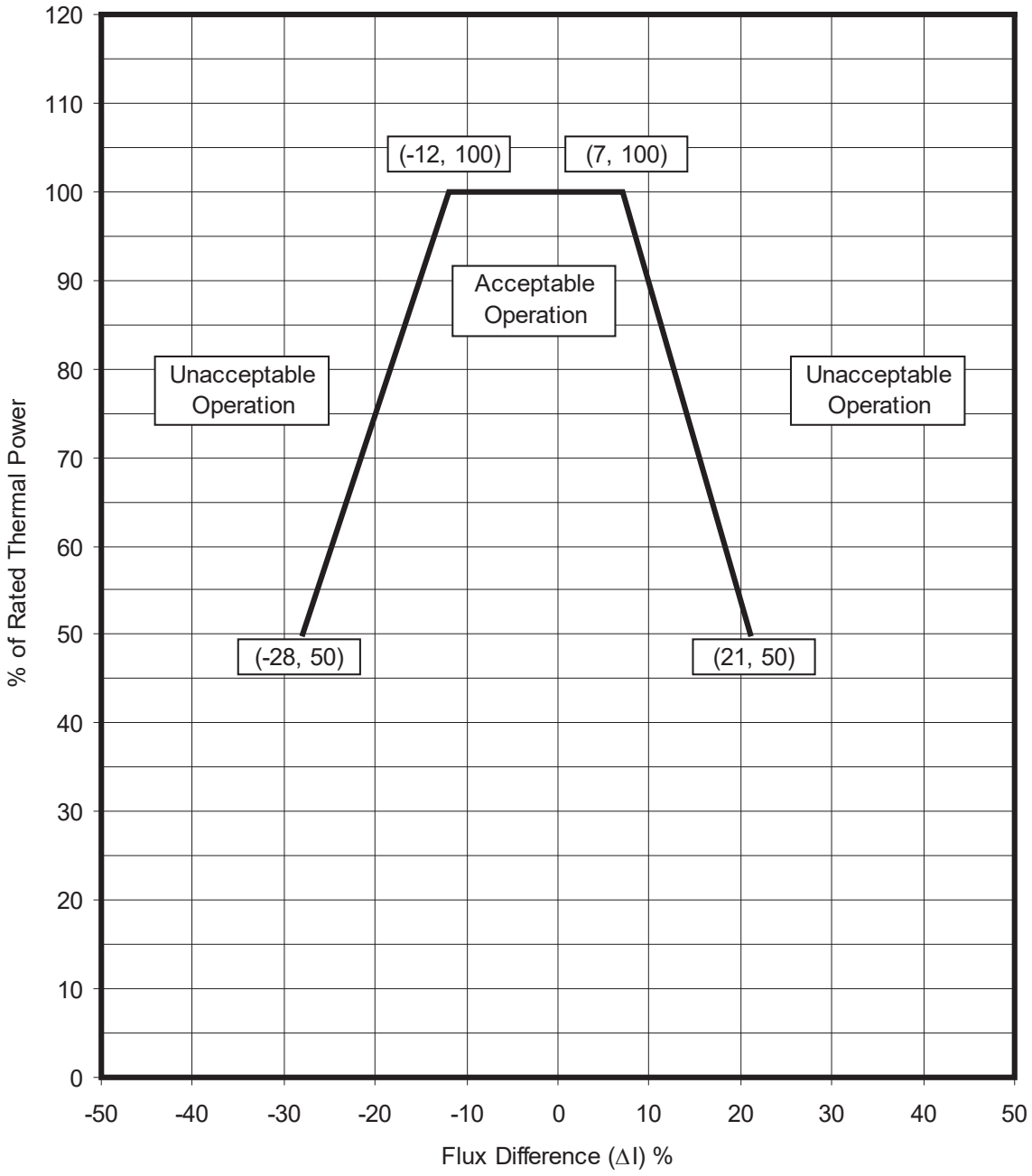

Figure 3
Axial Flux Difference Acceptable Operation Limits as a function of Rated Thermal Power (RAOC)

Table A.1
RAOC W(Z) Surveillance Factors (Normal Model) for D-AO of ≥-3% and ≤ +3%

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 4000 MWD/MTU (100% Power)	Max W(z) at 6000 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)
12.0740	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11.8728	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11.6715	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11.4703	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11.2691	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11.0678	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
10.8666	1.4763	1.4704	1.2823	1.3044	1.2570	1.1906	1.1504	1.1418	1.1588
10.6654	1.4314	1.4256	1.2785	1.2982	1.2522	1.1884	1.1484	1.1400	1.1573
10.4641	1.3870	1.3792	1.2719	1.2891	1.2447	1.1859	1.1440	1.1356	1.1532
10.2629	1.3406	1.3293	1.2631	1.2781	1.2386	1.1825	1.1380	1.1300	1.1474
10.0617	1.3038	1.2890	1.2531	1.2657	1.2315	1.1780	1.1308	1.1217	1.1407
9.8604	1.2698	1.2510	1.2418	1.2615	1.2220	1.1748	1.1235	1.1183	1.1330
9.6592	1.2363	1.2165	1.2307	1.2630	1.2115	1.1740	1.1201	1.1222	1.1274
9.4580	1.2079	1.1898	1.2245	1.2598	1.2064	1.1743	1.1225	1.1243	1.1273
9.2567	1.1925	1.1782	1.2307	1.2557	1.2043	1.1702	1.1238	1.1294	1.1335
9.0555	1.1804	1.1739	1.2384	1.2499	1.2020	1.1662	1.1243	1.1336	1.1421
8.8543	1.1650	1.1692	1.2415	1.2409	1.1973	1.1637	1.1277	1.1357	1.1492
8.6530	1.1491	1.1639	1.2427	1.2314	1.1938	1.1637	1.1370	1.1400	1.1555
8.4518	1.1313	1.1572	1.2415	1.2253	1.1955	1.1689	1.1514	1.1499	1.1659
8.2506	1.1121	1.1502	1.2385	1.2182	1.1954	1.1723	1.1637	1.1605	1.1771
8.0493	1.0932	1.1427	1.2336	1.2107	1.1931	1.1734	1.1737	1.1721	1.1893
7.8481	1.0743	1.1351	1.2274	1.2040	1.1894	1.1734	1.1820	1.1834	1.2009
7.6469	1.0572	1.1281	1.2206	1.1973	1.1842	1.1715	1.1881	1.1922	1.2099
7.4456	1.0422	1.1218	1.2137	1.1893	1.1775	1.1680	1.1923	1.1990	1.2166
7.2444	1.0277	1.1148	1.2052	1.1801	1.1694	1.1684	1.1945	1.2037	1.2212
7.0432	1.0160	1.1086	1.1970	1.1719	1.1604	1.1689	1.1948	1.2064	1.2236
6.8419	1.0074	1.1043	1.1902	1.1666	1.1551	1.1673	1.1933	1.2070	1.2237
6.6407	1.0034	1.1024	1.1855	1.1631	1.1543	1.1647	1.1903	1.2058	1.2219
6.4395	1.0023	1.1022	1.1821	1.1581	1.1516	1.1609	1.1859	1.2033	1.2186
6.2382	1.0013	1.1007	1.1769	1.1531	1.1477	1.1552	1.1797	1.1990	1.2134
6.0370	1.0031	1.1011	1.1734	1.1490	1.1453	1.1502	1.1718	1.1928	1.2062
5.8358	1.0073	1.1026	1.1708	1.1445	1.1433	1.1491	1.1629	1.1849	1.1972
5.6345	1.0105	1.1027	1.1662	1.1390	1.1397	1.1514	1.1564	1.1754	1.1865
5.4333	1.0136	1.1020	1.1605	1.1341	1.1363	1.1518	1.1551	1.1665	1.1756
5.2321	1.0190	1.1031	1.1565	1.1304	1.1366	1.1511	1.1558	1.1652	1.1701
5.0308	1.0255	1.1045	1.1528	1.1264	1.1370	1.1497	1.1583	1.1648	1.1704
4.8296	1.0322	1.1060	1.1483	1.1215	1.1362	1.1470	1.1610	1.1648	1.1721
4.6284	1.0389	1.1066	1.1431	1.1162	1.1349	1.1449	1.1628	1.1658	1.1723
4.4271	1.0455	1.1063	1.1372	1.1104	1.1331	1.1459	1.1650	1.1669	1.1718
4.2259	1.0524	1.1055	1.1308	1.1043	1.1308	1.1467	1.1680	1.1674	1.1705
4.0247	1.0593	1.1041	1.1238	1.0977	1.1281	1.1470	1.1710	1.1675	1.1689
3.8234	1.0667	1.1026	1.1166	1.0922	1.1251	1.1470	1.1735	1.1679	1.1662
3.6222	1.0734	1.1007	1.1090	1.0885	1.1222	1.1468	1.1760	1.1699	1.1653
3.4210	1.0814	1.1004	1.1029	1.0852	1.1209	1.1467	1.1798	1.1780	1.1713
3.2197	1.0978	1.1085	1.1050	1.0854	1.1226	1.1467	1.1874	1.1854	1.1774
3.0185	1.1157	1.1173	1.1074	1.0903	1.1331	1.1528	1.1979	1.1938	1.1839
2.8173	1.1382	1.1298	1.1132	1.1032	1.1508	1.1694	1.2144	1.2085	1.1947
2.6160	1.1685	1.1494	1.1264	1.1198	1.1699	1.1892	1.2369	1.2293	1.2090
2.4148	1.1996	1.1688	1.1397	1.1364	1.1890	1.2088	1.2582	1.2488	1.2223
2.2136	1.2314	1.1878	1.1528	1.1531	1.2077	1.2282	1.2789	1.2676	1.2387
2.0123	1.2634	1.2070	1.1653	1.1694	1.2257	1.2470	1.2988	1.2856	1.2556
1.8111	1.2958	1.2261	1.1771	1.1851	1.2427	1.2647	1.3173	1.3023	1.2713
1.6099	1.3278	1.2440	1.1879	1.1997	1.2583	1.2811	1.3342	1.3176	1.2858
1.4086	1.3592	1.2597	1.1965	1.2122	1.2714	1.2949	1.3483	1.3302	1.2978
1.2074	1.3891	1.2718	1.2013	1.2210	1.2806	1.3048	1.3580	1.3384	1.3057
1.0062	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.8049	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

Cycle Burnup (MWD/MTU)	$F_Q^W(Z)$ Penalty Factor
909	1.0200
1099	1.0204
1289	1.0200
1479	1.0200
1668	1.0212
1858	1.0223
2048	1.0230
2238	1.0232
2428	1.0228
2618	1.0218
2807	1.0203
2997	1.0200
8502	1.0200
8691	1.0202
8881	1.0210
9071	1.0216
9261	1.0222
9451	1.0227
9641	1.0231
9830	1.0233
10020	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. This Penalty Factor is applicable for both sets of W(Z) Surveillance Factors provided in Tables A.1 and A.3.

Table A.3
RAOC W(Z) Surveillance Factors (Perturbed Model) for D-AO of ≥ 0% and ≤ +6%

Height (ft)	Max W(z) at 150 MWD/MTU (100% Power)	Max W(z) at 4000 MWD/MTU (100% Power)	Max W(z) at 6000 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)
12.0740	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11.8728	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11.6715	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11.4703	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11.2691	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11.0678	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
10.8666	1.1965	1.2605	1.2049	1.1293	1.0978	1.1049	1.1425
10.6654	1.2017	1.2558	1.2019	1.1274	1.0973	1.1032	1.1337
10.4641	1.2032	1.2484	1.1963	1.1231	1.0946	1.0990	1.1248
10.2629	1.2025	1.2393	1.1889	1.1201	1.0905	1.0928	1.1088
10.0617	1.1990	1.2311	1.1807	1.1185	1.0854	1.0890	1.0929
9.8604	1.1956	1.2230	1.1707	1.1181	1.0810	1.0885	1.0845
9.6592	1.1937	1.2123	1.1622	1.1217	1.0793	1.0881	1.0849
9.4580	1.1905	1.2007	1.1600	1.1293	1.0796	1.0860	1.0912
9.2567	1.1869	1.2002	1.1607	1.1295	1.0828	1.0881	1.0989
9.0555	1.1880	1.2017	1.1606	1.1291	1.0887	1.0939	1.1074
8.8543	1.1939	1.1981	1.1573	1.1300	1.0963	1.0999	1.1146
8.6530	1.2009	1.1945	1.1545	1.1312	1.1070	1.1060	1.1240
8.4518	1.2067	1.1963	1.1588	1.1385	1.1223	1.1163	1.1423
8.2506	1.2100	1.1963	1.1627	1.1440	1.1358	1.1287	1.1587
8.0493	1.2108	1.1938	1.1649	1.1473	1.1471	1.1421	1.1725
7.8481	1.2096	1.1899	1.1661	1.1495	1.1569	1.1549	1.1848
7.6469	1.2064	1.1844	1.1659	1.1513	1.1649	1.1656	1.1949
7.4456	1.2013	1.1773	1.1644	1.1545	1.1710	1.1745	1.2029
7.2444	1.1941	1.1682	1.1617	1.1580	1.1754	1.1814	1.2088
7.0432	1.1879	1.1613	1.1577	1.1601	1.1779	1.1866	1.2126
6.8419	1.1841	1.1584	1.1552	1.1607	1.1788	1.1898	1.2142
6.6407	1.1820	1.1570	1.1546	1.1603	1.1784	1.1914	1.2140
6.4395	1.1808	1.1540	1.1522	1.1585	1.1766	1.1918	1.2125
6.2382	1.1783	1.1499	1.1493	1.1549	1.1732	1.1905	1.2090
6.0370	1.1736	1.1473	1.1477	1.1519	1.1678	1.1874	1.2036
5.8358	1.1697	1.1447	1.1455	1.1518	1.1624	1.1828	1.1963
5.6345	1.1674	1.1410	1.1432	1.1538	1.1597	1.1762	1.1874
5.4333	1.1641	1.1390	1.1440	1.1553	1.1594	1.1691	1.1788
5.2321	1.1634	1.1391	1.1448	1.1566	1.1586	1.1697	1.1748
5.0308	1.1627	1.1389	1.1464	1.1574	1.1619	1.1708	1.1746
4.8296	1.1607	1.1377	1.1482	1.1565	1.1705	1.1712	1.1768
4.6284	1.1581	1.1360	1.1491	1.1560	1.1786	1.1742	1.1806
4.4271	1.1548	1.1338	1.1494	1.1598	1.1864	1.1795	1.1849
4.2259	1.1508	1.1311	1.1492	1.1637	1.1937	1.1846	1.1887
4.0247	1.1464	1.1284	1.1486	1.1679	1.2007	1.1883	1.1915
3.8234	1.1412	1.1247	1.1480	1.1730	1.2075	1.1956	1.1953
3.6222	1.1363	1.1224	1.1483	1.1793	1.2141	1.2086	1.2016
3.4210	1.1336	1.1257	1.1534	1.1867	1.2206	1.2213	1.2096
3.2197	1.1347	1.1292	1.1589	1.1933	1.2262	1.2336	1.2172
3.0185	1.1438	1.1341	1.1695	1.2036	1.2367	1.2448	1.2243
2.8173	1.1606	1.1458	1.1865	1.2190	1.2560	1.2625	1.2313
2.6160	1.1764	1.1645	1.2065	1.2383	1.2810	1.2885	1.2432
2.4148	1.1953	1.1836	1.2261	1.2607	1.3047	1.3126	1.2651
2.2136	1.2138	1.2023	1.2455	1.2824	1.3277	1.3358	1.2863
2.0123	1.2313	1.2204	1.2641	1.3030	1.3495	1.3577	1.3058
1.8111	1.2480	1.2375	1.2818	1.3225	1.3699	1.3781	1.3243
1.6099	1.2632	1.2531	1.2979	1.3401	1.3884	1.3966	1.3412
1.4086	1.2760	1.2663	1.3115	1.3550	1.4040	1.4121	1.3552
1.2074	1.2846	1.2757	1.3212	1.3657	1.4149	1.4228	1.3648
1.0062	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.8049	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
0.4025	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
0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000