WATTS BAR NUCLEAR PLANT UNIT 1, CYCLE 1

CORE OPERATING LIMITS REPORT

REVISION 1

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Revision 1

Pages affected 2 & 4

Reason for Revision To: (1) allow the use of an updated calculational method to perform Heat Flux Hot Channel Factor surveillance and (2) to conform to the new numbering of Technical Specifications and (3) to correct a typographical error.

COLR FOR WATTS BAR UNIT 1 CYCLE 1

1.0 CORE OPERATING LIMITS REPORT

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

The TSs affected by this report are listed below:

3.1.4 Moderator Temperature Coefficient (MTC)
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 ($F^N_{\Delta H}$)
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 TS 5.9.5.

The following abbreviations are used in this section:

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
RTP stands for RATED THERMAL POWER

2.1 Moderator Temperature Coefficient - MTC (LCO 3.1.4)

2.1.1 The MTC limits are:

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

The EOL/ARO/RTP-MTC shall be less negative than or equal to -4.0×10^{-4} $\Delta k/k/°F$ (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 -3.1×10^{-4} $\Delta k/k/°F$.

2.1.3 The 60 ppm surveillance limit is:

The measured 60 ppm/ARO/RTP-MTC should be less negative than or equal to -3.75×10^{-4} $\Delta k/k/°F$.

2.2 Shutdown Bank Insertion Limits (LCO 3.1.6)

2.2.1 The shutdown banks shall be withdrawn to a position greater than or equal to 225 steps withdrawn.

2.3 Control Bank Insertion Limits (LCO 3.1.7)

2.3.1 The control banks shall be limited in physical insertion as shown in Figure 1.

2.4 Heat Flux Hot Channel Factor - $F_Q(Z)$ (LCO 3.2.1)

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

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

where $P = \dfrac{\text{THERMAL POWER}}{\text{RATED THERMAL POWER}}$

2.4.1 CFQ = 2.40

2.4.2 K(Z) is provided in Figure 2.

2.4.3 $F_Q^C(Z) = F_Q^m(Z) * 1.0815$

where: $F_Q^m(Z)$ is the measured value of $F_Q(Z)$ obtained from incore flux map results and 1.0815 is a factor that accounts for fuel manufacturing tolerances and flux map measurement uncertainty.

2.4.4 $F_Q^W(Z) = F_Q^C(Z) * W(Z)$

where: W(Z) values are provided in Figures 5 through 10. The figures provide sufficient information to determine W(Z) versus core height for all cycle burnups.

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

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

$$\text{where } P = \frac{\text{THERMAL POWER}}{\text{RATED THERMAL POWER}}$$

$F_{\Delta H}^{RTP} = 1.55$

$PF = 0.3$

2.6 Axial Flux Difference - AFD (LCO 3.2.3)

2.6.1 The AFD Limits for cycle burnup between 0 MWd/MTU and 4,000 MWd/MTU is provided in Figure 3.

2.6.2 The AFD Limits for cycle burnup between 3,500 MWd/MTU and 17,000 MWd/MTU is provided in Figure 4.

2.7 Refueling Boron Concentration (LCO 3.9.1)

2.7.1 The refueling boron concentration shall be ≥ 2000 ppm.

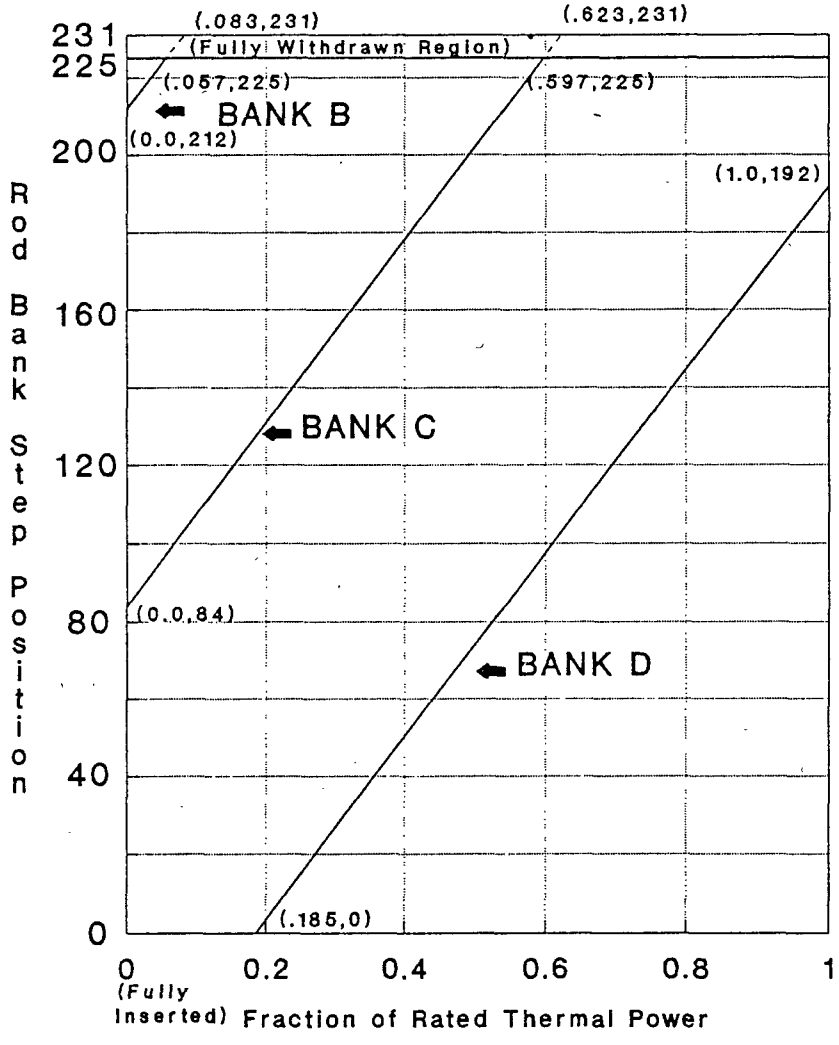


FIGURE 1

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, inclusive.

COLR For Watts Bar Unit 1 Cycle 1

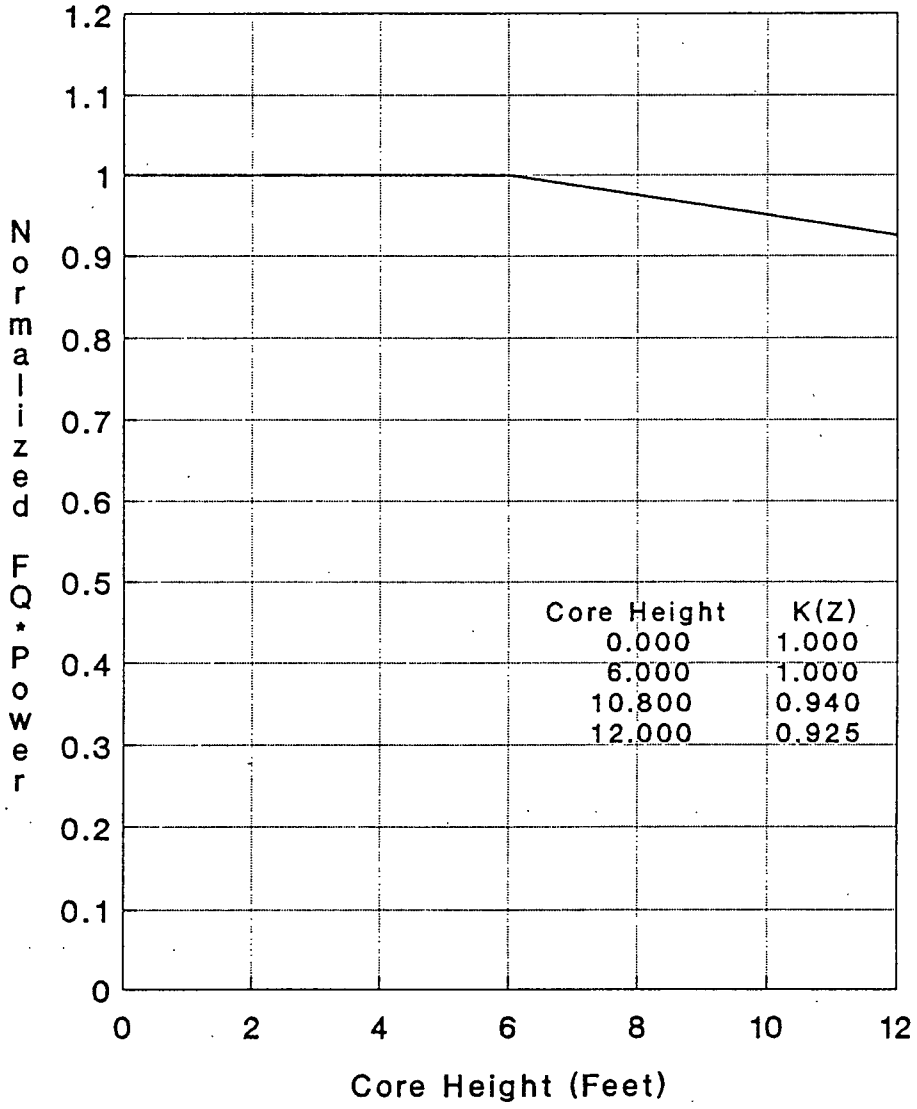


FIGURE 2

K(Z) - Normalized Fq(Z) as a Function of Core Height

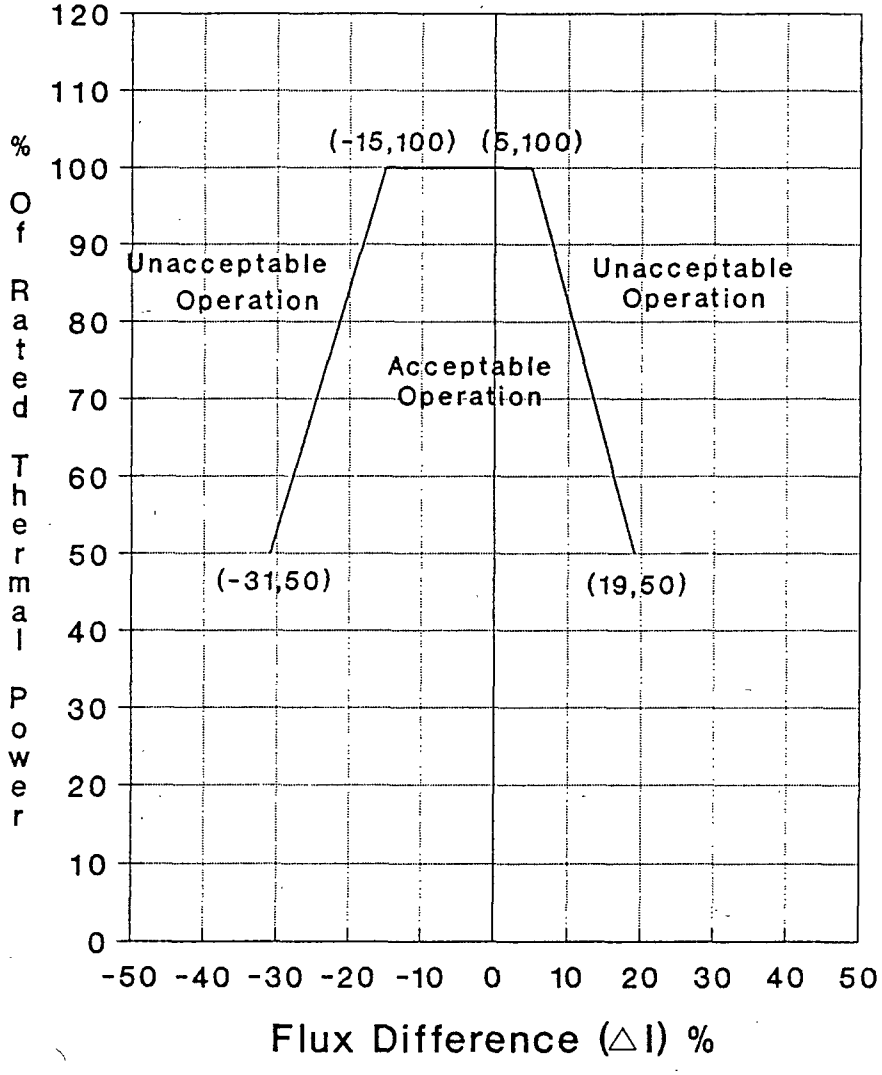


FIGURE 3

AXIAL FLUX DIFFERENCE Acceptable Operation Limits as a Function of RATED THERMAL POWER (RAOC)

For Cycle Burnup 0 MWd/MTU to 4,000 MWd/MTU

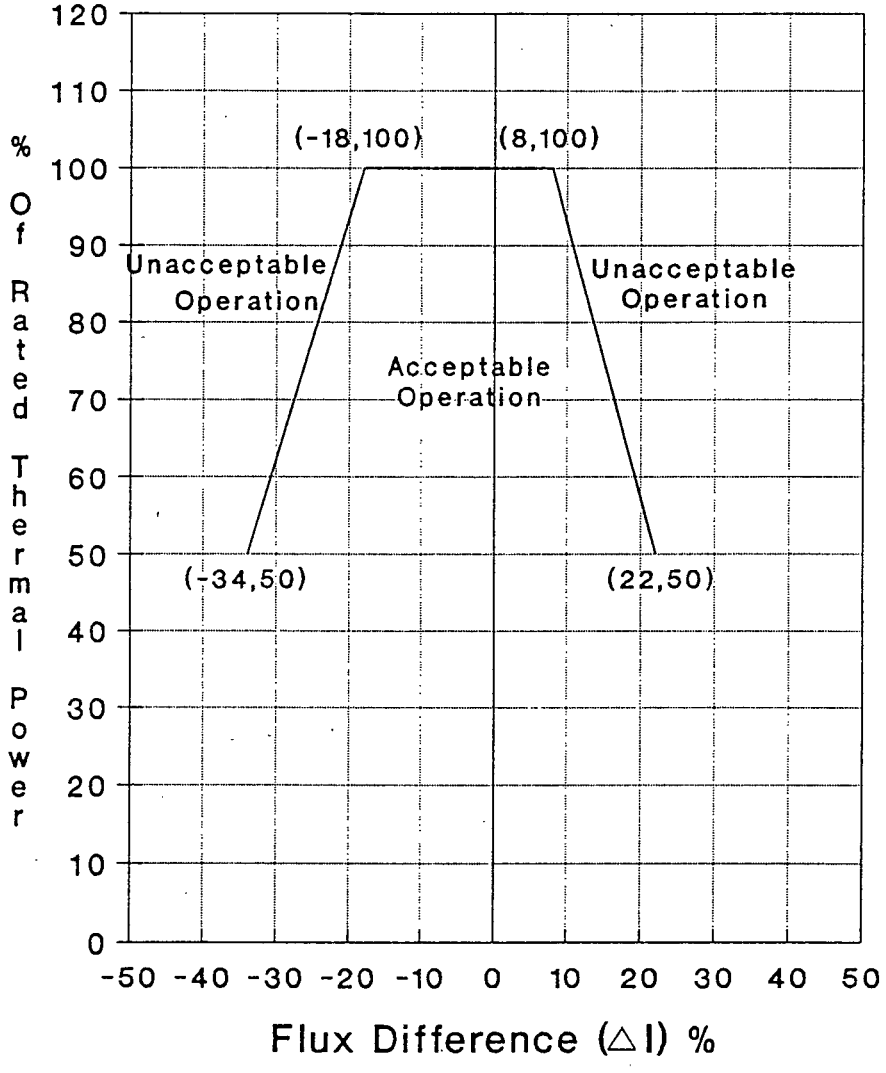
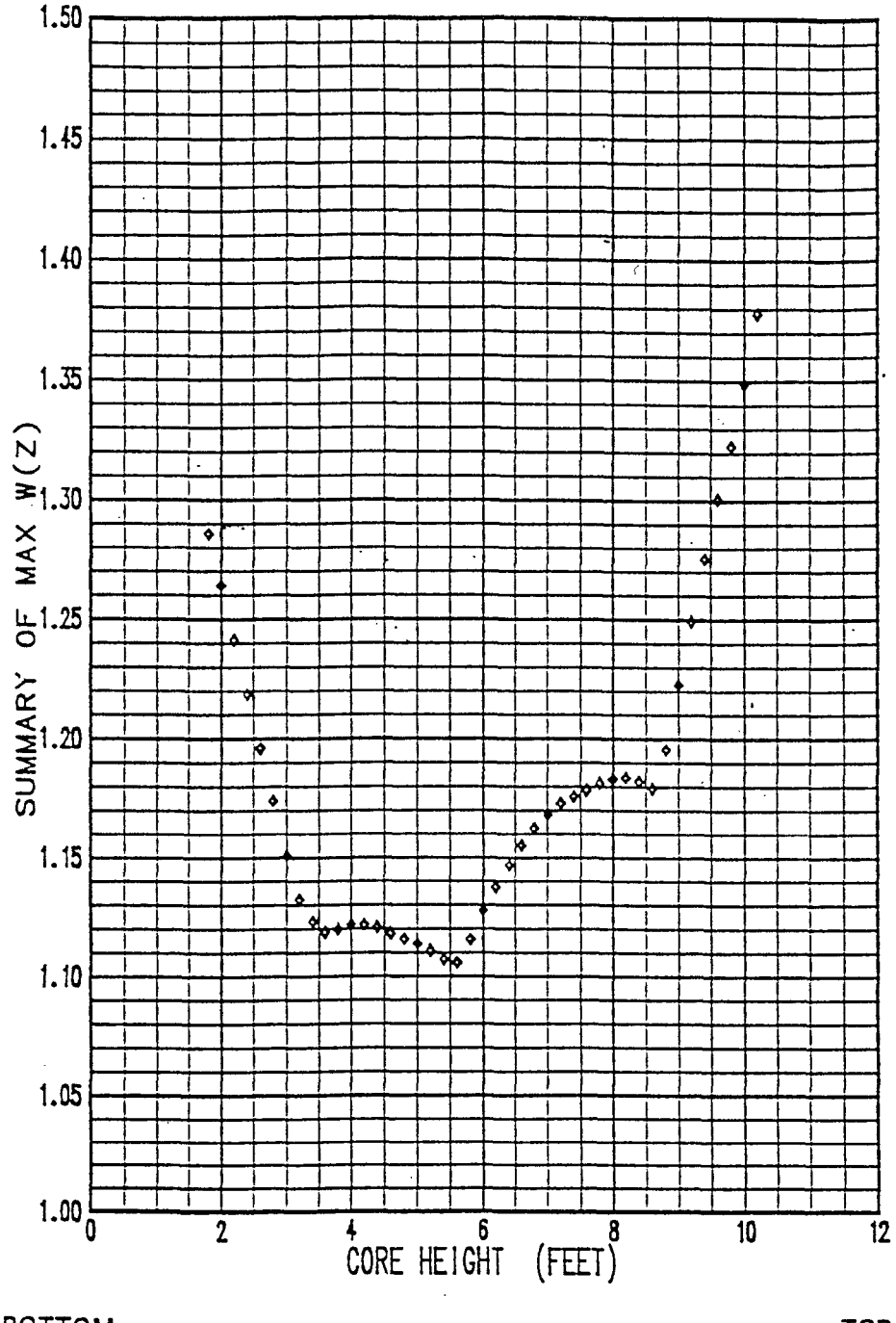


FIGURE 4

AXIAL FLUX DIFFERENCE Acceptable Operation Limits as a Function of RATED THERMAL POWER (RAOC)

For Cycle Burnup 3,500 MWd/MTU to 17,000 MWd/MTU



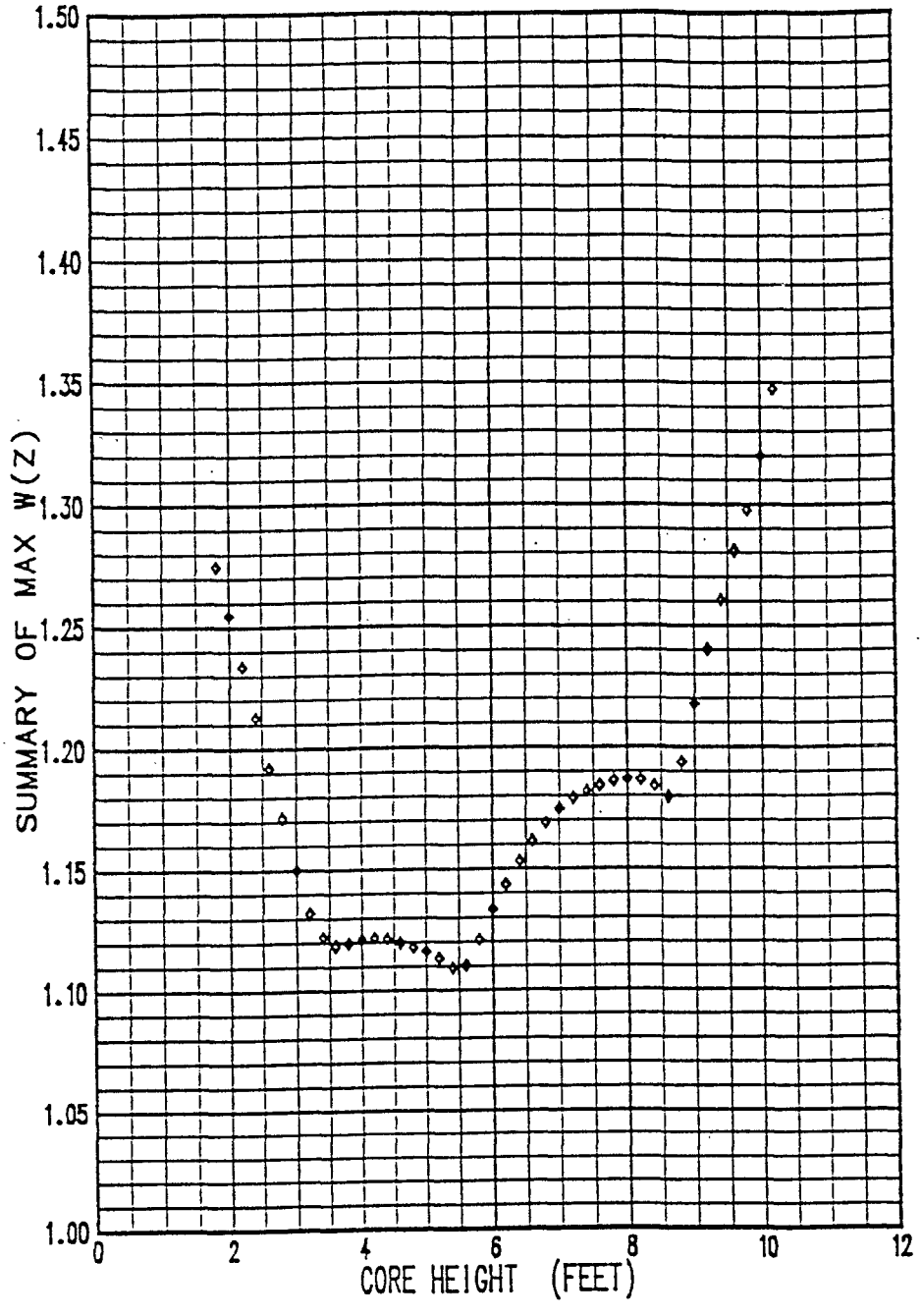
HEIGHT (FEET)	MAX W(Z)
0.0000	1.0000
0.2000	1.0000
0.4000	1.0000
0.6000	1.0000
0.8000	1.0000
1.0000	1.0000
1.2000	1.0000
1.4000	1.0000
1.6000	1.0000
1.8000	1.2859
2.0000	1.2641
2.2000	1.2414
2.4000	1.2187
2.6000	1.1961
2.8000	1.1740
3.0000	1.1509
3.2000	1.1323
3.4000	1.1229
3.6000	1.1185
3.8000	1.1199
4.0000	1.1218
4.2000	1.1217
4.4000	1.1205
4.6000	1.1181
4.8000	1.1156
5.0000	1.1134
5.2000	1.1107
5.4000	1.1071
5.6000	1.1058
5.8000	1.1155
6.0000	1.1278
6.2000	1.1376
6.4000	1.1469
6.6000	1.1552
6.8000	1.1624
7.0000	1.1683
7.2000	1.1729
7.4000	1.1760
7.6000	1.1786
7.8000	1.1815
8.0000	1.1832
8.2000	1.1838
8.4000	1.1822
8.6000	1.1793
8.8000	1.1957
9.0000	1.2227
9.2000	1.2494
9.4000	1.2756
9.6000	1.3007
9.8000	1.3229
10.0000	1.3489
10.2000	1.3782
10.4000	1.0000
10.6000	1.0000
10.8000	1.0000
11.0000	1.0000
11.2000	1.0000
11.4000	1.0000
11.6000	1.0000
11.8000	1.0000
12.0000	1.0000

FIGURE 5

WATTS BAR UNIT 1 CYCLE 1

RAOC SUMMARY OF MAX W(Z) AT 150 MWD/MTU WITH HFP AFD BAND OF +5/-15%

* TOP AND BOTTOM 15% EXCLUDED AS PER TECH SPEC 3.2.1.2



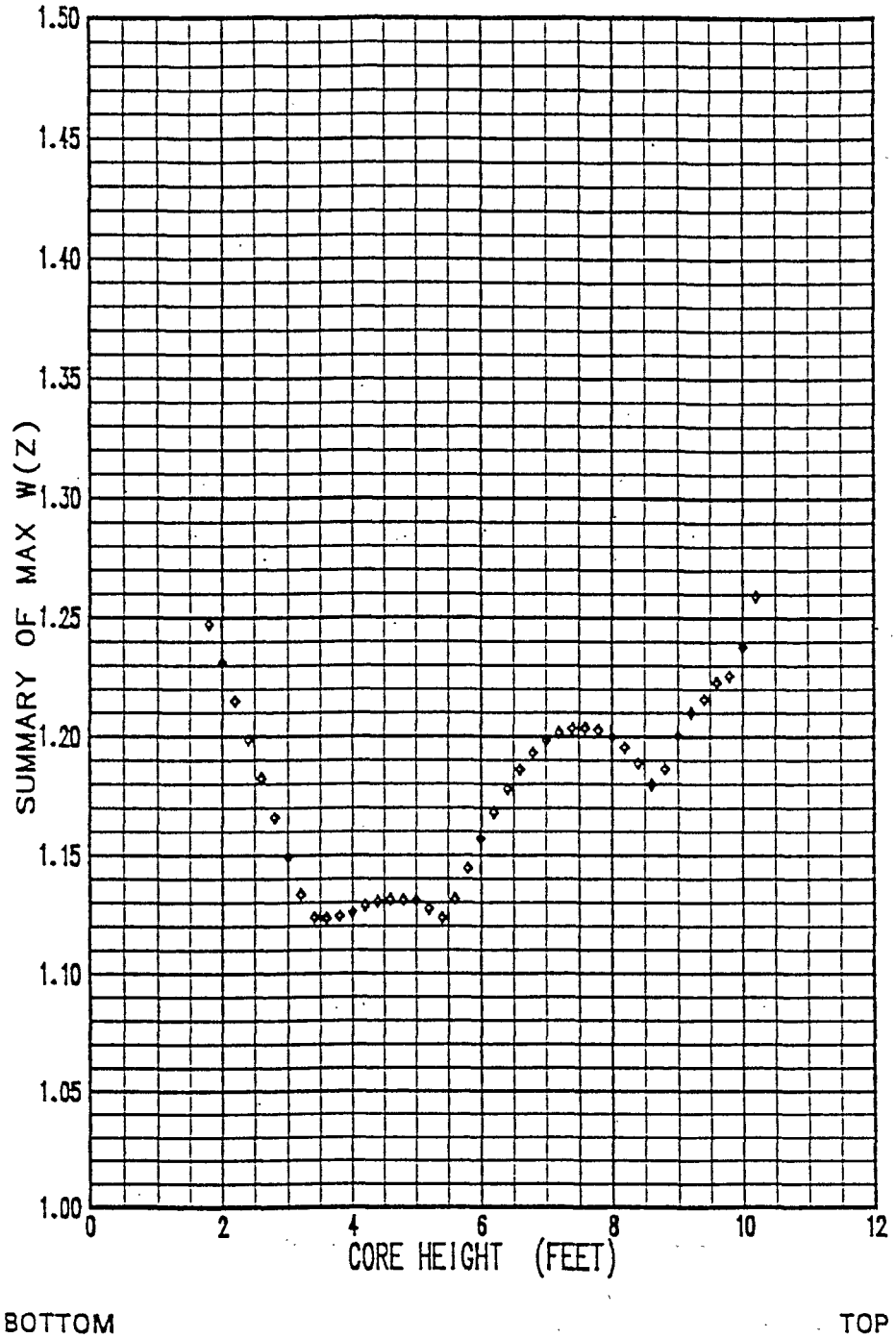
HEIGHT (FEET)	MAX W(Z)
0.0000	1.0000
0.2000	1.0000
0.4000	1.0000
0.6000	1.0000
0.8000	1.0000
1.0000	1.0000
1.2000	1.0000
1.4000	1.0000
1.6000	1.0000
1.8000	1.2751
2.0000	1.2549
2.2000	1.2338
2.4000	1.2129
2.6000	1.1920
2.8000	1.1715
3.0000	1.1501
3.2000	1.1322
3.4000	1.1222
3.6000	1.1186
3.8000	1.1197
4.0000	1.1213
4.2000	1.1218
4.4000	1.1214
4.6000	1.1197
4.8000	1.1177
5.0000	1.1161
5.2000	1.1131
5.4000	1.1092
5.6000	1.1103
5.8000	1.1209
6.0000	1.1332
6.2000	1.1435
6.4000	1.1530
6.6000	1.1614
6.8000	1.1687
7.0000	1.1746
7.2000	1.1790
7.4000	1.1820
7.6000	1.1842
7.8000	1.1863
8.0000	1.1870
8.2000	1.1866
8.4000	1.1839
8.6000	1.1796
8.8000	1.1938
9.0000	1.2178
9.2000	1.2402
9.4000	1.2607
9.6000	1.2809
9.8000	1.2977
10.0000	1.3200
10.2000	1.3474
10.4000	1.0000
10.6000	1.0000
10.8000	1.0000
11.0000	1.0000
11.2000	1.0000
11.4000	1.0000
11.6000	1.0000
11.8000	1.0000
12.0000	1.0000

FIGURE 6

WATTS BAR UNIT 1 CYCLE 1

RAOC SUMMARY OF MAX W(Z) AT 1000 MWD/MTU WITH HFP AFD BAND OF +5/-15

* TOP AND BOTTOM 15% EXCLUDED AS PER TECH SPEC 3.2.1.2



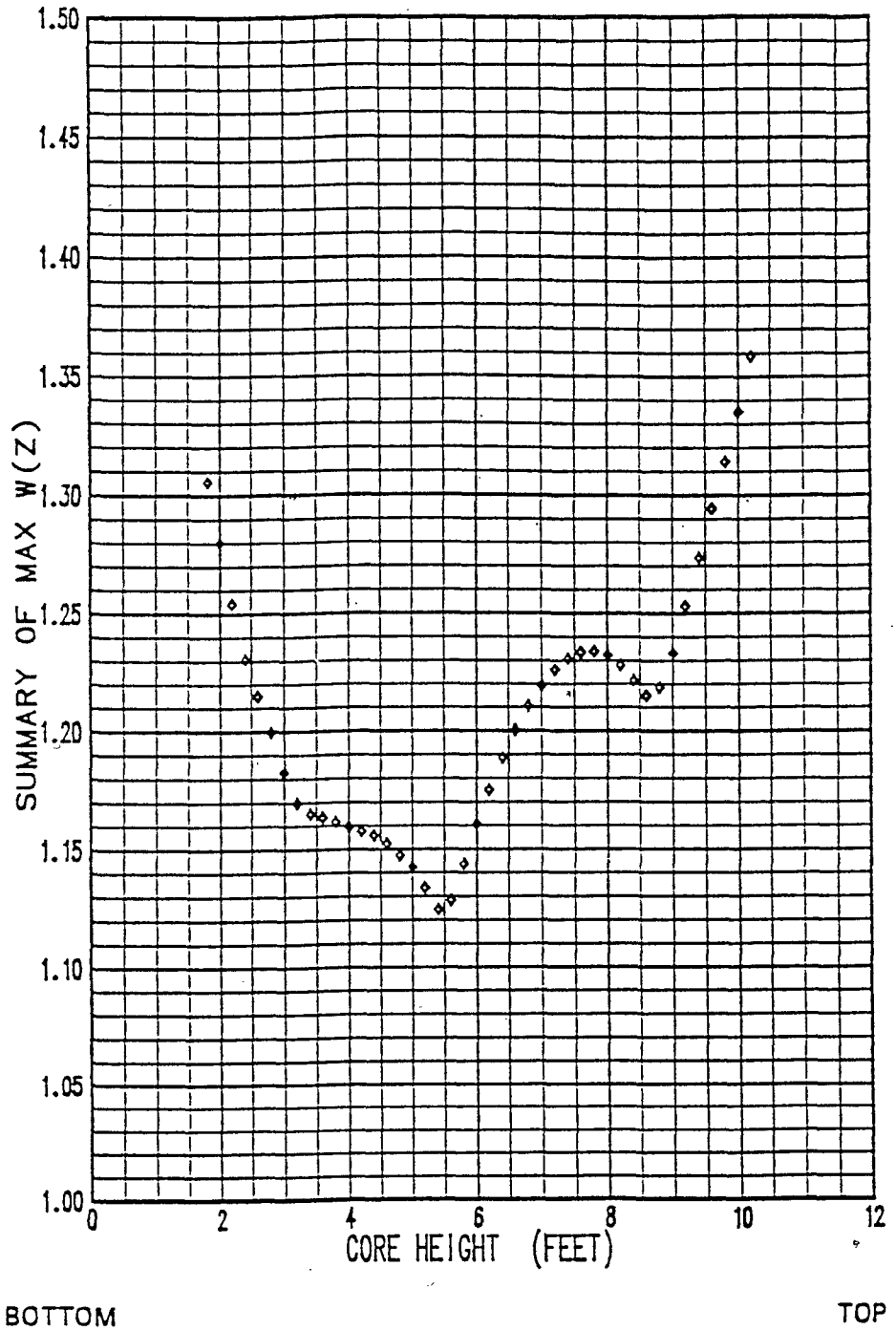
HEIGHT (FEET)	MAX W(Z)
0.0000	1.0000
0.2000	1.0000
0.4000	1.0000
0.6000	1.0000
0.8000	1.0000
1.0000	1.0000
1.2000	1.0000
1.4000	1.0000
1.6000	1.0000
1.8000	1.2474
2.0000	1.2314
2.2000	1.2150
2.4000	1.1986
2.6000	1.1822
2.8000	1.1660
3.0000	1.1492
3.2000	1.1334
3.4000	1.1237
3.6000	1.1233
3.8000	1.1243
4.0000	1.1261
4.2000	1.1287
4.4000	1.1306
4.6000	1.1313
4.8000	1.1310
5.0000	1.1308
5.2000	1.1274
5.4000	1.1235
5.6000	1.1315
5.8000	1.1445
6.0000	1.1571
6.2000	1.1681
6.4000	1.1779
6.6000	1.1862
6.8000	1.1930
7.0000	1.1983
7.2000	1.2018
7.4000	1.2035
7.6000	1.2037
7.8000	1.2027
8.0000	1.1999
8.2000	1.1956
8.4000	1.1888
8.6000	1.1798
8.8000	1.1864
9.0000	1.2005
9.2000	1.2102
9.4000	1.2159
9.6000	1.2229
9.8000	1.2258
10.0000	1.2380
10.2000	1.2594
10.4000	1.0000
10.6000	1.0000
10.8000	1.0000
11.0000	1.0000
11.2000	1.0000
11.4000	1.0000
11.6000	1.0000
11.8000	1.0000
12.0000	1.0000

FIGURE 7

WATTS BAR UNIT 1 CYCLE 1

RAOC SUMMARY OF MAX W(Z) AT 4000 MWD/MTU WITH HFP AFD BAND OF +5/-15

* TOP AND BOTTOM 15% EXCLUDED AS PER TECH SPEC 3.2.1.2



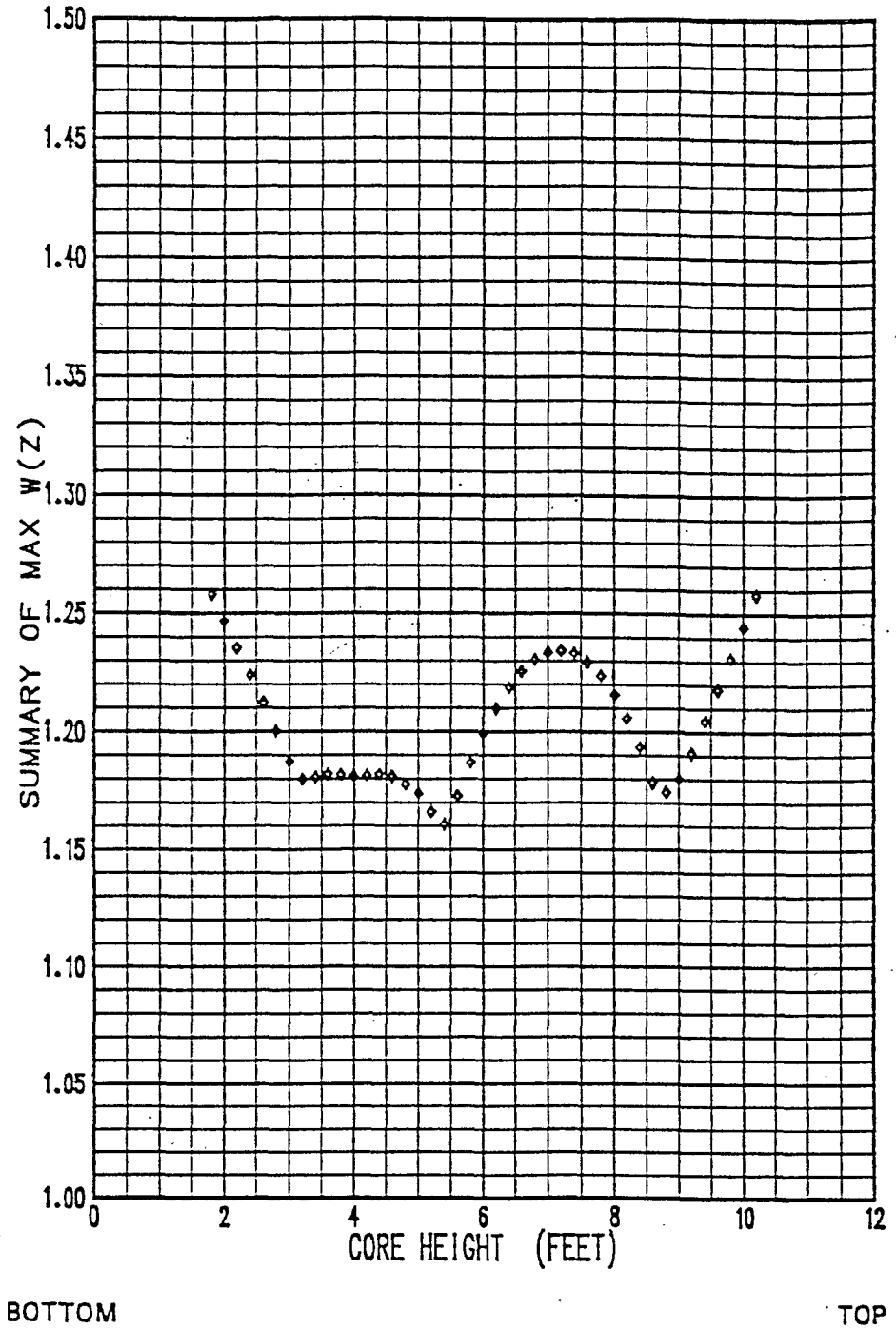
HEIGHT (FEET)	MAX W(Z)
0.0000	1.0000
0.2000	1.0000
0.4000	1.0000
0.6000	1.0000
0.8000	1.0000
1.0000	1.0000
1.2000	1.0000
1.4000	1.0000
1.6000	1.0000
1.8000	1.3056
2.0000	1.2802
2.2000	1.2542
2.4000	1.2308
2.6000	1.2151
2.8000	1.1997
3.0000	1.1826
3.2000	1.1698
3.4000	1.1651
3.6000	1.1635
3.8000	1.1616
4.0000	1.1593
4.2000	1.1576
4.4000	1.1558
4.6000	1.1523
4.8000	1.1474
5.0000	1.1422
5.2000	1.1335
5.4000	1.1244
5.6000	1.1283
5.8000	1.1437
6.0000	1.1606
6.2000	1.1750
6.4000	1.1885
6.6000	1.2004
6.8000	1.2107
7.0000	1.2193
7.2000	1.2261
7.4000	1.2308
7.6000	1.2334
7.8000	1.2339
8.0000	1.2321
8.2000	1.2280
8.4000	1.2216
8.6000	1.2151
8.8000	1.2187
9.0000	1.2330
9.2000	1.2529
9.4000	1.2735
9.6000	1.2944
9.8000	1.3141
10.0000	1.3353
10.2000	1.3588
10.4000	1.0000
10.6000	1.0000
10.8000	1.0000
11.0000	1.0000
11.2000	1.0000
11.4000	1.0000
11.6000	1.0000
11.8000	1.0000
12.0000	1.0000

FIGURE 8

WATTS BAR UNIT 1 CYCLE 1

RAOC SUMMARY OF MAX W(Z) AT 3500 MWD/MTU WITH HFP AFD BAND OF +8/-18

* TOP AND BOTTOM 15% EXCLUDED AS PER TECH SPEC 3.2.1.2



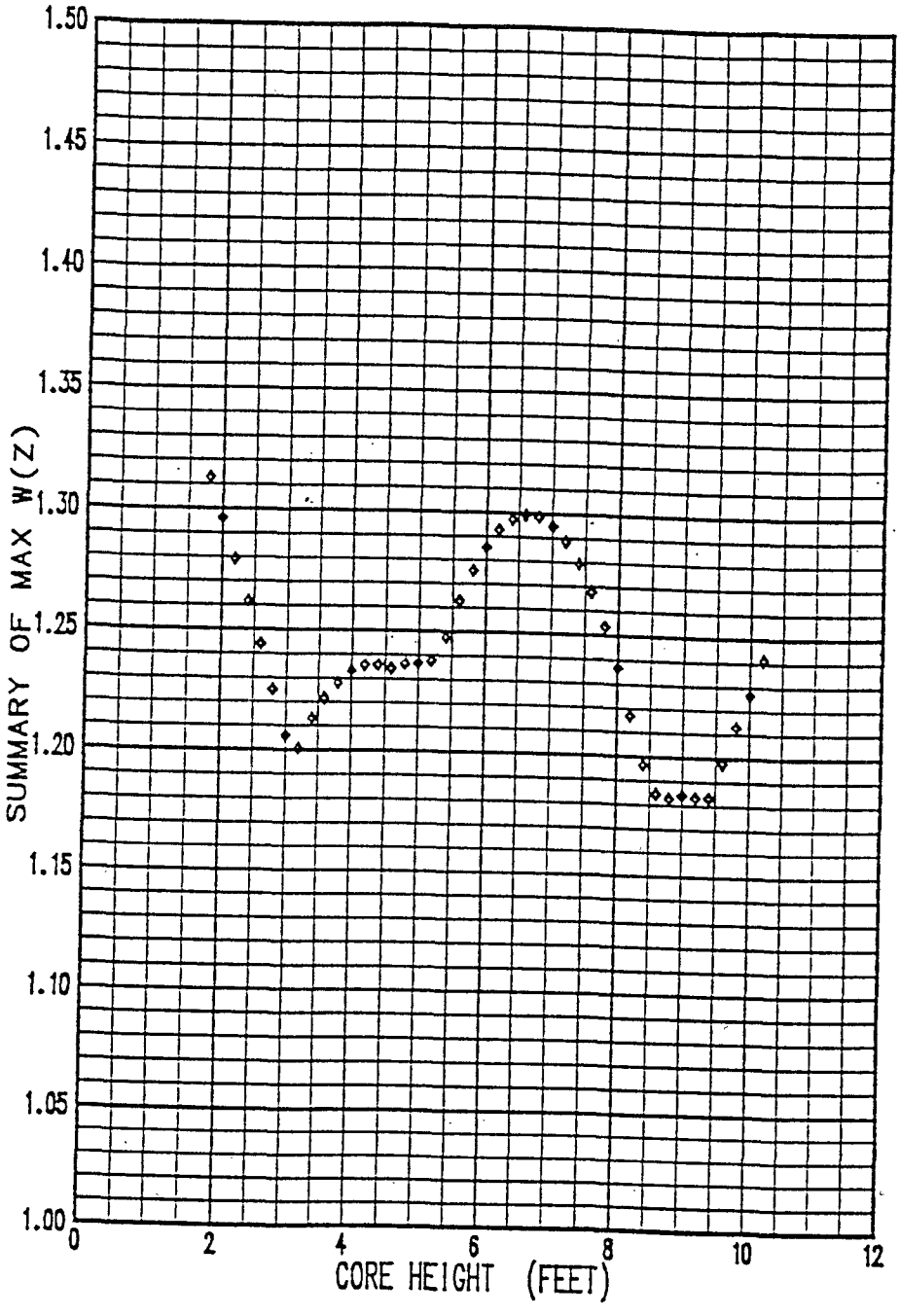
HEIGHT (FEET)	MAX W(Z)
0.0000	1.0000
0.2000	1.0000
0.4000	1.0000
0.6000	1.0000
0.8000	1.0000
1.0000	1.0000
1.2000	1.0000
1.4000	1.0000
1.6000	1.0000
1.8000	1.2581
2.0000	1.2469
2.2000	1.2355
2.4000	1.2239
2.6000	1.2122
2.8000	1.2004
3.0000	1.1875
3.2000	1.1798
3.4000	1.1807
3.6000	1.1820
3.8000	1.1816
4.0000	1.1810
4.2000	1.1814
4.4000	1.1820
4.6000	1.1808
4.8000	1.1777
5.0000	1.1738
5.2000	1.1662
5.4000	1.1607
5.6000	1.1727
5.8000	1.1870
6.0000	1.1992
6.2000	1.2099
6.4000	1.2187
6.6000	1.2256
6.8000	1.2306
7.0000	1.2336
7.2000	1.2344
7.4000	1.2331
7.6000	1.2296
7.8000	1.2238
8.0000	1.2158
8.2000	1.2060
8.4000	1.1936
8.6000	1.1787
8.8000	1.1746
9.0000	1.1802
9.2000	1.1911
9.4000	1.2049
9.6000	1.2182
9.8000	1.2314
10.0000	1.2446
10.2000	1.2582
10.4000	1.0000
10.6000	1.0000
10.8000	1.0000
11.0000	1.0000
11.2000	1.0000
11.4000	1.0000
11.6000	1.0000
11.8000	1.0000
12.0000	1.0000

FIGURE 9

WATTS BAR UNIT 1 CYCLE 1

RAOC SUMMARY OF MAX W(Z) AT 8000 MWD/MTU WITH HFP AFD BAND OF +8/-18

* TOP AND BOTTOM 15% EXCLUDED AS PER TECH SPEC 3.2.1.2



HEIGHT (FEET)	MAX W(Z)
0.0000	1.0000
0.2000	1.0000
0.4000	1.0000
0.6000	1.0000
0.8000	1.0000
1.0000	1.0000
1.2000	1.0000
1.4000	1.0000
1.6000	1.0000
1.8000	1.3127
2.0000	1.2962
2.2000	1.2792
2.4000	1.2618
2.6000	1.2438
2.8000	1.2251
3.0000	1.2060
3.2000	1.2007
3.4000	1.2131
3.6000	1.2215
3.8000	1.2280
4.0000	1.2330
4.2000	1.2355
4.4000	1.2357
4.6000	1.2342
4.8000	1.2365
5.0000	1.2367
5.2000	1.2377
5.4000	1.2475
5.6000	1.2627
5.8000	1.2756
6.0000	1.2854
6.2000	1.2927
6.4000	1.2973
6.6000	1.2993
6.8000	1.2985
7.0000	1.2949
7.2000	1.2886
7.4000	1.2796
7.6000	1.2679
7.8000	1.2535
8.0000	1.2369
8.2000	1.2171
8.4000	1.1967
8.6000	1.1847
8.8000	1.1827
9.0000	1.1844
9.2000	1.1832
9.4000	1.1834
9.6000	1.1980
9.8000	1.2131
10.0000	1.2268
10.2000	1.2413
10.4000	1.0000
10.6000	1.0000
10.8000	1.0000
11.0000	1.0000
11.2000	1.0000
11.4000	1.0000
11.6000	1.0000
11.8000	1.0000
12.0000	1.0000

FIGURE 10

WATTS BAR UNIT 1 CYCLE 1

RAOC SUMMARY OF MAX W(Z) AT 14000 MWD/MTU WITH HFP AFD BAND OF +8/-18

* TOP AND BOTTOM 15% EXCLUDED AS PER TECH SPEC 3.2.1.2