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May 4, 2001

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CALLAWAY PLANT
DOCKET NUMBER 50-483
CALLAWAY CYCLE 12
CORE OPERATING LIMITS REPORT

Attached is the Callaway Plant Cycle 12 Core Operating Limits Report (COLR). This report is provided to the NRC Staff for information. It has been prepared in accordance with the requirements of Technical Specification 5.6.5. If you have any questions concerning this report, please contact us.

Very truly yours,

John D. Blosser
Manager, Regulatory Affairs

DJW/jdg

Attachment: Appendix A, Callaway Cycle 12
Core Operating Limits Report, Rev. 0

A001

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Appendix A

CALLAWAY CYCLE 12

CORE OPERATING LIMITS REPORT

(Revision 0)

February 2001

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Callaway Plant Cycle 12 has been prepared in accordance with the requirements of Technical Specification 5.6.5.

The Core Operating Limits affecting the following Technical Specifications are included in this report.

3.1.1, 3.1.4, 3.1.5, 3.1.6, 3.1.8	Shutdown Margin
3.1.3	Moderator Temperature Coefficient
3.1.5	Shutdown Bank Insertion Limits
3.1.6	Control Bank Insertion Limits
3.2.1	Heat Flux Hot Channel Factor
3.2.2	Nuclear Enthalpy Rise Hot Channel Factor
3.2.3	Axial Flux Difference

2.0 OPERATING LIMITS

The cycle-specific parameter limits for the specifications listed in Section 1.0 are presented in the subsections which follow. These limits have been developed using the NRC-approved methodologies specified in Technical Specification 5.6.5.

2.1 Shutdown Margin
(Specifications 3.1.1, 3.1.4, 3.1.5, 3.1.6, and 3.1.8)

2.1.1 The Shutdown Margin in MODES 1-4 shall be greater than or equal to 1.3% $\Delta k/k$.

2.1.2 The Shutdown Margin in MODE 5 shall be greater than or equal to 1.0% $\Delta k/k$.

2.2 Moderator Temperature Coefficient
(Specification 3.1.3)

2.2.1 The Moderator Temperature Coefficient shall be less positive than the limits shown in Figure 1. These limits shall be referred to as upper limit.

The Moderator Temperature Coefficient shall be less negative than -47.9 pcm/°F. This limit shall be referred to as the lower limit.

2.2.2 The MTC 300 ppm surveillance limit is -40.4 pcm/°F (all rods withdrawn, Rated Thermal Power condition).

2.2.3 The MTC 60 ppm surveillance limit is -45.1 pcm/°F (all rods withdrawn, Rated Thermal Power condition).

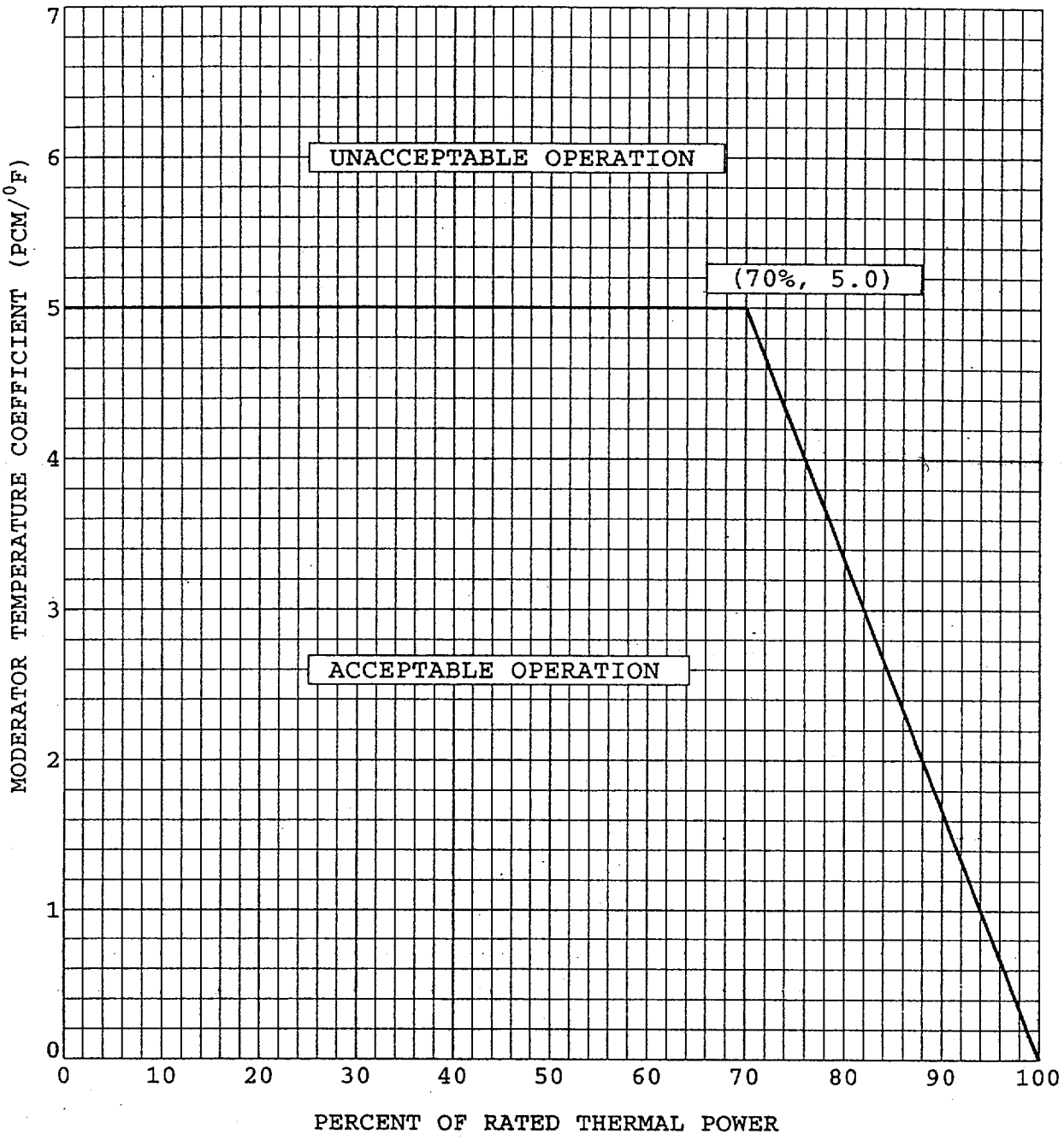


Figure 1

Callaway Cycle 12
Moderator Temperature Coefficient
Versus Power Level

2.3 Shutdown Bank Insertion Limits
(Specification 3.1.5)

The shutdown banks shall be withdrawn to at least 225 steps.

2.4 Control Bank Insertion Limits
(Specification 3.1.6)

2.4.1 Control Bank insertion limits are specified by Figure 2.

2.4.2 Control Bank withdrawal sequence is A-B-C-D. The insertion sequence is the reverse of the withdrawal sequence.

2.4.3 The difference between each sequential Control Bank position is 115 steps when not fully inserted and not fully withdrawn.

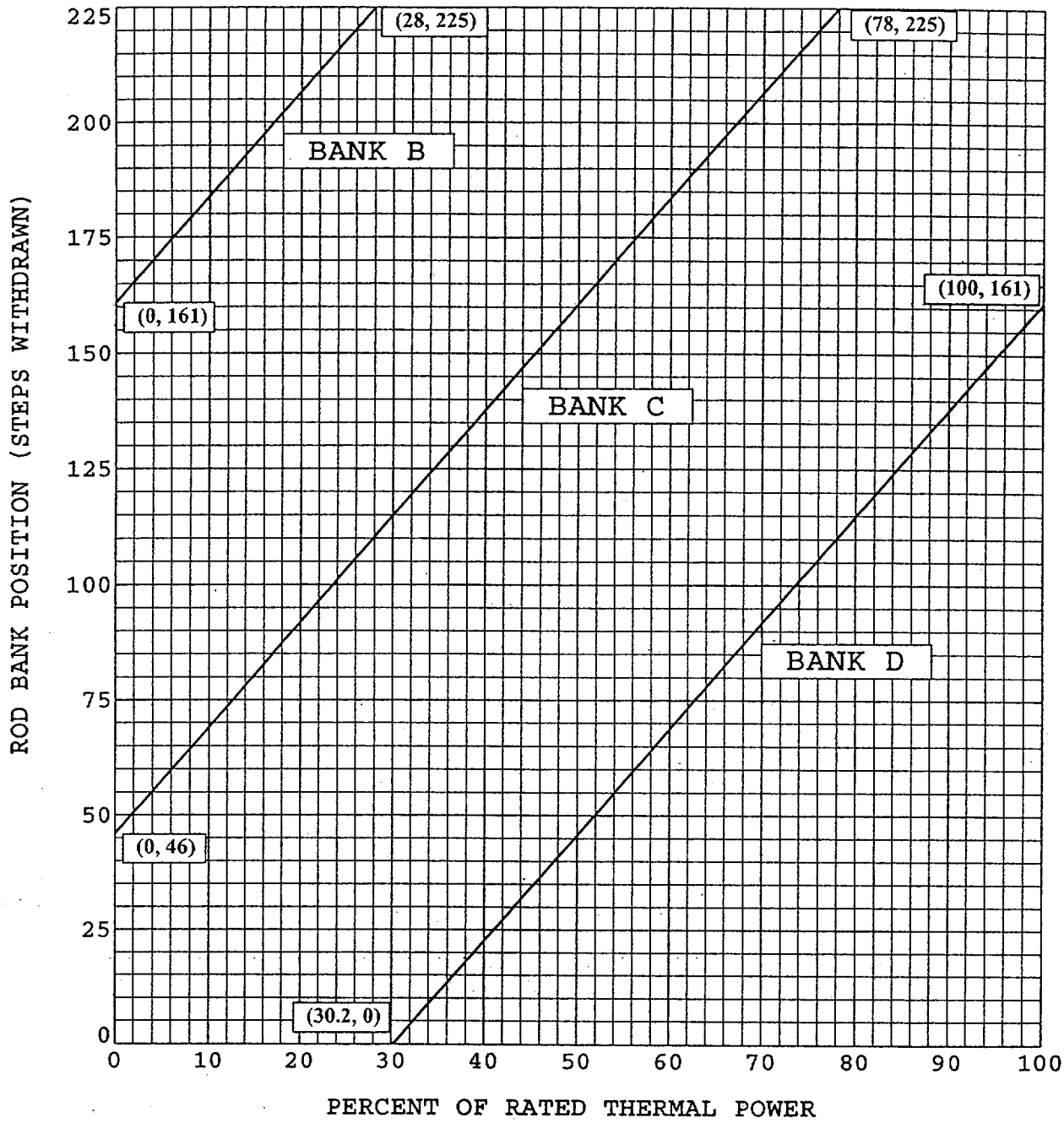


Figure 2

Callaway Cycle 12
Rod Bank Insertion Limits
Versus Rated Thermal Power - Four Loop Operation

2.5 Heat Flux Hot Channel Factor - $F_Q(Z)$
(Specification 3.2.1)

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

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

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

2.5.1 $F_Q^{RTP} = 2.45$ for all Cycle 12 burnups less than 8000 MWD/MTU, and $F_Q^{RTP} = 2.50$ for all Cycle 12 burnups greater than or equal to 8000 MWD/MTU.

2.5.2 K(Z) is provided in Figure 3.

2.5.3 The W(z) functions that are to be used in Technical Specification 3.2.1 and Surveillance Requirement 3.2.1.2 for determining $F_Q^W(z)$ are shown in Figures 4 through 8.

The W(z) values have been determined for several burnups up to 18000 MWD/MTU in Cycle 12. This permits determination of W(z) at any cycle burnup up to 18000 MWD/MTU through the use of three point interpolation. For cycle burnups greater than 18000 MWD/MTU, use of 18000 MWD/MTU W(z) values without interpolation or extrapolation is conservative. The W(z) values were determined assuming Cycle 12 operates with RAOC strategy. Also included is a W(z) function that bounds the W(z) Curve for all Cycle 12 burnups. Use of the bounding W(z) curve will be conservative for any Cycle 12 burnup; however, additional margin may be gained by using the burnup dependent W(z) values.

The W(z) values are provided for 73 axial points within the core height boundaries of 0 and 12 feet at intervals of 0.167 feet.

Table A.1 shows the burnup dependent F_Q penalty factors for Cycle 12. These values shall be used to increase $F_Q^W(z)$ when required by Technical Specification Surveillance Requirement 3.2.1.2. A 2% penalty factor should be used at all cycle burnups that are outside the range of Table A.1.

TABLE A.1

F_Q PENALTY FACTORS AS A FUNCTION OF CYCLE BURNUP

Cycle 12 Burnup	$F_Q^W(z)$ Penalty Factor (%)
All Cycle 12 Burnups	< 2.00% Penalty

Note: All cycle burnups not in the range of the above table shall use a 2.0% penalty factor for compliance with Surveillance Requirement 3.2.1.2.

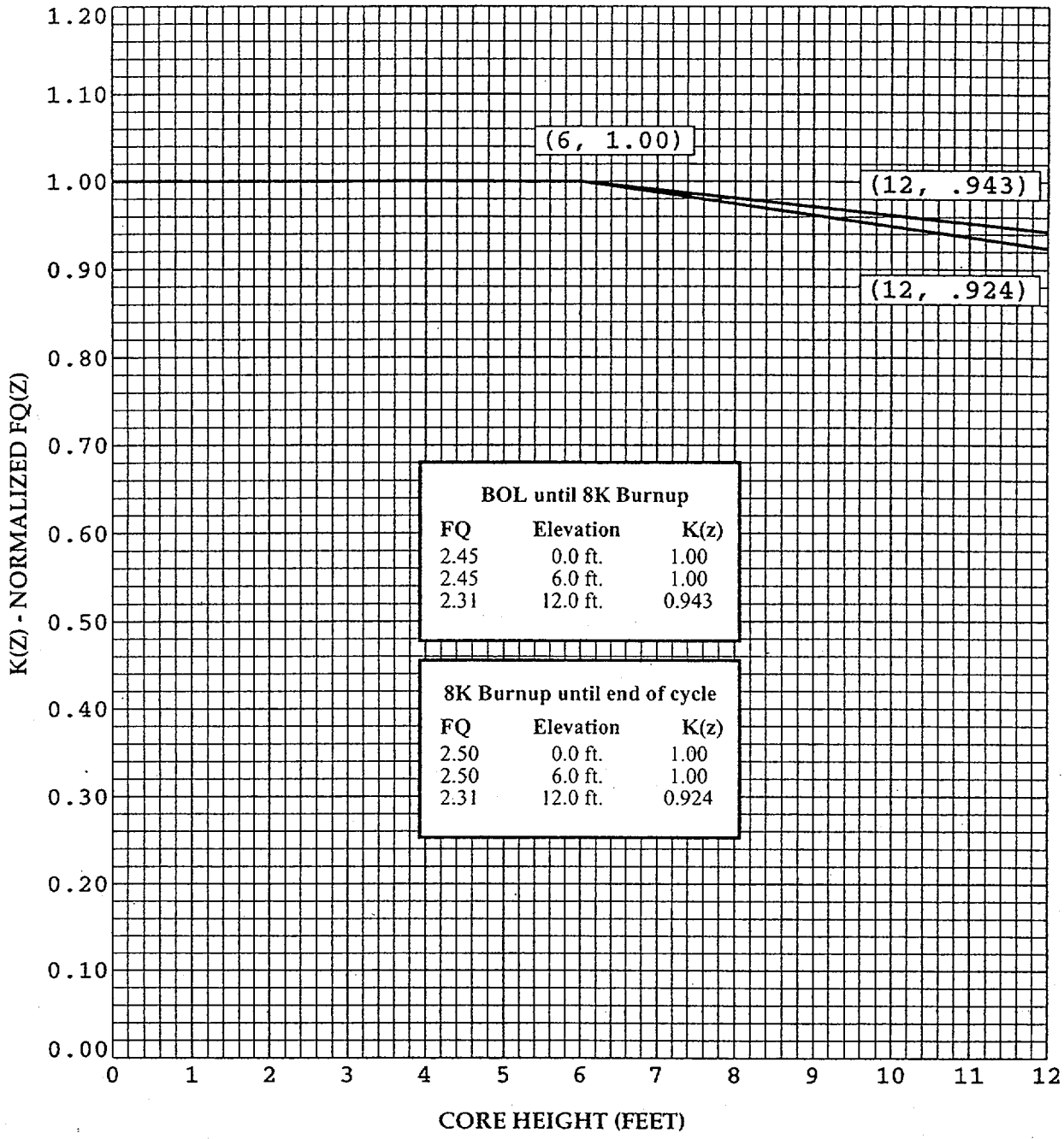
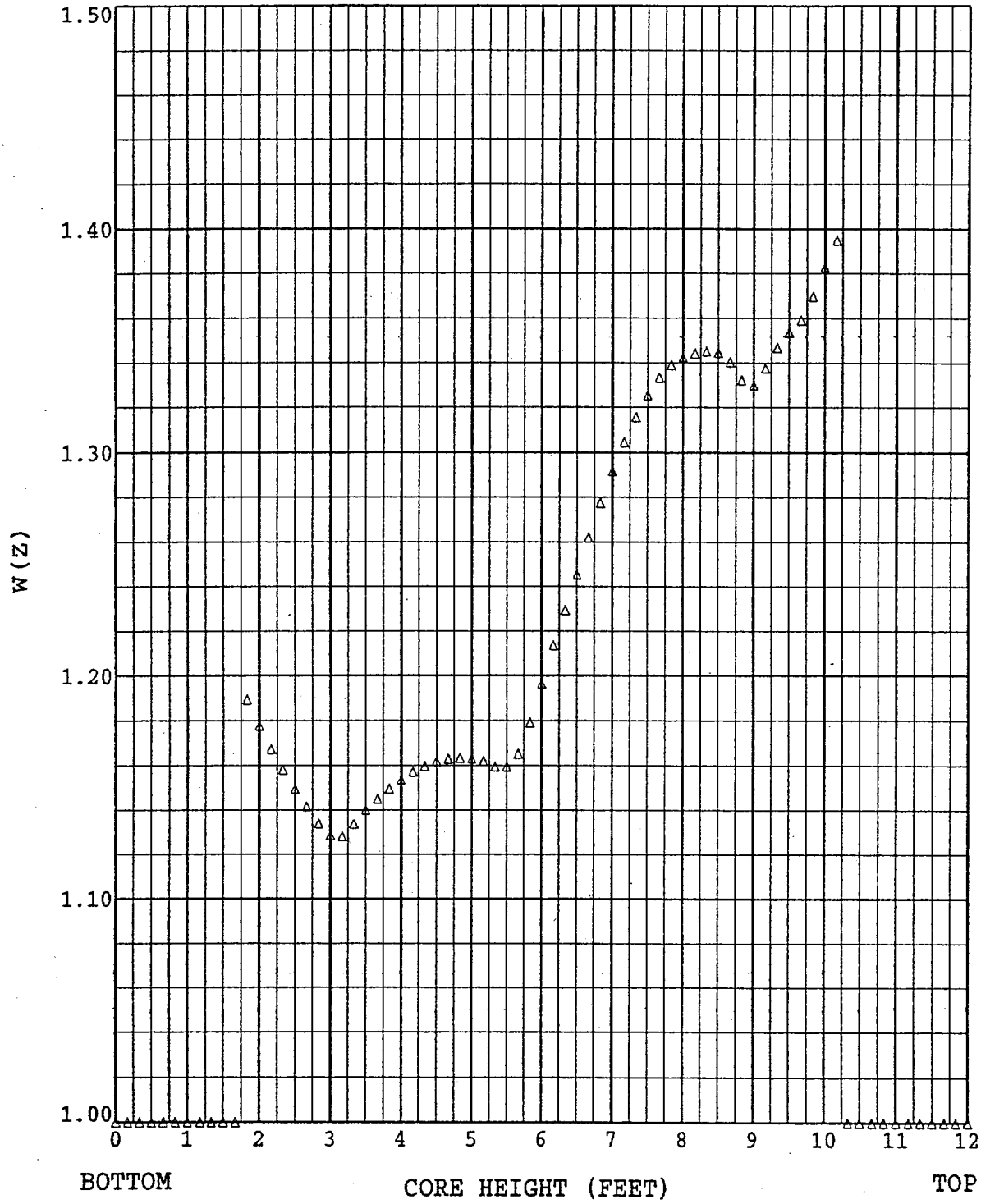


Figure 3

Callaway Cycle 12
K(z) - Normalized $F_Q(z)$
As a Function of Core Height

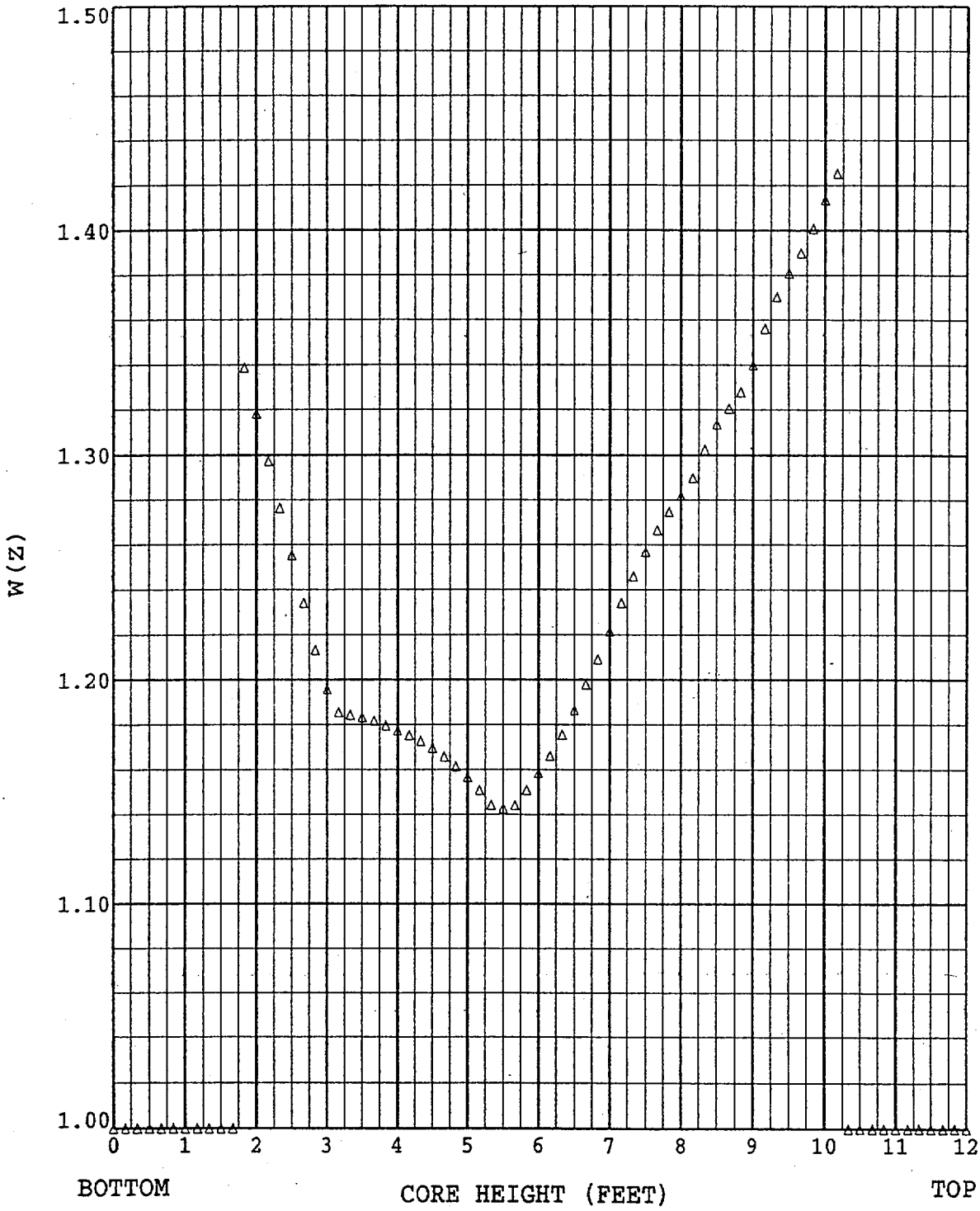


	HEIGHT (FEET)	150. W(Z)
*	0.000	1.0000
*	0.167	1.0000
*	0.333	1.0000
*	0.500	1.0000
*	0.667	1.0000
*	0.833	1.0000
*	1.000	1.0000
*	1.167	1.0000
*	1.333	1.0000
*	1.500	1.0000
*	1.667	1.0000
	1.833	1.1895
	2.000	1.1779
	2.167	1.1672
	2.333	1.1581
	2.500	1.1496
	2.667	1.1415
	2.833	1.1341
	3.000	1.1287
	3.167	1.1282
	3.333	1.1339
	3.500	1.1401
	3.667	1.1450
	3.833	1.1496
	4.000	1.1537
	4.167	1.1571
	4.333	1.1598
	4.500	1.1618
	4.667	1.1630
	4.833	1.1633
	5.000	1.1631
	5.167	1.1619
	5.333	1.1595
	5.500	1.1594
	5.667	1.1653
	5.833	1.1792
	6.000	1.1965
	6.167	1.2136
	6.333	1.2293
	6.500	1.2455
	6.667	1.2620
	6.833	1.2775
	7.000	1.2917
	7.167	1.3045
	7.333	1.3158
	7.500	1.3254
	7.667	1.3332
	7.833	1.3391
	8.000	1.3426
	8.167	1.3443
	8.333	1.3452
	8.500	1.3446
	8.667	1.3404
	8.833	1.3322
	9.000	1.3300
	9.167	1.3375
	9.333	1.3469
	9.500	1.3536
	9.667	1.3590
	9.833	1.3696
	10.000	1.3828
	10.167	1.3949
*	10.333	1.0000
*	10.500	1.0000
*	10.667	1.0000
*	10.833	1.0000
*	11.000	1.0000
*	11.167	1.0000
*	11.333	1.0000
*	11.500	1.0000
*	11.667	1.0000
*	11.833	1.0000
*	12.000	1.0000

Figure 4

Callaway Cycle 12
W(z) at 150 MWD/MTU

* Top and bottom 15% excluded as per Tech Spec SR 3.2.1.2

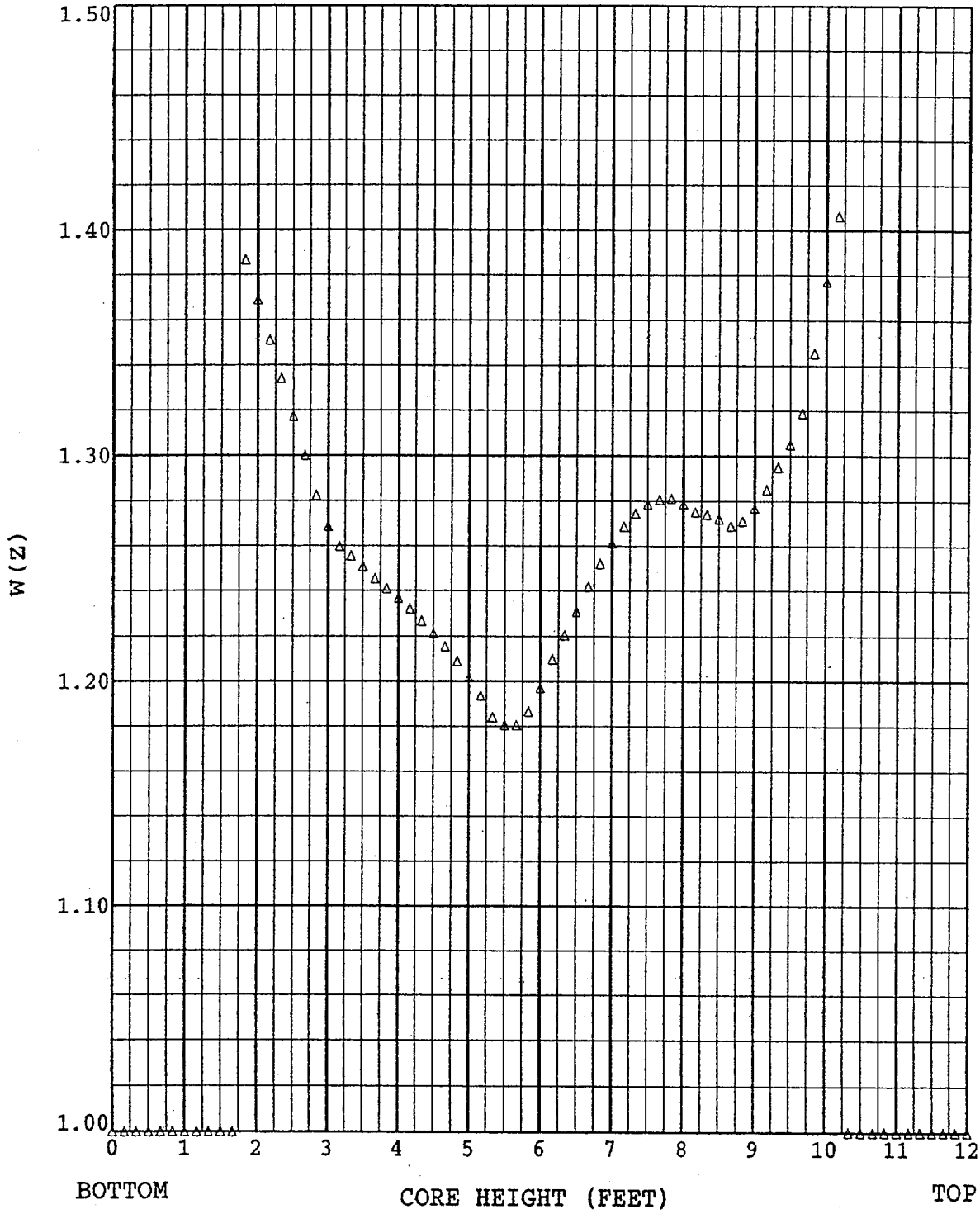


	HEIGHT (FEET)	4000. W(Z)
*	0.000	1.0000
*	0.167	1.0000
*	0.333	1.0000
*	0.500	1.0000
*	0.667	1.0000
*	0.833	1.0000
*	1.000	1.0000
*	1.167	1.0000
*	1.333	1.0000
*	1.500	1.0000
*	1.667	1.0000
	1.833	1.3386
	2.000	1.3183
	2.167	1.2973
	2.333	1.2763
	2.500	1.2553
	2.667	1.2341
	2.833	1.2132
	3.000	1.1957
	3.167	1.1855
	3.333	1.1844
	3.500	1.1834
	3.667	1.1817
	3.833	1.1796
	4.000	1.1774
	4.167	1.1753
	4.333	1.1727
	4.500	1.1696
	4.667	1.1658
	4.833	1.1614
	5.000	1.1566
	5.167	1.1509
	5.333	1.1441
	5.500	1.1426
	5.667	1.1440
	5.833	1.1509
	6.000	1.1585
	6.167	1.1661
	6.333	1.1756
	6.500	1.1865
	6.667	1.1978
	6.833	1.2092
	7.000	1.2214
	7.167	1.2341
	7.333	1.2460
	7.500	1.2569
	7.667	1.2665
	7.833	1.2748
	8.000	1.2819
	8.167	1.2899
	8.333	1.3025
	8.500	1.3136
	8.667	1.3206
	8.833	1.3279
	9.000	1.3399
	9.167	1.3561
	9.333	1.3703
	9.500	1.3809
	9.667	1.3898
	9.833	1.4009
	10.000	1.4138
	10.167	1.4253
*	10.333	1.0000
*	10.500	1.0000
*	10.667	1.0000
*	10.833	1.0000
*	11.000	1.0000
*	11.167	1.0000
*	11.333	1.0000
*	11.500	1.0000
*	11.667	1.0000
*	11.833	1.0000
*	12.000	1.0000

Figure 5

Callaway Cycle 12
W(z) at 4000 MWD/MTU

* Top and bottom 15% excluded as per Tech Spec SR 3.2.1.2

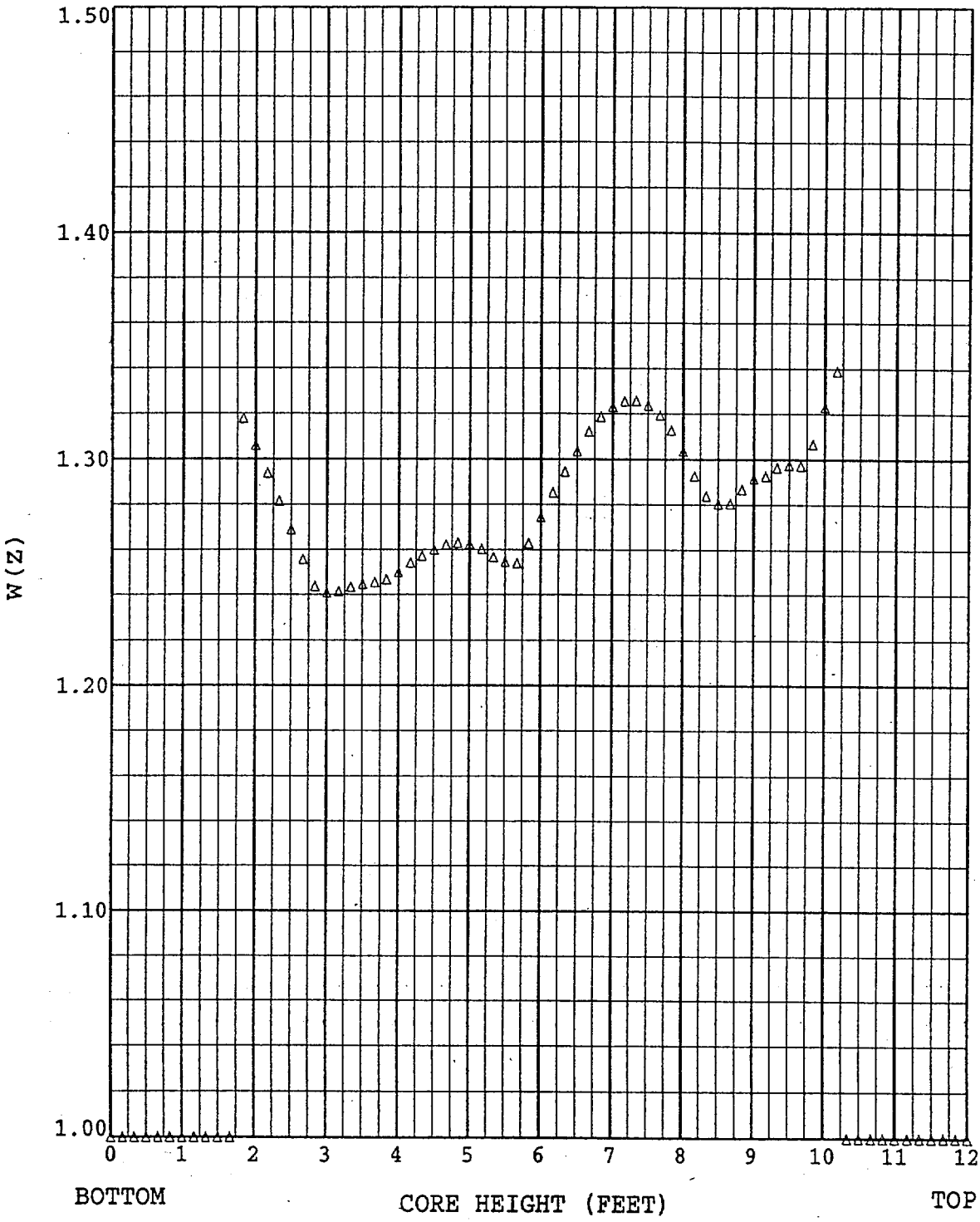


	HEIGHT (FEET)	10000. W(Z)
*	0.000	1.0000
*	0.167	1.0000
*	0.333	1.0000
*	0.500	1.0000
*	0.667	1.0000
*	0.833	1.0000
*	1.000	1.0000
*	1.167	1.0000
*	1.333	1.0000
*	1.500	1.0000
*	1.667	1.0000
	1.833	1.3866
	2.000	1.3689
	2.167	1.3510
	2.333	1.3341
	2.500	1.3174
	2.667	1.3001
	2.833	1.2825
	3.000	1.2685
	3.167	1.2598
	3.333	1.2555
	3.500	1.2509
	3.667	1.2455
	3.833	1.2411
	4.000	1.2369
	4.167	1.2322
	4.333	1.2268
	4.500	1.2213
	4.667	1.2155
	4.833	1.2089
	5.000	1.2018
	5.167	1.1936
	5.333	1.1840
	5.500	1.1807
	5.667	1.1806
	5.833	1.1866
	6.000	1.1971
	6.167	1.2098
	6.333	1.2205
	6.500	1.2310
	6.667	1.2418
	6.833	1.2521
	7.000	1.2613
	7.167	1.2687
	7.333	1.2745
	7.500	1.2785
	7.667	1.2807
	7.833	1.2811
	8.000	1.2787
	8.167	1.2751
	8.333	1.2741
	8.500	1.2720
	8.667	1.2690
	8.833	1.2710
	9.000	1.2770
	9.167	1.2851
	9.333	1.2950
	9.500	1.3051
	9.667	1.3190
	9.833	1.3455
	10.000	1.3772
	10.167	1.4064
*	10.333	1.0000
*	10.500	1.0000
*	10.667	1.0000
*	10.833	1.0000
*	11.000	1.0000
*	11.167	1.0000
*	11.333	1.0000
*	11.500	1.0000
*	11.667	1.0000
*	11.833	1.0000
*	12.000	1.0000

Figure 6

Callaway Cycle 12
W(z) at 10000 MWD/MTU

* Top and bottom 15% excluded as per Tech Spec SR 3.2.1.2

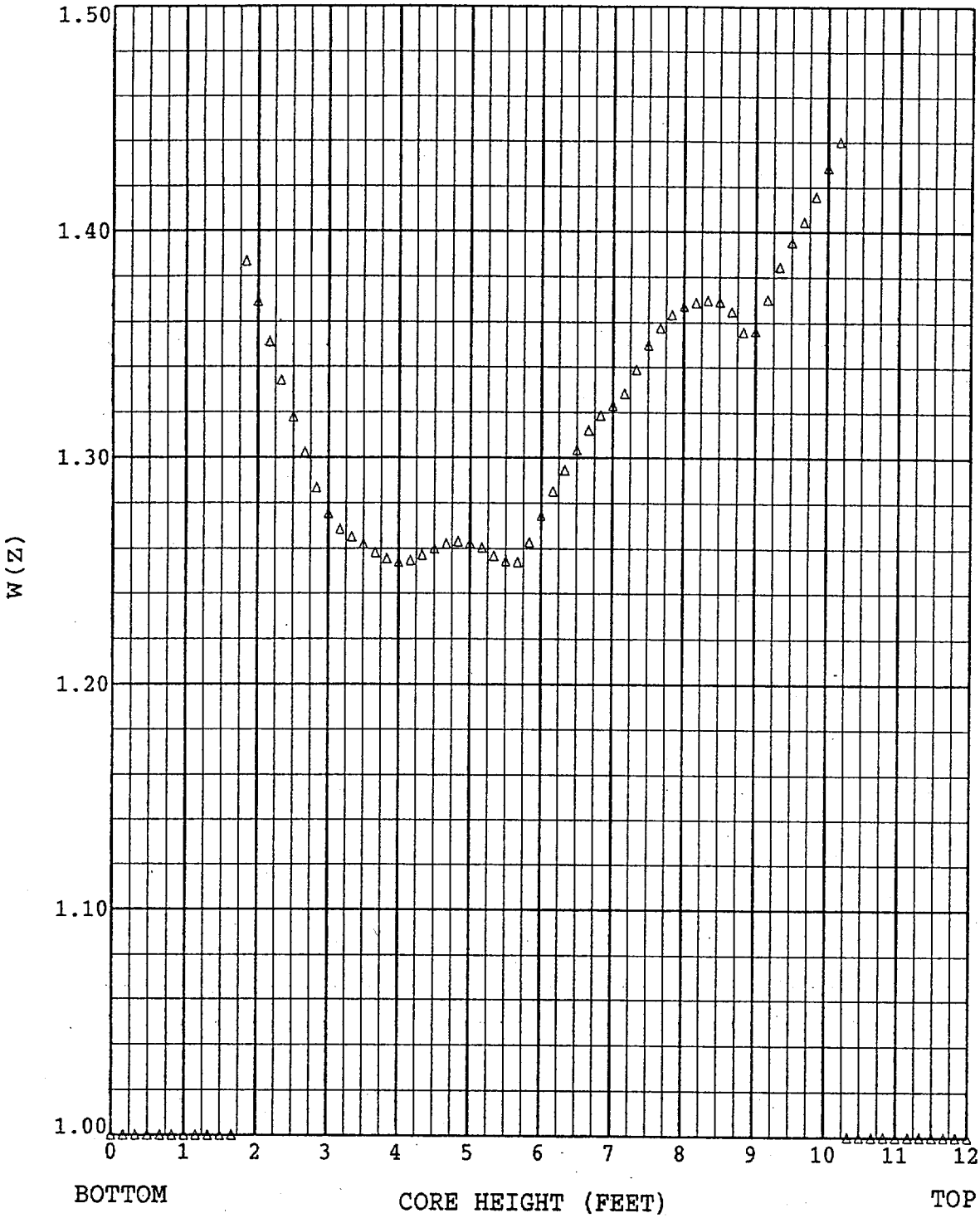


	HEIGHT (FEET)	18000. W(Z)
*	0.000	1.0000
*	0.167	1.0000
*	0.333	1.0000
*	0.500	1.0000
*	0.667	1.0000
*	0.833	1.0000
*	1.000	1.0000
*	1.167	1.0000
*	1.333	1.0000
*	1.500	1.0000
*	1.667	1.0000
	1.833	1.3179
	2.000	1.3060
	2.167	1.2938
	2.333	1.2814
	2.500	1.2689
	2.667	1.2558
	2.833	1.2437
	3.000	1.2410
	3.167	1.2414
	3.333	1.2434
	3.500	1.2446
	3.667	1.2455
	3.833	1.2467
	4.000	1.2500
	4.167	1.2542
	4.333	1.2572
	4.500	1.2600
	4.667	1.2622
	4.833	1.2630
	5.000	1.2624
	5.167	1.2603
	5.333	1.2567
	5.500	1.2545
	5.667	1.2540
	5.833	1.2628
	6.000	1.2745
	6.167	1.2852
	6.333	1.2944
	6.500	1.3035
	6.667	1.3122
	6.833	1.3187
	7.000	1.3231
	7.167	1.3255
	7.333	1.3257
	7.500	1.3237
	7.667	1.3194
	7.833	1.3129
	8.000	1.3036
	8.167	1.2927
	8.333	1.2838
	8.500	1.2804
	8.667	1.2805
	8.833	1.2868
	9.000	1.2916
	9.167	1.2927
	9.333	1.2964
	9.500	1.2975
	9.667	1.2972
	9.833	1.3068
	10.000	1.3230
	10.167	1.3389
*	10.333	1.0000
*	10.500	1.0000
*	10.667	1.0000
*	10.833	1.0000
*	11.000	1.0000
*	11.167	1.0000
*	11.333	1.0000
*	11.500	1.0000
*	11.667	1.0000
*	11.833	1.0000
*	12.000	1.0000

Figure 7

Callaway Cycle 12
W(z) at 18000 MWD/MTU

* Top and bottom 15% excluded as per Tech Spec SR 3.2.1.2



	HEIGHT (FEET)	MAX W(Z)
*	0.000	1.0000
*	0.167	1.0000
*	0.333	1.0000
*	0.500	1.0000
*	0.667	1.0000
*	0.833	1.0000
*	1.000	1.0000
*	1.167	1.0000
*	1.333	1.0000
*	1.500	1.0000
*	1.667	1.0000
	1.833	1.3866
	2.000	1.3689
	2.167	1.3510
	2.333	1.3341
	2.500	1.3180
	2.667	1.3025
	2.833	1.2867
	3.000	1.2754
	3.167	1.2685
	3.333	1.2652
	3.500	1.2621
	3.667	1.2583
	3.833	1.2556
	4.000	1.2541
	4.167	1.2548
	4.333	1.2572
	4.500	1.2600
	4.667	1.2622
	4.833	1.2630
	5.000	1.2624
	5.167	1.2603
	5.333	1.2567
	5.500	1.2545
	5.667	1.2540
	5.833	1.2628
	6.000	1.2745
	6.167	1.2852
	6.333	1.2944
	6.500	1.3035
	6.667	1.3122
	6.833	1.3188
	7.000	1.3231
	7.167	1.3284
	7.333	1.3390
	7.500	1.3498
	7.667	1.3575
	7.833	1.3634
	8.000	1.3671
	8.167	1.3688
	8.333	1.3697
	8.500	1.3692
	8.667	1.3649
	8.833	1.3557
	9.000	1.3561
	9.167	1.3703
	9.333	1.3846
	9.500	1.3954
	9.667	1.4044
	9.833	1.4156
	10.000	1.4286
	10.167	1.4402
*	10.333	1.0000
*	10.500	1.0000
*	10.667	1.0000
*	10.833	1.0000
*	11.000	1.0000
*	11.167	1.0000
*	11.333	1.0000
*	11.500	1.0000
*	11.667	1.0000
*	11.833	1.0000
*	12.000	1.0000

Figure 8

Callaway Cycle 12
Bounding W(z)

* Top and bottom 15% excluded as per Tech Spec SR 3.2.1.2

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

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

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

2.6.1 $F_{\Delta H}^{RTP} = 1.59$

2.6.2 $PF_{\Delta H} = 0.3$

2.7 Axial Flux Difference
(Specification 3.2.3)

The Axial Flux Difference (AFD) Limits are provided in Figure 9.

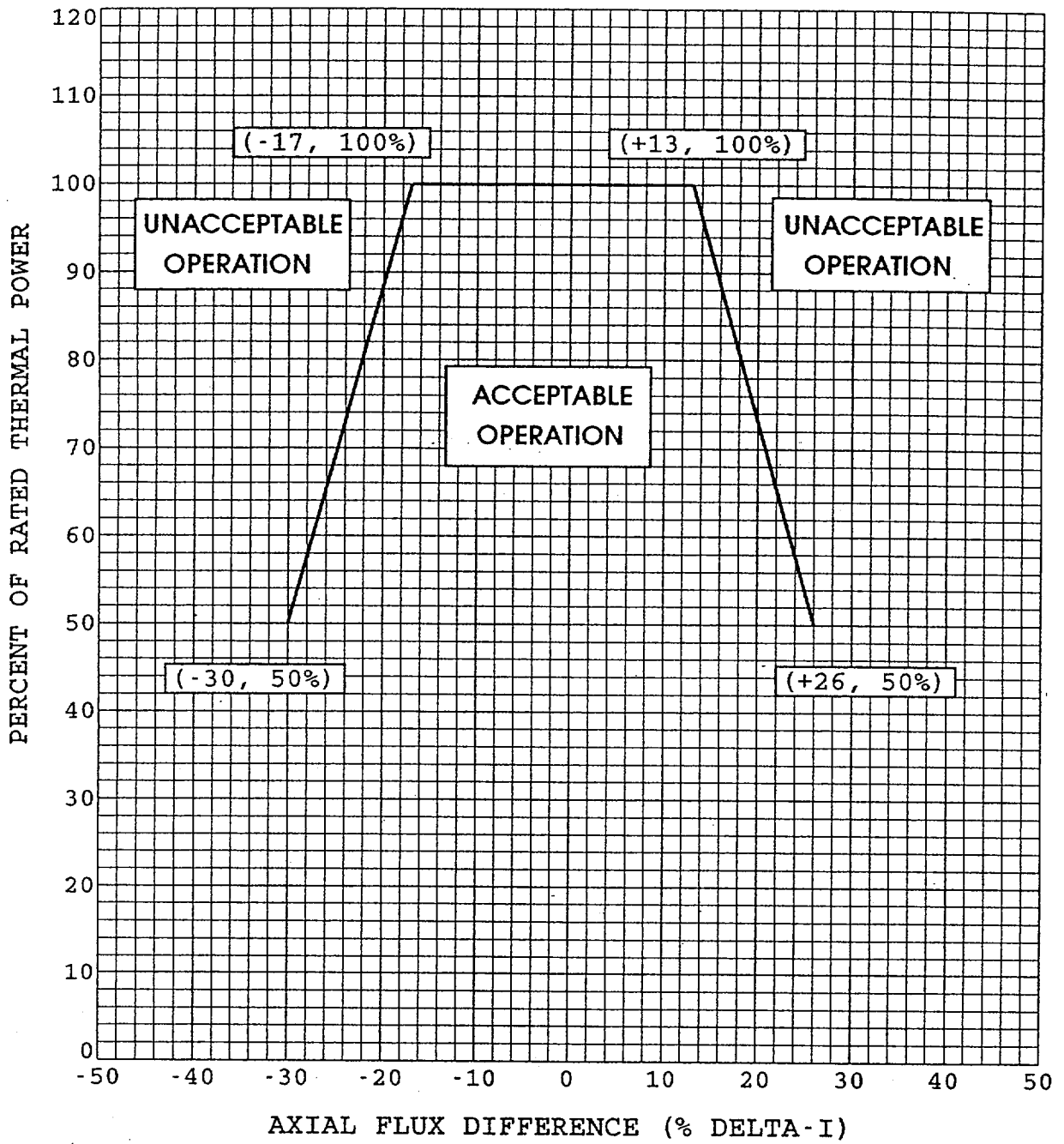


Figure 9

Callaway Cycle 12
Axial Flux Difference Limits as a Function of Rated Thermal Power for RAOC