

SHEARON HARRIS UNIT 1 CYCLE 4  
CORE OPERATING LIMITS REPORT

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1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Shearon Harris Unit 1 Cycle 4 has been prepared in accordance with the requirements of Technical Specification 6.9.1.6

The Technical Specifications affected by this report are listed below:

3/4.1.1.3	Moderator Temperature Coefficient
3/4.1.3.5	Shutdown Rod Insertion Limit
3/4.1.3.6	Control Rod Insertion Limits
3/4.2.1	Axial Flux Difference
3/4.2.2	Heat Flux Hot Channel Factor - $F_Q(Z)$
3/4.2.3	Nuclear Enthalpy Rise Hot Channel Factor- $F_{\Delta H}$

## 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 Technical Specification 6.9.1.6 and given in Section 3.

### 2.1 Moderator Temperature Coefficient (Specification 3/4.1.1.3)

#### 2.1.1 The Moderator Temperature Coefficient (MTC) limits are:

The Positive MTC Limit (ARO/HZP) shall be less positive than +5.0 pcm/°F for power levels up to 70% RTP with a linear ramp to 0 pcm/°F at 100% RTP.

The Negative MTC Limit (ARO/RTP) shall be less negative than -49 pcm/°F.

#### 2.1.2 The MTC Surveillance limit is:

The 300 ppm/ARO/RTP-MTC should be less negative than or equal to -41.5 pcm/°F.

where: ARO stands for All Rods Out  
HZP stands for Hot Zero THERMAL POWER  
RTP stands for RATED THERMAL POWER

### 2.2 Shutdown Rod Insertion Limit (Specification 3/4.1.3.5)

#### 2.2.1 Fully withdrawn for all shutdown rods shall be 228 steps.

### 2.3 Control Rod Insertion Limits (Specification 3/4.1.3.6)

#### 2.3.1 The control rod banks shall be limited in physical insertion as specified in Figure 1. Fully withdrawn for all control rods shall be 228 steps.

### 2.4 Axial Flux Difference (Specification 3/4.2.1)

#### 2.4.1 The acceptable operational space for Relaxed Axial Offset Control (RAOC) operation is specified in Figure 2.

#### 2.4.2 The AXIAL FLUX DIFFERENCE (AFD) target band for Base Load operation is $\pm 5\%$ .

#### 2.4.3 The APL<sup>ND</sup> for Base Load operation is 85% of RATED THERMAL POWER.

2.5 Heat Flux Hot Channel Factor -  $F_Q(Z)$  (Specification 3/4.2.2)

$$2.5.1 \quad F_Q(Z) \leq \frac{F_Q^{RTP}}{P} * K(Z) \text{ for } P > 0.5$$

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

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

$$2.5.2 \quad F_Q^{RTP} = 2.45$$

2.5.3  $K(Z)$  is specified in Figure 3.

2.5.4  $W(z)$  Curves for RAOC Operation are specified in Figures 4 through 6. These  $W(z)$  curves are sufficient to determine the RAOC  $W(z)$  versus core height for Cycle 4 burnups through the end of full power reactivity plus a power coastdown of up to 1219 MWD/MTU through the use of three point interpolation.

2.5.5  $W(z)$  Curves for Base Load Operation are specified in Figures 7 through 9. These  $W(z)$  curves are sufficient to determine the Base Load  $W(z)$  versus core height for Cycle 4 burnups through the end of full power reactivity plus a power coastdown of up to 1219 MWD/MTU through the use of three point interpolation.

2.6 Nuclear Enthalpy Rise Hot Channel Factor -  $F_{\Delta H}$  (Specification 3/4.2.3)

$$2.6.1 \quad F_{\Delta H} \leq F_{\Delta H}^{RTP} * (1 + PF_{\Delta H} * (1-P))$$

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

$$2.6.2a \quad F_{\Delta H}^{RTP} = 1.62 \text{ for LOPAR fuel}$$

$$2.6.2b \quad F_{\Delta H}^{RTP} = 1.65 \text{ for VANTAGE-5 fuel}$$

$$2.6.3a \quad PF_{\Delta H} = 0.3 \text{ for LOPAR fuel}$$

$$2.6.3b \quad PF_{\Delta H} = 0.35 \text{ for VANTAGE-5 fuel}$$

3.0 METHODOLOGY REFERENCES

- 3.1 WCAP-9272-P-A, "Westinghouse Reload Safety Evaluation Methodology," July 1985 (W Proprietary).

(Methodology for Specification 3.1.1.3 - Moderator Temperature Coefficient, 3.1.3.5 - Shutdown Rod Insertion Limit, 3.1.3.6 - Control Rod Insertion Limit, 3.2.1 - Axial Flux Difference, 3.2.2 - Heat Flux Hot Channel Factor, and 3.2.3 - Nuclear Enthalpy Rise Hot Channel Factor).

- 3.2 WCAP-11914, "Safety Evaluation Supporting a More Negative EOL Moderator Temperature Coefficient Technical Specification for the Shearon Harris Nuclear Power Plant," August 1988 (W Proprietary). Approved by NRC Safety Evaluation dated May 22, 1989.

(Methodology for Specification 3.1.1.3 - Moderator Temperature Coefficient).

- 3.3 WCAP-10216-P-A, "Relaxation of Constant Axial Offset Control  $F_Q$  Surveillance Technical Specification," June 1983 (W Proprietary).

(Methodology for Specifications 3.2.1 - Axial Flux Difference (Relaxed Axial Offset Control) and 3.2.2 - Heat Flux Hot Channel Factor ( $F_Q$  Methodology for  $W(Z)$  Surveillance requirements).)

- 3.4 WCAP-10266-P-A, Rev. 2, "The 1981 Version of the Westinghouse ECCS Evaluation Model Using the BASH Code," March 1987 (W Proprietary.)

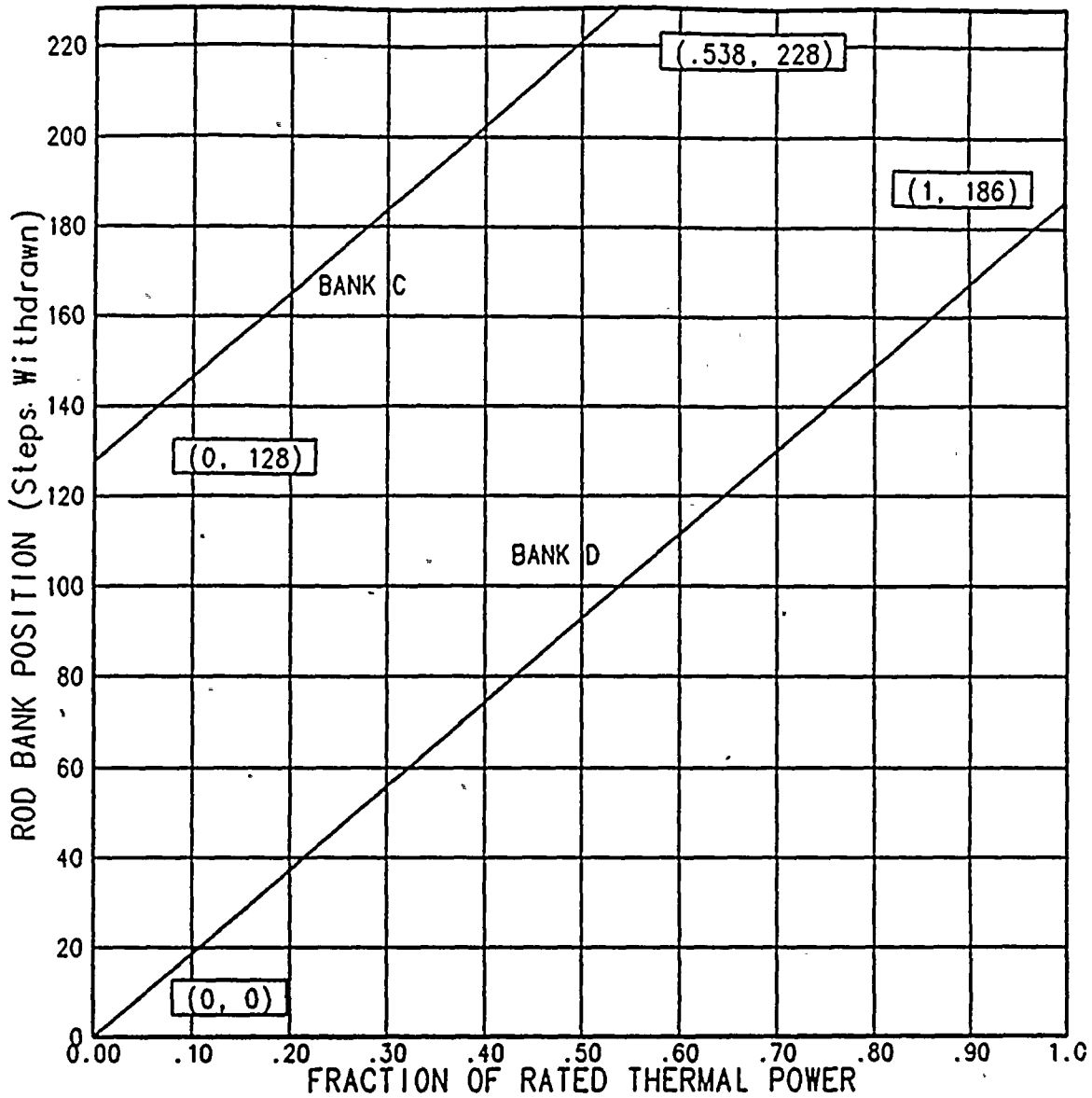
(Methodology for Specification 3.2.2 - Heat Flux Hot Channel Factor).

- 3.5 WCAP-8385, "Power Distribution Control and Load Following Procedures - Topical Report," September 1974 (W Proprietary).

(Methodology for Specification 3.2.1 - Axial Flux Difference (Constant Axial Offset Control).)

- 3.6 WCAP-11832-P-A, "Extension of Methodology for Calculating Transition Core DNBR Penalties," January 1990 (W Proprietary).

**FIGURE 1**  
**SHEARON HARRIS UNIT 1 CYCLE 4**  
**ROD GROUP INSERTION LIMITS VERSUS THERMAL POWER**  
**(THREE-LOOP OPERATION)**



**(Fully withdrawn shall be 228 steps)**

**Note: Control Banks A and B Must be Withdrawn From  
The Core Prior To Power Operation**

This figure is  
referred to by  
Technical  
Specifications  
3.1.3.1.d.2  
3.1.3.5  
3.1.3.6

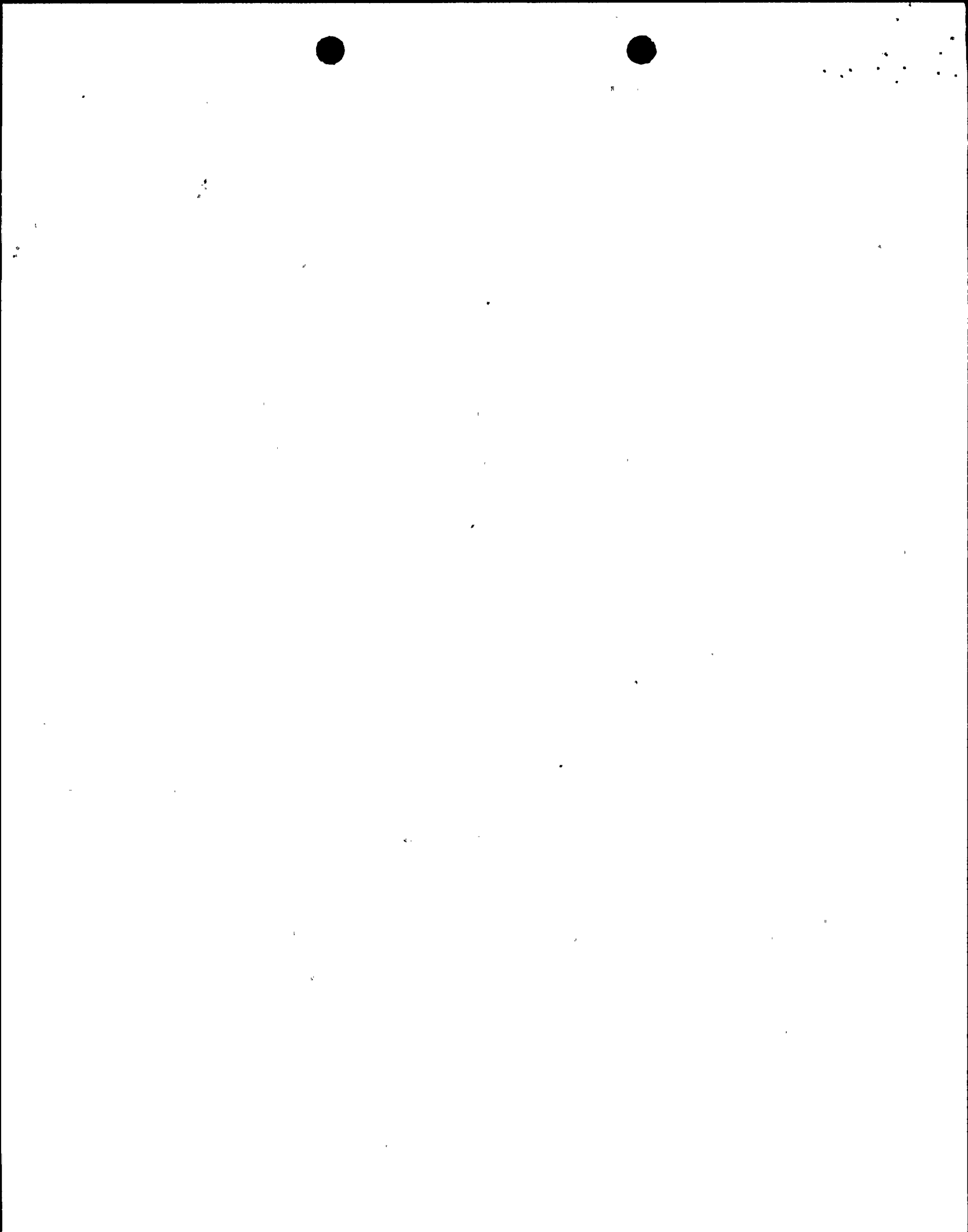
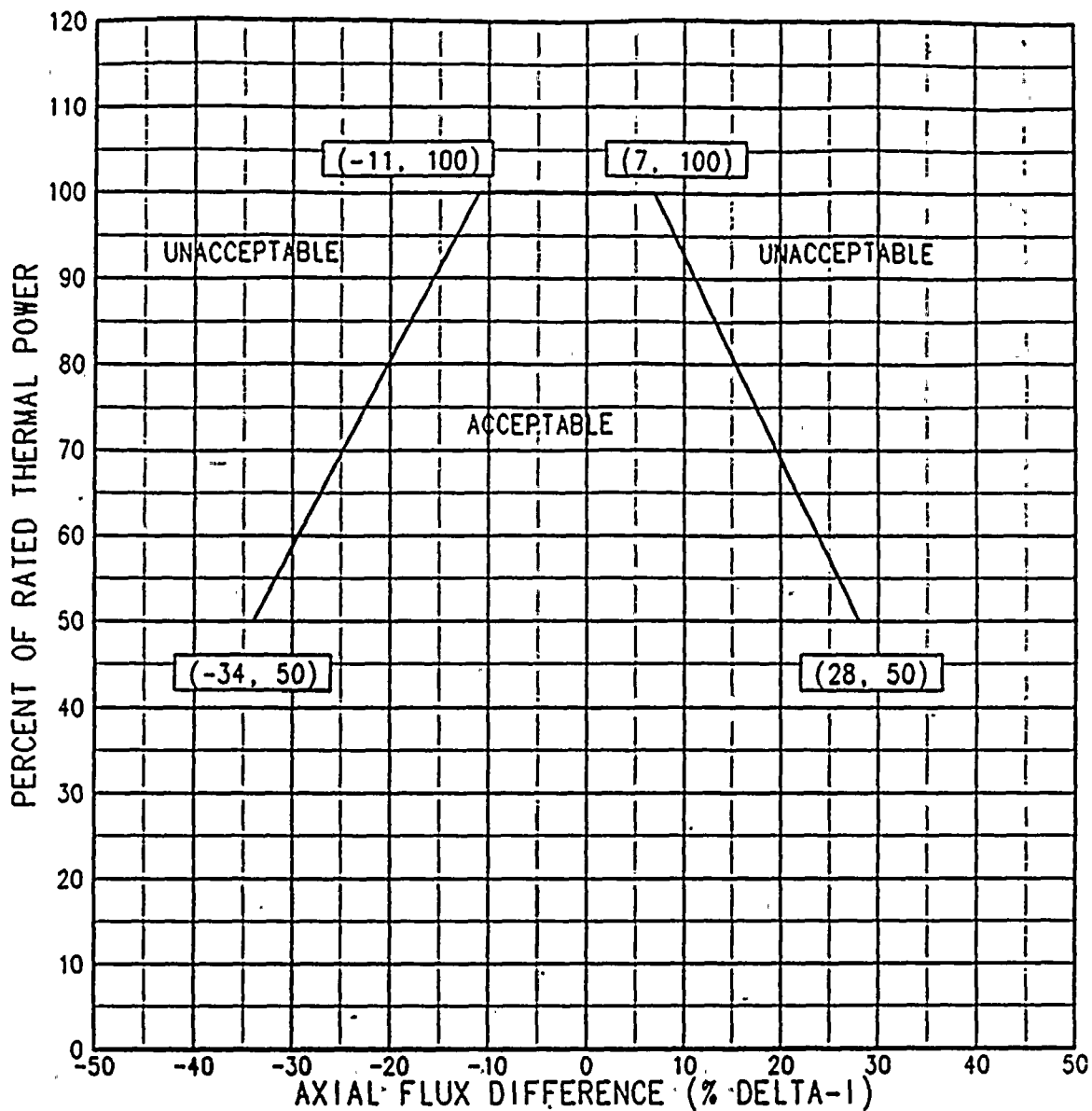




FIGURE 2

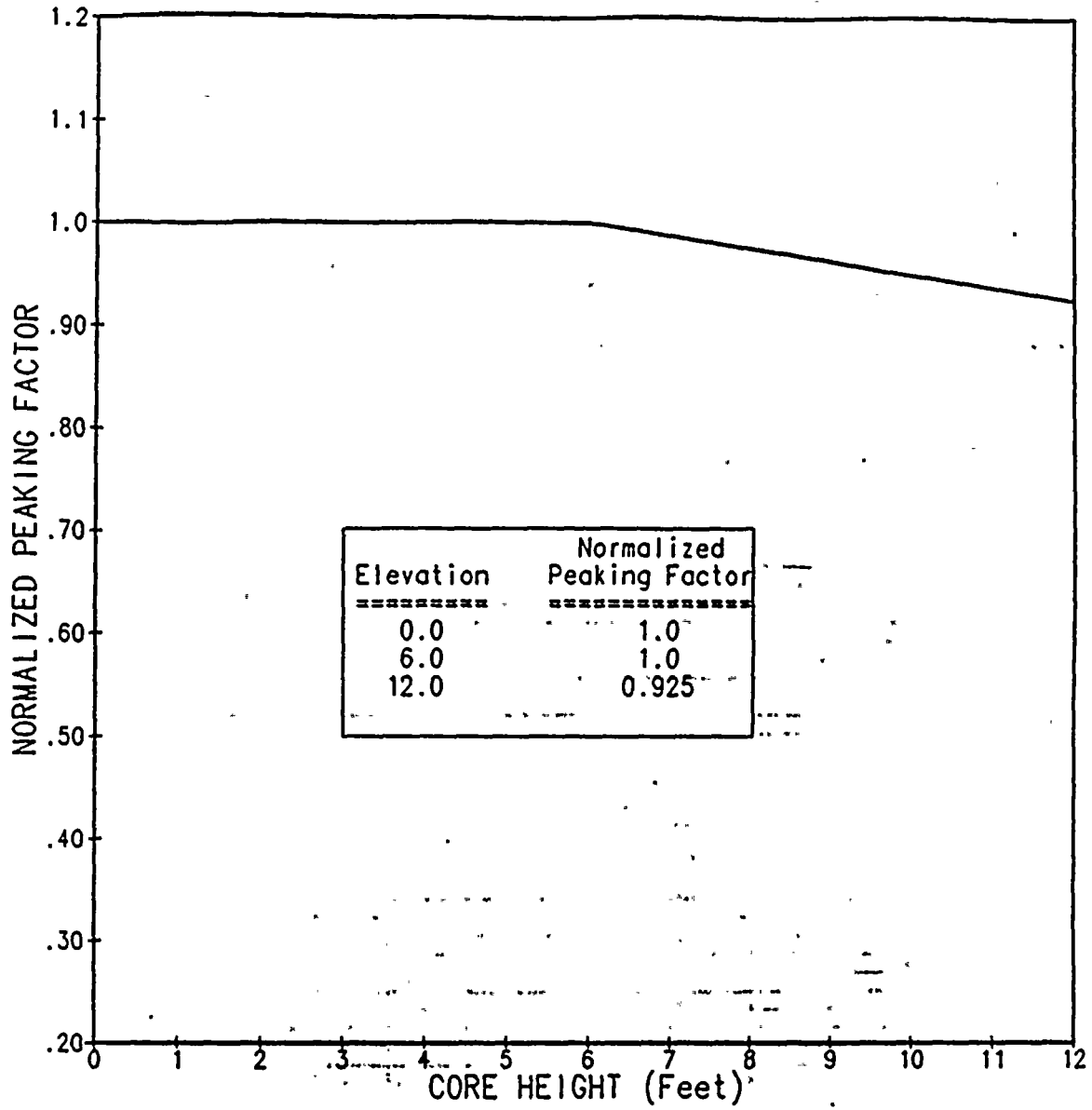
SHEARON HARRIS UNIT 1 CYCLE 4  
AXIAL FLUX DIFFERENCE LIMITS AS A FUNCTION OF  
RATED THERMAL POWER FOR RAOC



This figure is referred to by  
Technical Specifications  
3.2.1  
4.2.2.2f  
B3/4.2.1

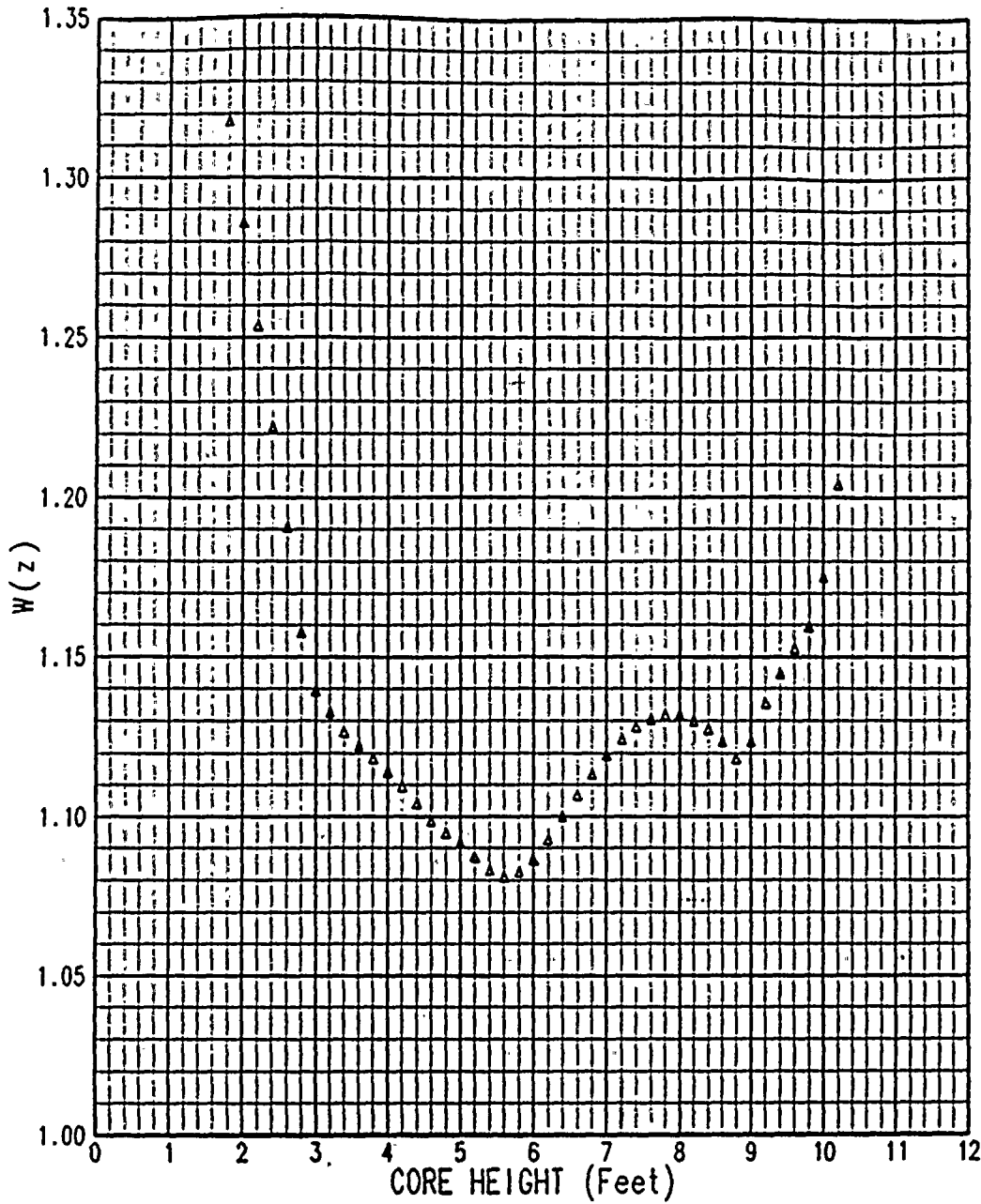
FIGURE 3

SHEARON HARRIS UNIT 1 CYCLE 4  
K(z) - LOCAL AXIAL PENALTY FUNCTION FOR  $F_Q(z)$



This figure is referred to by Technical Specification 3/4.2.2

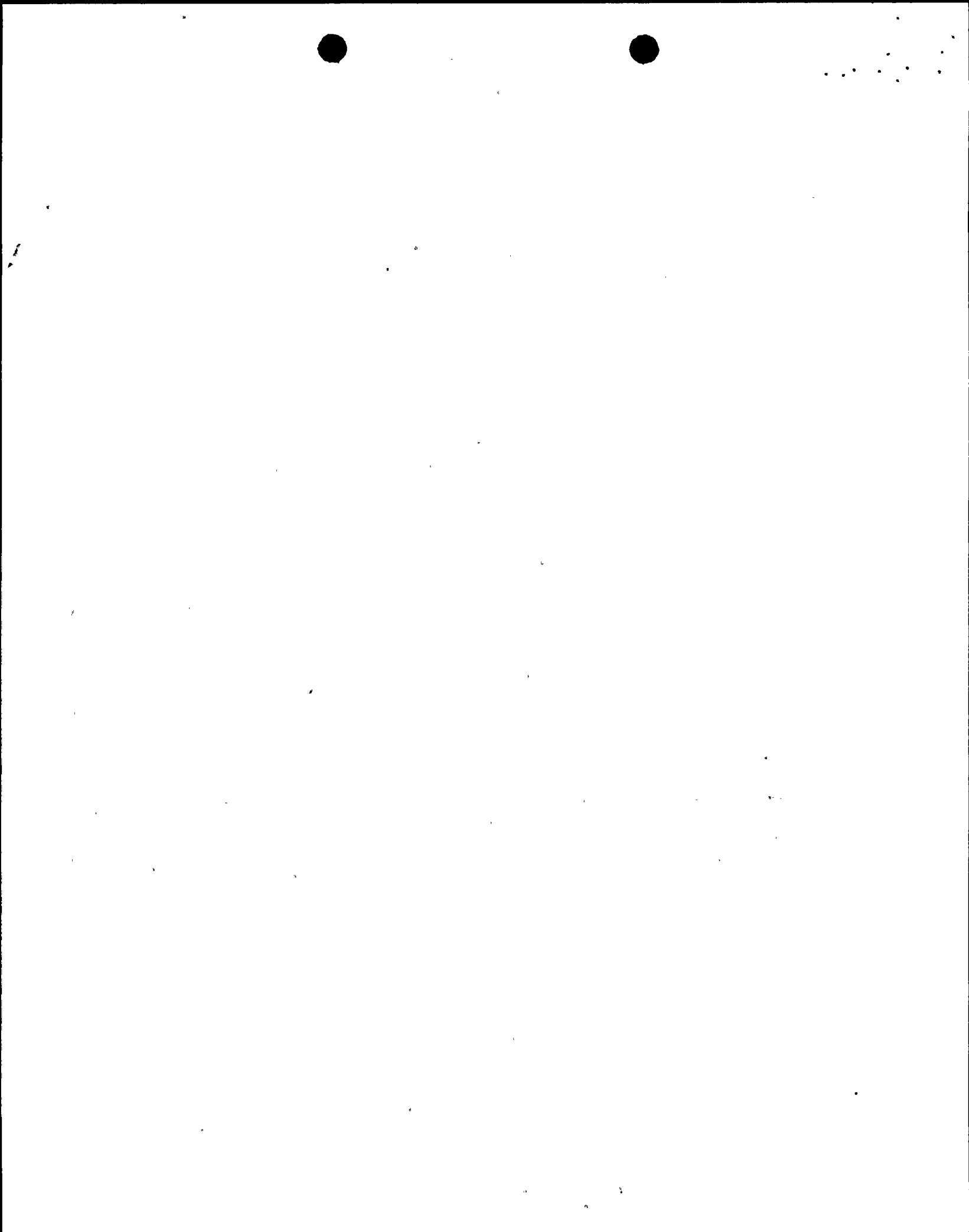
**FIGURE 4**  
**SHEARON HARRIS UNIT 1 CYCLE 4**  
**RAOC W(z) AT 150 MWD/MTU**



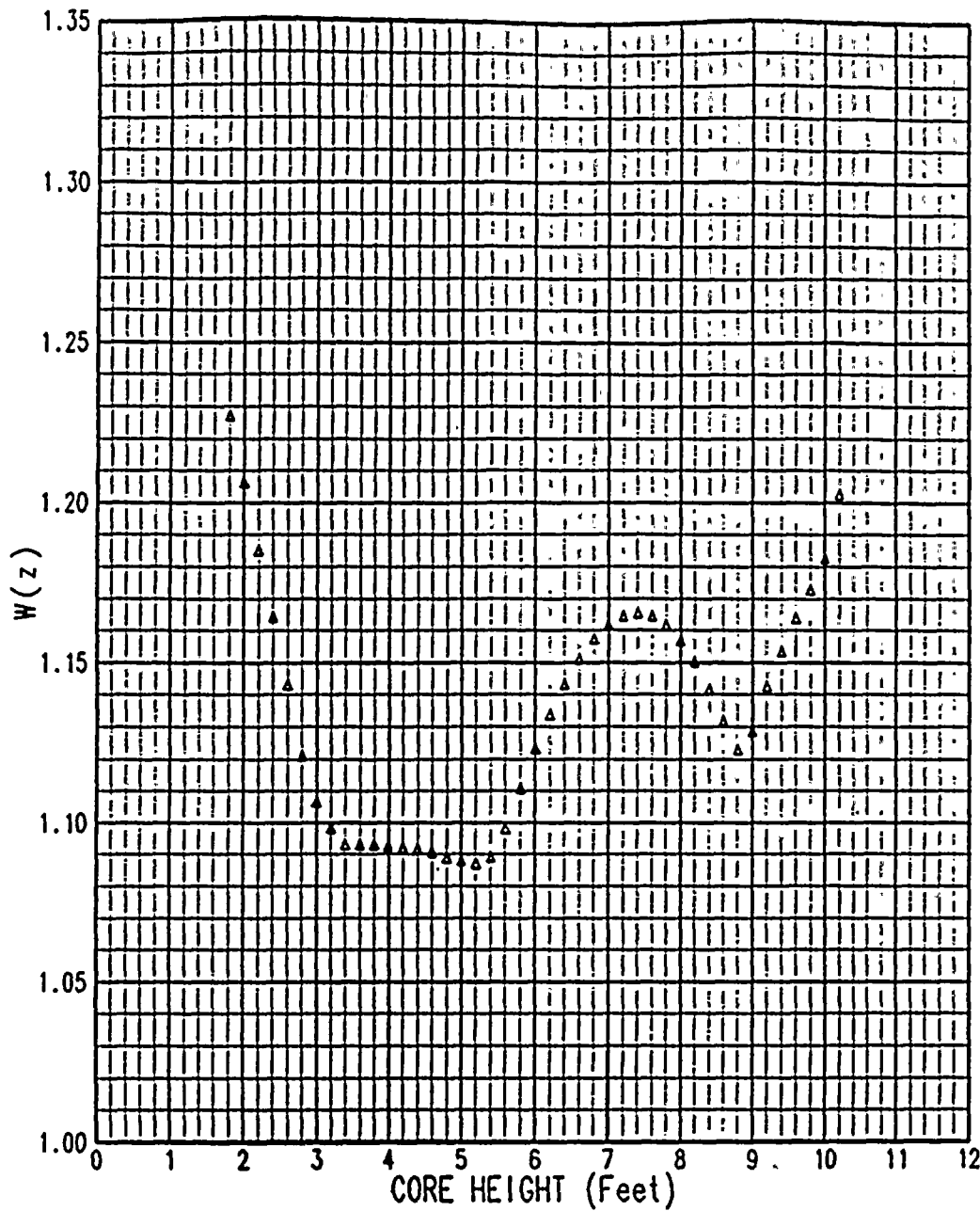
Height (Feet)	BOL W(z)
* 0.00	1.0000
* 0.20	1.0000
* 0.40	1.0000
* 0.60	1.0000
* 0.80	1.0000
* 1.00	1.0000
* 1.20	1.0000
* 1.40	1.0000
* 1.60	1.0000
1.80	1.3177
2.00	1.2859
2.20	1.2539
2.40	1.2222
2.60	1.1909
2.80	1.1578
3.00	1.1395
3.20	1.1328
3.40	1.1256
3.60	1.1223
3.80	1.1185
4.00	1.1143
4.20	1.1098
4.40	1.1044
4.60	1.0986
4.80	1.0950
5.00	1.0918
5.20	1.0875
5.40	1.0832
5.60	1.0811
5.80	1.0827
6.00	1.0868
6.20	1.0927
6.40	1.1002
6.60	1.1069
6.80	1.1135
7.00	1.1195
7.20	1.1244
7.40	1.1282
7.60	1.1307
7.80	1.1319
8.00	1.1317
8.20	1.1301
8.40	1.1275
8.60	1.1238
8.80	1.1185
9.00	1.1238
9.20	1.1358
9.40	1.1450
9.60	1.1527
9.80	1.1594
10.00	1.1751
10.20	1.2040
* 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

\* Top and Bottom 15% excluded as per Technical Specification 4.2.2.2.

This figure is referred to by Technical Specifications 4.2.2.2c B3/4.2.2



**FIGURE 5**  
**SHEARON HARRIS UNIT 1 CYCLE 4**  
**RAOC W(Z) AT 7000 MWD/MTU**

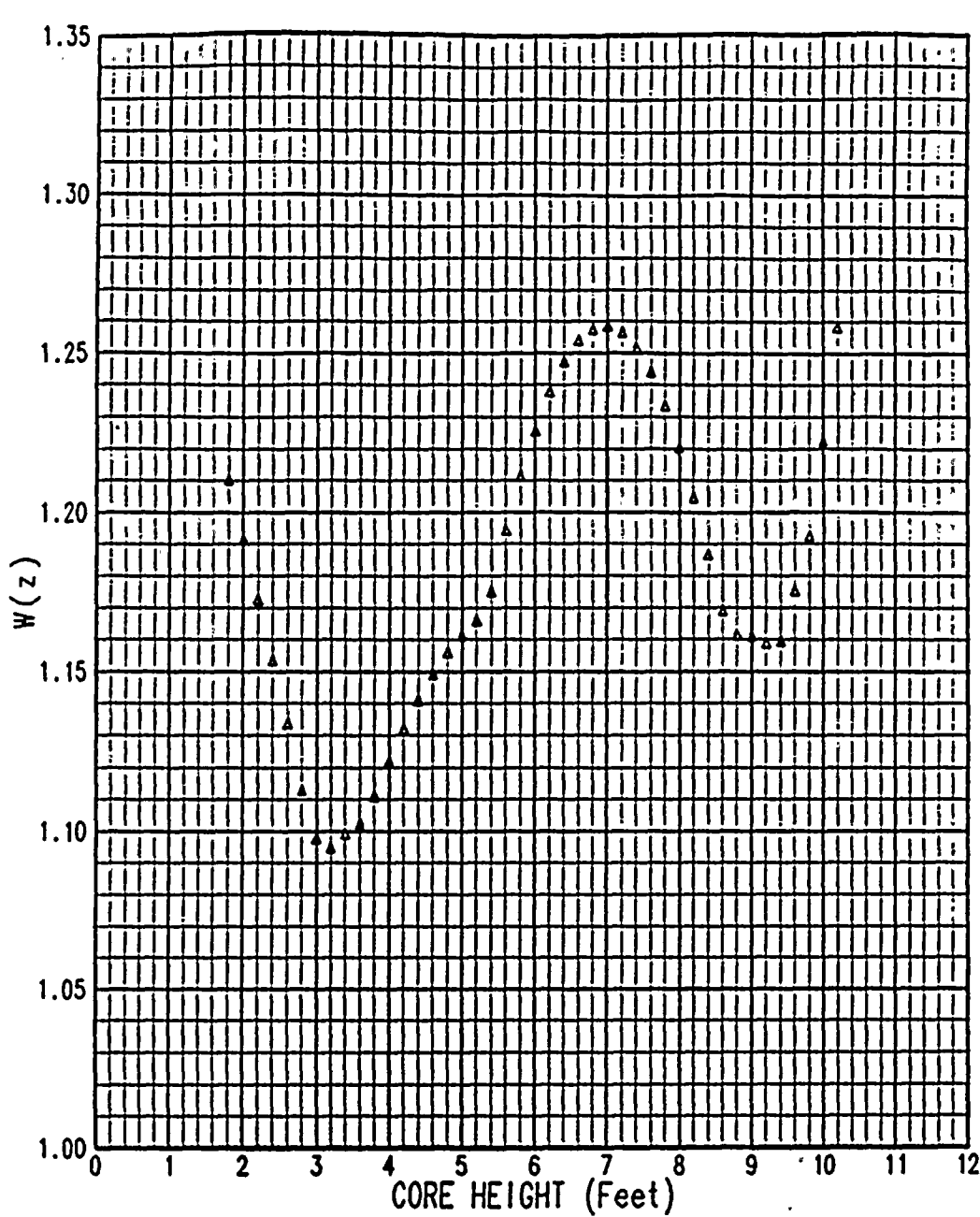


Height (Feet)	MOL W(z)
* 0.00	1.0000
* 0.20	1.0000
* 0.40	1.0000
* 0.60	1.0000
* 0.80	1.0000
* 1.00	1.0000
* 1.20	1.0000
* 1.40	1.0000
* 1.60	1.0000
* 1.80	1.2274
* 2.00	1.2085
* 2.20	1.1854
* 2.40	1.1644
* 2.60	1.1433
* 2.80	1.1211
* 3.00	1.1066
* 3.20	1.0985
* 3.40	1.0930
* 3.60	1.0930
* 3.80	1.0930
* 4.00	1.0926
* 4.20	1.0922
* 4.40	1.0916
* 4.60	1.0907
* 4.80	1.0891
* 5.00	1.0881
* 5.20	1.0873
* 5.40	1.0892
* 5.60	1.0982
* 5.80	1.1110
* 6.00	1.1233
* 6.20	1.1340
* 6.40	1.1434
* 6.60	1.1513
* 6.80	1.1575
* 7.00	1.1619
* 7.20	1.1647
* 7.40	1.1656
* 7.60	1.1647
* 7.80	1.1618
* 8.00	1.1570
* 8.20	1.1503
* 8.40	1.1419
* 8.60	1.1320
* 8.80	1.1232
* 9.00	1.1288
* 9.20	1.1426
* 9.40	1.1535
* 9.60	1.1639
* 9.80	1.1728
* 10.00	1.1828
* 10.20	1.2026
* 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

\* Top and Bottom 15% excluded as per Technical Specification 4.2.2.2.

This figure is referred to by Technical Specifications 4.2.2.2c B3/4.2.2

**FIGURE 6**  
**SHEARON HARRIS UNIT 1 CYCLE 4**  
**RAOC W(Z) AT 1550 MWD/MTU**

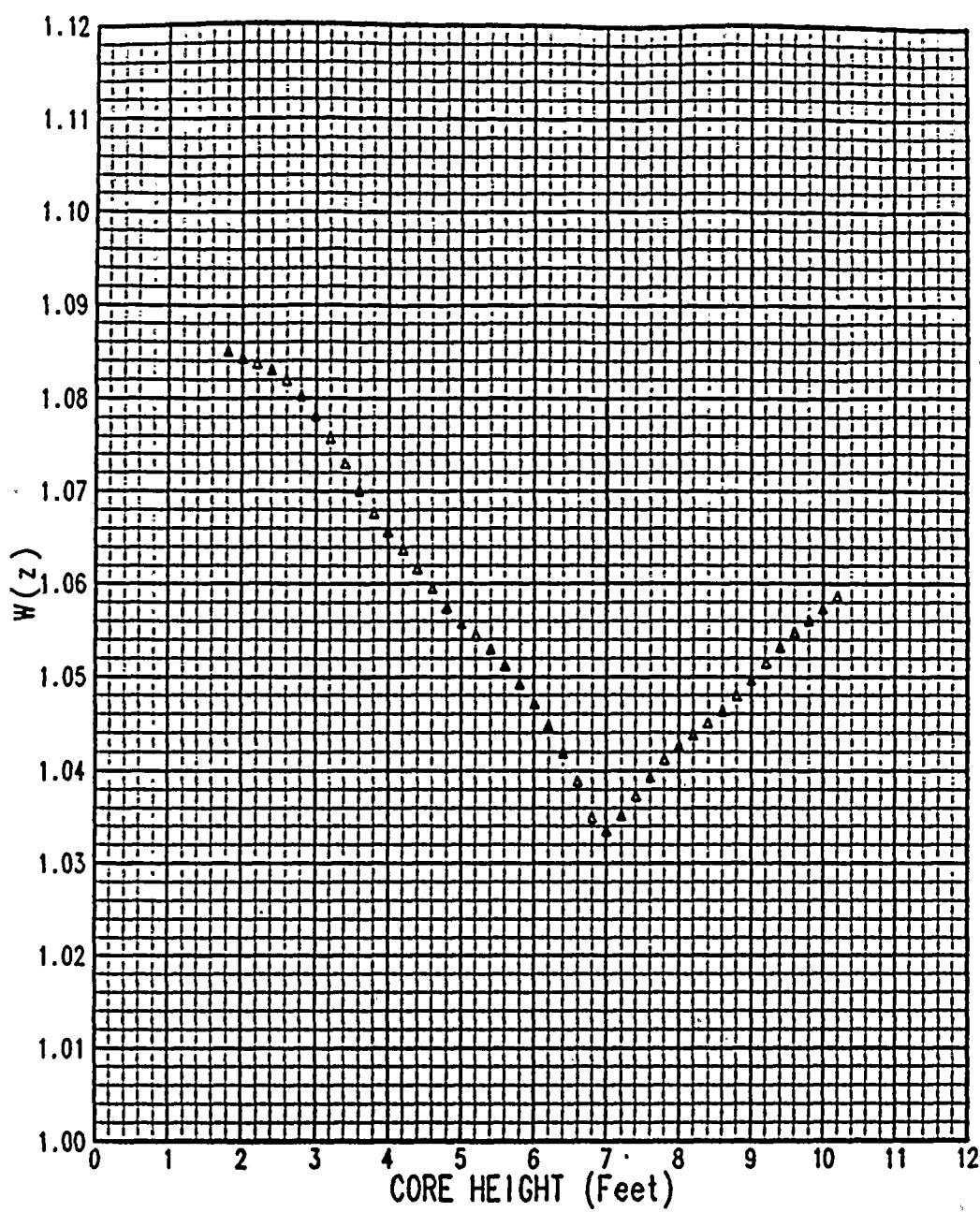


Height (Feet)	EOL W(z)
* 0.00	1.0000
* 0.20	1.0000
* 0.40	1.0000
* 0.60	1.0000
* 0.80	1.0000
* 1.00	1.0000
* 1.20	1.0000
* 1.40	1.0000
* 1.60	1.0000
* 1.80	1.2103
2.00	1.1916
2.20	1.1727
2.40	1.1535
2.60	1.1340
2.80	1.1131
3.00	1.0980
3.20	1.0949
3.40	1.0994
3.60	1.1024
3.80	1.1111
4.00	1.1219
4.20	1.1319
4.40	1.1411
4.60	1.1493
4.80	1.1563
5.00	1.1617
5.20	1.1661
5.40	1.1753
5.60	1.1945
5.80	1.2117
6.00	1.2259
6.20	1.2381
6.40	1.2474
6.60	1.2540
6.80	1.2577
7.00	1.2586
7.20	1.2567
7.40	1.2518
7.60	1.2442
7.80	1.2337
8.00	1.2205
8.20	1.2049
8.40	1.1870
8.60	1.1691
8.80	1.1616
9.00	1.1611
9.20	1.1591
9.40	1.1598
9.60	1.1755
9.80	1.1926
10.00	1.2223
10.20	1.2585
* 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

\* Top and Bottom 15% excluded as per Technical Specification 4.2.2.2.

This figure is referred to by Technical Specifications 4.2.2.2c B3/4.2.2

**FIGURE 7**  
**SHEARON HARRIS UNIT 1 CYCLE 4**  
**BASE LOAD W(Z) AT 150 MWD/MTU**  
**FOR POWER LEVELS ABOVE 85% OF RATED THERMAL POWER**

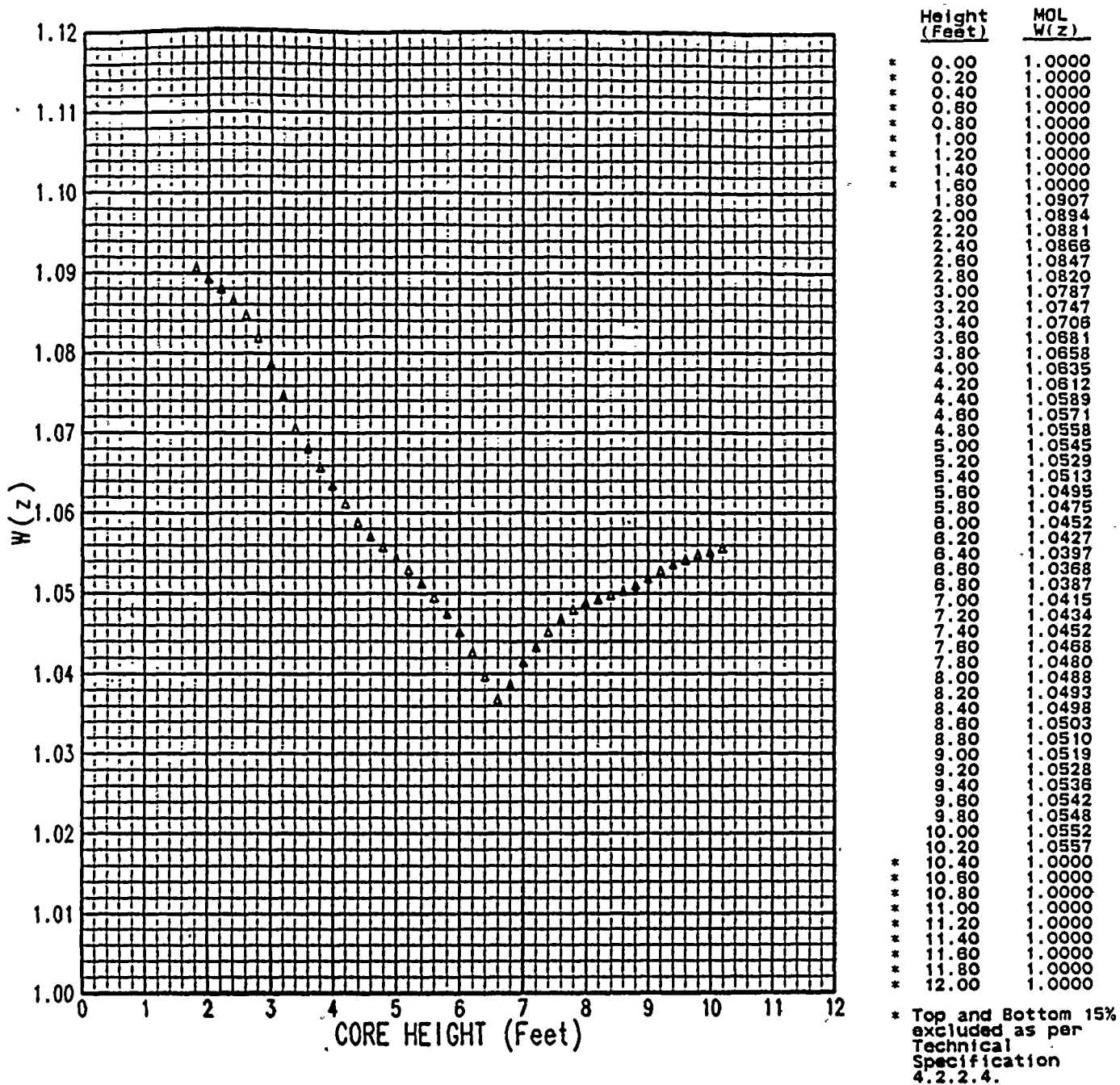


Height (Feet)	BOL W(z)
* 0.00	1.0000
* 0.20	1.0000
* 0.40	1.0000
* 0.60	1.0000
* 0.80	1.0000
* 1.00	1.0000
* 1.20	1.0000
* 1.40	1.0000
* 1.60	1.0000
1.80	1.0851
2.00	1.0844
2.20	1.0838
2.40	1.0831
2.60	1.0820
2.80	1.0803
3.00	1.0782
3.20	1.0758
3.40	1.0730
3.60	1.0701
3.80	1.0677
4.00	1.0657
4.20	1.0638
4.40	1.0617
4.60	1.0596
4.80	1.0575
5.00	1.0558
5.20	1.0545
5.40	1.0530
5.60	1.0512
5.80	1.0493
6.00	1.0472
6.20	1.0448
6.40	1.0420
6.60	1.0389
6.80	1.0350
7.00	1.0336
7.20	1.0352
7.40	1.0374
7.60	1.0394
7.80	1.0412
8.00	1.0427
8.20	1.0439
8.40	1.0451
8.60	1.0464
8.80	1.0480
9.00	1.0497
9.20	1.0515
9.40	1.0532
9.60	1.0548
9.80	1.0561
10.00	1.0574
10.20	1.0587
* 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

\* Top and Bottom 15% excluded as per Technical Specification 4.2.2.4.

This figure is referred to by Technical Specifications 4.2.2.3a, 4.2.2.4c, B3/4.2.2

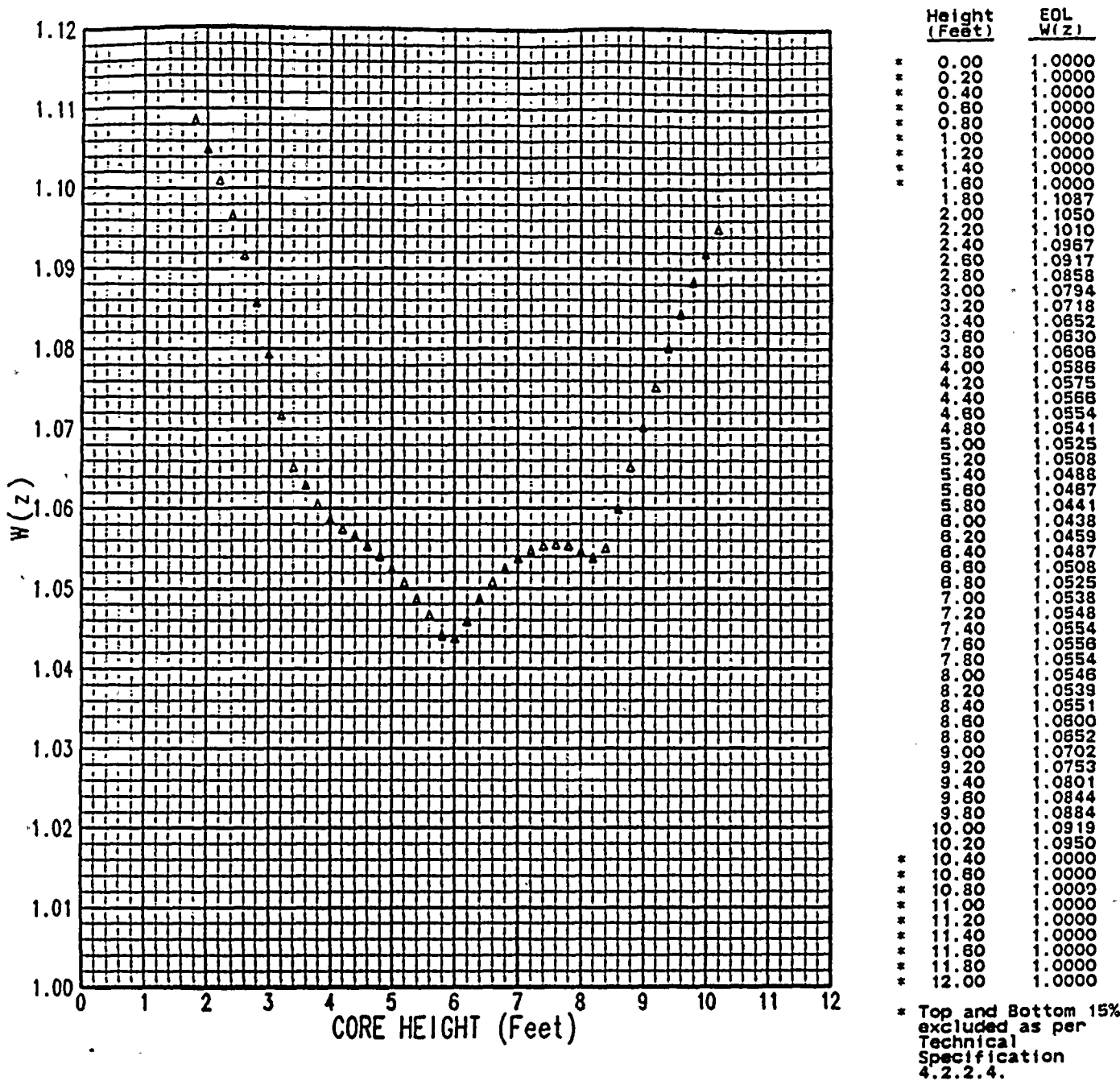
**FIGURE 8**  
**SHEARON HARRIS UNIT 1 CYCLE 4**  
**BASE LOAD W(Z) AT 7000 MWD/MTU**  
**FOR POWER LEVELS ABOVE 85% OF RATED THERMAL POWER**



This figure is referred to by  
 Technical Specifications  
 4.2.2.3a  
 4.2.2.4c  
 B3/4.2.2



**FIGURE 9**  
**SHEARON HARRIS UNIT 1 CYCLE 4**  
**BASE LOAD W(Z) AT 15500 MWD/MTU**  
**FOR POWER LEVELS ABOVE 85% OF RATED THERMAL POWER**



This figure is referred to by Technical Specifications 4.2.2.3a, 4.2.2.4c, and B3/4.2.2.

