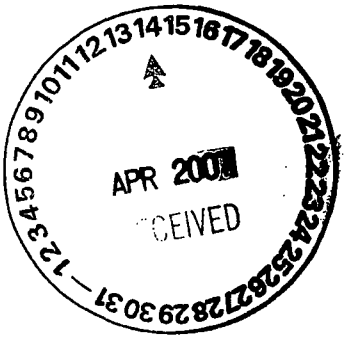
Callaway Cycle 16

Core Operating Limits Report
Revision 0

March 2007



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Curve Book Figure 13-1, Rev 46

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Callaway Plant Cycle 16 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% Δk/k.

2.1.2 The Shutdown Margin prior to blocking Safety Injection below P-11 in MODES 3 and 4 shall be greater than 0% Δk/k as calculated at 200°F.

2.1.3 The Shutdown Margin in MODE 5 shall be greater than or equal to 1.0% Δk/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2.2.2 The MTC 300 ppm surveillance limit is -40.4 pcm/°F (all rods withdrawn, Rated Thermal Power condition).

2.2.3 The MTC 60 ppm surveillance limit is -45.5 pcm/°F (all rods withdrawn, Rated Thermal Power condition).

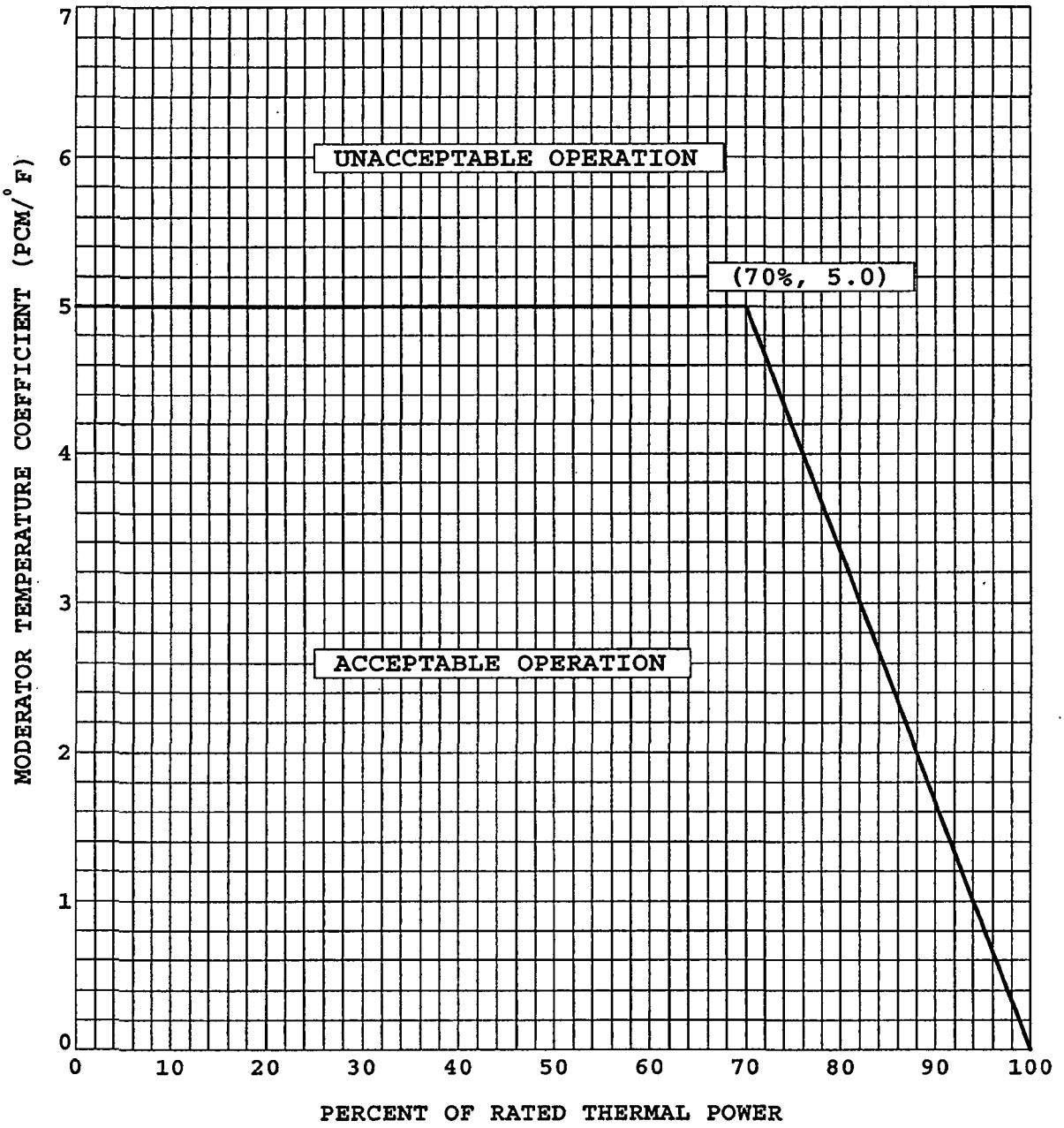

Figure 1

Callaway Cycle 16
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.

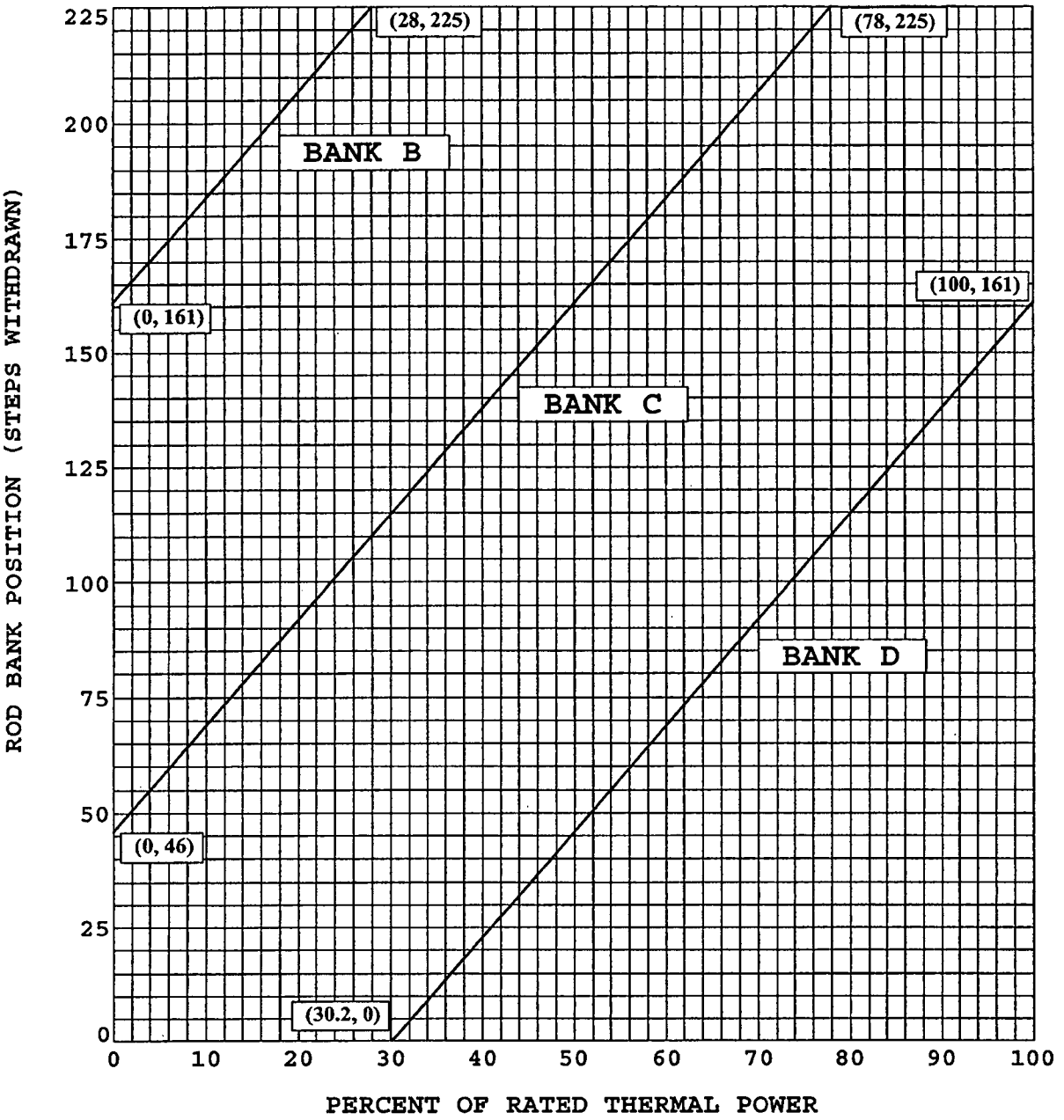

Figure 2

Callaway Cycle 16
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: $$P = \frac{\text{THERMAL POWER}}{\text{RATED THERMAL POWER}}$$

2.5.1 $F_Q^{RTP} = 2.50$.

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 Table A.1.

The W(z) values have been determined for several burnups up to 20000 MWD/MTU in Cycle 16. This permits determination of W(z) at any cycle burnup up to 20000 MWD/MTU through the use of three point interpolation. For cycle burnups greater than 20000 MWD/MTU, use of 20000 MWD/MTU W(z) values without interpolation or extrapolation is conservative. The W(z) values were determined assuming Cycle 16 operates with RAOC strategy. Also included is a W(z) function that bounds the W(z) values for all Cycle 16 burnups. Use of the bounding W(z) values will be conservative for any Cycle 16 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 0.17 feet.

Table A.2 shows the burnup dependent F_Q penalty factors for Cycle 16. 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.2.

Table A.1
W(z) versus Core Height
(Top and Bottom 6% Excluded)

Height (feet)	150 MWD/MTU	4000 MWD/MTU	10000 MWD/MTU	20000 MWD/MTU	Bounding W(z)
0.00 (bottom)	1.0000	1.0000	1.0000	1.0000	1.0000
0.17	1.0000	1.0000	1.0000	1.0000	1.0000
0.33	1.0000	1.0000	1.0000	1.0000	1.0000
0.50	1.0000	1.0000	1.0000	1.0000	1.0000
0.67	1.0000	1.0000	1.0000	1.0000	1.0000
0.83	1.3934	1.4732	1.4016	1.3370	1.4732
1.00	1.3853	1.4618	1.3944	1.3324	1.4618
1.17	1.3730	1.4462	1.3835	1.3244	1.4462
1.33	1.3588	1.4281	1.3704	1.3144	1.4281
1.50	1.3438	1.4084	1.3559	1.3039	1.4084
1.67	1.3284	1.3877	1.3405	1.2930	1.3878
1.83	1.3122	1.3662	1.3244	1.2817	1.3662
2.00	1.2951	1.3436	1.3076	1.2699	1.3436
2.17	1.2774	1.3202	1.2904	1.2578	1.3202
2.33	1.2594	1.2965	1.2733	1.2455	1.2967
2.50	1.2412	1.2730	1.2568	1.2332	1.2732
2.67	1.2240	1.2488	1.2426	1.2203	1.2509
2.83	1.2093	1.2253	1.2316	1.2072	1.2327
3.00	1.1969	1.2105	1.2225	1.1985	1.2225
3.17	1.1886	1.2022	1.2145	1.1949	1.2146
3.33	1.1859	1.1936	1.2071	1.1936	1.2084
3.50	1.1833	1.1867	1.2008	1.1936	1.2030
3.67	1.1797	1.1821	1.1952	1.1944	1.1987
3.83	1.1771	1.1788	1.1896	1.1998	1.2005
4.00	1.1752	1.1752	1.1834	1.2052	1.2052
4.17	1.1732	1.1709	1.1768	1.2091	1.2091
4.33	1.1706	1.1662	1.1705	1.2121	1.2121
4.50	1.1675	1.1610	1.1640	1.2143	1.2143
4.67	1.1639	1.1552	1.1573	1.2152	1.2152
4.83	1.1596	1.1490	1.1508	1.2150	1.2150
5.00	1.1552	1.1421	1.1439	1.2136	1.2136
5.17	1.1495	1.1349	1.1366	1.2108	1.2108
5.33	1.1425	1.1273	1.1289	1.2065	1.2065
5.50	1.1412	1.1182	1.1198	1.2025	1.2025
5.67	1.1457	1.1101	1.1134	1.2015	1.2015
5.83	1.1505	1.1086	1.1178	1.2059	1.2059
6.00	1.1588	1.1088	1.1267	1.2145	1.2145
6.17	1.1709	1.1129	1.1420	1.2247	1.2247
6.33	1.1837	1.1213	1.1562	1.2340	1.2340
6.50	1.1958	1.1315	1.1693	1.2424	1.2424
6.67	1.2065	1.1420	1.1815	1.2504	1.2504
6.83	1.2158	1.1529	1.1923	1.2583	1.2583

Table A.1
W(z) versus Core Height
(Top and Bottom 6% Excluded)

Height (feet)	150 MWD/MTU	4000 MWD/MTU	10000 MWD/MTU	20000 MWD/MTU	Bounding W(z)
7.00	1.2239	1.1643	1.2019	1.2656	1.2656
7.17	1.2301	1.1759	1.2100	1.2714	1.2714
7.33	1.2339	1.1874	1.2160	1.2754	1.2754
7.50	1.2387	1.1981	1.2220	1.2777	1.2777
7.67	1.2447	1.2079	1.2283	1.2782	1.2782
7.83	1.2489	1.2168	1.2330	1.2770	1.2773
8.00	1.2540	1.2237	1.2378	1.2739	1.2739
8.17	1.2617	1.2304	1.2439	1.2691	1.2691
8.33	1.2703	1.2410	1.2500	1.2630	1.2715
8.50	1.2763	1.2517	1.2550	1.2540	1.2763
8.67	1.2797	1.2606	1.2584	1.2448	1.2797
8.83	1.2854	1.2708	1.2608	1.2438	1.2858
9.00	1.2946	1.2800	1.2603	1.2449	1.2955
9.17	1.3059	1.2883	1.2571	1.2502	1.3065
9.33	1.3159	1.3007	1.2572	1.2580	1.3178
9.50	1.3218	1.3167	1.2605	1.2633	1.3273
9.67	1.3254	1.3335	1.2719	1.2679	1.3350
9.83	1.3343	1.3484	1.2818	1.2831	1.3484
10.00	1.3486	1.3690	1.2906	1.3017	1.3692
10.17	1.3669	1.3982	1.2994	1.3172	1.3982
10.33	1.3877	1.4279	1.3078	1.3318	1.4279
10.50	1.4104	1.4550	1.3195	1.3459	1.4550
10.67	1.4333	1.4782	1.3351	1.3590	1.4782
10.83	1.4540	1.4975	1.3494	1.3700	1.4975
11.00	1.4690	1.5123	1.3597	1.3770	1.5123
11.17	1.4723	1.5199	1.3651	1.3763	1.5199
11.33	1.0000	1.0000	1.0000	1.0000	1.0000
11.50	1.0000	1.0000	1.0000	1.0000	1.0000
11.67	1.0000	1.0000	1.0000	1.0000	1.0000
11.83	1.0000	1.0000	1.0000	1.0000	1.0000
12.00 (top)	1.0000	1.0000	1.0000	1.0000	1.0000

Table A.2

F_Q Penalty Factors as a Function of Cycle Burnup

Cycle 16 Burnup	$F_Q^W(z)$ Penalty Factor (%)
1009	2.06
1180	2.33
1352	2.31
1524	2.26

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.

For values of burnup between two of those listed in the first column, the greater of the two corresponding penalty factors shall be used for compliance with Surveillance Requirement 3.2.1.2.

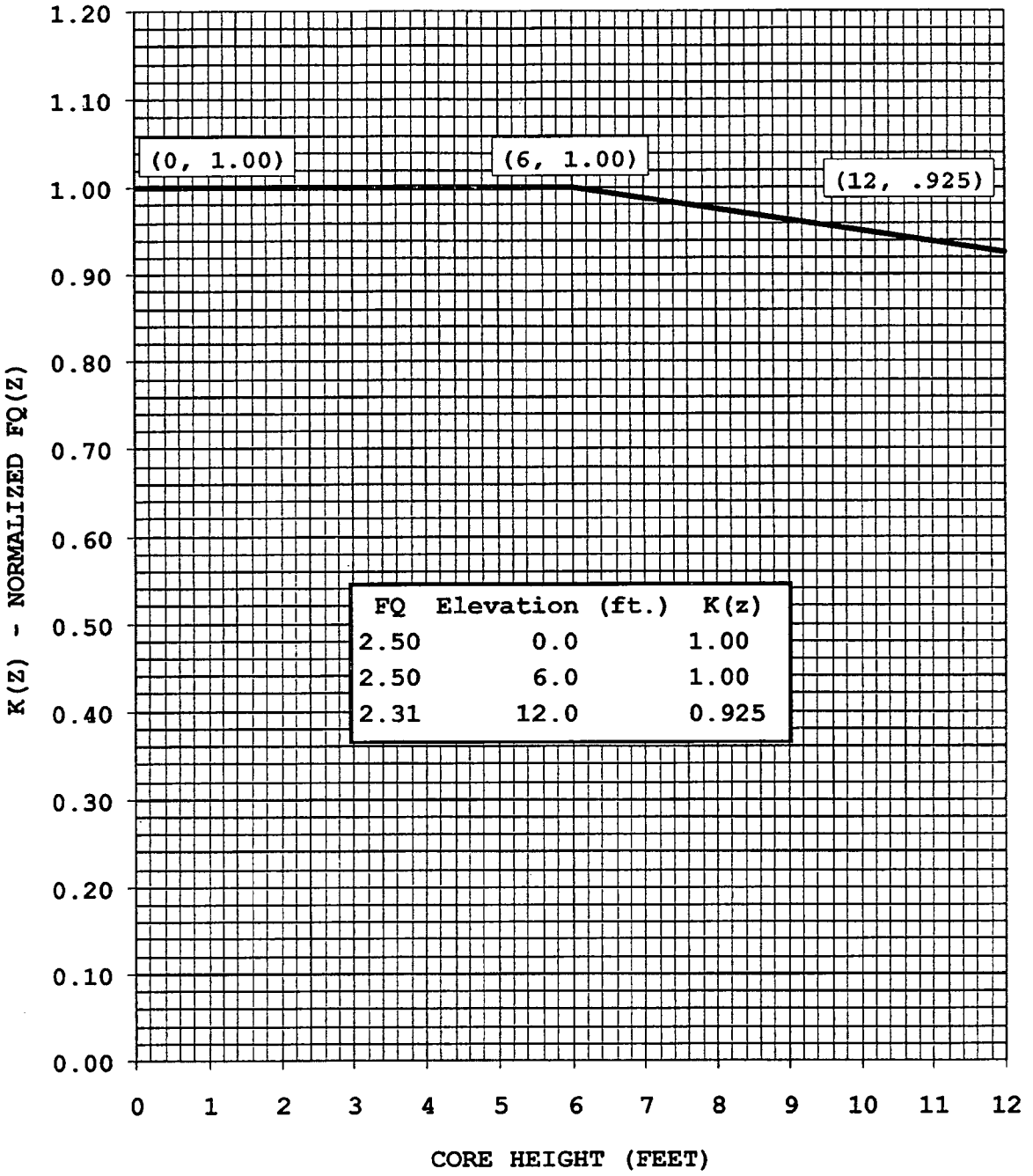

Figure 3

Callaway Cycle 16
K(z) - Normalized $F_Q(z)$
as a Function of Core Height

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 4.

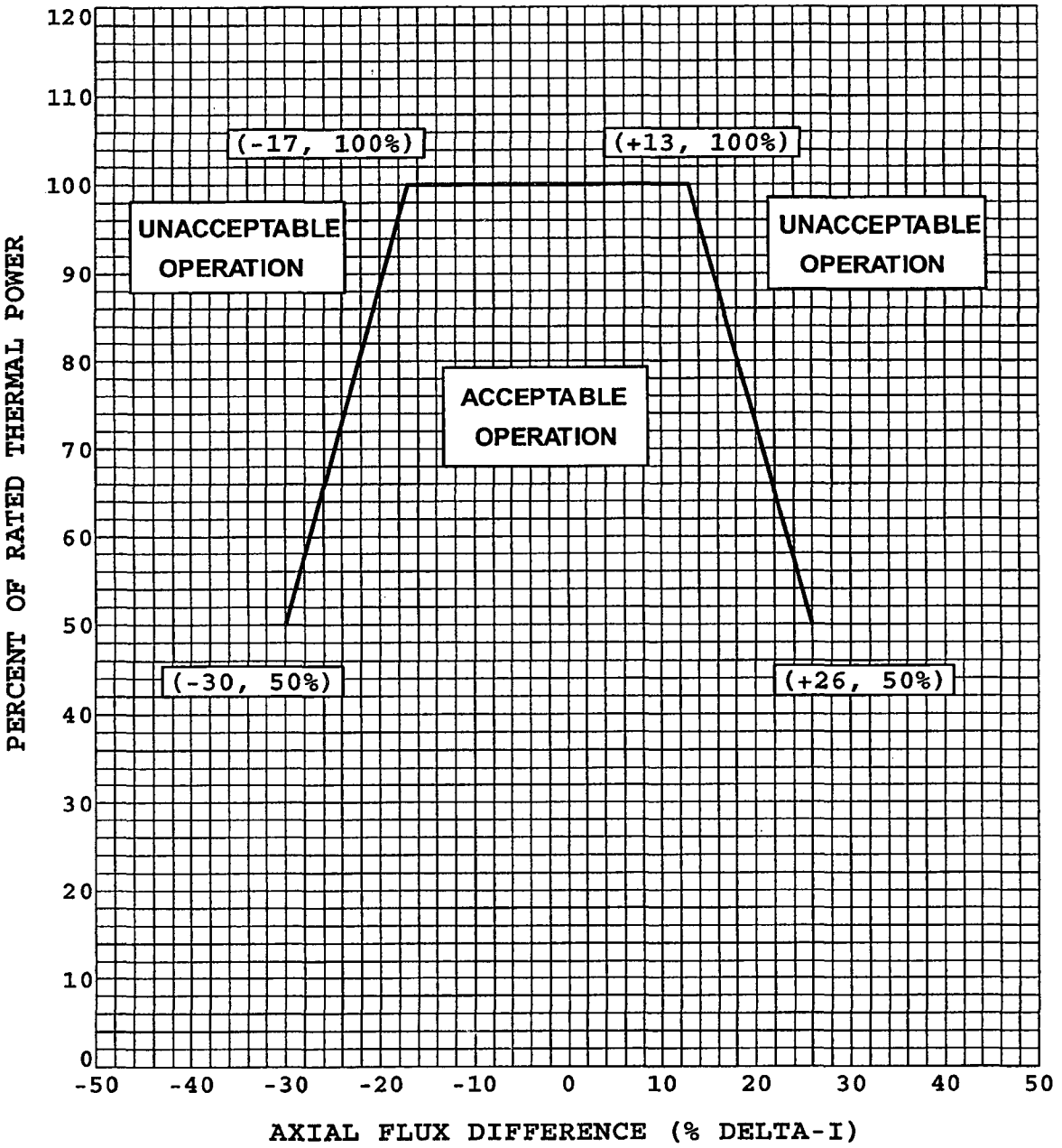

Figure 4

Callaway Cycle 16
Axial Flux Difference Limits as a Function of Rated Thermal Power for RAOC