ERX-13-001, Rev. 0

CPNPP UNIT 1 CYCLE 17

CORE OPERATING LIMITS REPORT

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TABLE OF CONTENTS

DISCLAIMER	ii
TABLE OF CONTENTS	iii
LIST OF TABLES	iv
LIST OF FIGURES	v
SECTION	PAGE
1.0 CORE OPERATING LIMITS REPORT	1
2.0 OPERATING LIMITS	2
2.1 SAFETY LIMITS	2
2.2 SHUTDOWN MARGIN	2
2.3 MODERATOR TEMPERATURE COEFFICIENT	2
2.4 ROD GROUP ALIGNMENT LIMITS	3
2.5 SHUTDOWN BANK INSERTION LIMITS	3
2.6 CONTROL BANK INSERTION LIMITS	4
2.7 PHYSICS TESTS EXCEPTIONS - MODE 2	4
2.8 HEAT FLUX HOT CHANNEL FACTOR	4
2.9 NUCLEAR ENTHALPY RISE HOT CHANNEL FACTOR	6
2.10 AXIAL FLUX DIFFERENCE	6
2.11 REACTOR TRIP SYSTEM INSTRUMENTATION	6
2.12 RCS PRESSURE, TEMPERATURE, AND FLOW DEPARTURE FROM NUCLEATE BOILING LIMITS	7
2.13 BORON CONCENTRATION	8
3.0 REFERENCES	8

LIST OF TABLES

TABLE PAGE

1 $F_Q(Z)$ MARGIN DECREASES IN EXCESS OF 2% PER 31 EFPD 9

LIST OF FIGURES

FIGURE		PAGE
1	REACTOR CORE SAFETY LIMITS	10
2	ROD BANK INSERTION LIMITS VERSUS THERMAL POWER	11
3	K(Z) - NORMALIZED $F_Q(Z)$ AS A FUNCTION OF CORE HEIGHT	12
4	W(Z) AS A FUNCTION OF CORE HEIGHT - (150 MWD/MTU)	13
5	W(Z) AS A FUNCTION OF CORE HEIGHT - (1,000 MWD/MTU)	14
6	W(Z) AS A FUNCTION OF CORE HEIGHT - (3,000 MWD/MTU)	15
7	W(Z) AS A FUNCTION OF CORE HEIGHT - (12,000 MWD/MTU)	16
8	W(Z) AS A FUNCTION OF CORE HEIGHT - (20,000 MWD/MTU)	17
9	AXIAL FLUX DIFFERENCE LIMITS AS A FUNCTION OF RATED THERMAL POWER	18

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for CPNPP UNIT 1 CYCLE 17 has been prepared in accordance with the requirements of Technical Specification 5.6.5.

The Technical Specifications affected by this report are listed below:

SL 2.1	SAFETY LIMITS
LCO 3.1.1	SHUTDOWN MARGIN
LCO 3.1.3	MODERATOR TEMPERATURE COEFFICIENT
LCO 3.1.4	ROD GROUP ALIGNMENT LIMITS
LCO 3.1.5	SHUTDOWN BANK INSERTION LIMITS
LCO 3.1.6	CONTROL BANK INSERTION LIMITS
LCO 3.1.8	PHYSICS TESTS EXCEPTIONS - MODE 2
LCO 3.2.1	HEAT FLUX HOT CHANNEL FACTOR
LCO 3.2.2	NUCLEAR ENTHALPY RISE HOT CHANNEL FACTOR
LCO 3.2.3	AXIAL FLUX DIFFERENCE
LCO 3.3.1	REACTOR TRIP SYSTEM INSTRUMENTATION
LCO 3.4.1	RCS PRESSURE, TEMPERATURE, AND FLOW DEPARTURE FROM NUCLEATE BOILING LIMITS
LCO 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 Technical Specification 5.6.5b, Items 1 through 4 and 7 through 15. These limits have been determined such that all applicable limits of the safety analysis are met.

2.1 SAFETY LIMITS (SL 2.1)

2.1.1 In MODES 1 and 2, the combination of thermal power, reactor coolant system highest loop average temperature, and pressurizer pressure shall not exceed the safety limits specified in Figure 1.

2.2 SHUTDOWN MARGIN (SDM) (LCO 3.1.1)

2.2.1 The SDM shall be greater than or equal to 1.3% $\Delta k/k$ in MODE 2 with $K_{eff} < 1.0$, and in MODES 3, 4, and 5.

2.3 MODERATOR TEMPERATURE COEFFICIENT (MTC) (LCO 3.1.3)

2.3.1 The MTC upper and lower limits, respectively, are:

The BOL/ARO/HZP-MTC shall be less positive than +5 pcm/°F.

The EOL/ARO/RTP-MTC shall be less negative than -40 pcm/°F.

2.3.2 SR 3.1.3.2

The MTC surveillance limit is:

The 300 ppm/ARO/RTP-MTC shall be less negative than or equal to -31 pcm/°F.

The 60 ppm/ARO/RTP-MTC shall be less negative than or equal to -38 pcm/°F.

where: 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

2.4 ROD GROUP ALIGNMENT LIMITS (LCO 3.1.4)

2.4.1 The SDM shall be greater than or equal to 1.3% Δk/k in MODES 1 and 2.

2.5 SHUTDOWN BANK INSERTION LIMITS (LCO 3.1.5)

2.5.1 The shutdown rods shall be fully withdrawn. Fully withdrawn shall be the condition where shutdown rods are at a position within the interval of 218 and 231 steps withdrawn, inclusive.

2.6 CONTROL BANK INSERTION LIMITS (LCO 3.1.6)

2.6.1 The control banks shall be limited in physical insertion as shown in Figure 2.

2.6.2 The control banks shall always be withdrawn and inserted in the prescribed sequence. For withdrawal, the sequence is control bank A, control bank B, control bank C, and control bank D. The insertion sequence is the reverse of the withdrawal sequence.

2.6.3 A 115 step Tip-to-Tip relationship between each sequential control bank shall be maintained.

2.7 PHYSICS TESTS EXCEPTIONS - MODE 2 (LCO 3.1.8)

2.7.1 The SDM shall be greater than or equal to 1.3% $\Delta k/k$ in MODE 2 during PHYSICS TESTS.

2.8 HEAT FLUX HOT CHANNEL FACTOR ($F_Q(Z)$) (LCO 3.2.1)

2.8.1 $$F_Q(Z) \leq \frac{F_Q^{RTP}}{P} [K(Z)] \text{ for } P > 0.5$$

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

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

2.8.2 $F_Q^{RTP} = 2.50$

2.8.3 K(Z) is provided in Figure 3.

2.8.4 Elevation and burnup dependent W(Z) values are provided in Figures 4, 5, 6, 7 and 8. For W(Z) data at a desired burnup not listed in the figures, but less than the maximum listed burnup, values at 3 or more burnup steps should be used to interpolate the W(Z) data to the desired burnup with a polynomial type fit that uses the nearest three burnup steps. For W(Z) data at a desired burnup outside of the listed burnup steps, a linear extrapolation of the W(Z) data for the nearest two burnup steps can be used.

2.8.5 SR 3.2.1.2

If the two most recent $F_Q(Z)$ evaluations show an increase in the expression

maximum over Z [$F_Q^C(Z)$ / K(Z)],

the burnup dependent values in Table 1 shall be used instead of a constant 2% to increase $F_Q^W(Z)$ per Surveillance Requirement 3.2.1.2.a. A constant factor of 2% shall be used for all cycle burnups that are outside the range of Table 1.

2.9 NUCLEAR ENTHALPY RISE HOT CHANNEL FACTOR ($F^N_{\Delta H}$) (LCO 3.2.2)

2.9.1 $F^N_{\Delta H} \leq F^{RTP}_{\Delta H} [1 + PF_{\Delta H} (1-P)]$

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

2.9.2 $F^{RTP}_{\Delta H}$ = 1.60 for all Fuel Assembly Regions

2.9.3 $PF_{\Delta H}$ = 0.3

2.10 AXIAL FLUX DIFFERENCE (AFD) (LCO 3.2.3)

2.10.1 The AFD Acceptable Operation Limits are provided in Figure 9.

2.11 REACTOR TRIP SYSTEM (RTS) INSTRUMENTATION (LCO 3.3.1)

2.11.1 The numerical values pertaining to the Overtemperature N-16 reactor trip setpoint are listed below;

K_1 = 1.15

K_2 = 0.0139 /°F

K_3 = 0.00071 /psig

T_c° = indicated loop specific T_c at Rated Thermal Power, °F

P^1 ≥ 2235 psig

τ_1 ≥ 10 sec

τ_2 ≤ 3 sec

$f_1(\Delta q) = -2.78 \cdot \{(q_t-q_b) + 18\%\}$ when $(q_t-q_b) \leq -18\%$ RTP

$= 0\%$ when -18% RTP $< (q_t-q_b) < +10.0\%$ RTP

$= 2.34 \cdot \{(q_t-q_b) - 10.0\%\}$ when $(q_t-q_b) \geq +10.0\%$ RTP

2.12 RCS PRESSURE, TEMPERATURE, AND FLOW DEPARTURE FROM NUCLEATE BOILING (DNB) LIMITS (LCO 3.4.1)

2.12.1 RCS DNB parameters for pressurizer pressure, RCS average temperature, and RCS total flow rate shall be within the surveillance limits specified below:

2.12.2 SR 3.4.1.1

Pressurizer pressure ≥ 2220 psig (4 channels)

≥ 2222 psig (3 channels)

The pressurizer pressure limits correspond to the analytical limit of 2205 psig used in the safety analysis with allowance for measurement uncertainty. These uncertainties are based on the use of control board indications and the number of available channels.

2.12.3 SR 3.4.1.2

RCS average temperature ≤ 588 °F (4 channels)

≤ 588 °F (3 channels)

The RCS average temperature limits correspond to the analytical limit of 591.9 °F which is bounded by that used in the safety analysis with allowance for measurement uncertainty. These uncertainties are based on the use of control board indications and the number of available channels.

2.12.4 SR 3.4.1.3

The RCS total flow rate shall be ≥ 403,700 gpm.

2.12.5 SR 3.4.1.4

The RCS total flow rate based on precision heat balance shall be ≥ 403,700 gpm.

The required RCS flow, based on an elbow tap differential pressure instrument measurement prior to MODE 1 after the refueling outage, shall be greater than 327,000 gpm.

2.13 BORON CONCENTRATION (LCO 3.9.1)

2.13.1 The required refueling boron concentration is ≥ 1835 ppm.

3.0 REFERENCES

Technical Specification 5.6.5.

Table 1
$F_Q(Z)$ MARGIN DECREASES IN EXCESS OF 2% PER 31 EFPD

Cycle Burnup (MWD/MTU)	Maximum Decrease In $F_Q(Z)$ MARGIN (Percent)
0	2.21
150	2.21
365	3.80
580	4.69
795	5.00
1010	4.83
1224	4.22
1439	3.37
1654	2.44
1869	2.00
4233	2.00
4448	2.03
4662	2.51
4877	2.94
5307	3.77
5522	4.10
5737	3.86
6167	3.22
6596	2.56
7026	2.00

Note: All cycle burnups outside the range of the table shall use a constant 2% decrease in $F_Q(Z)$ margin for compliance with the 3.2.1.2.a Surveillance Requirements. Linear interpolation is acceptable to determine the $F_Q(Z)$ margin decrease for cycle burnups which fall between the specified burnups.

Figure 1
Reactor Core Safety Limits

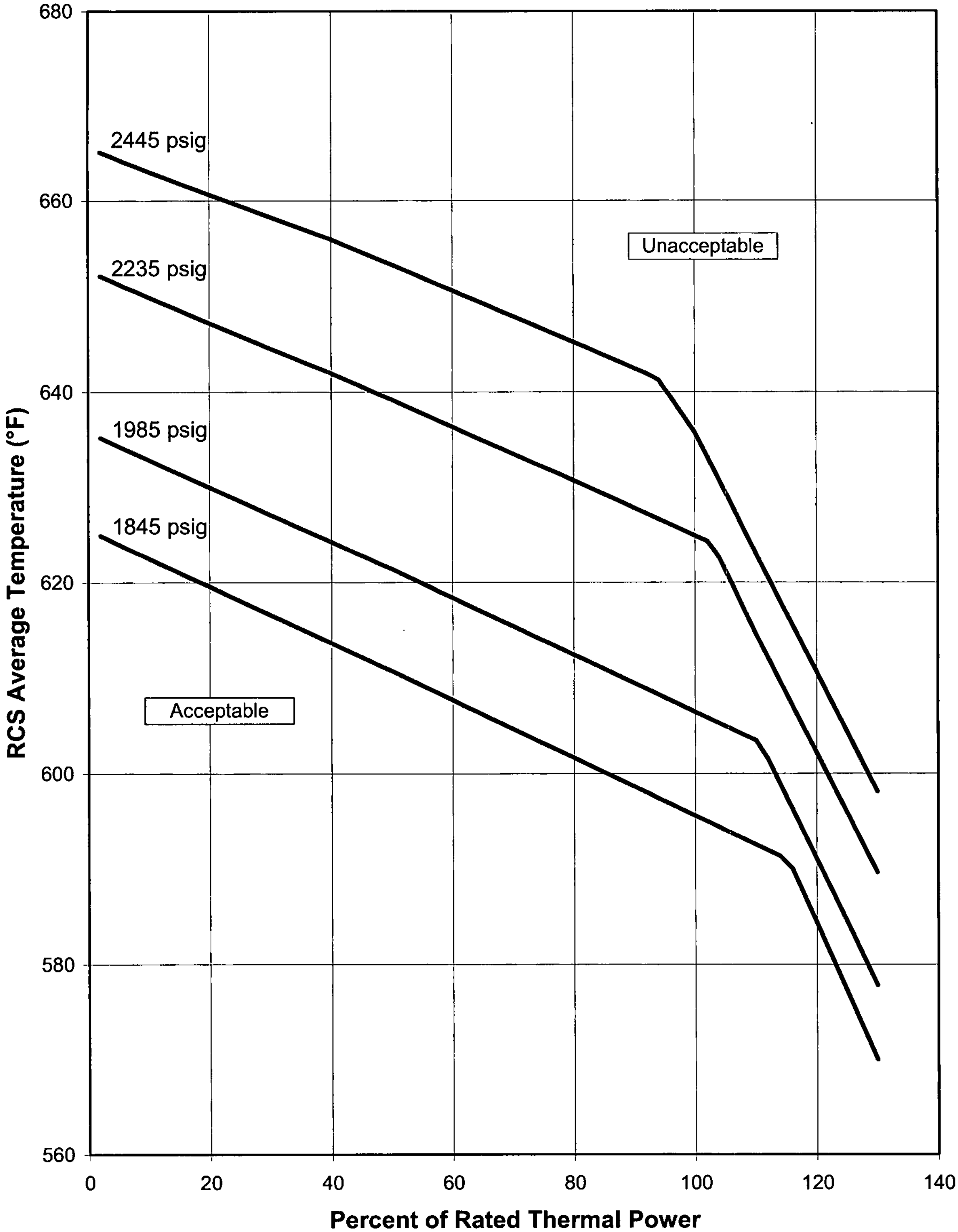
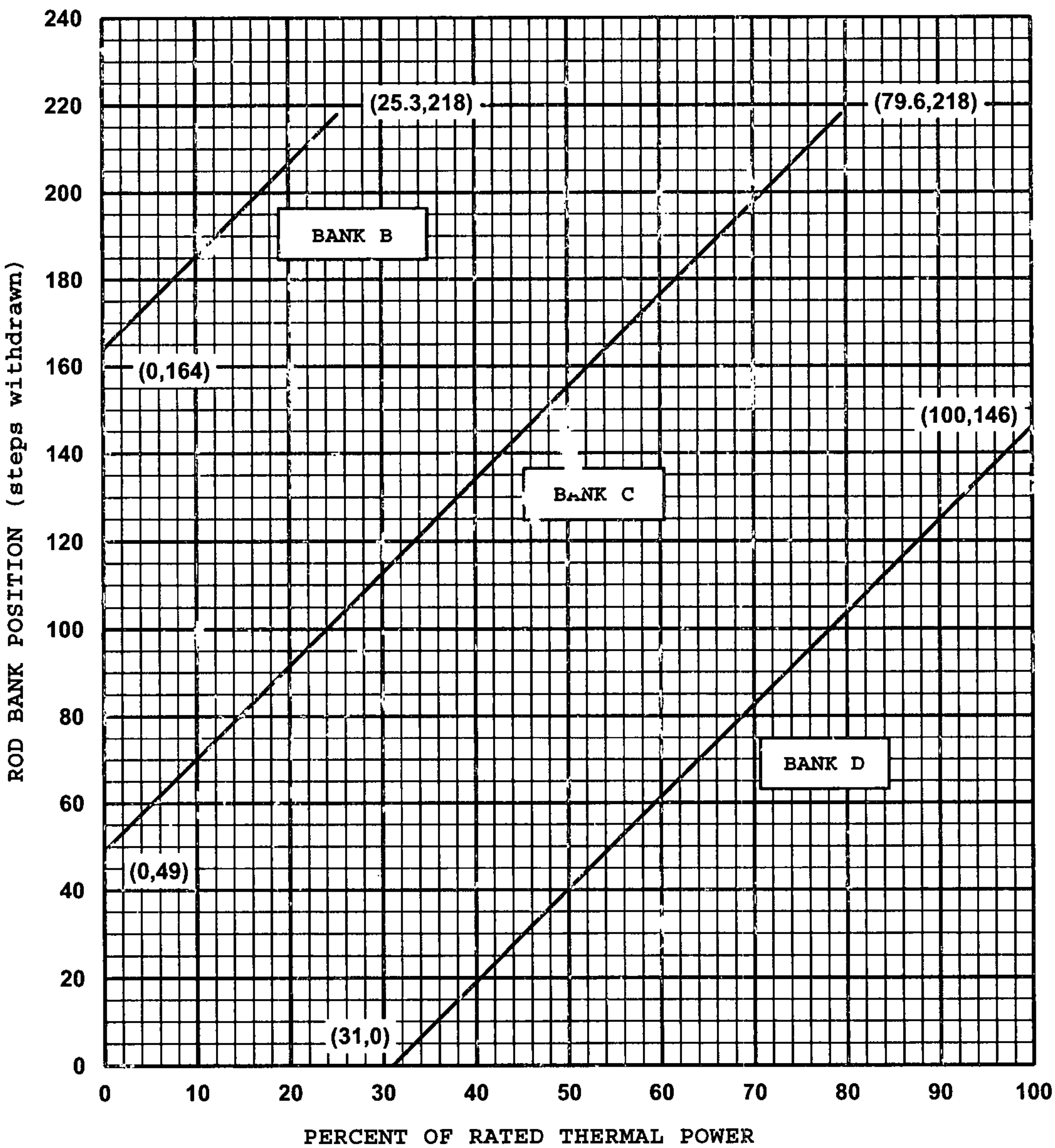


FIGURE 2

ROD BANK INSERTION LIMITS VERSUS THERMAL POWER



NOTES:

1. Fully withdrawn shall be the condition where control rods are at a position within the interval of 218 and 231 steps withdrawn, inclusive.

2. Control Bank A shall be fully withdrawn.

FIGURE 3

K(Z) - NORMALIZED $F_Q(Z)$ AS A FUNCTION OF CORE HEIGHT

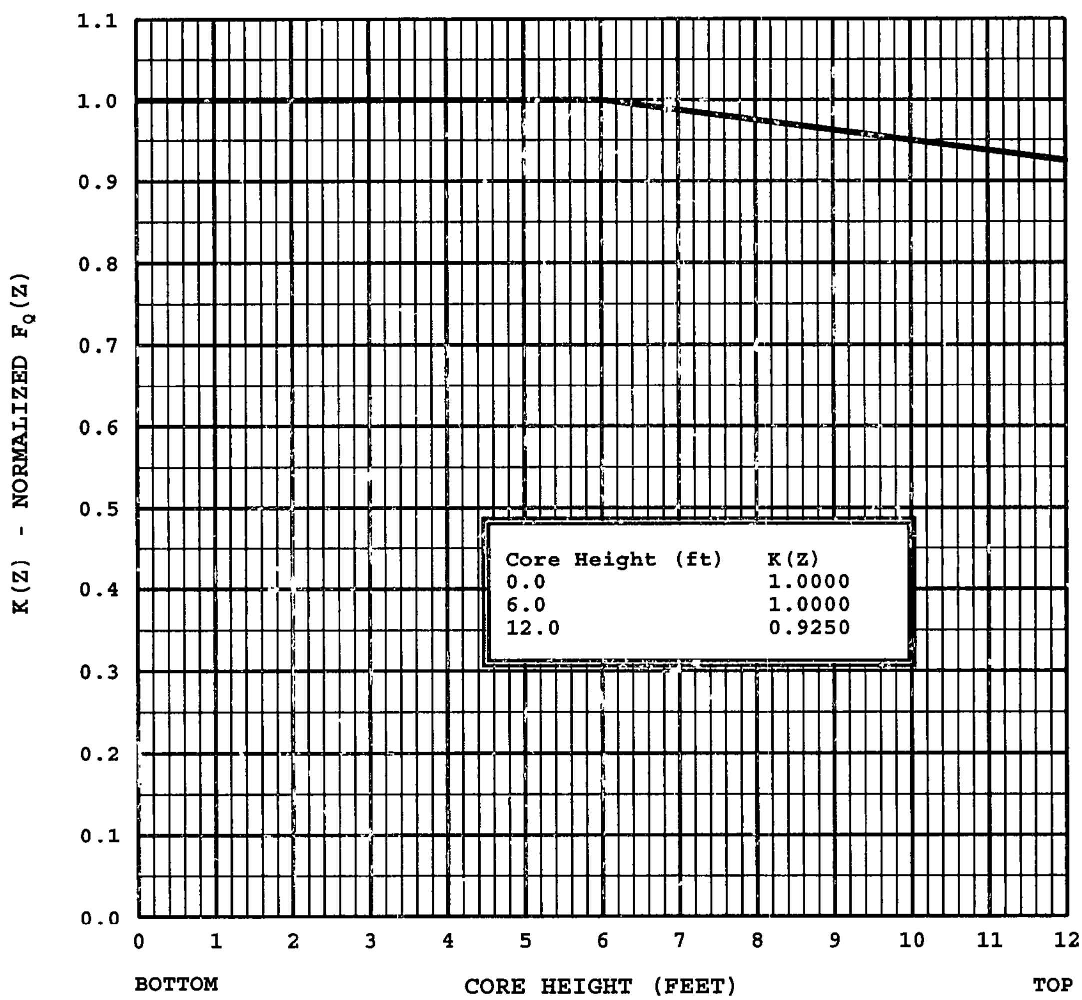
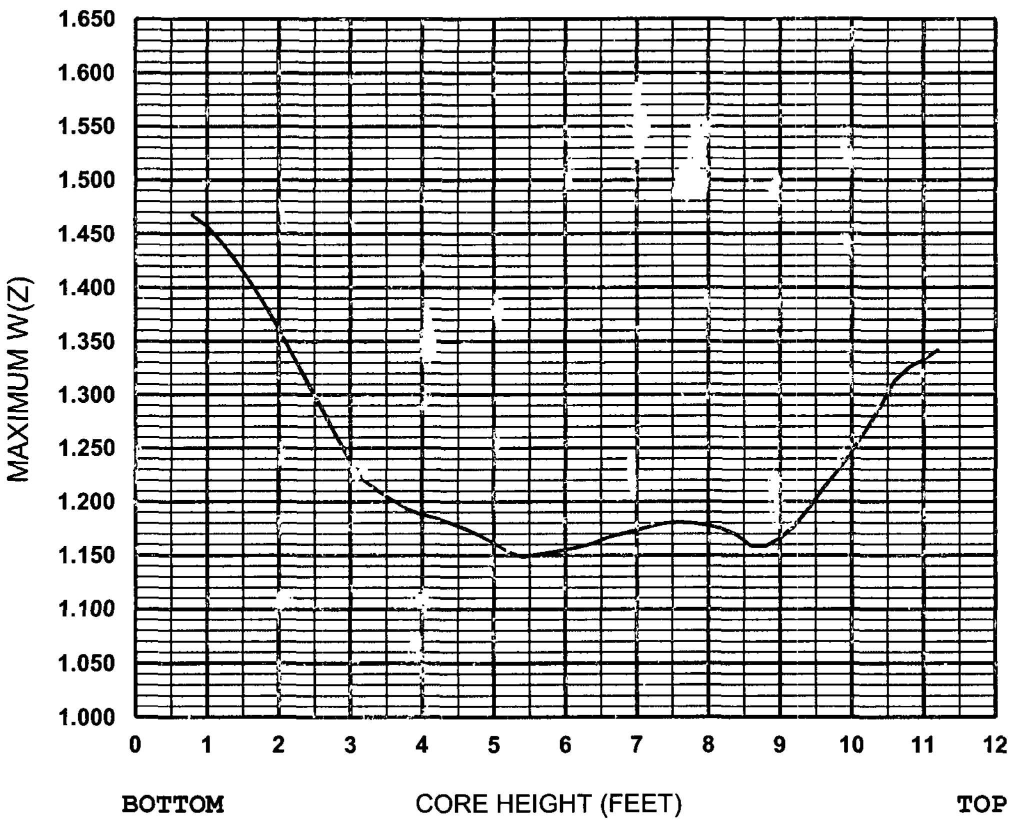


FIGURE 4

W(Z) AS A FUNCTION OF CORE HEIGHT
(150 MWD/MTU)

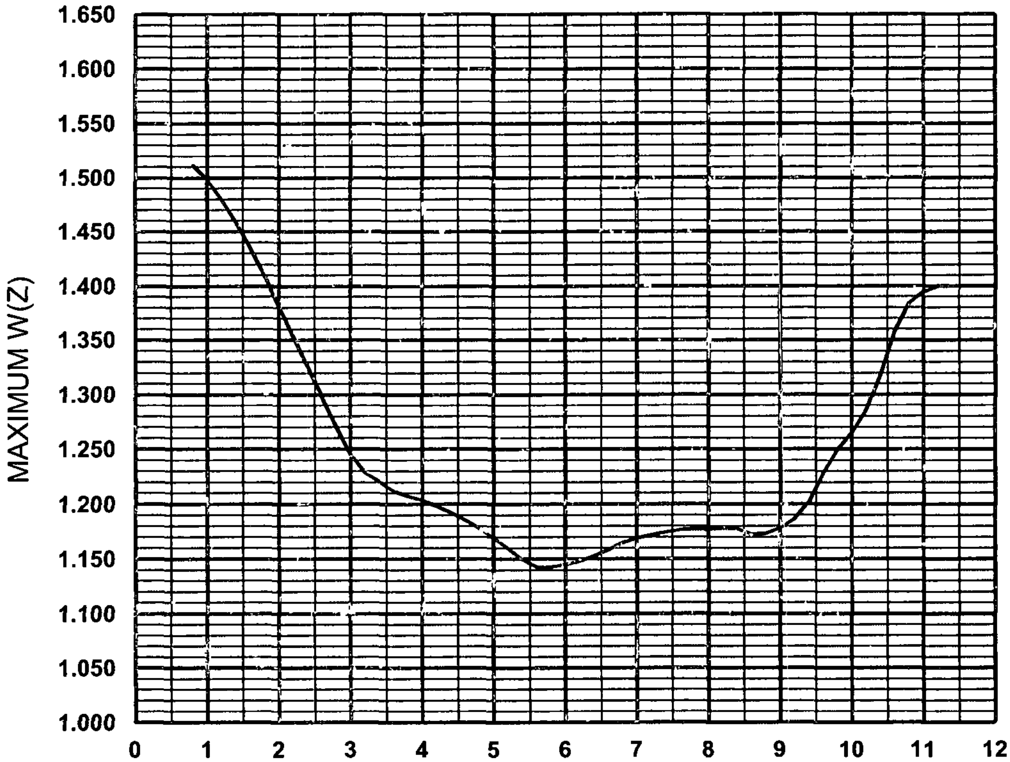


Axial Node	W(Z)	Axial Node	W(Z)	Axial Node	W(Z)	Axial Node	W(Z)
58 - 61	---	44	1.1587	30	1.1530	16	1.2378
57	1.3418	43	1.1692	29	1.1509	15	1.2618
56	1.3331	42	1.1746	28	1.1484	14	1.2871
55	1.3259	41	1.1774	27	1.1534	13	1.3123
54	1.3133	40	1.1799	26	1.1616	12	1.3371
53	1.2887	39	1.1807	25	1.1685	11	1.3612
52	1.2672	38	1.1797	24	1.1746	10	1.3842
51	1.2472	37	1.1769	23	1.1800	9	1.4056
50	1.2282	36	1.1732	22	1.1847	8	1.4253
49	1.2121	35	1.1702	21	1.1879	7	1.4428
48	1.1931	34	1.1668	20	1.1929	6	1.4573
47	1.1771	33	1.1613	19	1.2013	5	1.4672
46	1.1657	32	1.1578	18	1.2096	1 - 4	---
45	1.1583	31	1.1551	17	1.2201		

Core Height (ft) = (Node - 1) * 0.2013217

FIGURE 5

W(Z) AS A FUNCTION OF CORE HEIGHT
(1,000 MWD/MTU)

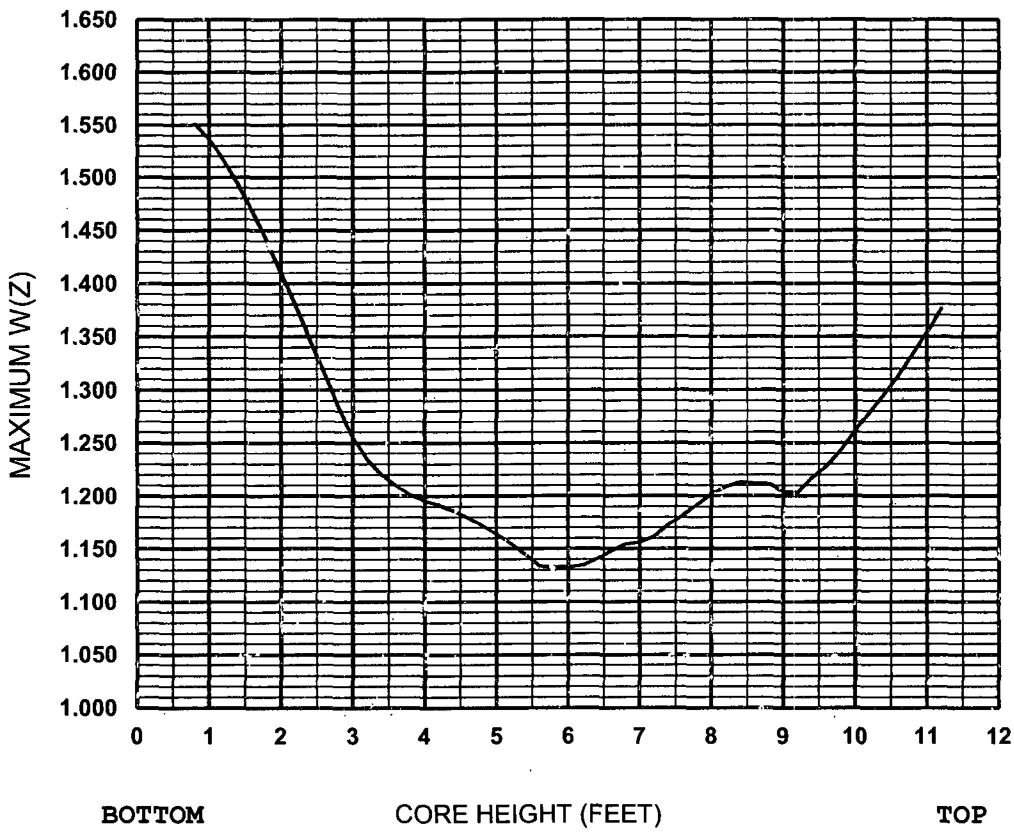


Axial Node	W(Z)	Axial Node	W(Z)	Axial Node	W(Z)	Axial Node	W(Z)
58 - 61	---	44	1.1727	30	1.1427	16	1.2451
57	1.4000	43	1.1777	29	1.1425	15	1.2703
56	1.3944	42	1.1783	28	1.1495	14	1.2982
55	1.3835	41	1.1770	27	1.1596	13	1.3257
54	1.3578	40	1.1771	26	1.1693	12	1.3532
53	1.3186	39	1.1766	25	1.1779	11	1.3814
52	1.2850	38	1.1744	24	1.1856	10	1.4092
51	1.2647	37	1.1718	23	1.1923	9	1.4350
50	1.2494	36	1.1690	22	1.1982	8	1.4588
49	1.2285	35	1.1647	21	1.2034	7	1.4802
48	1.2020	34	1.1586	20	1.2073	6	1.4983
47	1.1862	33	1.1525	19	1.2119	5	1.5116
46	1.1782	32	1.1481	18	1.2205	1 - 4	---
45	1.1732	31	1.1448	17	1.2287		

Core Height (ft) = (Node - 1) * 0.2013217

FIGURE 6

W(Z) AS A FUNCTION OF CORE HEIGHT
(3,000 MWD/MTU)

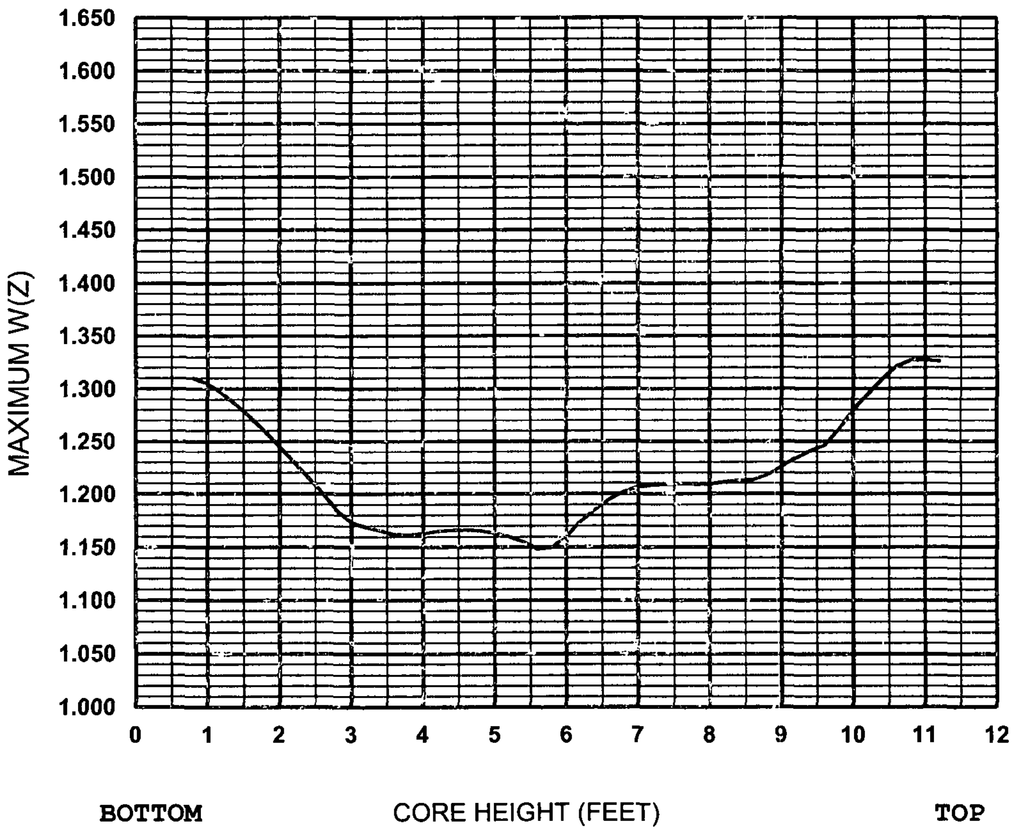


Axial Node	W(Z)	Axial Node	W(Z)	Axial Node	W(Z)	Axial Node	W(Z)
58 - 61	---	44	1.2119	30	1.1326	16	1.2558
57	1.3761	43	1.2131	29	1.1335	15	1.2840
56	1.3539	42	1.2089	28	1.1447	14	1.3161
55	1.3333	41	1.2015	27	1.1551	13	1.3478
54	1.3132	40	1.1919	26	1.1640	12	1.3794
53	1.2959	39	1.1811	25	1.1723	11	1.4104
52	1.2789	38	1.1726	24	1.1795	10	1.4401
51	1.2610	37	1.1613	23	1.1859	9	1.4680
50	1.2431	36	1.1560	22	1.1915	8	1.4937
49	1.2280	35	1.1540	21	1.1956	7	1.5167
48	1.2171	34	1.1480	20	1.2010	6	1.5365
47	1.2033	33	1.1403	19	1.2099	5	1.5514
46	1.2040	32	1.1342	18	1.2204	1 - 4	---
45	1.2114	31	1.1327	17	1.2347		

Core Height (ft) = (Node - 1) * 0.2013217

FIGURE 7

W(Z) AS A FUNCTION OF CORE HEIGHT
(12,000 MWD/MTU)

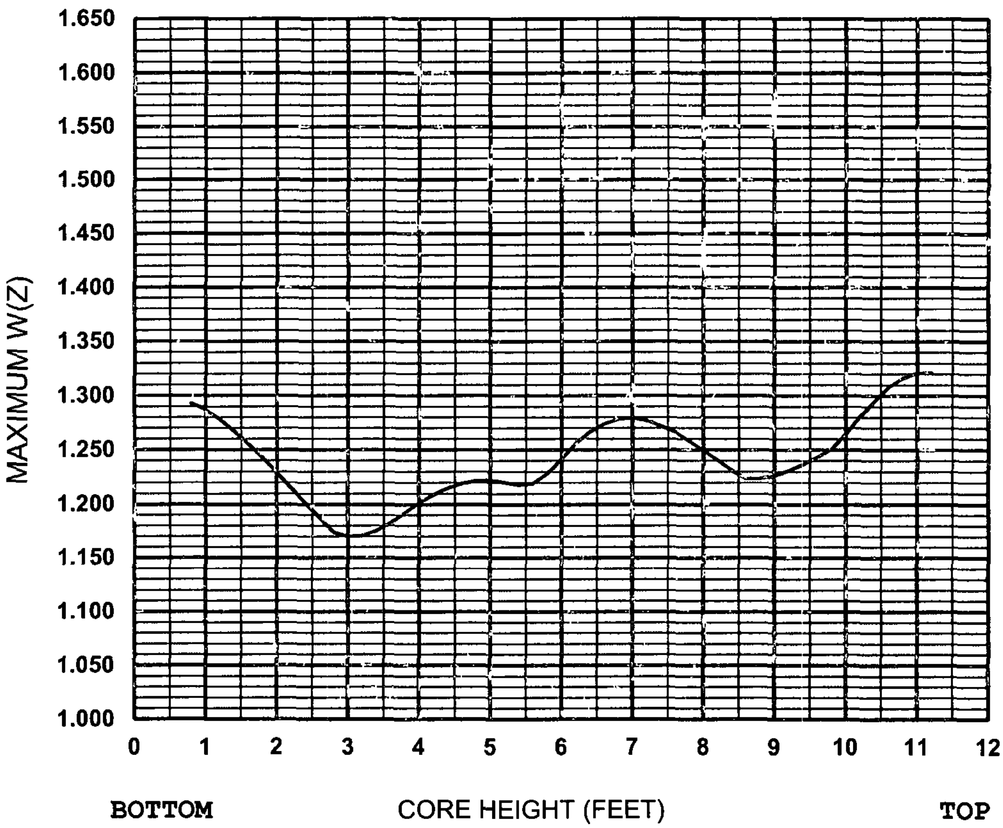


Axial Node	W(Z)	Axial Node	W(Z)	Axial Node	W(Z)	Axial Node	W(Z)
58 - 61	---	44	1.2128	30	1.1497	16	1.1736
57	1.3261	43	1.2127	29	1.1484	15	1.1845
56	1.3272	42	1.2110	28	1.1549	14	1.2005
55	1.3270	41	1.2090	27	1.1599	13	1.2156
54	1.3210	40	1.2090	26	1.1631	12	1.2306
53	1.3093	39	1.2098	25	1.1653	11	1.2453
52	1.2949	38	1.2087	24	1.1662	10	1.2594
51	1.2794	37	1.2085	23	1.1660	9	1.2727
50	1.2616	36	1.2066	22	1.1649	8	1.2850
49	1.2462	35	1.2018	21	1.1627	7	1.2959
48	1.2410	34	1.1947	20	1.1615	6	1.3048
47	1.2339	33	1.1854	19	1.1620	5	1.3101
46	1.2257	32	1.1743	18	1.1658	1 - 4	---
45	1.2179	31	1.1605	17	1.1688		

Core Height (ft) = (Node - 1) * 0.2013217

FIGURE 8

W(Z) AS A FUNCTION OF CORE HEIGHT
(20,000 MWD/MTU)



Axial Node	W(Z)	Axial Node	W(Z)	Axial Node	W(Z)	Axial Node	W(Z)
58 - 61	---	44	1.2239	30	1.2280	16	1.1699
57	1.3212	43	1.2312	29	1.2193	15	1.1737
56	1.3213	42	1.2406	28	1.2180	14	1.1876
55	1.3163	41	1.2493	27	1.2205	13	1.2017
54	1.3078	40	1.2580	26	1.2224	12	1.2156
53	1.2945	39	1.2664	25	1.2218	11	1.2293
52	1.2806	38	1.2719	24	1.2193	10	1.2425
51	1.2644	37	1.2770	23	1.2149	9	1.2551
50	1.2506	36	1.2794	22	1.2088	8	1.2670
49	1.2432	35	1.2781	21	1.2013	7	1.2779
48	1.2368	34	1.2737	20	1.1923	6	1.2871
47	1.2312	33	1.2662	19	1.1829	5	1.2926
46	1.2264	32	1.2558	18	1.1752	1 - 4	---
45	1.2238	31	1.2421	17	1.1707		

Core Height (ft) = (Node - 1) * 0.2013217

FIGURE 9

AXIAL FLUX DIFFERENCE LIMITS AS A FUNCTION OF RATED THERMAL POWER