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U. S. Nuclear Regulatory Commission
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Joseph M. Farley Nuclear Plant – Unit 2
Cycle 26 Core Operating Limits Report

Ladies and Gentlemen:

In accordance with Technical Specification 5.6.5.d, Southern Nuclear Operating Company (SNC) submits the enclosed Core Operating Limits Report (COLR) for the Joseph M. Farley Nuclear Plant (FNP) – Unit 2 Cycle 26 Version 1.

This letter contains no NRC commitments. If you have any questions, please contact Ken McElroy at 205.992.7369.

Respectfully submitted,

Justin T. Wheat
Regulatory Affairs Manager

JTW/NDJ/CJ

Enclosure: Core Operating Limits Report for FNP Unit 2 Cycle 26 Version 1

cc: Regional Administrator, Region II
NRR Project Manager – Farley Nuclear Plant
Senior Resident Inspector – Farley Nuclear Plant
RTYPE: CFA04.054

Joseph M. Farley Nuclear Plant – Unit 2
Cycle 26 Core Operating Limits Report

Enclosure

Core Operating Limits Report for FNP Unit 2 Cycle 26 Version 1

SOUTHERN COMPANY

Energy to Serve Your World®

Joseph M. Farley Nuclear Plant

Core Operating Limits Report

Unit 2 - Cycle 26

Version 1

July 2017

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for FNP UNIT 2 CYCLE 26 has been prepared in accordance with the requirements of Technical Specification 5.6.5.

The Technical Requirement affected by this report is listed below:

13.1.1 SHUTDOWN MARGIN - MODES 1 and 2 (with $k_{eff} \geq 1$)

The Technical Specifications affected by this report are listed below:

2.1.1 Reactor Core Safety Limits for THERMAL POWER
3.1.1 SHUTDOWN MARGIN - MODES 2 (with $k_{eff} < 1$), 3, 4 and 5
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 - $F_Q(Z)$
3.2.2 Nuclear Enthalpy Rise Hot Channnel Factor - $F_{\Delta H}^N$
3.2.3 Axial Flux Difference
3.3.1 Reactor Trip System Instrumentation Overtemperature ΔT (OTΔT) and Overpower ΔT (OPΔT) Setpoint Parameter Values for Table 3.3.1-1
3.4.1 RCS DNB Parameters for Pressurizer Pressure, RCS Average Temperature, and RCS Total Flow Rate
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 NRC-approved methodologies, including those specified in Technical Specification 5.6.5.

2.1 SHUTDOWN MARGIN - MODES 1 and 2 (with $k_{eff} \geq 1.0$) (Technical Requirement 13.1.1)

2.1.1 The SHUTDOWN MARGIN shall be greater than or equal to 1.77 percent $\Delta k/k$.

2.2 SHUTDOWN MARGIN - MODES 2 (with $k_{eff} < 1.0$), 3, 4 and 5 (Specification 3.1.1)

2.2.1 Modes 2 ($k_{eff} < 1.0$), 3 and 4 - The SHUTDOWN MARGIN shall be greater than or equal to 1.77 percent $\Delta k/k$.

2.2.2 Mode 5 - The SHUTDOWN MARGIN shall be greater than or equal to 1.0 percent $\Delta k/k$.

2.3 Moderator Temperature Coefficient (Specification 3.1.3)

2.3.1 The Moderator Temperature Coefficient (MTC) limits are:

The BOL/ARO-MTC shall be less than or equal to $+0.7 \times 10^{-4}$ $\Delta k/k/°F$ for power levels up to 70 percent RTP with a linear ramp to 0 $\Delta k/k/°F$ at 100 percent RTP.

The EOL/ARO/RTP-MTC shall be less negative than -4.3×10^{-4} $\Delta k/k/°F$.

2.3.2 The MTC Surveillance limits are:

The 300 ppm/ARO/RTP-MTC should be less negative than or equal to -3.65×10^{-4} $\Delta k/k/°F$.

The revised predicted near-EOL 300 ppm MTC shall be calculated using Figure 5 and the following algorithm:

Revised Predicted MTC = Predicted MTC* + AFD Correction** + Predictive Correction***

where,
* Predicted MTC is calculated from Figure 5 at the burnup corresponding to the measurement of 300 ppm at RTP conditions,
** AFD Correction is the more negative value of:
{0 pcm/°F or (ΔAFD * AFD Sensitivity)}
where: ΔAFD is the measured AFD minus the predicted AFD from an incore flux map taken at or near the burnup corresponding to 300 ppm,
AFD Sensitivity = 0.07 pcm/°F / ΔAFD
***Predictive Correction is -3 pcm/°F.

The 100 ppm/ARO/RTP-MTC should be less negative than -4.0×10^{-4} $\Delta k/k/°F$.

where: BOL stands for Beginning of Cycle Life
ARO stands for All Rods Out
EOL stands for End of Cycle Life
RTP stands for RATED THERMAL POWER

2.4 Shutdown Bank Insertion Limits (Specification 3.1.5)

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

2.5 Control Bank Insertion Limits (Specification 3.1.6)

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

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

2.6.1 $F_Q(Z) \le \frac{F_Q^{RTP}}{P} * K(Z)$ for P > 0.5

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

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

2.6.2 $F_Q^{RTP} = 2.50$

2.6.3 K(Z) is provided in Figure 2.

2.6.4 $F_Q(Z) \le \frac{F_Q^{RTP} * K(Z)}{P * W(Z)}$ for P > 0.5

$F_Q(Z) \le \frac{F_Q^{RTP} * K(Z)}{0.5 * W(Z)}$ for P ≤ 0.5

2.6.5 Full Power W(Z) values are provided in Table 4.
Part Power (48% RTP) W(Z) values are provided in Table 5.

2.6.6 The $F_Q(Z)$ penalty factors are provided in Table 1.

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

2.7.1 $F_{\Delta H}^{N} \leq F_{\Delta H}^{RTP} * (1 + PF_{\Delta H} * (1 - P))$

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

2.7.2 $F_{\Delta H}^{RTP} = 1.70$

2.7.3 $PF_{\Delta H} = 0.3$

2.8 Axial Flux Difference (Specification 3.2.3)

2.8.1 The Axial Flux Difference (AFD) acceptable operation limits are provided in Figure 3.

2.9 Boron Concentration (Specification 3.9.1)

2.9.1 The boron concentration shall be greater than or equal to 2000 ppm.[1]

2.10 Reactor Core Safety Limits for THERMAL POWER (Specification 2.1.1)

2.10.1 In MODES 1 and 2, the combination of THERMAL POWER, Reactor Coolant System (RCS) highest loop average temperature, and pressurizer pressure shall not exceed the safety limits specified in Figure 4.

2.11 Reactor Trip System Instrumentation Overtemperature ΔT (OTΔT) and Overpower ΔT (OPΔT) Setpoint Parameter Values for Table 3.3.1-1 (Specification 3.3.1)

2.11.1 The Reactor Trip System Instrumentation Overtemperature ΔT (OTΔT) and Overpower ΔT (OPΔT) setpoint parameter values for TS Table 3.3.1-1 are listed in COLR Tables 2 and 3.

2.12 RCS DNB Parameters for Pressurizer Pressure, RCS Average Temperature, and RCS Total Flow Rate (Specification 3.4.1)

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

a. Pressurizer pressure ≥ 2209 psig;
b. RCS average temperature ≤ 580.3°F; and
c. The minimum RCS total flow rate shall be ≥ 273,900 GPM when using the precision heat balance method and ≥ 274,800 GPM when using the elbow tap method.

[1] This concentration bounds the condition of $k_{eff} \leq 0.95$ (all rods in less the most reactive rod) and subcriticality (all rods out) over the entire cycle. This concentration includes additional boron to address uncertainties and B^{10} depletion.

Table 1
$F_Q(Z)$ Penalty Factor

Cycle Burnup (MWD/MTU)	$F_Q(Z)$ Penalty Factor
0	1.0339
150	1.0339
354	1.0298
559	1.0248
763	1.0201
968	1.0200
6282	1.0200
6487	1.0242
6691	1.0293
6896	1.0321
7100	1.0295
7304	1.0267
7509	1.0239
7713	1.0210
7918	1.0200

Notes:

1. The Penalty Factor, to be applied to $F_Q(Z)$ in accordance with SR 3.2.1.2, is the maximum factor by which $F_Q(Z)$ is expected to increase over a 39 EFPD interval (surveillance interval of 31 EFPD plus the maximum allowable extension not to exceed 25% of the surveillance interval per SR 3.0.2) starting from the burnup at which the $F_Q(Z)$ was determined.
2. Linear interpolation is adequate for intermediate cycle burnups.
3. For all cycle burnups outside the range of the table, a penalty factor of 1.0200 shall be used.

Table 2
Reactor Trip System Instrumentation - Overtemperature ΔT (OTΔT)
Setpoint Parameter Values

$T' \leq 577.2°F$	$P' = 2235$ psig	
$K_1 = 1.17$	$K_2 = 0.017/°F$	$K_3 = 0.000825/psi$
$\tau_1 \geq 30$ sec	$\tau_2 \leq 4$ sec	
$\tau_4 = 0$ sec	$\tau_5 \leq 6$ sec	$\tau_6 \leq 6$ sec

$f_1(\Delta I) =$	$-2.48 \{23 + (q_t - q_b)\}$	when $(q_t - q_b) \leq -23\%$ RTP
	0% of RTP	when -23% RTP $< (q_t - q_b) \leq 15\%$ RTP
	$2.05 \{(q_t - q_b) - 15\}$	when $(q_t - q_b) > 15\%$ RTP

Table 3
Reactor Trip System Instrumentation - Overpower ΔT (OPΔT)
Setpoint Parameter Values

$T'' \leq 577.2°F$

$K_4 = 1.10$	$K_5 = 0.02/°F$ for increasing T_{avg}	$K_6 = 0.00109/°F$ when $T > T''$
	$K_5 = 0/°F$ for decreasing T_{avg}	$K_6 = 0/°F$ when $T \leq T''$

$\tau_3 \geq 10$ sec
$\tau_4 = 0$ sec
$\tau_5 \leq 6$ sec
$\tau_6 \leq 6$ sec

$f_2(\Delta I) = 0\%$ RTP for all ΔI

Table 4
RAOC W(Z)

	Axial Point	Elevation (feet)	150 MWD/MTU	3000 MWD/MTU	6000 MWD/MTU	10000 MWD/MTU	14000 MWD/MTU	18000 MWD/MTU
*	1	12.00	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
*	2	11.80	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
*	3	11.60	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
*	4	11.40	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
*	5	11.20	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	6	11.00	1.1255	1.1449	1.2133	1.2457	1.2563	1.2149
	7	10.80	1.1254	1.1465	1.2117	1.2474	1.2540	1.2067
	8	10.60	1.1210	1.1427	1.2054	1.2405	1.2342	1.1951
	9	10.40	1.1195	1.1545	1.2114	1.2272	1.2216	1.1865
	10	10.20	1.1208	1.1617	1.2177	1.2148	1.2148	1.1790
	11	10.00	1.1302	1.1583	1.2146	1.2113	1.2081	1.1720
	12	9.80	1.1357	1.1506	1.2077	1.2108	1.2009	1.1753
	13	9.60	1.1384	1.1450	1.2029	1.2133	1.1934	1.1831
	14	9.40	1.1402	1.1352	1.1918	1.2165	1.1887	1.1892
	15	9.20	1.1384	1.1357	1.1925	1.2155	1.2009	1.1936
	16	9.00	1.1418	1.1356	1.1904	1.2233	1.2094	1.2001
	17	8.80	1.1423	1.1397	1.1863	1.2250	1.2128	1.2234
	18	8.60	1.1464	1.1511	1.1885	1.2301	1.2163	1.2459
	19	8.40	1.1590	1.1612	1.1989	1.2436	1.2279	1.2661
	20	8.20	1.1686	1.1697	1.2058	1.2535	1.2427	1.2854
	21	8.00	1.1766	1.1763	1.2105	1.2605	1.2540	1.3013
	22	7.80	1.1826	1.1809	1.2133	1.2649	1.2627	1.3138
	23	7.60	1.1859	1.1830	1.2134	1.2663	1.2686	1.3229
	24	7.40	1.1878	1.1838	1.2121	1.2659	1.2727	1.3299
	25	7.20	1.1873	1.1821	1.2079	1.2615	1.2725	1.3315
	26	7.00	1.1853	1.1787	1.2028	1.2545	1.2699	1.3293
	27	6.80	1.1819	1.1741	1.1969	1.2460	1.2667	1.3250
	28	6.60	1.1766	1.1679	1.1891	1.2355	1.2615	1.3183
	29	6.40	1.1705	1.1607	1.1802	1.2233	1.2542	1.3089
	30	6.20	1.1637	1.1528	1.1702	1.2095	1.2449	1.2968
	31	6.00	1.1558	1.1439	1.1594	1.1947	1.2341	1.2831
	32	5.80	1.1469	1.1342	1.1478	1.1791	1.2222	1.2680
	33	5.60	1.1371	1.1273	1.1353	1.1646	1.2087	1.2506
	34	5.40	1.1286	1.1303	1.1219	1.1577	1.1947	1.2308
	35	5.20	1.1357	1.1417	1.1227	1.1588	1.1930	1.2294
	36	5.00	1.1433	1.1518	1.1293	1.1588	1.1899	1.2256
	37	4.80	1.1515	1.1616	1.1350	1.1581	1.1877	1.2230
	38	4.60	1.1608	1.1708	1.1404	1.1563	1.1837	1.2181
	39	4.40	1.1693	1.1794	1.1451	1.1537	1.1785	1.2115
	40	4.20	1.1770	1.1870	1.1491	1.1501	1.1719	1.2033
	41	4.00	1.1832	1.1938	1.1525	1.1458	1.1657	1.1937
	42	3.80	1.1921	1.1995	1.1549	1.1397	1.1600	1.1813
	43	3.60	1.2031	1.2061	1.1564	1.1340	1.1530	1.1656
	44	3.40	1.2123	1.2142	1.1573	1.1320	1.1452	1.1538
	45	3.20	1.2207	1.2223	1.1596	1.1298	1.1374	1.1441
	46	3.00	1.2271	1.2290	1.1679	1.1312	1.1273	1.1381
	47	2.80	1.2415	1.2513	1.1892	1.1431	1.1339	1.1465
	48	2.60	1.2686	1.2826	1.2141	1.1577	1.1468	1.1622
	49	2.40	1.2975	1.3136	1.2385	1.1718	1.1587	1.1771
	50	2.20	1.3262	1.3450	1.2634	1.1863	1.1711	1.1924
	51	2.00	1.3548	1.3762	1.2877	1.1997	1.1822	1.2060
	52	1.80	1.3830	1.4068	1.3116	1.2128	1.1929	1.2189
	53	1.60	1.4095	1.4357	1.3344	1.2257	1.2040	1.2323
	54	1.40	1.4346	1.4629	1.3560	1.2382	1.2152	1.2460
	55	1.20	1.4579	1.4881	1.3761	1.2503	1.2262	1.2596
	56	1.00	1.4791	1.5107	1.3944	1.2617	1.2372	1.2733
*	57	0.80	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
*	58	0.60	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
*	59	0.40	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
*	60	0.20	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
*	61	0.00	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

* **Top and bottom 5 axial points excluded per Technical Specification B3.2.1.**

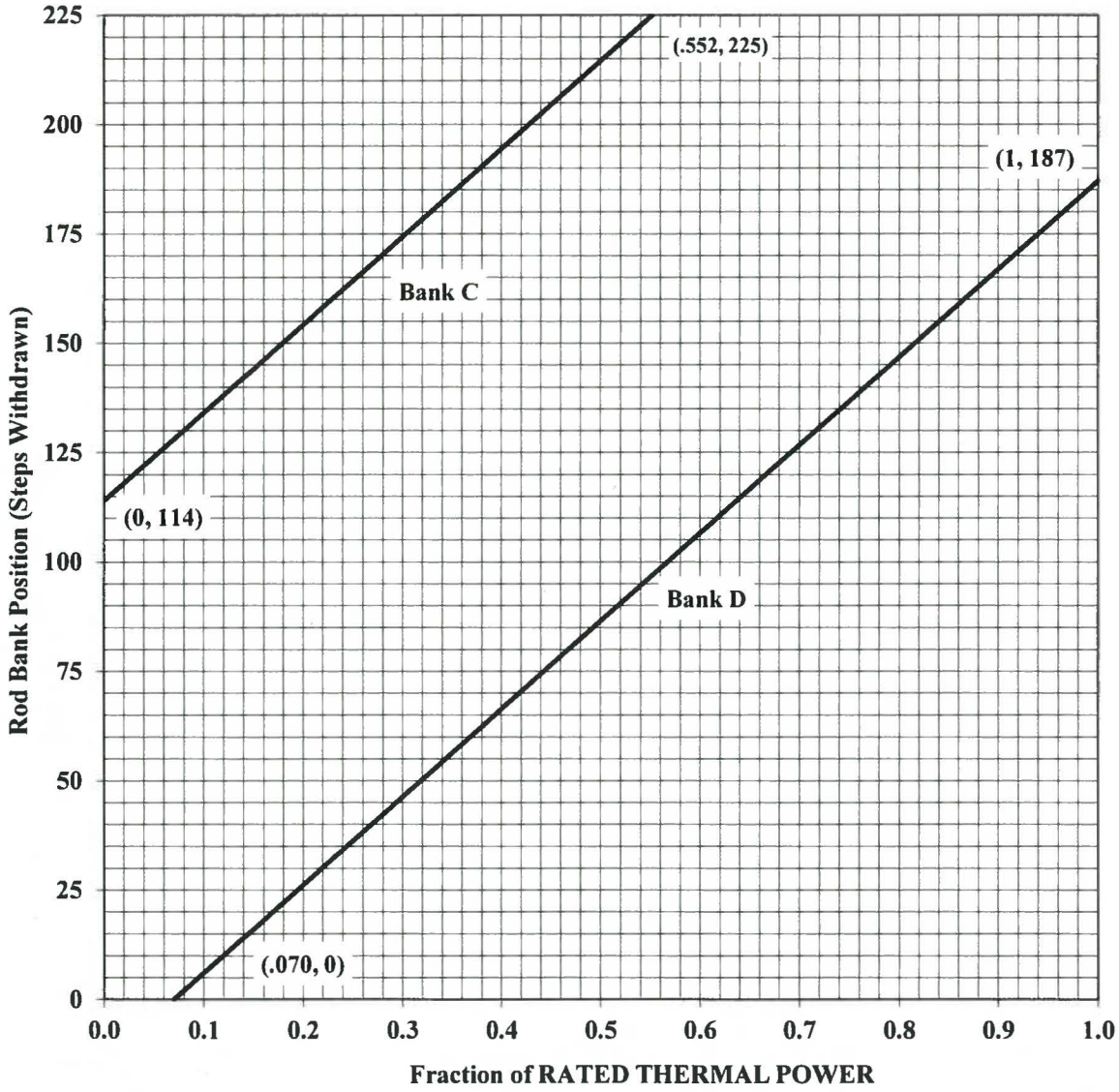
Table 5
Part Power (48%) RAOC W(Z)

	Axial Point	Elevation (feet)	150 MWD/MTU
*	1	12.00	1.0000
*	2	11.80	1.0000
*	3	11.60	1.0000
*	4	11.40	1.0000
*	5	11.20	1.0000
	6	11.00	1.1692
	7	10.80	1.1626
	8	10.60	1.1483
	9	10.40	1.1372
	10	10.20	1.1295
	11	10.00	1.1289
	12	9.80	1.1220
	13	9.60	1.1115
	14	9.40	1.1001
	15	9.20	1.0867
	16	9.00	1.0788
	17	8.80	1.0704
	18	8.60	1.0677
	19	8.40	1.0733
	20	8.20	1.0782
	21	8.00	1.0814
	22	7.80	1.0840
	23	7.60	1.0844
	24	7.40	1.0855
	25	7.20	1.0857
	26	7.00	1.0848
	27	6.80	1.0816
	28	6.60	1.0793
	29	6.40	1.0776
	30	6.20	1.0714
	31	6.00	1.0674
	32	5.80	1.0639
	33	5.60	1.0613
	34	5.40	1.0563
	35	5.20	1.0675
	36	5.00	1.0802
	37	4.80	1.0939
	38	4.60	1.1089
	39	4.40	1.1226
	40	4.20	1.1355
	41	4.00	1.1473
	42	3.80	1.1630
	43	3.60	1.1811
	44	3.40	1.1975
	45	3.20	1.2131
	46	3.00	1.2264
	47	2.80	1.2477
	48	2.60	1.2814
	49	2.40	1.3173
	50	2.20	1.3537
	51	2.00	1.3913
	52	1.80	1.4284
	53	1.60	1.4640
	54	1.40	1.4984
	55	1.20	1.5310
	56	1.00	1.5609
*	57	0.80	1.0000
*	58	0.60	1.0000
*	59	0.40	1.0000
*	60	0.20	1.0000
*	61	0.00	1.0000

* **Top and bottom 5 axial points excluded per Technical Specification B3.2.1.**

Figure 1
Rod Bank Insertion Limits versus Rated Thermal Power

Fully Withdrawn – 225 to 231 steps, inclusive



Fully Withdrawn shall be the condition where control rods are at a position within the interval ≥ 225 and ≤ 231 steps withdrawn.

Note: The Rod Bank Insertion Limits are based on the control bank withdrawal sequence A, B, C, D and a control bank tip-to-tip distance of 128 steps.

Figure 2
K(Z) – Normalized $F_Q(Z)$ as a Function of Core Height

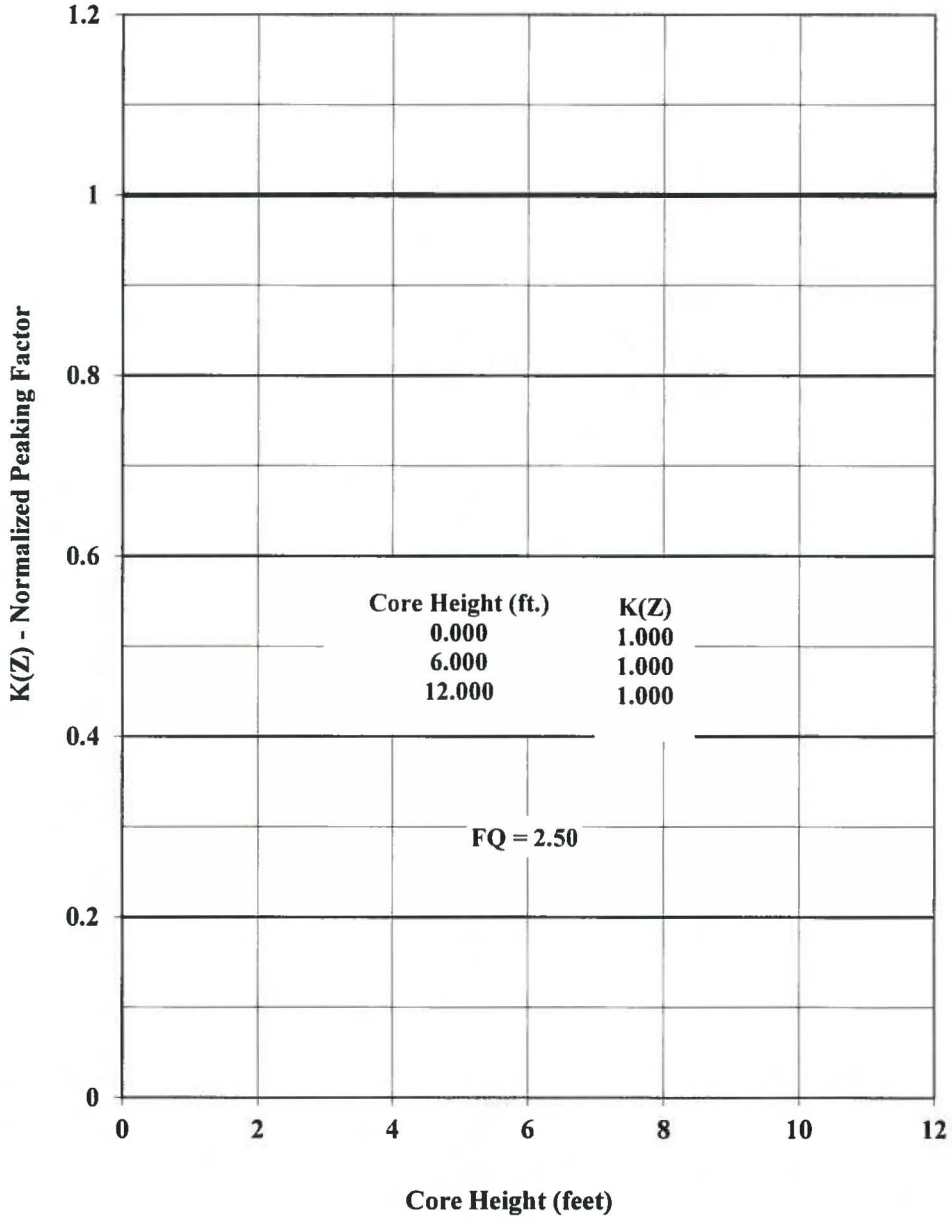


Figure 3
Axial Flux Difference Limits as a Function of
Rated Thermal Power for RAOC

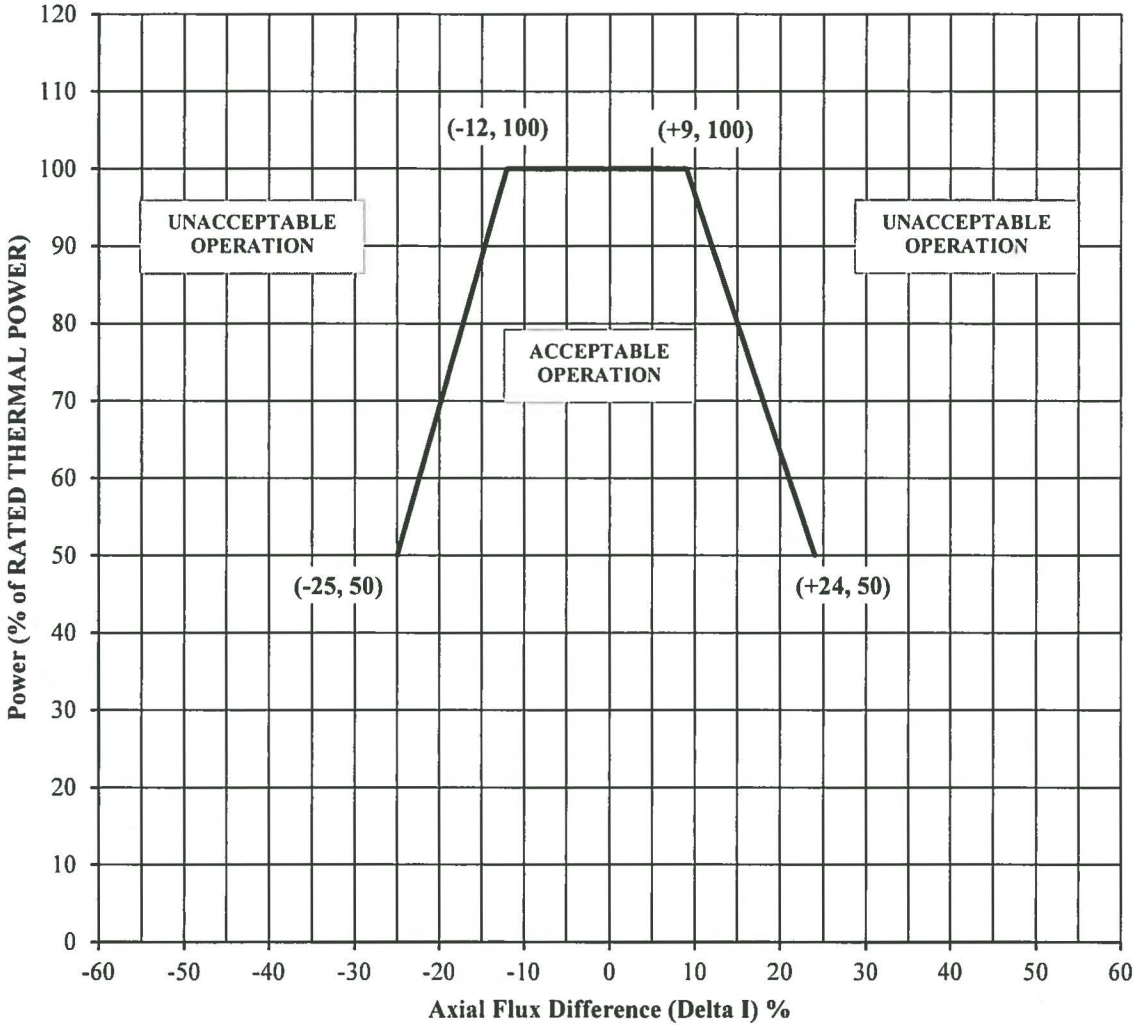


Figure 4
Reactor Core Safety Limits

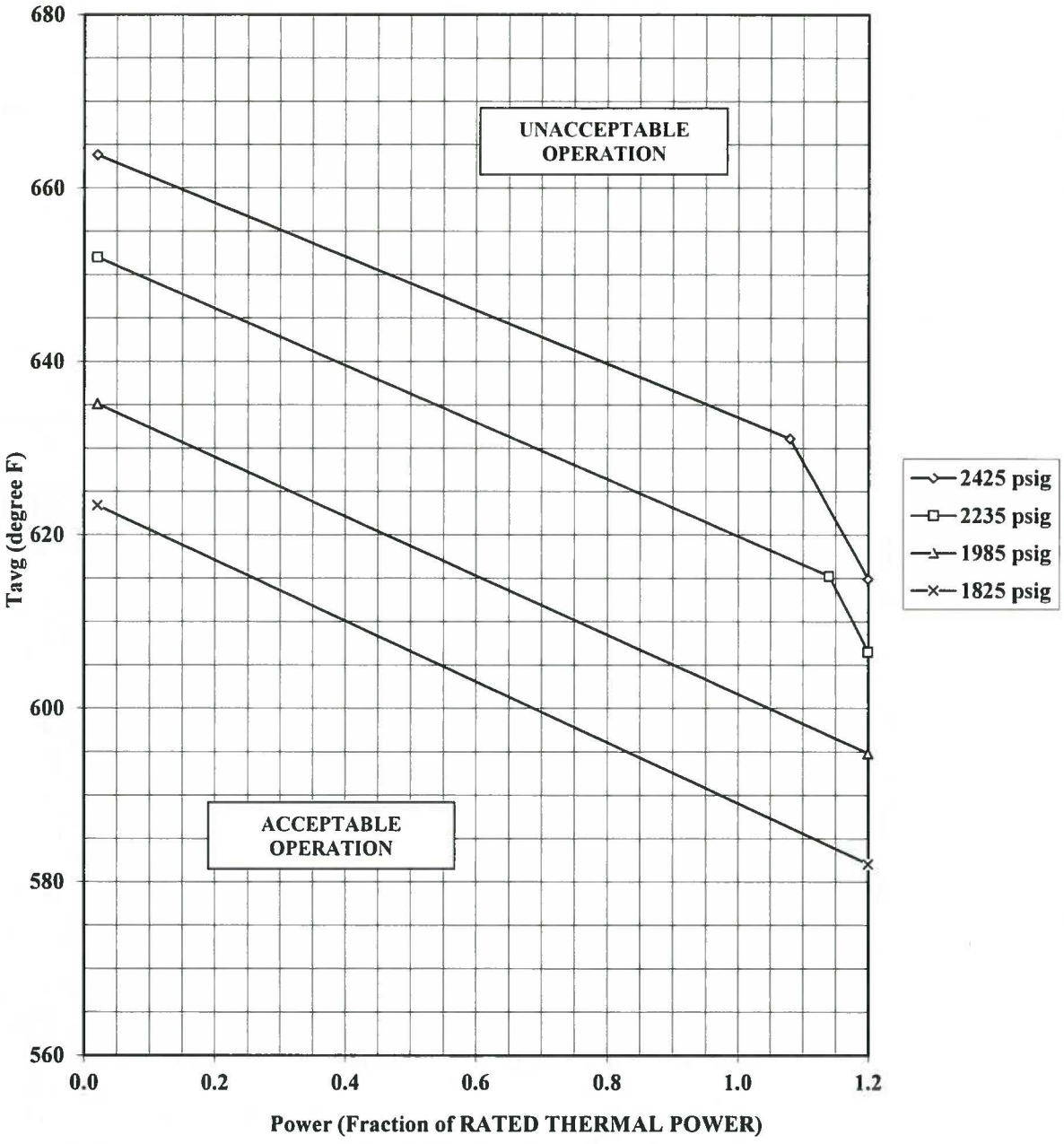
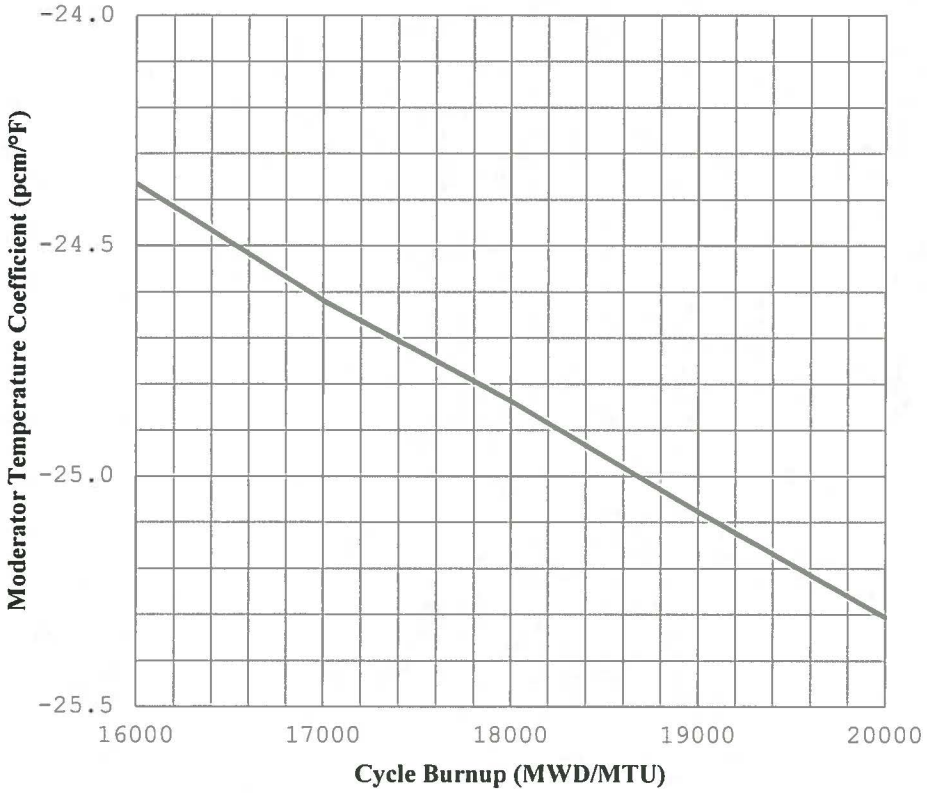


Figure 5
PREDICTED HFP 300 PPM MTC VS CYCLE BURNUP



Cycle Burnup (MWD/MTU)	Moderator Temperature Coefficient (pcm/°F)
16000	-24.37
17000	-24.62
18000	-24.84
19000	-25.08
20000	-25.31