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U. S. Nuclear Regulatory Commission
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Joseph M. Farley Nuclear Plant – Unit 1
Cycle 28 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 1 Cycle 28 Version 1.

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

Respectfully submitted,

C. R. Pierce

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Regulatory Affairs Director

CRP/RMJ

Enclosure: Core Operating Limits Report for FNP Unit 1 Cycle 28 Version 1

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Joseph M. Farley Nuclear Plant – Unit 1
Cycle 28 Core Operating Limits Report

Enclosure

Core Operating Limits Report for FNP Unit 1 Cycle 28 Version 1

SOUTHERN COMPANY

Energy to Serve Your World®

Joseph M. Farley Nuclear Plant

Core Operating Limits Report

Unit 1 - Cycle 28

Version 1

June 2016

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for FNP UNIT 1 CYCLE 28 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 $F_Q(Z) \leq \frac{F_Q^{RTP}}{P} * K(Z)$ for P > 0.5

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

$F_Q(Z) \leq \frac{F_Q^{RTP} * K(Z)}{0.5 * W(Z)}$ 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
30	1.0510
150	1.0510
354	1.0478
559	1.0438
763	1.0387
967	1.0336
1172	1.0299
1376	1.0242
1581	1.0200
6894	1.0200
7099	1.0233
7303	1.0256
7507	1.0268
7712	1.0262
7916	1.0256
8120	1.0249
8325	1.0242
8529	1.0225
8734	1.0204
8938	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	1.1146	1.1174	1.2319	1.2307	1.2073	1.2290
	7	10.80	1.1121	1.1244	1.2278	1.2291	1.2045	1.2265
	8	10.60	1.1084	1.1366	1.2214	1.2236	1.2002	1.2214
	9	10.40	1.1042	1.1445	1.2142	1.2223	1.1978	1.2155
	10	10.20	1.1095	1.1438	1.2062	1.2205	1.1980	1.2101
	11	10.00	1.1215	1.1384	1.1973	1.2203	1.2014	1.2047
	12	9.80	1.1279	1.1314	1.1880	1.2221	1.2041	1.1989
	13	9.60	1.1346	1.1274	1.1804	1.2244	1.2090	1.1925
	14	9.40	1.1329	1.1188	1.1727	1.2207	1.2081	1.1884
	15	9.20	1.1269	1.1203	1.1726	1.2254	1.2174	1.1935
	16	9.00	1.1291	1.1256	1.1698	1.2272	1.2233	1.1959
	17	8.80	1.1276	1.1299	1.1657	1.2243	1.2244	1.1947
	18	8.60	1.1306	1.1353	1.1681	1.2261	1.2248	1.1904
	19	8.40	1.1444	1.1455	1.1777	1.2365	1.2309	1.1959
	20	8.20	1.1552	1.1547	1.1842	1.2434	1.2459	1.2159
	21	8.00	1.1645	1.1620	1.1887	1.2479	1.2571	1.2319
	22	7.80	1.1718	1.1676	1.1915	1.2501	1.2658	1.2454
	23	7.60	1.1763	1.1706	1.1919	1.2497	1.2717	1.2562
	24	7.40	1.1793	1.1724	1.1911	1.2479	1.2761	1.2655
	25	7.20	1.1802	1.1718	1.1876	1.2422	1.2762	1.2704
	26	7.00	1.1795	1.1697	1.1834	1.2353	1.2740	1.2722
	27	6.80	1.1774	1.1663	1.1784	1.2276	1.2708	1.2734
	28	6.60	1.1733	1.1614	1.1718	1.2181	1.2655	1.2726
	29	6.40	1.1685	1.1555	1.1642	1.2071	1.2579	1.2696
	30	6.20	1.1630	1.1490	1.1558	1.1948	1.2483	1.2643
	31	6.00	1.1563	1.1415	1.1465	1.1815	1.2371	1.2573
	32	5.80	1.1486	1.1331	1.1367	1.1675	1.2245	1.2490
	33	5.60	1.1405	1.1257	1.1260	1.1526	1.2101	1.2386
	34	5.40	1.1389	1.1328	1.1164	1.1419	1.1926	1.2249
	35	5.20	1.1497	1.1420	1.1219	1.1415	1.1861	1.2217
	36	5.00	1.1584	1.1510	1.1274	1.1406	1.1858	1.2208
	37	4.80	1.1677	1.1613	1.1328	1.1409	1.1835	1.2182
	38	4.60	1.1782	1.1713	1.1377	1.1408	1.1801	1.2139
	39	4.40	1.1879	1.1806	1.1421	1.1399	1.1753	1.2078
	40	4.20	1.1966	1.1889	1.1462	1.1382	1.1694	1.2002
	41	4.00	1.2044	1.1964	1.1515	1.1358	1.1625	1.1913
	42	3.80	1.2117	1.2033	1.1567	1.1317	1.1534	1.1795
	43	3.60	1.2214	1.2084	1.1606	1.1280	1.1435	1.1655
	44	3.40	1.2321	1.2180	1.1649	1.1266	1.1373	1.1507
	45	3.20	1.2402	1.2286	1.1687	1.1249	1.1307	1.1373
	46	3.00	1.2541	1.2461	1.1734	1.1251	1.1332	1.1265
	47	2.80	1.2758	1.2756	1.1782	1.1351	1.1441	1.1300
	48	2.60	1.2984	1.3074	1.1961	1.1479	1.1555	1.1377
	49	2.40	1.3200	1.3384	1.2179	1.1604	1.1670	1.1494
	50	2.20	1.3416	1.3698	1.2394	1.1732	1.1787	1.1629
	51	2.00	1.3644	1.4008	1.2604	1.1851	1.1891	1.1746
	52	1.80	1.3915	1.4312	1.2811	1.1967	1.1992	1.1857
	53	1.60	1.4172	1.4597	1.3007	1.2082	1.2095	1.1973
	54	1.40	1.4412	1.4862	1.3193	1.2195	1.2200	1.2093
	55	1.20	1.4633	1.5106	1.3365	1.2303	1.2304	1.2212
	56	1.00	1.4831	1.5323	1.3521	1.2406	1.2407	1.2332
*	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.**

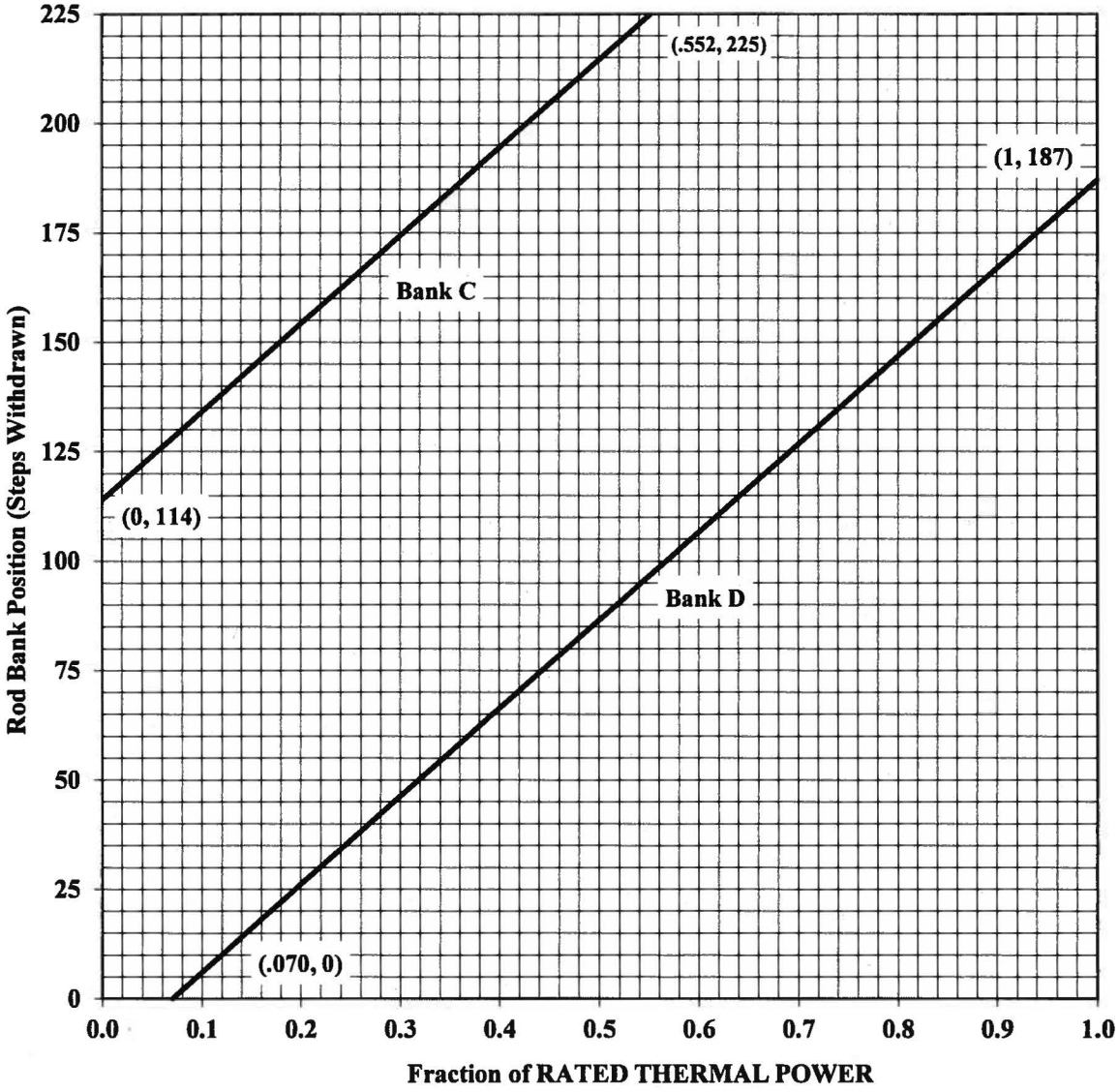
Table 5
Part Power (48%) RAOC W(Z)

	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	1.2144
	7	10.80	1.2010
	8	10.60	1.1847
	9	10.40	1.1664
	10	10.20	1.1552
	11	10.00	1.1513
	12	9.80	1.1395
	13	9.60	1.1289
	14	9.40	1.1123
	15	9.20	1.0931
	16	9.00	1.0821
	17	8.80	1.0688
	18	8.60	1.0618
	19	8.40	1.0653
	20	8.20	1.0741
	21	8.00	1.0721
	22	7.80	1.0755
	23	7.60	1.0774
	24	7.40	1.0832
	25	7.20	1.0817
	26	7.00	1.0772
	27	6.80	1.0753
	28	6.60	1.0775
	29	6.40	1.0794
	30	6.20	1.0701
	31	6.00	1.0679
	32	5.80	1.0677
	33	5.60	1.0699
	34	5.40	1.0676
	35	5.20	1.0813
	36	5.00	1.0952
	37	4.80	1.1099
	38	4.60	1.1259
	39	4.40	1.1410
	40	4.20	1.1552
	41	4.00	1.1689
	42	3.80	1.1829
	43	3.60	1.1990
	44	3.40	1.2168
	45	3.20	1.2321
	46	3.00	1.2528
	47	2.80	1.2816
	48	2.60	1.3111
	49	2.40	1.3397
	50	2.20	1.3678
	51	2.00	1.3992
	52	1.80	1.4348
	53	1.60	1.4687
	54	1.40	1.5028
	55	1.20	1.5376
	56	1.00	1.5685
*	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

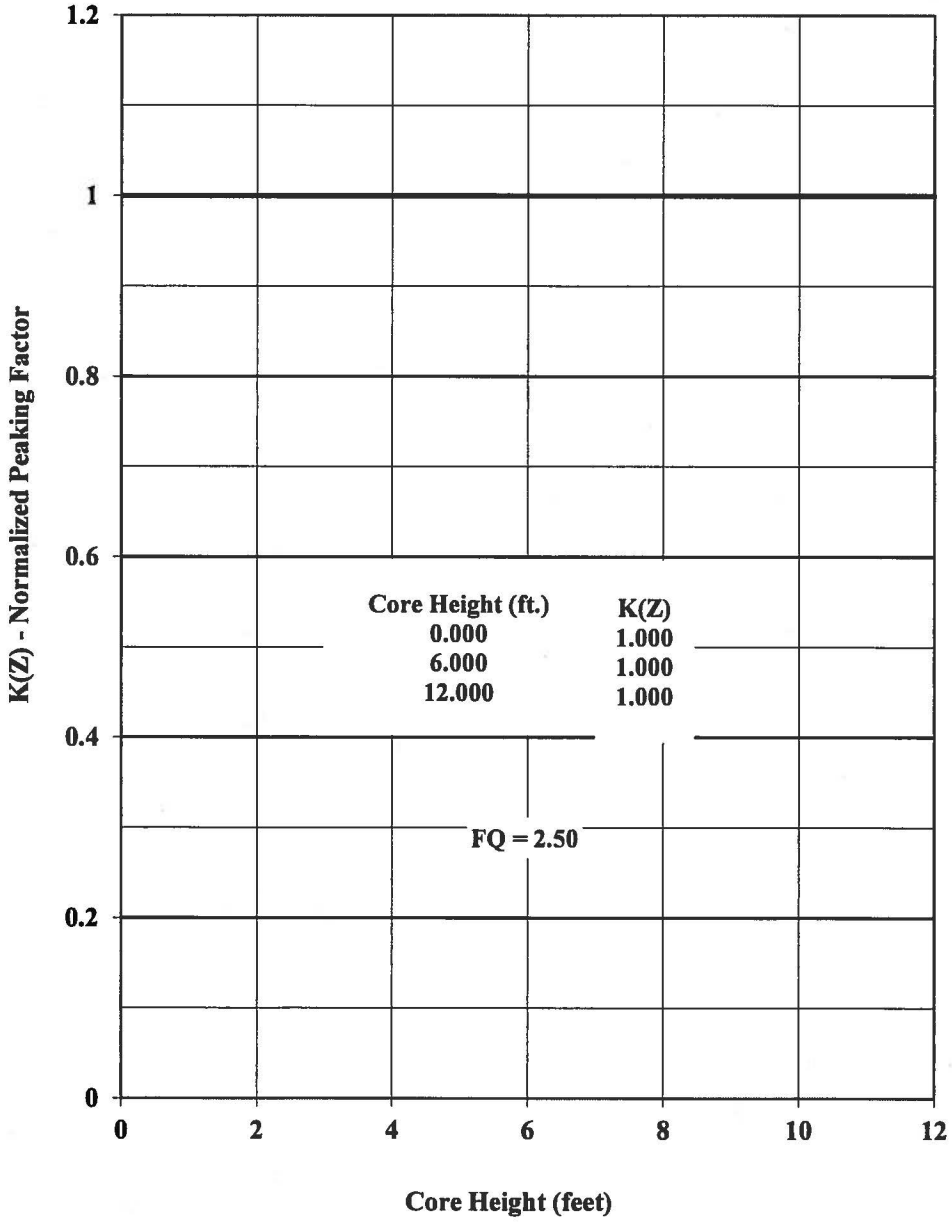


Figure 3
Axial Flux Difference Limits as a Function of
Rated Thermal Power for RAOC

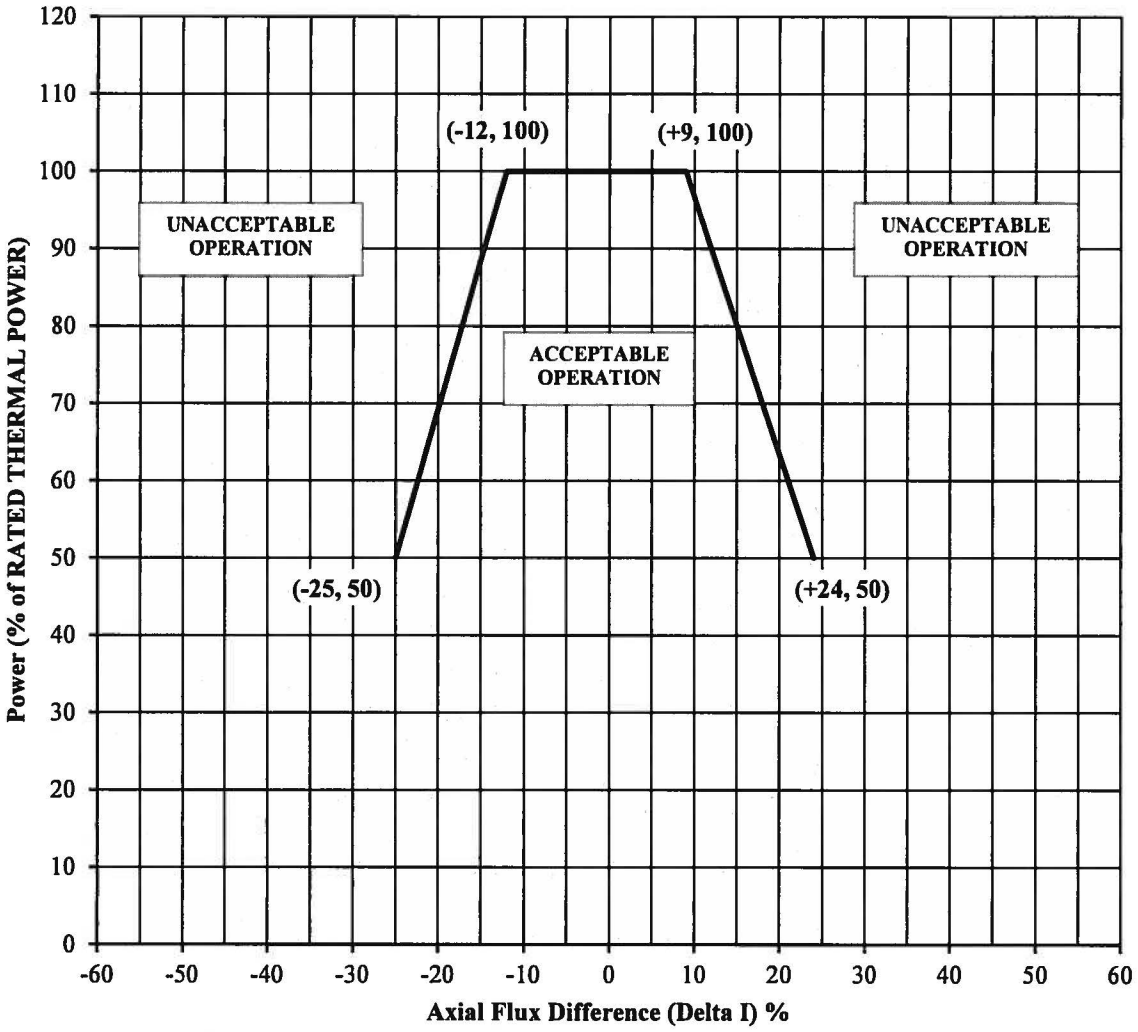


Figure 4
Reactor Core Safety Limits

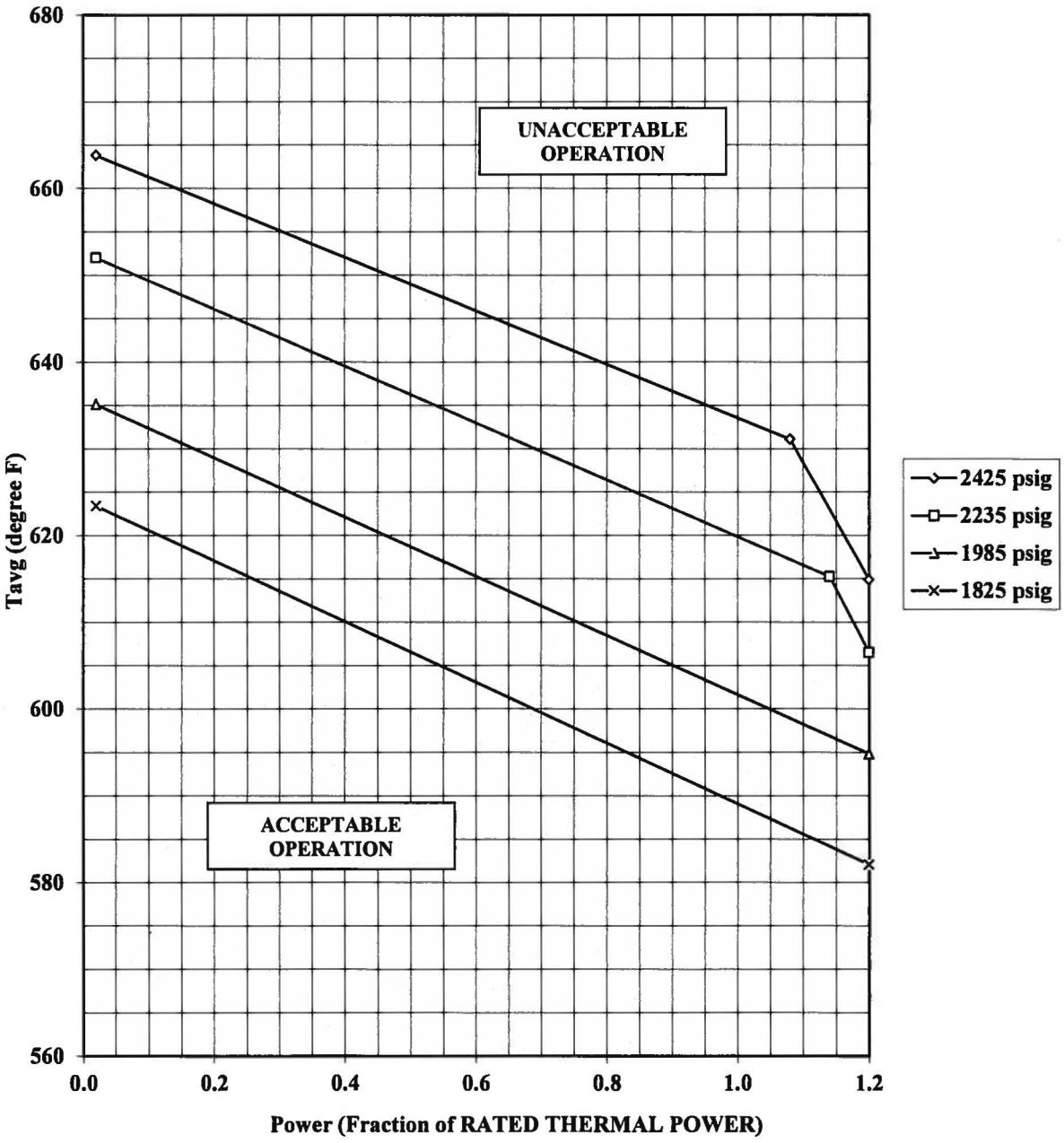
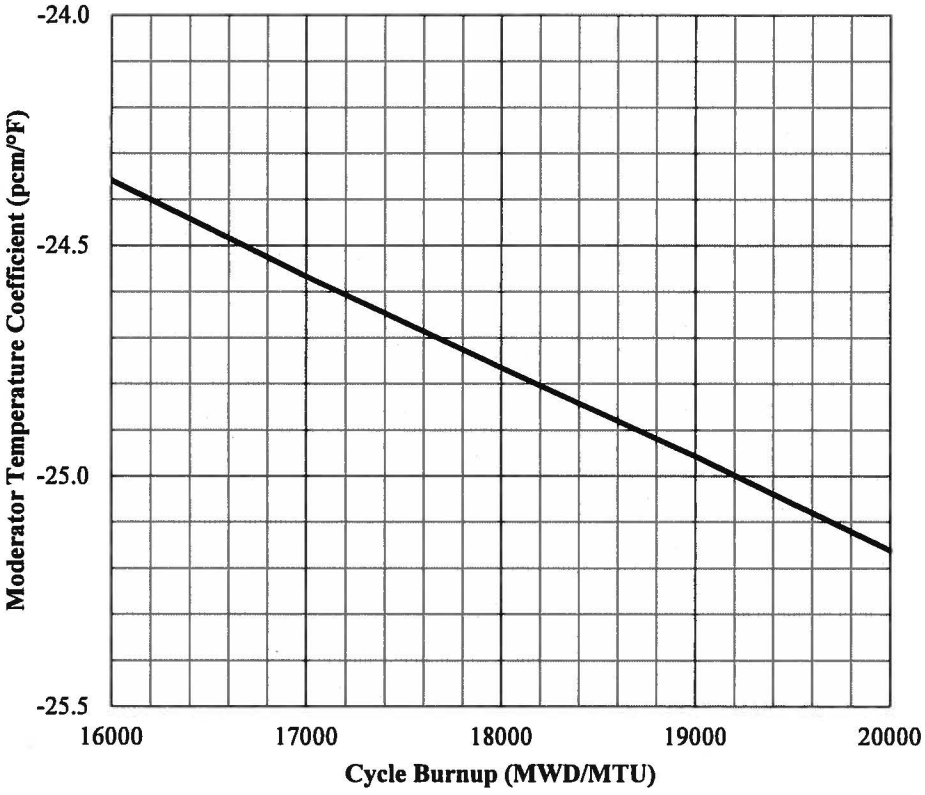


Figure 5
PREDICTED HFP 300 PPM MTC VS CYCLE BURNUP



Cycle Burnup (MWD/MTU)	Moderator Temperature Coefficient (pcm/°F)
16000	-24.36
17000	-24.57
18000	-24.77
19000	-24.96
20000	-25.16