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February 11, 2016

L-16-048

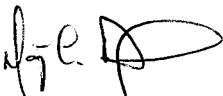
ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001**SUBJECT:**Beaver Valley Power Station, Unit Nos. 1 and 2
Docket No. 50-334, License No. DPR-66
Docket No. 50-412, License No. NPF-73
Core Operating Limits Reports Midcycle Revision

Pursuant to the requirements of Beaver Valley Power Station, Unit Nos. 1 (BVPS-1) and 2 (BVPS-2) Technical Specification 5.6.3, "CORE OPERATING LIMITS REPORT (COLR)," FirstEnergy Nuclear Operating Company hereby submits the BVPS-1 COLR for midcycle revision 24-2 and the BVPS-2 COLR for midcycle revision 19-1. Technical Specification 5.6.3.d requires, in part, that the COLR be provided to the Nuclear Regulatory Commission upon issuance for any midcycle revisions or supplements. These midcycle COLR revisions were made effective on January 28, 2016.

The COLRs were revised to apply plant specific uncertainty to the measured values of the nuclear enthalpy rise hot channel factor and heat flux hot channel factor if the number of measured incore detector thimbles is less than 75 percent and at least 50 percent of the total number of thimbles. When the number of measured thimbles is reduced to this range, the minimum required number of measured thimbles per core quadrant was changed to three. The changes are based on a plant-specific incore flux thimble deletion study.

There are no regulatory commitments contained in this submittal. If there are any questions or if additional information is required, please contact Mr. Thomas A. Lentz, Manager – Fleet Licensing, at (330) 315-6810.

Sincerely,,



Marty L. Richey

Beaver Valley Power Station, Unit Nos. 1 and 2
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Enclosures:

- A. Beaver Valley Power Station, Unit No. 1, Core Operating Limits Report, Midcycle Revision 24-2
- B. Beaver Valley Power Station, Unit No. 2, Core Operating Limits Report, Midcycle Revision 19-1

cc: NRC Region I Administrator
NRC Resident Inspector
NRC Project Manager
Director BRP/DEP
Site BRP/DEP Representative

Enclosure A
L-16-048

Beaver Valley Power Station, Unit No. 1
Core Operating Limits Report, Midcycle Revision 24-2
(16 Pages Follow)

5.0 ADMINISTRATIVE CONTROLS

5.1 Core Operating Limits Report

This Core Operating Limits Report provides the cycle specific parameter limits developed in accordance with the NRC approved methodologies specified in Technical Specification Administrative Control 5.6.3.

5.1.1 SL 2.1.1 Reactor Core Safety Limits

See Figure 5.1-1.

5.1.2 SHUTDOWN MARGIN (SDM)

- a. In MODES 1, 2, 3, and 4, SHUTDOWN MARGIN shall be $\geq 1.77\% \Delta k/k$.⁽¹⁾
- b. Prior to manually blocking the Low Pressurizer Pressure Safety Injection Signal, the Reactor Coolant System shall be borated to \geq the MODE 5 boron concentration and shall remain \geq this boron concentration at all times when this signal is blocked.
- c. In MODE 5, SHUTDOWN MARGIN shall be $\geq 1.0\% \Delta k/k$.

5.1.3 LCO 3.1.3 Moderator Temperature Coefficient (MTC)

- a. Upper Limit - MTC shall be maintained within the acceptable operation limit specified in Technical Specification Figure 3.1.3-1.
- b. Lower Limit - MTC shall be maintained less negative than $-4.4 \times 10^{-4} \Delta k/k/^\circ F$ at RATED THERMAL POWER.
- c. 300 ppm Surveillance Limit: $(-37 \text{ pcm}/^\circ F)$
- d. The revised predicted near-EOL 300 ppm MTC shall be calculated using Figure 5.1-5 and the following algorithm from Reference 11 :

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

where,

* Predicted MTC is calculated from Figure 5.1-5 at the burnup corresponding to the measurement of 300 ppm at RTP conditions,

** AFD Correction is the more negative value of :

$\{0 \text{ pcm}/^\circ F \text{ or } (\Delta AFD * AFD \text{ Sensitivity})\}$

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.

and

$AFD \text{ Sensitivity} = 0.05 \text{ pcm}/^\circ F / \Delta AFD$

***Predictive Correction is $-3 \text{ pcm}/^\circ F$.

(1) The MODE 1 and MODE 2 with $k_{eff} \geq 1.0$ SDM requirements are included to address SDM requirements (e.g., MODE 1 Required Actions to verify SDM) that are not within the applicability of LCO 3.1.1, SHUTDOWN MARGIN (SDM).

5.1 Core Operating Limits Report

If the revised predicted MTC is less negative than the SR 3.1.3.2 limit (COLR 5.1.3.c) and all of the benchmark data contained in the surveillance procedure are met, then an MTC measurement, in accordance with SR 3.1.3.2, is not required.

- e. 60 ppm Surveillance Limit: (- 43 pcm/°F)

5.1.4 LCO 3.1.5 Shutdown Bank Insertion Limits

The Shutdown Banks shall be withdrawn to at least 225 steps.⁽²⁾

5.1.5 LCO 3.1.6 Control Bank Insertion Limits

- a. Control Banks A and B shall be withdrawn to at least 225 steps.⁽²⁾
- b. Control Banks C and D shall be limited in physical insertion as shown in Figure 5.1-2.⁽²⁾
- c. Sequence Limits - The sequence of withdrawal shall be A, B, C and D bank, in that order.
- d. Overlap Limits⁽²⁾ - Overlap shall be such that step 129 on banks A, B, and C corresponds to step 1 on the following bank. When C bank is fully withdrawn, these limits are verified by confirming D bank is withdrawn at least to a position equal to the all-rods-out position minus 128 steps.

5.1.6 LCO 3.2.1 Heat Flux Hot Channel Factor (F_Q(Z))

The Heat Flux Hot Channel Factor - F_Q(Z) limit is defined by:

$$F_Q(Z) \leq \left[\frac{CFQ}{P} \right] * K(Z) \quad \text{for } P > 0.5$$

$$F_Q(Z) \leq \left[\frac{CFQ}{0.5} \right] * K(Z) \quad \text{for } P \leq 0.5$$

Where: CFQ = 2.40 $P = \frac{\text{THERMAL POWER}}{\text{RATED THERMAL POWER}}$

K(Z) = the function obtained from Figure 5.1-3.

$$F_Q^C(Z) = F_Q^M(Z) * 1.0815^\$$$

$$F_Q^W(Z) = F_Q^C(Z) * W(Z)$$

(2) As indicated by the group demand counter

§ An additional uncertainty is to be applied if the number of measured thimbles for the moveable incore detector system is less than 75% of the total number of thimbles. If there are less than 75% of the total number of thimbles and at least 50% of the total number of thimbles measured, an additional uncertainty of (0.01)^(3-T/12.5) is added to the measurement uncertainty, 1.05, where T is the total number of measured thimbles. This adjusted measurement uncertainty is then multiplied by 1.03 to obtain the total uncertainty to be applied. At least three measured thimbles per core quadrant are also required.

5.1 Core Operating Limits Report

The W(Z) values are provided in Table 5.1-1 and 5.1-2. The W(Z) values in Table 5.1-1 were generated assuming that they will be used for full power surveillance. The W(Z) values in Table 5.1-2 were generated assuming that they will be used for a part power surveillance during initial cycle startup following the refueling outage. When a part power surveillance is performed, the W(Z) values should be multiplied by the factor 1/P, when P > 0.5. When P is ≤ 0.5, the W(Z) values should be multiplied by the factor 1/(0.5), or 2.0. This is consistent with the adjustment in the F_Q(Z) limit at part power conditions.

The F_Q(Z) penalty function, applied when the analytic F_Q(Z) function increases from one monthly measurement to the next, is provided in Table 5.1-3.

5.1.7 LCO 3.2.2 Nuclear Enthalpy Rise Hot Channel Factor (F_{ΔH}^N)

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

Where: CF_{ΔH} = 1.62

PF_{ΔH} = 0.3

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

5.1.8 LCO 3.2.3 Axial Flux Difference (AFD)

The AFD acceptable operation limits are provided in Figure 5.1-4.

5.1.9 LCO 3.3.1 Reactor Trip System Instrumentation - Overtemperature and Overpower ΔT Parameter Values from Table Notations 1 and 2

a. Overtemperature ΔT Setpoint Parameter Values:

<u>Parameter</u>	<u>Value</u>
Overtemperature ΔT reactor trip setpoint	K1 ≤ 1.242
Overtemperature ΔT reactor trip setpoint Tavg coefficient	K2 ≥ 0.0183/°F
Overtemperature ΔT reactor trip setpoint pressure coefficient	K3 ≥ 0.001/psia
Tavg at RATED THERMAL POWER	T' ≤ 577.9°F ⁽¹⁾

§ An additional uncertainty is to be applied if the number of measured thimbles for the moveable incore detector system is less than 75% of the total number of thimbles. If there are less than 75% of the total number of thimbles and at least 50% of the total number of thimbles measured, an additional uncertainty of (0.01)*(3-T/12.5) is added to the standard uncertainty on FNΔH of 1.04, where T is the total number of measured thimbles. At least three measured thimbles per core quadrant are also required.

(1) T' represents the cycle-specific Full Power Tavg value used in core design.

5.1 Core Operating Limits Report

Nominal pressurizer pressure	$P' \geq 2250$ psia
Measured reactor vessel average temperature lead/lag time constants	$\tau_1 \geq 30$ secs $\tau_2 \leq 4$ secs
Measured reactor vessel ΔT lag time constant	$\tau_4 \leq 6$ secs
Measured reactor vessel average temperature lag time constant	$\tau_5 \leq 2$ secs

$f(\Delta I)$ is a function of the indicated difference between top and bottom detectors of the power-range nuclear ion chambers; with gains to be selected based on measured instrument response during plant startup tests such that:

- (i) For $q_t - q_b$ between -37% and +15%, $f(\Delta I) = 0$ (where q_t and q_b are percent RATED THERMAL POWER in the top and bottom halves of the core respectively, and $q_t + q_b$ is total THERMAL POWER in percent of RATED THERMAL POWER).
- (ii) For each percent that the magnitude of $(q_t - q_b)$ exceeds -37%, the ΔT trip setpoint shall be automatically reduced by 2.52% of its value at RATED THERMAL POWER.
- (iii) For each percent that the magnitude of $(q_t - q_b)$ exceeds +15%, the ΔT trip setpoint shall be automatically reduced by 1.47% of its value at RATED THERMAL POWER.

b. Overpower ΔT Setpoint Parameter Values:

<u>Parameter</u>	<u>Value</u>
Overpower ΔT reactor trip setpoint	$K4 \leq 1.085$
Overpower ΔT reactor trip setpoint Tavg rate/lag coefficient	$K5 \geq 0.02/^\circ F$ for increasing average temperature $K5 = 0/^\circ F$ for decreasing average temperature
Overpower ΔT reactor trip setpoint Tavg heatup coefficient	$K6 \geq 0.0021/^\circ F$ for $T > T''$ $K6 = 0/^\circ F$ for $T \leq T''$
Tavg at RATED THERMAL POWER	$T'' \leq 577.9^\circ F^{(2)}$
Measured reactor vessel average temperature rate/lag time constant	$\tau_3 \geq 10$ secs
Measured reactor vessel ΔT lag time constant	$\tau_4 \leq 6$ secs
Measured reactor vessel average temperature lag time constant	$\tau_5 \leq 2$ secs

(2) T'' represents the cycle-specific Full Power Tavg value used in core design.

5.1 Core Operating Limits Report

5.1.10 LCO 3.4.1, RCS Pressure, Temperature, and Flow Departure from Nucleate Boiling (DNB) Limits

<u>Parameter</u>	<u>Indicated Value</u>
Reactor Coolant System T _{avg}	T _{avg} ≤ 581.5°F ⁽¹⁾
Pressurizer Pressure	Pressure ≥ 2218 psia ⁽²⁾
Reactor Coolant System Total Flow Rate	Flow ≥ 267,300 gpm ⁽³⁾

5.1.11 LCO 3.9.1 Boron Concentration (MODE 6)

The boron concentration of the Reactor Coolant System, the refueling canal, and the refueling cavity shall be maintained ≥ 2400 ppm. This value includes a 50 ppm conservative allowance for uncertainties.

-
- (1) The Reactor Coolant System (RCS) indicated T_{avg} value is determined by adding the appropriate allowances for rod control operation and verification via control board indication (3.6°F) to the cycle specific full power T_{avg} used in the core design.
 - (2) The pressurizer pressure value includes allowances for pressurizer pressure control operation and verification via control board indication.
 - (3) The RCS total flow rate includes allowances for normalization of the cold leg elbow taps with a beginning of cycle precision RCS flow calorimetric measurement and verification on a periodic basis via control board indication.

5.1 Core Operating Limits Report

5.1.12 References

1. WCAP-9272-P-A, "WESTINGHOUSE RELOAD SAFETY EVALUATION METHODOLOGY," July 1985 (Westinghouse Proprietary).
2. WCAP-8745-P-A, "Design Bases for the Thermal Overpower ΔT and Thermal Overtemperature ΔT Trip Functions," September 1986.
3. WCAP-12945-P-A, Volume 1 (Revision 2) and Volumes 2 through 5 (Revision 1), "Code Qualification Document for Best Estimate LOCA Analysis," March 1998 (Westinghouse Proprietary).
4. WCAP-10216-P-A, Revision 1A, "Relaxation of Constant Axial Offset Control- F_Q Surveillance Technical Specification," February 1994.
5. WCAP-14565-P-A, "VIPRE-01 Modeling and Qualification for Pressurized Water Reactor Non-LOCA Thermal-Hydraulic Safety Analysis," October 1999.
6. WCAP-12610-P-A, "VANTAGE+ Fuel Assembly Reference Core Report," April 1995 (Westinghouse Proprietary).
7. WCAP-15025-P-A, "Modified WRB-2 Correlation, WRB-2M, for Predicting Critical Heat Flux in 17x17 Rod Bundles with Modified LPD Mixing Vane Grids," April 1999.
8. Caldon, Inc. Engineering Report-80P, "Improving Thermal Power Accuracy and Plant Safety While Increasing Operating Power Level Using the LEFM \sqrt{TM} System," Revision 0, March 1997.
9. Caldon, Inc. Engineering Report-160P, "Supplement to Topical Report ER-80P: Basis for a Power Uprate With the LEFM \sqrt{TM} System," Revision 0, May 2000.
10. WCAP-16009-P-A, "Realistic Large Break LOCA Evaluation Methodology Using Automated Statistical Treatment of Uncertainty Method (ASTRUM)," Revision 0, January 2005.
11. WCAP-13749-P-A, "Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement," March 1997 (Westinghouse Proprietary).
12. WCAP-16045-P-A, "Qualification of the Two-Dimensional Transport Code PARAGON," August 2004.
13. WCAP-16045-P-A, Addendum 1-A, "Qualification of the NEXUS Nuclear Data Methodology," August 2007.

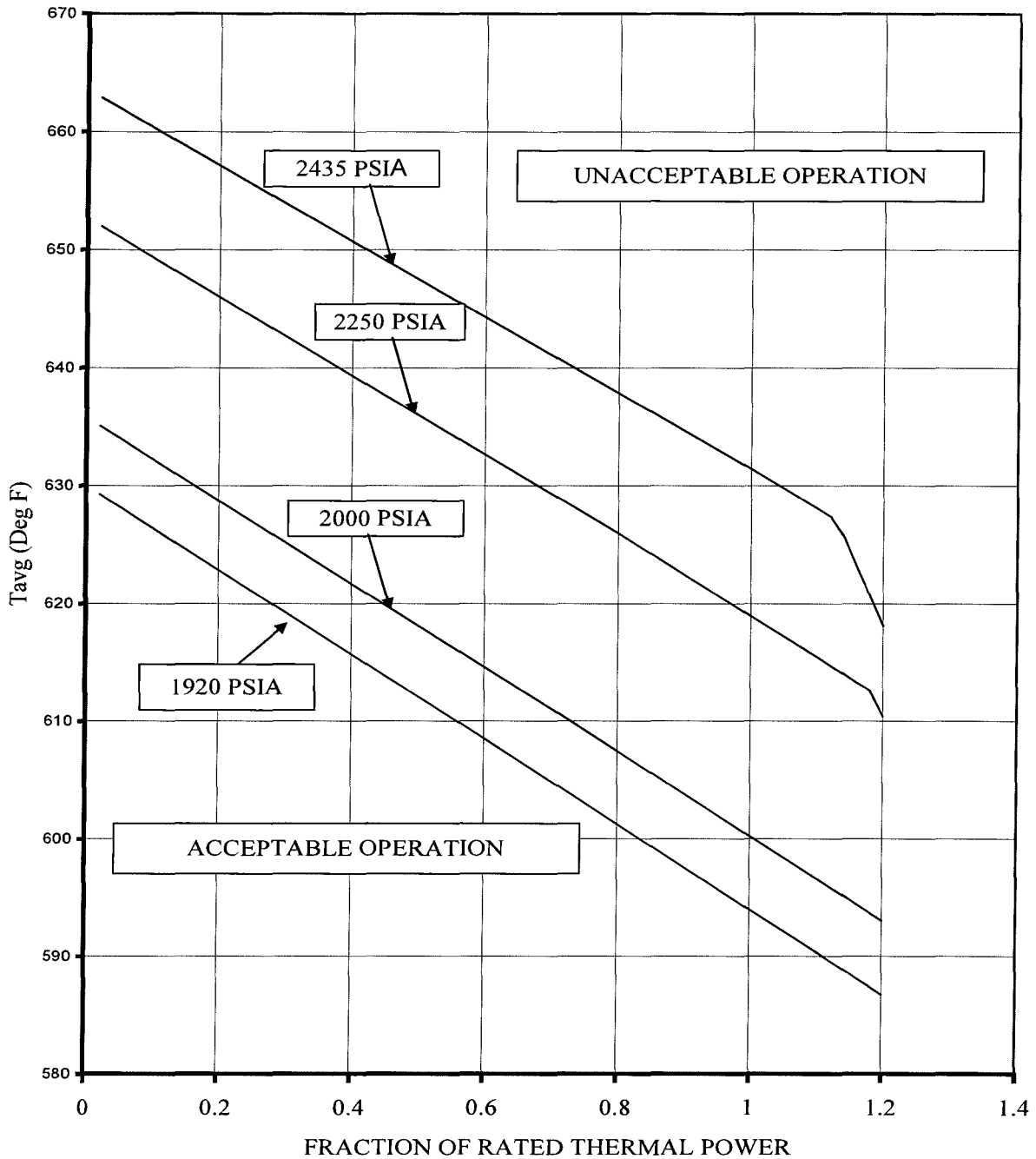


Figure 5.1-1 (Page 1 of 1)

REACTOR CORE SAFETY LIMIT
THREE LOOP OPERATION
(Technical Specification Safety Limit 2.1.1)

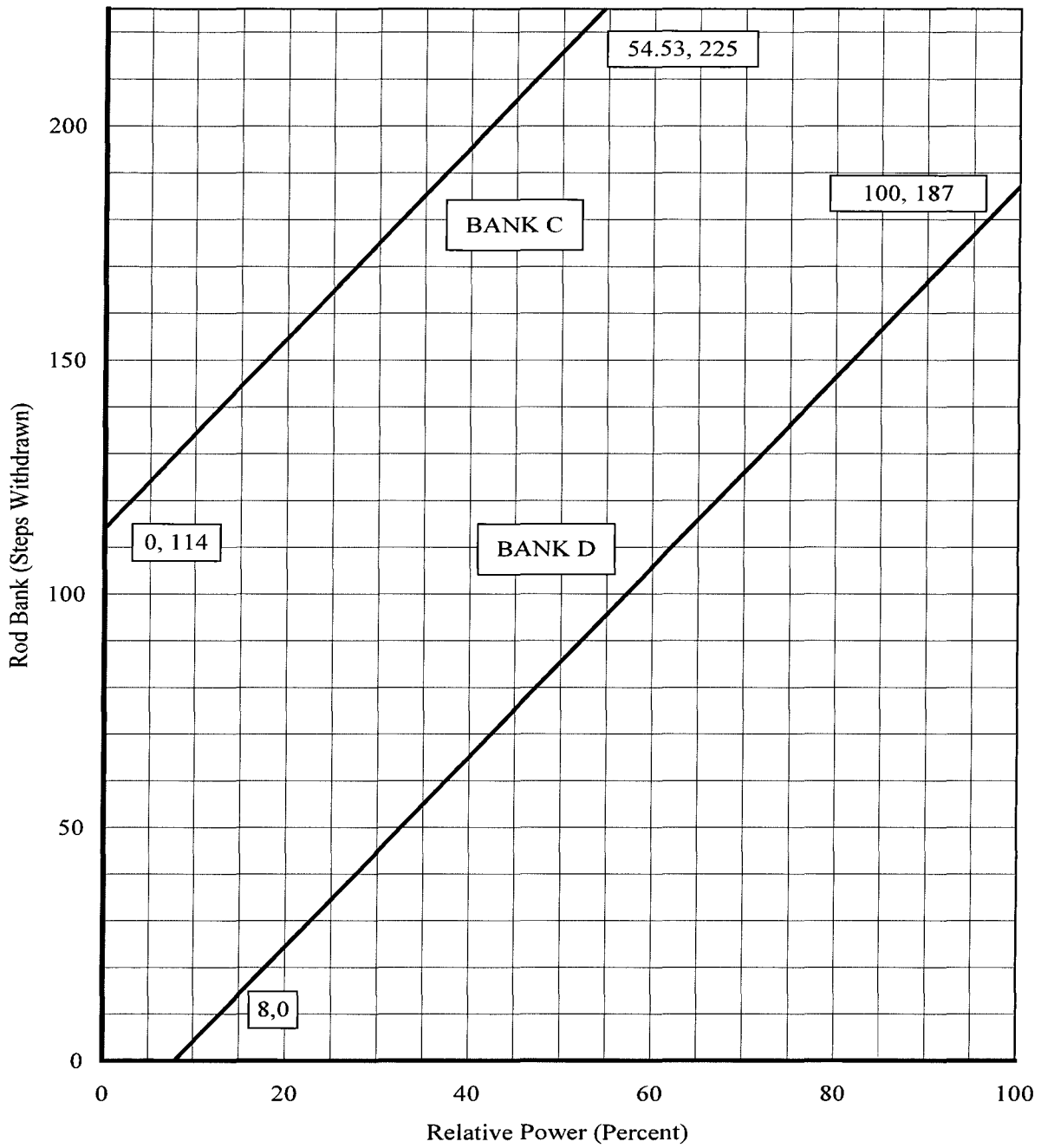


Figure 5.1-2 (Page 1 of 1)
CONTROL ROD INSERTION LIMITS

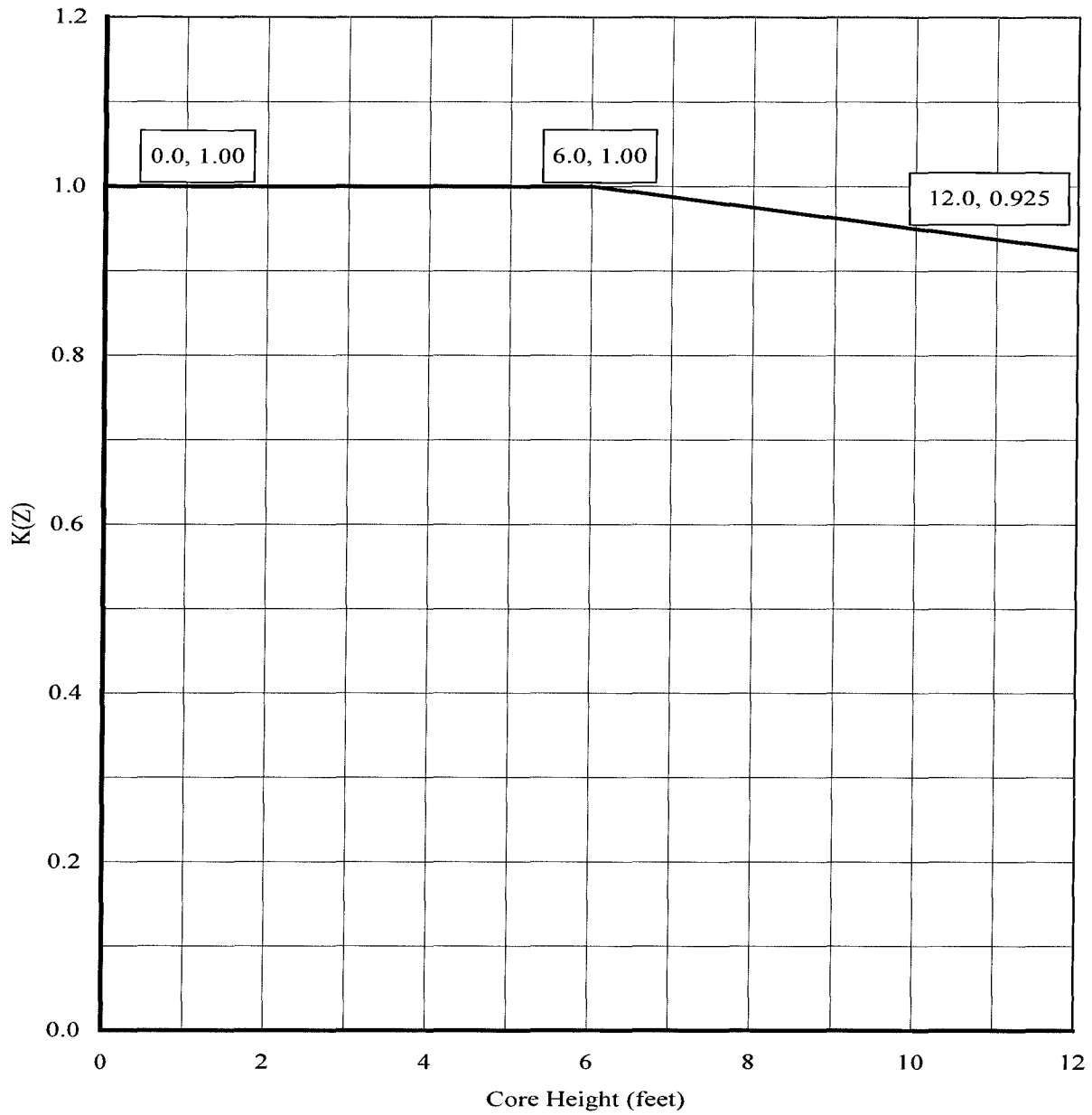


Figure 5.1-3 (Page 1 of 1)

F₀T NORMALIZED OPERATING ENVELOPE, K(Z)

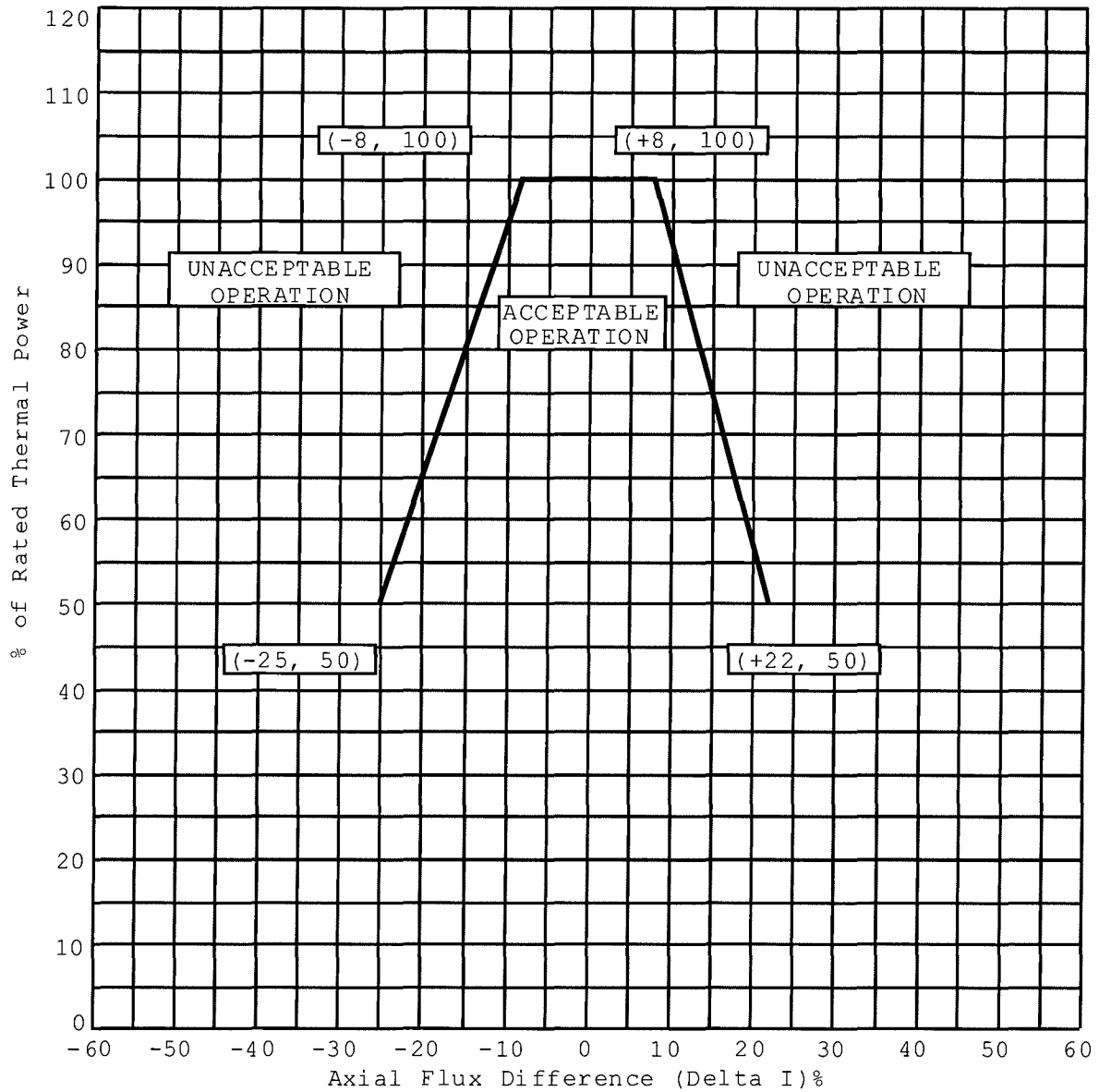


Figure 5.1-4 (Page 1 of 1)

AXIAL FLUX DIFFERENCE LIMITS AS A FUNCTION OF
PERCENT OF RATED THERMAL POWER FOR RAOC

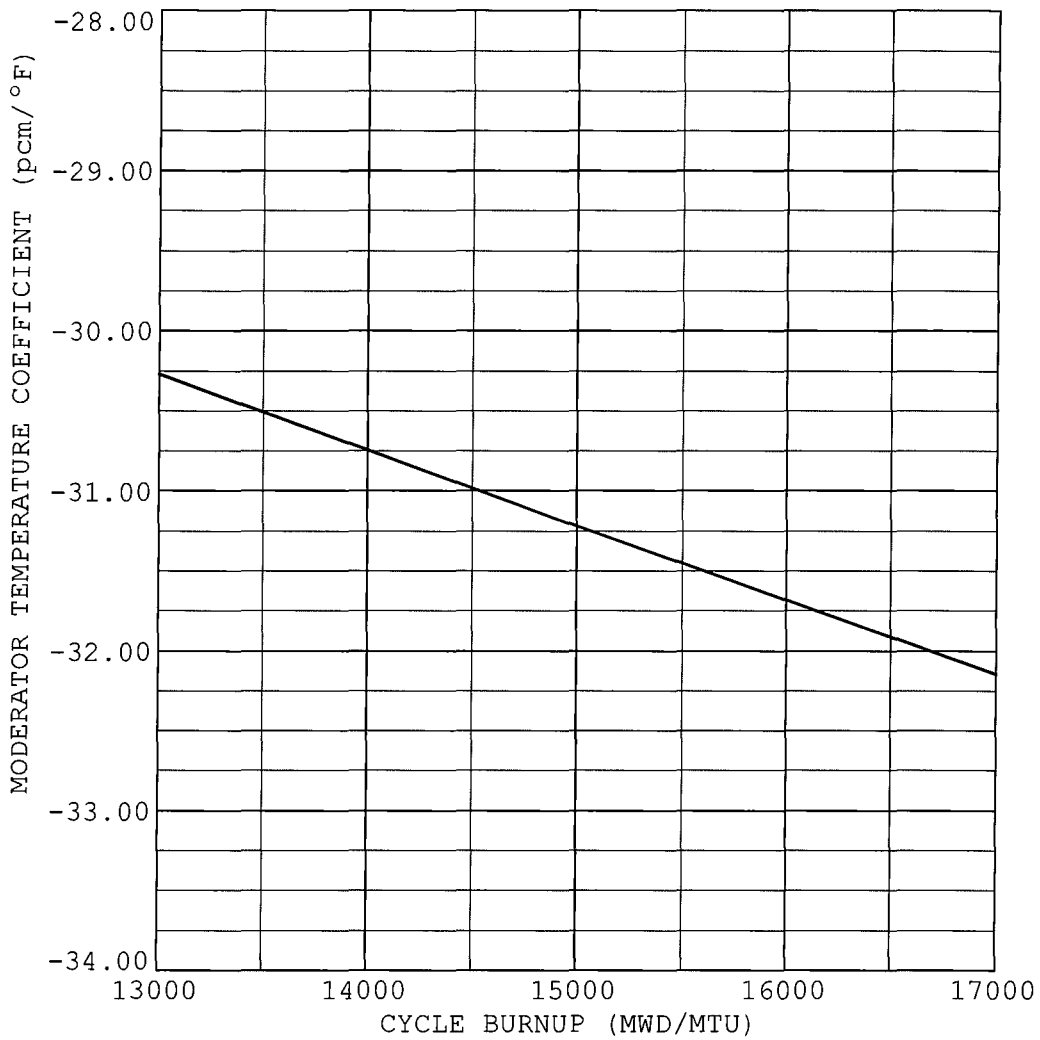


Figure 5.1-5 (Page 1 of 1)
HOT FULL POWER PREDICTED
MODERATOR TEMPERATURE COEFFICIENT
AS A FUNCTION OF CYCLE BURNUP
WHEN 300 PPM IS ACHIEVED

Table 5.1-1 (Page 1 of 2)
F_Q Surveillance W(Z) Function versus Burnup at 100% RTP

Exclusion Zone	Axial Point	Elevation (feet)	150 MWD/MTU	3000 MWD/MTU	10000 MWD/MTU	18000 MWD/MTU
*	1	12.08	1.0000	1.0000	1.0000	1.0000
*	2	11.88	1.0000	1.0000	1.0000	1.0000
*	3	11.68	1.0000	1.0000	1.0000	1.0000
*	4	11.47	1.0000	1.0000	1.0000	1.0000
*	5	11.27	1.0000	1.0000	1.0000	1.0000
*	6	11.07	1.0000	1.0000	1.0000	1.0000
*	7	10.87	1.0000	1.0000	1.0000	1.0000
	8	10.67	1.1358	1.1361	1.2445	1.2326
	9	10.47	1.1294	1.1320	1.2372	1.2152
	10	10.27	1.1223	1.1291	1.2289	1.1939
	11	10.07	1.1151	1.1248	1.2199	1.1758
	12	9.86	1.1058	1.1197	1.2095	1.1743
	13	9.66	1.1023	1.1138	1.2008	1.1775
	14	9.46	1.1055	1.1092	1.1950	1.1804
	15	9.26	1.1061	1.1084	1.1897	1.1817
	16	9.06	1.1071	1.1084	1.1881	1.1862
	17	8.86	1.1154	1.1157	1.1930	1.1898
	18	8.66	1.1271	1.1267	1.2046	1.1954
	19	8.46	1.1356	1.1347	1.2137	1.2067
	20	8.25	1.1427	1.1413	1.2207	1.2184
	21	8.05	1.1481	1.1462	1.2253	1.2276
	22	7.85	1.1518	1.1494	1.2275	1.2341
	23	7.65	1.1538	1.1508	1.2273	1.2379
	24	7.45	1.1542	1.1506	1.2248	1.2392
	25	7.25	1.1534	1.1493	1.2201	1.2382
	26	7.05	1.1523	1.1476	1.2145	1.2350
	27	6.84	1.1505	1.1453	1.2080	1.2306
	28	6.64	1.1475	1.1417	1.2003	1.2254
	29	6.44	1.1436	1.1372	1.1910	1.2187
	30	6.24	1.1386	1.1316	1.1801	1.2101
	31	6.04	1.1324	1.1251	1.1681	1.1998
	32	5.84	1.1265	1.1176	1.1544	1.1879

Note: Top and Bottom 10% Excluded

Table 5.1-1 (Page 2 of 2)
F_Q Surveillance W(Z) Function versus Burnup at 100% RTP

Exclusion Zone	Axial Point	Elevation (feet)	150 MWD/MTU	3000 MWD/MTU	10000 MWD/MTU	18000 MWD/MTU
	33	5.64	1.1230	1.1120	1.1402	1.1742
	34	5.44	1.1229	1.1122	1.1285	1.1599
	35	5.23	1.1255	1.1154	1.1185	1.1522
	36	5.03	1.1309	1.1192	1.1119	1.1473
	37	4.83	1.1370	1.1222	1.1073	1.1414
	38	4.63	1.1422	1.1247	1.1021	1.1345
	39	4.43	1.1469	1.1268	1.0978	1.1267
	40	4.23	1.1511	1.1285	1.0934	1.1180
	41	4.03	1.1547	1.1298	1.0878	1.1088
	42	3.83	1.1577	1.1309	1.0840	1.0989
	43	3.62	1.1604	1.1317	1.0840	1.0887
	44	3.42	1.1629	1.1327	1.0844	1.0810
	45	3.22	1.1633	1.1376	1.0843	1.0738
	46	3.02	1.1693	1.1532	1.0851	1.0750
	47	2.82	1.1856	1.1788	1.0900	1.0870
	48	2.62	1.2048	1.2044	1.0989	1.0977
	49	2.42	1.2240	1.2304	1.1137	1.1088
	50	2.21	1.2450	1.2568	1.1302	1.1205
	51	2.01	1.2672	1.2827	1.1459	1.1331
	52	1.81	1.2886	1.3080	1.1616	1.1470
	53	1.61	1.3090	1.3322	1.1767	1.1603
	54	1.41	1.3278	1.3543	1.1907	1.1730
*	55	1.21	1.0000	1.0000	1.0000	1.0000
*	56	1.01	1.0000	1.0000	1.0000	1.0000
*	57	0.81	1.0000	1.0000	1.0000	1.0000
*	58	0.60	1.0000	1.0000	1.0000	1.0000
*	59	0.40	1.0000	1.0000	1.0000	1.0000
*	60	0.20	1.0000	1.0000	1.0000	1.0000
*	61	0.00	1.0000	1.0000	1.0000	1.0000

Note: Top and Bottom 10% Excluded

Table 5.1-2 (Page 1 of 2)
 F_Q Surveillance W(Z) Function versus Burnup at 75% RTP

Exclusion Zone	Axial Point	Elevation (feet)	75% RTP
*	1	12.08	1.0000
*	2	11.88	1.0000
*	3	11.68	1.0000
*	4	11.47	1.0000
*	5	11.27	1.0000
*	6	11.07	1.0000
*	7	10.87	1.0000
	8	10.67	1.2023
	9	10.47	1.1828
	10	10.27	1.1630
	11	10.07	1.1437
	12	9.86	1.1213
	13	9.66	1.1052
	14	9.46	1.0972
	15	9.26	1.0876
	16	9.06	1.0792
	17	8.86	1.0792
	18	8.66	1.0834
	19	8.46	1.0861
	20	8.25	1.0885
	21	8.05	1.0897
	22	7.85	1.0899
	23	7.65	1.0903
	24	7.45	1.0904
	25	7.25	1.0899
	26	7.05	1.0895
	27	6.84	1.0891
	28	6.64	1.0877
	29	6.44	1.0855
	30	6.24	1.0826
	31	6.04	1.0786
	32	5.84	1.0750

Note: Top and Bottom 10% Excluded

Table 5.1-2 (Page 2 of 2)
F_Q Surveillance W(Z) Function versus Burnup at 75% RTP

Exclusion Zone	Axial Point	Elevation (feet)	75% RTP
	33	5.64	1.0736
	34	5.44	1.0753
	35	5.23	1.0799
	36	5.03	1.0875
	37	4.83	1.0963
	38	4.63	1.1045
	39	4.43	1.1123
	40	4.23	1.1197
	41	4.03	1.1268
	42	3.83	1.1332
	43	3.62	1.1399
	44	3.42	1.1465
	45	3.22	1.1509
	46	3.02	1.1607
	47	2.82	1.1806
	48	2.62	1.2028
	49	2.42	1.2251
	50	2.21	1.2495
	51	2.01	1.2754
	52	1.81	1.3008
	53	1.61	1.3253
	54	1.41	1.3482
*	55	1.21	1.0000
*	56	1.01	1.0000
*	57	0.81	1.0000
*	58	0.60	1.0000
*	59	0.40	1.0000
*	60	0.20	1.0000
*	61	0.00	1.0000

Note: Top and Bottom 10% Excluded

Table 5.1-3 (Page 1 of 1)
 $F_Q(Z)$ Penalty Factor versus Burnup

Cycle Burnup (MWD/MTU)	$F_Q(Z)$ Penalty Factor
> 0	1.0200

Note: The Penalty Factor, to be applied to $F_Q(Z)$ in accordance with Technical Specification Surveillance Requirement (SR) 3.2.1.2, is the maximum factor by which $F_Q(Z)$ is expected to increase over a 39 Effective Full Power Day (EFPD) interval (surveillance interval of 31 EFPD plus the maximum allowable extension not to exceed 25% of the surveillance interval per Technical Specification SR 3.0.2) starting from the burnup at which the $F_Q(Z)$ was determined.

Enclosure B
L-16-048

Beaver Valley Power Station, Unit No. 2
Core Operating Limits Report, Midcycle Revision 19-1
(16 Pages Follow)

5.0 ADMINISTRATIVE CONTROLS

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This Core Operating Limits Report provides the cycle specific parameter limits developed in accordance with the NRC approved methodologies specified in Technical Specification Administrative Control 5.6.3.

5.1.1 SL 2.1.1 Reactor Core Safety Limits

See Figure 5.1-1.

5.1.2 SHUTDOWN MARGIN (SDM)

- a. In MODES 1, 2, 3, and 4, SHUTDOWN MARGIN shall be $\geq 1.77\% \Delta k/k$.⁽¹⁾
- b. Prior to manually blocking the Low Pressurizer Pressure Safety Injection Signal, the Reactor Coolant System shall be borated to \geq the MODE 5 boron concentration and shall remain \geq this boron concentration at all times when this signal is blocked.
- c. In MODE 5, SHUTDOWN MARGIN shall be $\geq 1.0\% \Delta k/k$.

5.1.3 LCO 3.1.3 Moderator Temperature Coefficient (MTC)

- a. Upper Limit - MTC shall be maintained within the acceptable operation limit specified in Technical Specification Figure 3.1.3-1.
- b. Lower Limit - MTC shall be maintained less negative than $-4.29 \times 10^{-4} \Delta k/k/^\circ F$ at RATED THERMAL POWER.
- c. 300 ppm Surveillance Limit: $(-35 \text{ pcm}/^\circ F)$
- d. The revised predicted near-EOL 300 ppm MTC shall be calculated using Figure 5.1-5 and the following algorithm from Reference 10 :

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

where,

* Predicted MTC is calculated from Figure 5.1-5 at the burnup corresponding to the measurement of 300 ppm at RTP conditions,

** AFD Correction is the more negative value of :

$\{0 \text{ pcm}/^\circ F \text{ or } (\Delta AFD * AFD \text{ Sensitivity})\}$

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.

and

$AFD \text{ Sensitivity} = 0.05 \text{ pcm}/^\circ F / \Delta AFD$

***Predictive Correction is $-3 \text{ pcm}/^\circ F$.

(1) The MODE 1 and MODE 2 with $k_{eff} \geq 1.0$ SDM requirements are included to address SDM requirements (e.g., MODE 1 Required Actions to verify SDM) that are not within the applicability of LCO 3.1.1, SHUTDOWN MARGIN (SDM).

5.1 Core Operating Limits Report

If the revised predicted MTC is less negative than the SR 3.1.3.2 limit (COLR 5.1.3.c) and all of the benchmark data contained in the surveillance procedure are met, then an MTC measurement in accordance with SR 3.1.3.2 is not required.

- e. 60 ppm Surveillance Limit: (- 41 pcm/°F)

5.1.4 LCO 3.1.5 Shutdown Bank Insertion Limits

The Shutdown Banks shall be withdrawn to at least 225 steps.⁽²⁾

5.1.5 LCO 3.1.6 Control Bank Insertion Limits

- a. Control Banks A and B shall be withdrawn to at least 225 steps.⁽²⁾
- b. Control Banks C and D shall be limited in physical insertion as shown in Figure 5.1-2.⁽²⁾
- c. Sequence Limits - The sequence of withdrawal shall be A, B, C and D bank, in that order.
- d. Overlap Limits⁽²⁾ - Overlap shall be such that step 129 on banks A, B, and C corresponds to step 1 on the following bank. When C bank is fully withdrawn, these limits are verified by confirming D bank is withdrawn at least to a position equal to the all-rods-out position minus 128 steps.

5.1.6 LCO 3.2.1 Heat Flux Hot Channel Factor (F_Q(Z))

The Heat Flux Hot Channel Factor - F_Q(Z) limit is defined by:

$$F_Q(Z) \leq \left[\frac{CFQ}{P} \right] * K(Z) \quad \text{for } P > 0.5$$

$$F_Q(Z) \leq \left[\frac{CFQ}{0.5} \right] * K(Z) \quad \text{for } P \leq 0.5$$

Where: CFQ = 2.40 $P = \frac{\text{THERMAL POWER}}{\text{RATED THERMAL POWER}}$

K(Z) = the function obtained from Figure 5.1-3.

$$F_Q^C(Z) = F_Q^M(Z) * 1.0815^{\$}$$

$$F_Q^W(Z) = F_Q^C(Z) * W(Z)$$

⁽²⁾ As indicated by the group demand counter

^{\\$} An additional uncertainty is to be applied if the number of measured thimbles for the moveable incore detector system is less than 75% of the total number of thimbles. If there are less than 75% of the total number of thimbles and at least 50% of the total number of thimbles measured, an additional uncertainty of (0.01)^(3-T/12.5) is added to the measurement uncertainty, 1.05, where T is the total number of measured thimbles. This adjusted measurement uncertainty is then multiplied by 1.03 to obtain the total uncertainty to be applied. At least three measured thimbles per core quadrant are also required.

5.1 Core Operating Limits Report

The W(Z) values are provided in Tables 5.1-1 and 5.1-2. The W(Z) values in Table 5.1-1 were generated assuming that they will be used for a full power surveillance. The W(Z) values in Table 5.1-2 were generated assuming that they will be used for a part power surveillance during initial cycle startup following the refueling outage. When a part power surveillance is performed, the W(Z) values should be multiplied by the factor 1/P, when P > 0.5. When P is ≤ 0.5, the W(Z) values should be multiplied by the factor 1/(0.5), or 2.0. This is consistent with the adjustment in the F_Q(Z) limit at part power conditions.

The F_Q(Z) penalty function, applied when the analytic F_Q(Z) function increases from one monthly measurement to the next, is provided in Table 5.1-3.

5.1.7 LCO 3.2.2 Nuclear Enthalpy Rise Hot Channel Factor (F_{ΔH}^N)

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

Where: CF_{ΔH} = 1.62

PF_{ΔH} = 0.3

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

5.1.8 LCO 3.2.3 Axial Flux Difference (AFD)

The AFD acceptable operation limits are provided in Figure 5.1-4.

5.1.9 LCO 3.3.1 Reactor Trip System Instrumentation - Overtemperature and Overpower ΔT Parameter Values from Table Notations 3 and 4

a. Overtemperature ΔT Setpoint Parameter Values:

<u>Parameter</u>	<u>Value</u>
Overtemperature ΔT reactor trip setpoint	K1 ≤ 1.239
Overtemperature ΔT reactor trip setpoint Tavg coefficient	K2 ≥ 0.0183/°F
Overtemperature ΔT reactor trip setpoint pressure coefficient	K3 ≥ 0.001/psia
Tavg at RATED THERMAL POWER	T' ≤ 574.2°F ⁽¹⁾

§ An additional uncertainty is to be applied if the number of measured thimbles for the moveable incore detector system is less than 75% of the total number of thimbles. If there are less than 75% of the total number of thimbles and at least 50% of the total number of thimbles measured, an additional uncertainty of (0.01)*(3-T/12.5) is added to the standard uncertainty on FNΔH of 1.04, where T is the total number of measured thimbles. At least three measured thimbles per core quadrant are also required.

(1) T' represents the cycle-specific Full Power Tavg value used in core design.

5.1 Core Operating Limits Report

Nominal pressurizer pressure	$P' \geq 2250$ psia
Measured reactor vessel ΔT lead/lag time constants (* The response time is toggled off to meet the analysis value of zero.)	$\tau_1 = 0$ sec* $\tau_2 = 0$ sec*
Measured reactor vessel ΔT lag time constant	$\tau_3 \leq 6$ secs
Measured reactor vessel average temperature lead/lag time constants	$\tau_4 \geq 30$ secs $\tau_5 \leq 4$ secs
Measured reactor vessel average temperature lag time constant	$\tau_6 \leq 2$ secs

f (ΔI) is a function of the indicated difference between top and bottom detectors of the power-range nuclear ion chambers; with gains to be selected based on measured instrument response during plant startup tests such that:

- (i) For $q_t - q_b$ between -37% and +15%, $f_1(\Delta I) = 0$, where q_t and q_b are percent RATED THERMAL POWER in the top and bottom halves of the core respectively, and $q_t + q_b$ is total THERMAL POWER in percent of RATED THERMAL POWER.
- (ii) For each percent that the magnitude of $(q_t - q_b)$ exceeds -37%, the ΔT trip setpoint shall be automatically reduced by 2.52% of its value at RATED THERMAL POWER.
- (iii) For each percent that the magnitude of $(q_t - q_b)$ exceeds +15%, the ΔT trip setpoint shall be automatically reduced by 1.47% of its value at RATED THERMAL POWER.

b. Overpower ΔT Setpoint Parameter Values:

<u>Parameter</u>	<u>Value</u>
Overpower ΔT reactor trip setpoint	$K4 \leq 1.094$
Overpower ΔT reactor trip setpoint Tavg rate/lag coefficient	$K5 \geq 0.02/^\circ F$ for increasing average temperature $K5 = 0/^\circ F$ for decreasing average temperature
Overpower ΔT reactor trip setpoint Tavg heatup coefficient	$K6 \geq 0.0021/^\circ F$ for $T > T''$ $K6 = 0/^\circ F$ for $T \leq T''$
Tavg at RATED THERMAL POWER	$T'' \leq 574.2^\circ F^{(1)}$
Measured reactor vessel ΔT lead/lag time constants	$\tau_1 = 0$ sec* $\tau_2 = 0$ sec*

(* The response time is toggled off to meet the analysis value of zero.)

(1) T'' represents the cycle-specific Full Power Tavg value used in core design.

5.1 Core Operating Limits Report

Measured reactor vessel ΔT lag time constant	$\tau_3 \leq 6$ secs
Measured reactor vessel average temperature lag time constant	$\tau_6 \leq 2$ secs
Measured reactor vessel average temperature rate/lag time constant	$\tau_7 \geq 10$ secs

5.1.10 LCO 3.4.1, RCS Pressure, Temperature, and Flow Departure from Nucleate Boiling (DNB) Limits

<u>Parameter</u>	<u>Indicated Value</u>
Reactor Coolant System Tavg	Tavg $\leq 577.8^\circ\text{F}^{(1)}$
Pressurizer Pressure	Pressure ≥ 2214 psia ⁽²⁾
Reactor Coolant System Total Flow Rate	Flow $\geq 267,300$ gpm ⁽³⁾

5.1.11 LCO 3.9.1 Boron Concentration (MODE 6)

The boron concentration of the Reactor Coolant System, the refueling canal, and the refueling cavity shall be maintained ≥ 2400 ppm. This value includes a 50 ppm conservative allowance for uncertainties.

-
- (1) The Reactor Coolant System (RCS) indicated Tavg value is determined by adding the appropriate allowances for rod control operation and verification via control board indication (3.6°F) to the cycle specific full power Tavg used in the core design.
 - (2) The pressurizer pressure value includes allowances for pressurizer pressure control operation and verification via control board indication.
 - (3) The RCS total flow rate includes allowances for normalization of the cold leg elbow taps with a beginning of cycle precision RCS flow calorimetric measurement and verification on a periodic basis via control board indication.

5.1 Core Operating Limits Report

5.1.12 References

1. WCAP-9272-P-A, "WESTINGHOUSE RELOAD SAFETY EVALUATION METHODOLOGY," July 1985 (Westinghouse Proprietary).
2. WCAP-8745-P-A, "Design Bases for the Thermal Overpower ΔT and Thermal Overtemperature ΔT Trip Functions," September 1986.
3. WCAP-12945-P-A, Volume 1 (Revision 2) and Volumes 2 through 5 (Revision 1), "Code Qualification Document for Best Estimate LOCA Analysis," March 1998 (Westinghouse Proprietary).
4. WCAP-10216-P-A, Revision 1A, "Relaxation of Constant Axial Offset Control- F_Q Surveillance Technical Specification," February 1994.
5. WCAP-14565-P-A, "VIPRE-01 Modeling and Qualification for Pressurized Water Reactor Non-LOCA Thermal-Hydraulic Safety Analysis," October 1999.
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7. WCAP-15025-P-A, "Modified WRB-2 Correlation, WRB-2M, for Predicting Critical Heat Flux in 17x17 Rod Bundles with Modified LPD Mixing Vane Grids," April 1999.
8. Caldon, Inc. Engineering Report-80P, "Improving Thermal Power Accuracy and Plant Safety While Increasing Operating Power Level Using the LEFM \sqrt{TM} System," Revision 0, March 1997.
9. Caldon, Inc. Engineering Report-160P, "Supplement to Topical Report ER-80P: Basis for a Power Uprate With the LEFM \sqrt{TM} System," Revision 0, May 2000.
10. WCAP-13749-P-A, "Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement," March 1997 (Westinghouse Proprietary).
11. WCAP-16045-P-A, "Qualification of the Two-Dimensional Transport Code PARAGON," August 2004.
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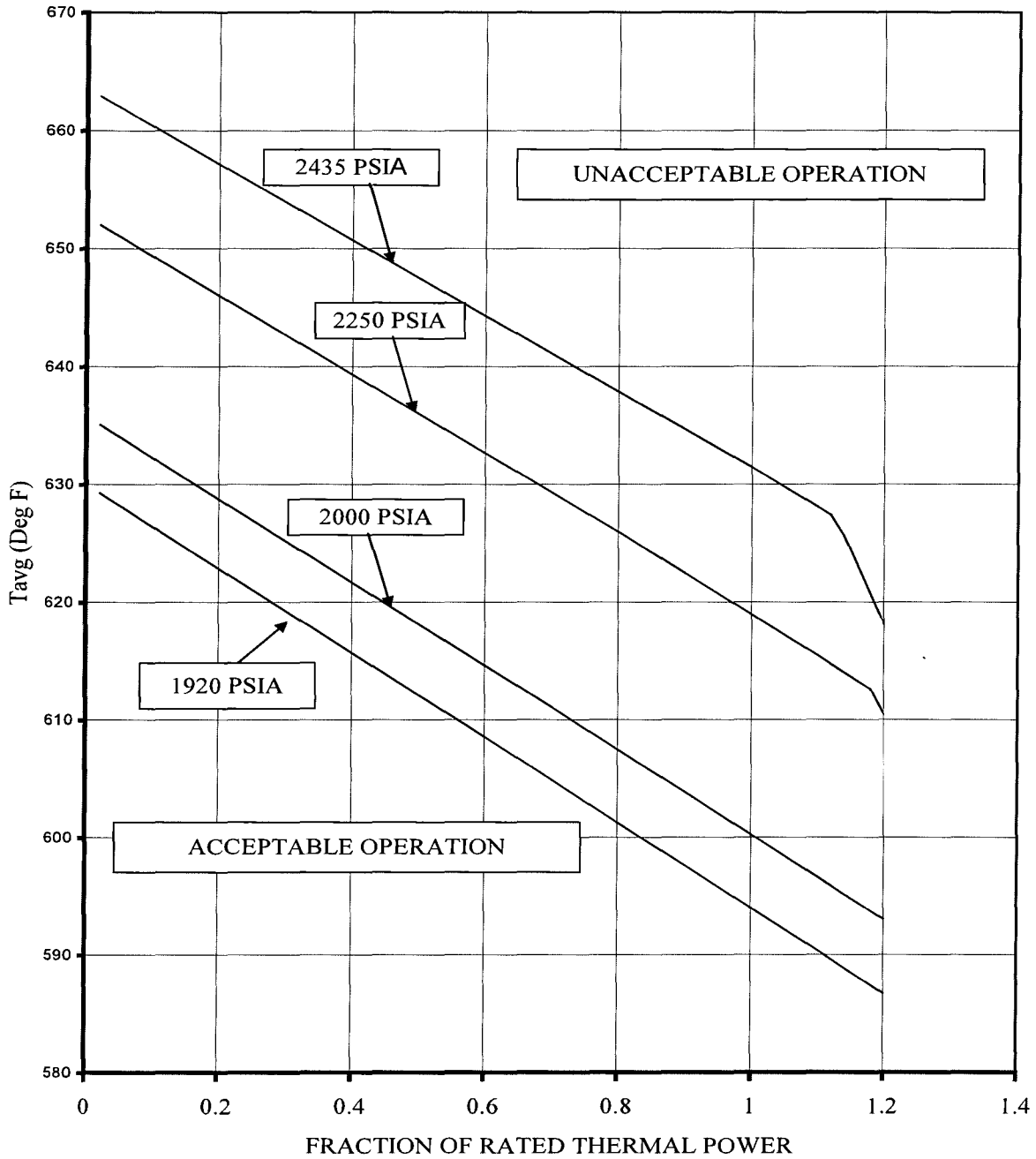


Figure 5.1-1 (Page 1 of 1)

REACTOR CORE SAFETY LIMIT
THREE LOOP OPERATION

(Technical Specification Safety Limit 2.1.1)

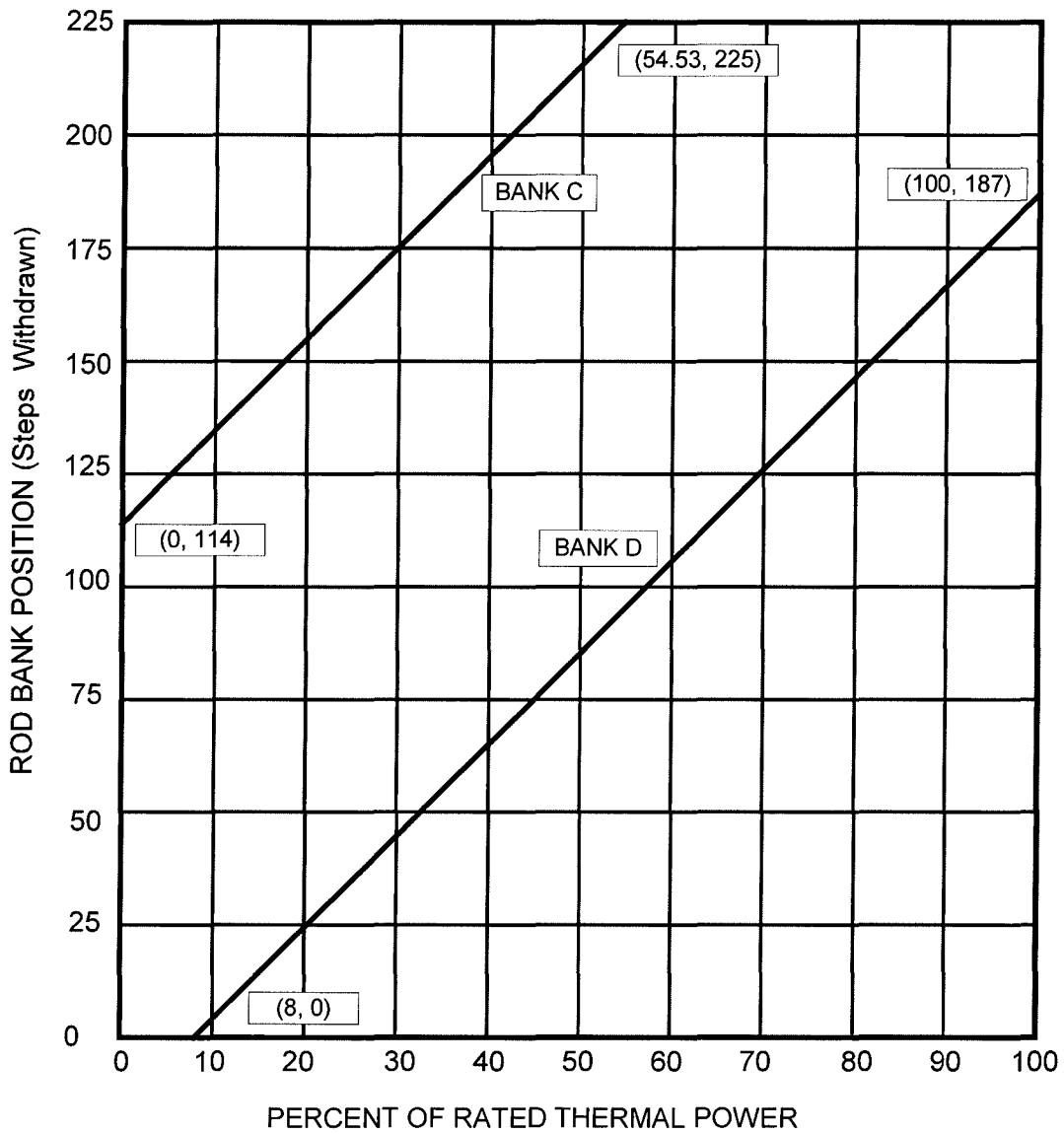


Figure 5.1-2 (Page 1 of 1)
CONTROL ROD INSERTION LIMITS AS A
FUNCTION OF RATED POWER LEVEL

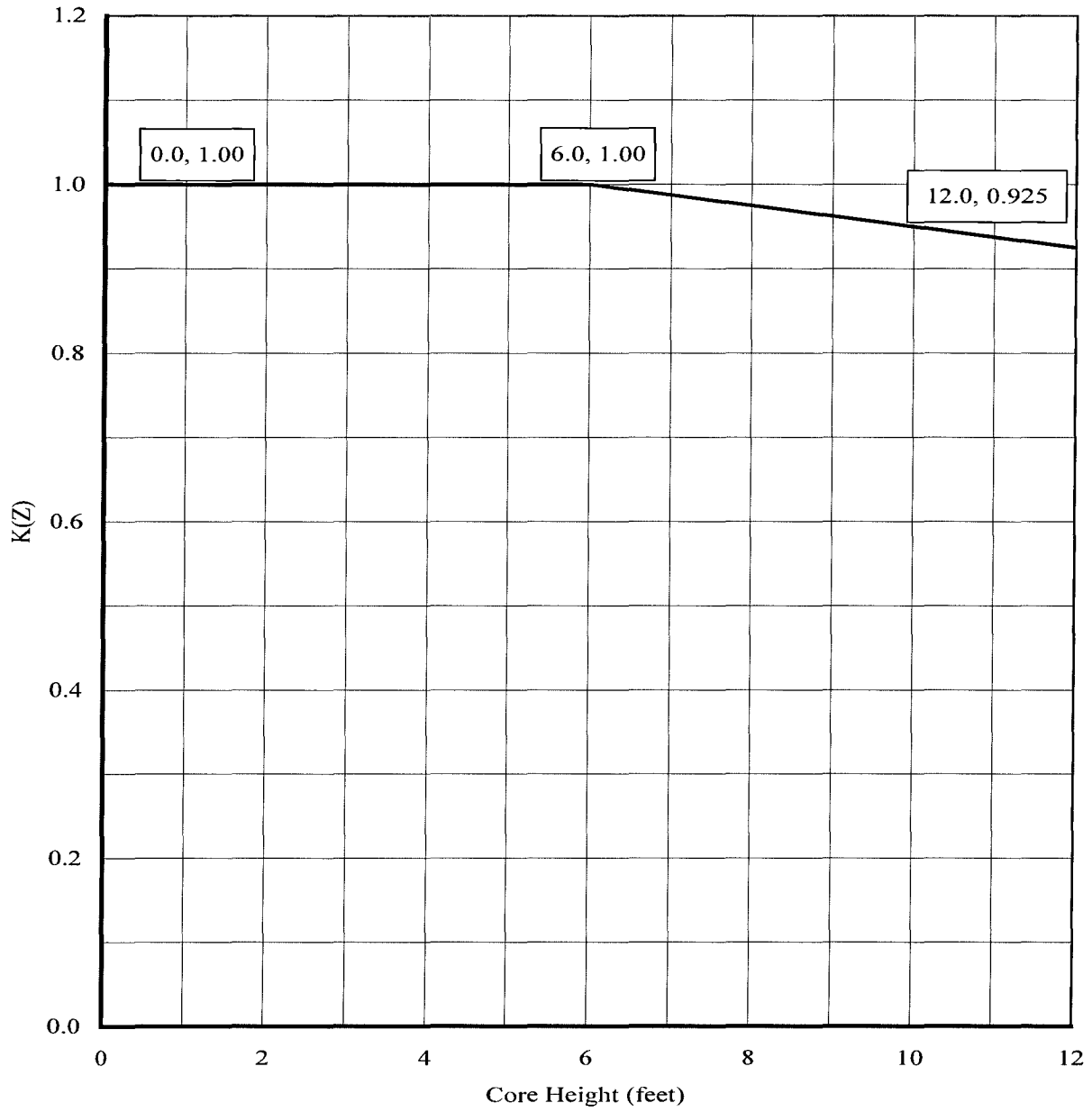


Figure 5.1-3 (Page 1 of 1)

F_{0T} NORMALIZED OPERATING ENVELOPE, K(Z)

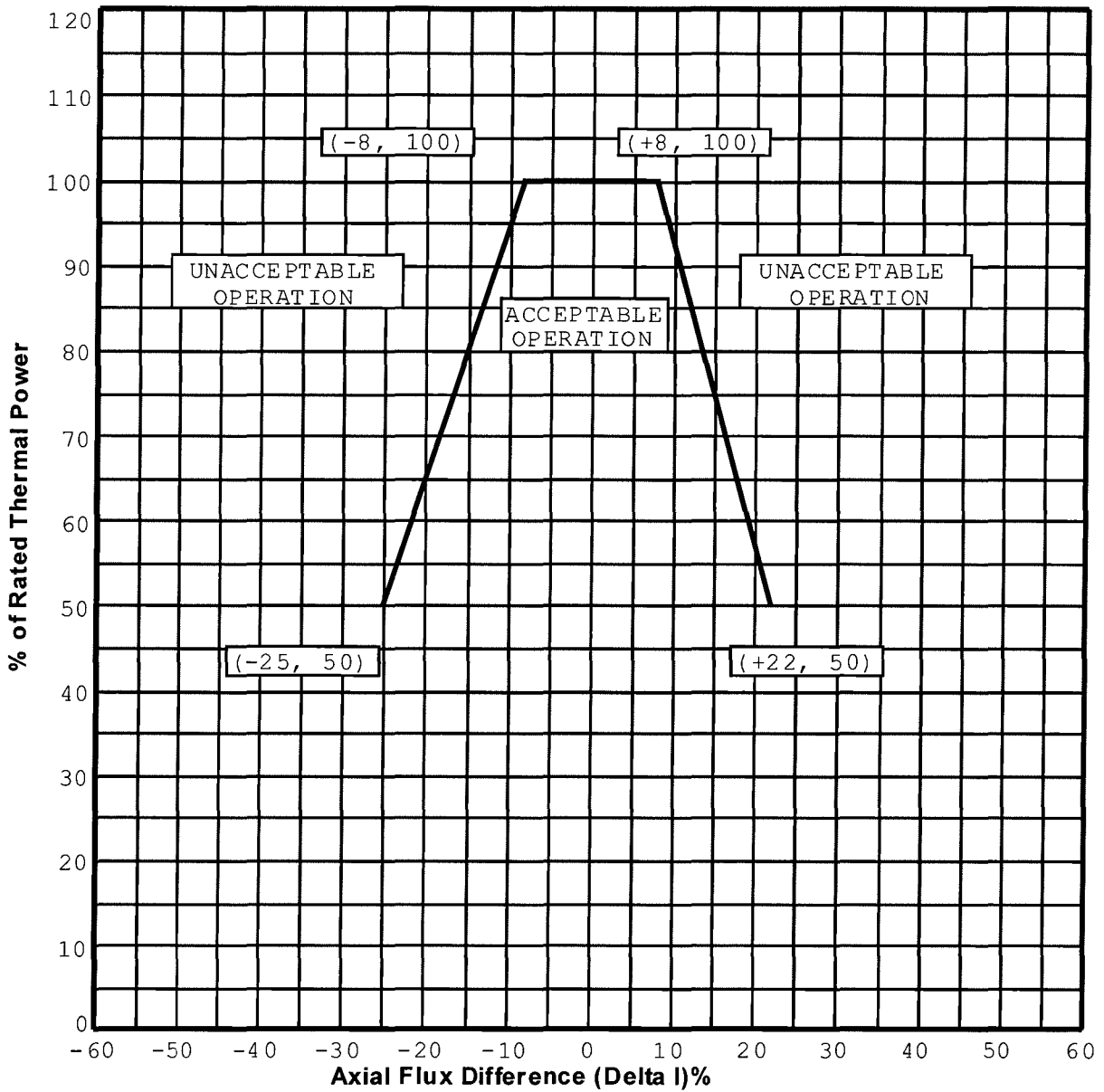


Figure 5.1-4 (Page 1 of 1)

AXIAL FLUX DIFFERENCE LIMITS AS A FUNCTION OF
PERCENT OF RATED THERMAL POWER FOR RAOC

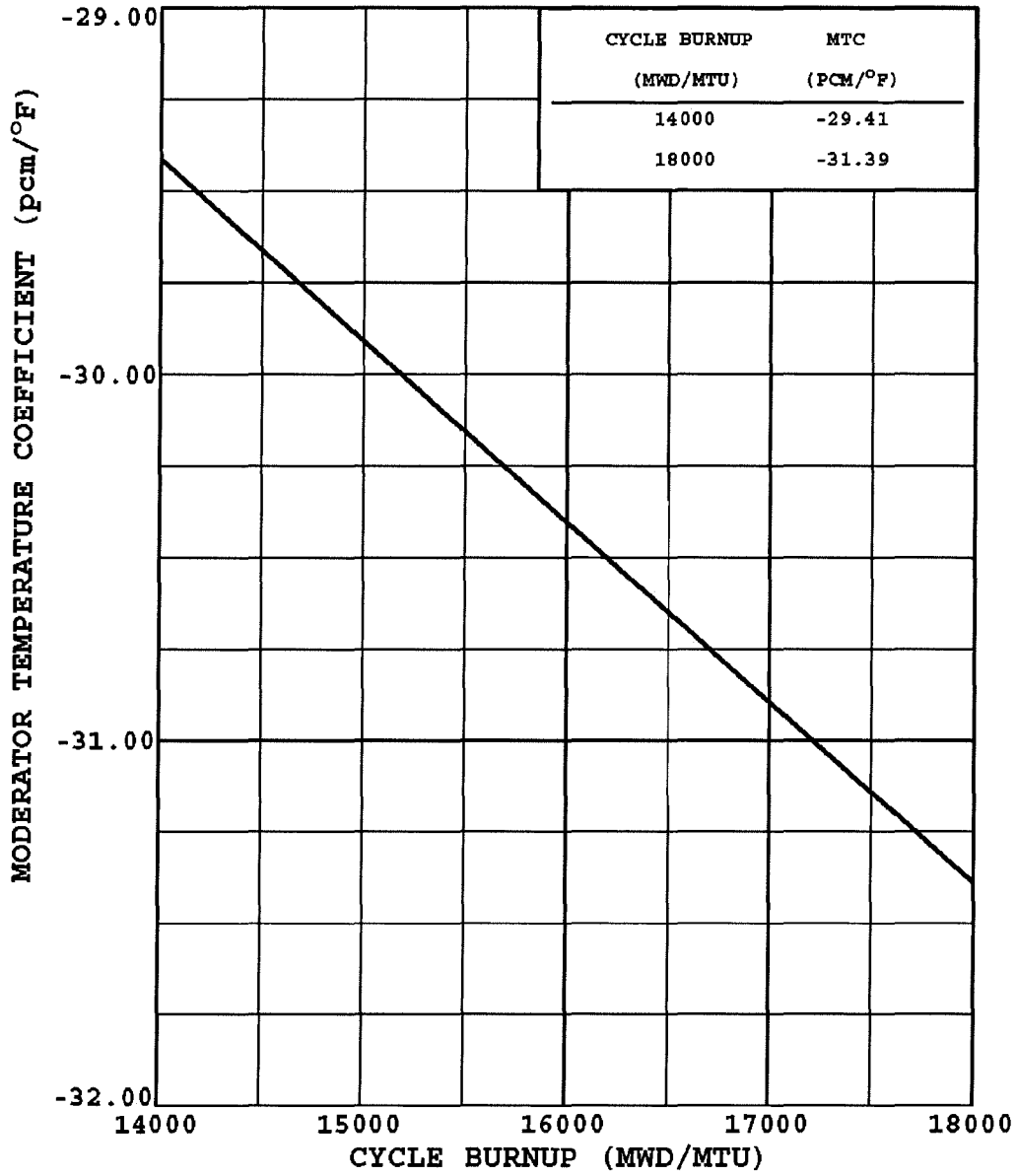


Figure 5.1-5 (Page 1 of 1)

HOT FULL POWER PREDICTED
 MODERATOR TEMPERATURE COEFFICIENT
 AS A FUNCTION OF CYCLE BURNUP
 WHEN 300 PPM IS ACHIEVED

Table 5.1-1 (Page 1 of 2)
F_Q Surveillance W(Z) Function versus Burnup at 100% RTP

Exclusion Zone	Axial Point	Elevation (feet)	150 (MWD/MTU)	3000 (MWD/MTU)	8000 (MWD/MTU)	12000 (MWD/MTU)	16000 (MWD/MTU)
*	1	12.1	1.0000	1.0000	1.0000	1.0000	1.0000
*	2	11.9	1.0000	1.0000	1.0000	1.0000	1.0000
*	3	11.7	1.0000	1.0000	1.0000	1.0000	1.0000
*	4	11.5	1.0000	1.0000	1.0000	1.0000	1.0000
*	5	11.3	1.0000	1.0000	1.0000	1.0000	1.0000
*	6	11.1	1.0000	1.0000	1.0000	1.0000	1.0000
*	7	10.9	1.0000	1.0000	1.0000	1.0000	1.0000
	8	10.7	1.1656	1.2218	1.2278	1.2247	1.2293
	9	10.5	1.1666	1.2140	1.2255	1.2214	1.2208
	10	10.3	1.1660	1.2075	1.2236	1.2176	1.2084
	11	10.1	1.1636	1.1999	1.2208	1.2119	1.2024
	12	9.9	1.1601	1.1905	1.2171	1.2054	1.1976
	13	9.7	1.1564	1.1804	1.2130	1.2025	1.1907
	14	9.5	1.1530	1.1694	1.2075	1.2005	1.1850
	15	9.3	1.1505	1.1572	1.1998	1.2028	1.1868
	16	9.1	1.1496	1.1470	1.1929	1.2060	1.1901
	17	8.9	1.1515	1.1417	1.1897	1.2093	1.1904
	18	8.7	1.1564	1.1413	1.1892	1.2153	1.1912
	19	8.5	1.1635	1.1449	1.1905	1.2241	1.1939
	20	8.3	1.1700	1.1495	1.1933	1.2307	1.1957
	21	8.1	1.1745	1.1535	1.1964	1.2340	1.1972
	22	7.9	1.1773	1.1558	1.1980	1.2353	1.2007
	23	7.6	1.1784	1.1567	1.1979	1.2348	1.2046
	24	7.4	1.1779	1.1562	1.1961	1.2323	1.2062
	25	7.2	1.1759	1.1547	1.1928	1.2280	1.2056
	26	7.0	1.1723	1.1524	1.1881	1.2219	1.2032
	27	6.8	1.1672	1.1489	1.1821	1.2142	1.1995
	28	6.6	1.1608	1.1440	1.1748	1.2051	1.1944
	29	6.4	1.1531	1.1381	1.1659	1.1943	1.1878
	30	6.2	1.1442	1.1310	1.1558	1.1817	1.1795
	31	6.0	1.1340	1.1225	1.1447	1.1676	1.1698
	32	5.8	1.1235	1.1140	1.1320	1.1526	1.1586

Note: Top and Bottom 10% Excluded

TABLE 5.1-1 (Page 2 of 2)
F_Q Surveillance W(Z) Function versus Burnup at 100% RTP

Exclusion Zone	Axial Point	Elevation (feet)	150 (MWD/MTU)	3000 (MWD/MTU)	8000 (MWD/MTU)	12000 (MWD/MTU)	16000 (MWD/MTU)
	33	5.6	1.1146	1.1069	1.1179	1.1378	1.1461
	34	5.4	1.1115	1.1015	1.1073	1.1258	1.1371
	35	5.2	1.1122	1.0984	1.1024	1.1176	1.1329
	36	5.0	1.1150	1.0979	1.0988	1.1126	1.1283
	37	4.8	1.1173	1.0991	1.0949	1.1093	1.1218
	38	4.6	1.1192	1.1000	1.0908	1.1052	1.1149
	39	4.4	1.1207	1.1005	1.0861	1.1004	1.1071
	40	4.2	1.1216	1.1013	1.0804	1.0952	1.0979
	41	4.0	1.1229	1.1030	1.0775	1.0899	1.0912
	42	3.8	1.1251	1.1059	1.0782	1.0845	1.0895
	43	3.6	1.1273	1.1091	1.0805	1.0790	1.0889
	44	3.4	1.1290	1.1116	1.0818	1.0737	1.0871
	45	3.2	1.1309	1.1134	1.0824	1.0718	1.0857
	46	3.0	1.1358	1.1196	1.0849	1.0717	1.0854
	47	2.8	1.1483	1.1393	1.0935	1.0818	1.0955
	48	2.6	1.1670	1.1663	1.1078	1.0986	1.1127
	49	2.4	1.1895	1.1920	1.1264	1.1143	1.1283
	50	2.2	1.2131	1.2172	1.1463	1.1295	1.1433
	51	2.0	1.2360	1.2427	1.1656	1.1450	1.1585
	52	1.8	1.2581	1.2676	1.1842	1.1601	1.1734
	53	1.6	1.2795	1.2914	1.2023	1.1747	1.1878
	54	1.4	1.2995	1.3138	1.2196	1.1888	1.2019
*	55	1.2	1.0000	1.0000	1.0000	1.0000	1.0000
*	56	1.0	1.0000	1.0000	1.0000	1.0000	1.0000
*	57	0.8	1.0000	1.0000	1.0000	1.0000	1.0000
*	58	0.6	1.0000	1.0000	1.0000	1.0000	1.0000
*	59	0.4	1.0000	1.0000	1.0000	1.0000	1.0000
*	60	0.2	1.0000	1.0000	1.0000	1.0000	1.0000
*	61	0.0	1.0000	1.0000	1.0000	1.0000	1.0000

Note: Top and Bottom 10% Excluded

Table 5.1-2 (Page 1 of 2)
F_Q Surveillance W(Z) Function at Initial Cycle Startup at 75% RTP

Exclusion Zone	Axial Point	Elevation (feet)	75% RTP
*	1	12.1	1.0000
*	2	11.9	1.0000
*	3	11.7	1.0000
*	4	11.5	1.0000
*	5	11.3	1.0000
*	6	11.1	1.0000
*	7	10.9	1.0000
	8	10.7	1.2426
	9	10.5	1.2289
	10	10.3	1.2147
	11	10.1	1.1998
	12	9.9	1.1837
	13	9.7	1.1683
	14	9.5	1.1541
	15	9.3	1.1417
	16	9.1	1.1311
	17	8.9	1.1244
	18	8.7	1.1221
	19	8.5	1.1234
	20	8.3	1.1248
	21	8.1	1.1249
	22	7.9	1.1242
	23	7.6	1.1230
	24	7.4	1.1208
	25	7.2	1.1175
	26	7.0	1.1133
	27	6.8	1.1080
	28	6.6	1.1020
	29	6.4	1.0950
	30	6.2	1.0875
	31	6.0	1.0791
	32	5.8	1.0704

Note: Top and Bottom 10% Excluded

Table 5.1-2 (Page 2 of 2)
F_Q Surveillance W(Z) Function at Initial Cycle Startup at 75% RTP

Exclusion Zone	Axial Point	Elevation (feet)	75% RTP
	33	5.6	1.0635
	34	5.4	1.0623
	35	5.2	1.0649
	36	5.0	1.0696
	37	4.8	1.0740
	38	4.6	1.0781
	39	4.4	1.0819
	40	4.2	1.0852
	41	4.0	1.0892
	42	3.8	1.0941
	43	3.6	1.0988
	44	3.4	1.1025
	45	3.2	1.1067
	46	3.0	1.1147
	47	2.8	1.1303
	48	2.6	1.1518
	49	2.4	1.1772
	50	2.2	1.2037
	51	2.0	1.2300
	52	1.8	1.2555
	53	1.6	1.2807
	54	1.4	1.3045
*	55	1.2	1.0000
*	56	1.0	1.0000
*	57	0.8	1.0000
*	58	0.6	1.0000
*	59	0.4	1.0000
*	60	0.2	1.0000
*	61	0.0	1.0000

Note: Top and Bottom 10% Excluded

Table 5.1-3 (Page 1 of 1)
 $F_Q(Z)$ Penalty Factor versus Burnup

Cycle Burnup (MWD/MTU)	$F_Q(Z)$ Penalty Factor
> 0	1.0200

Note: The Penalty Factor, to be applied to $F_Q(Z)$ in accordance with Technical Specification Surveillance Requirement (SR) 3.2.1.2, is the maximum factor by which $F_Q(Z)$ is expected to increase over a 39 Effective Full Power Day (EFPD) interval (surveillance interval of 31 EFPD plus the maximum allowable extension not to exceed 25% of the surveillance interval per Technical Specification SR 3.0.2) starting from the burnup at which the $F_Q(Z)$ was determined.
