FENOC™

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June 6, 2017

L-17-071

ATTN: Document Control Desk
U. S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT:
Beaver Valley Power Station, Unit No. 2
Docket No. 50-412, License No. NPF-73
Cycle 20 Core Operating Limits Report

Pursuant to the requirements of Beaver Valley Power Station, Unit No. 2 Technical Specification 5.6.3, "CORE OPERATING LIMITS REPORT (COLR)," FirstEnergy Nuclear Operating Company hereby submits the COLR for Cycle 20. Technical Specification 5.6.3.d requires, in part, that the COLR be provided to the Nuclear Regulatory Commission upon issuance for each reload cycle. The Cycle 20 COLR was made effective on May 4, 2017.

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

Enclosure:

Beaver Valley Power Station, Unit No. 2, Core Operating Limits Report, Cycle 20

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

Enclosure
L-17-071

Beaver Valley Power Station, Unit No. 2
Core Operating Limits Report, Cycle 20
(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 ≥ 1.77% Δk/k.[(1)]

b. Prior to manually blocking the Low Pressurizer Pressure Safety Injection Signal, the Reactor Coolant System shall be borated to ≥ the MODE 5 boron concentration and shall remain ≥ this boron concentration at all times when this signal is blocked.

c. In MODE 5, SHUTDOWN MARGIN shall be ≥ 1.0% Δk/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 - 4.29×10^{-4} Δk/k/°F at RATED THERMAL POWER.

c. 300 ppm Surveillance Limit: (- 35 pcm/°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 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.

and

AFD Sensitivity = 0.10 pcm/°F / ΔAFD

***Predictive Correction is -3 pcm/°F.

(1) The MODE 1 and MODE 2 with k_{eff} ≥ 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: (- 40.5 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:

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

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

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

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, and 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 ($F^N_{\Delta H}$)

$$F^N_{\Delta H} \le CF_{\Delta H} * (1 + PF_{\Delta H}(1-P))^{\$}$$

Where: $CF_{\Delta H}$ = 1.59 up to 6,000 MWD/MTU

And,

$CF_{\Delta H}$ = 1.62 from 6,000 MWD/MTU to EOL

$PF_{\Delta H}$ = 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:

Parameter	Value
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, and 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' ≥ 2250 psia
Measured reactor vessel ΔT lead/lag time constants (* The response time is toggled off to meet the analysis value of zero.)	τ_1 = 0 sec* τ_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:

Parameter	Value
Overpower ΔT reactor trip setpoint	K4 ≤ 1.094
Overpower ΔT reactor trip setpoint Tavg rate/lag coefficient	K5 ≥ 0.02/°F for increasing average temperature K5 = 0/°F for decreasing average temperature
Overpower ΔT reactor trip setpoint Tavg heatup coefficient	K6 ≥ 0.0021/°F for T > T" K6 = 0/°F for T ≤ T"
Tavg at RATED THERMAL POWER	T" ≤ 574.2°F[(1)]
Measured reactor vessel ΔT lead/lag time constants	τ_1 = 0 sec* τ_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

Parameter	Indicated Value
Reactor Coolant System Tavg	Tavg ≤ 577.8°F(1)
Pressurizer Pressure	Pressure ≥ 2214 psia(2)
Reactor Coolant System Total Flow Rate	Flow ≥ 267,483 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.

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√™ 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√™ 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.

12. WCAP-16045-P-A, Addendum 1-A, "Qualification of the NEXUS Nuclear Data Methodology," August 2007.

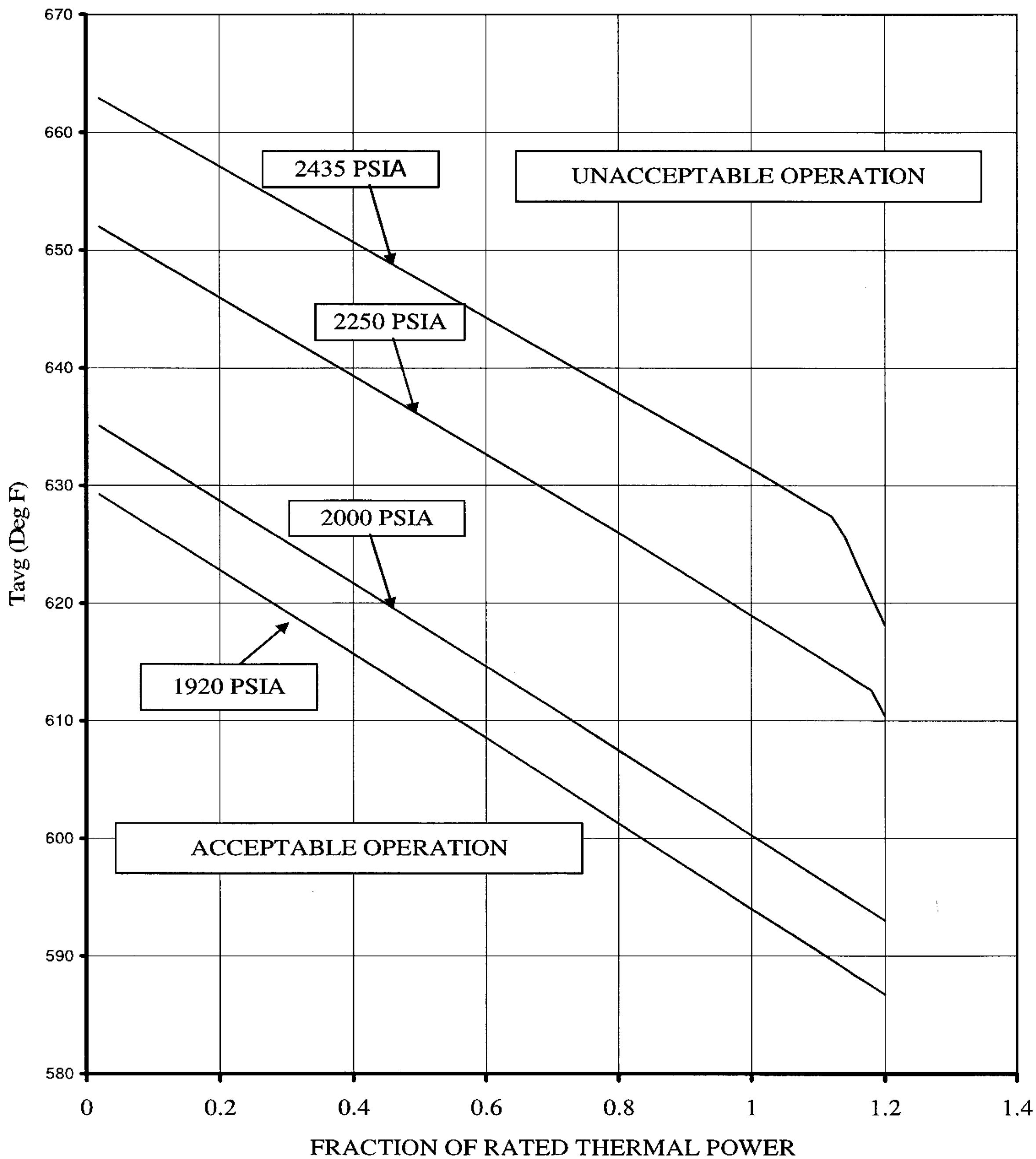

Figure 5.1-1 (Page 1 of 1)

REACTOR CORE SAFETY LIMIT
THREE LOOP OPERATION

(Technical Specification Safety Limit 2.1.1)

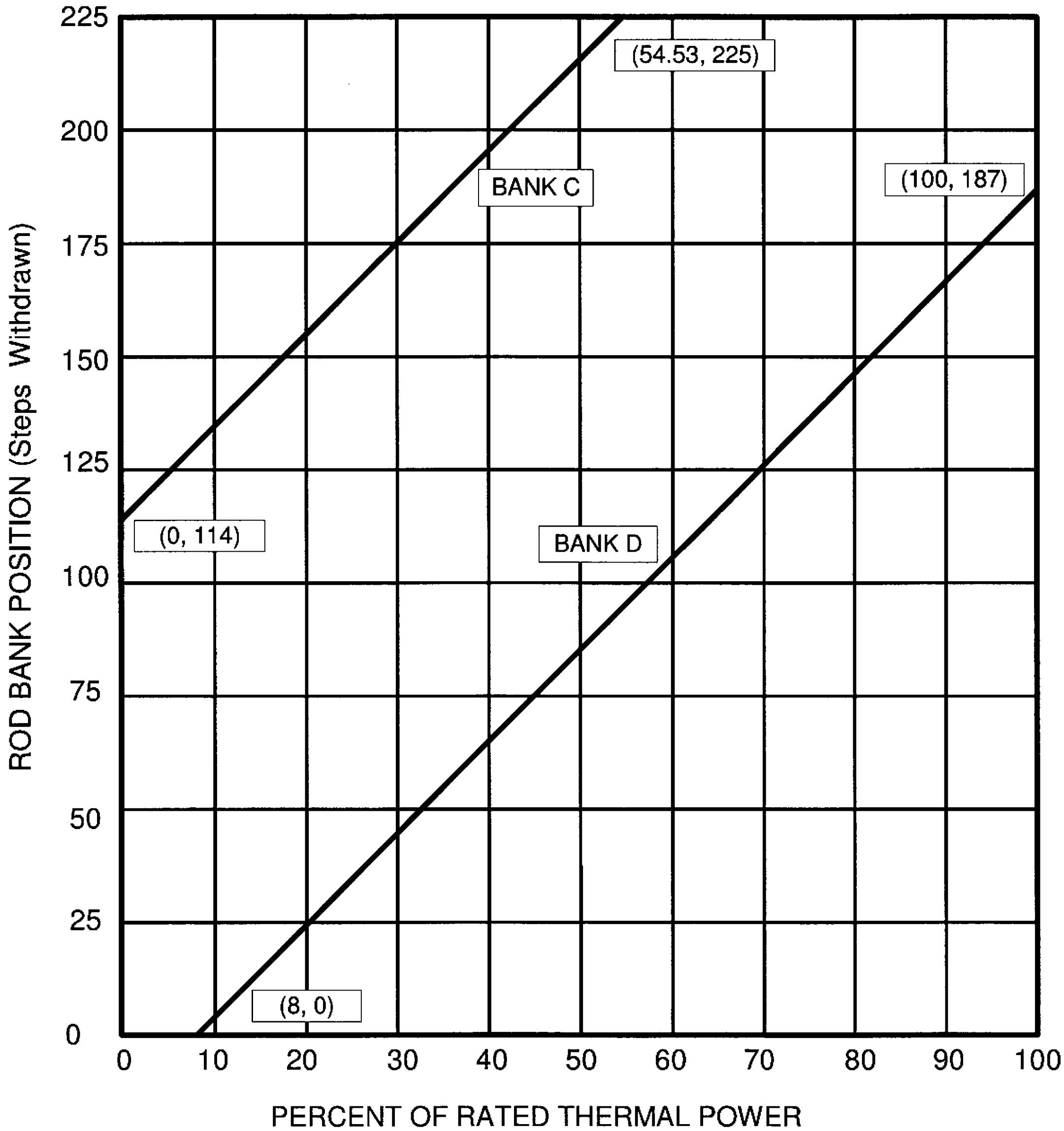

Figure 5.1-2 (Page 1 of 1)

CONTROL ROD INSERTION LIMITS AS A

FUNCTION OF RATED POWER LEVEL

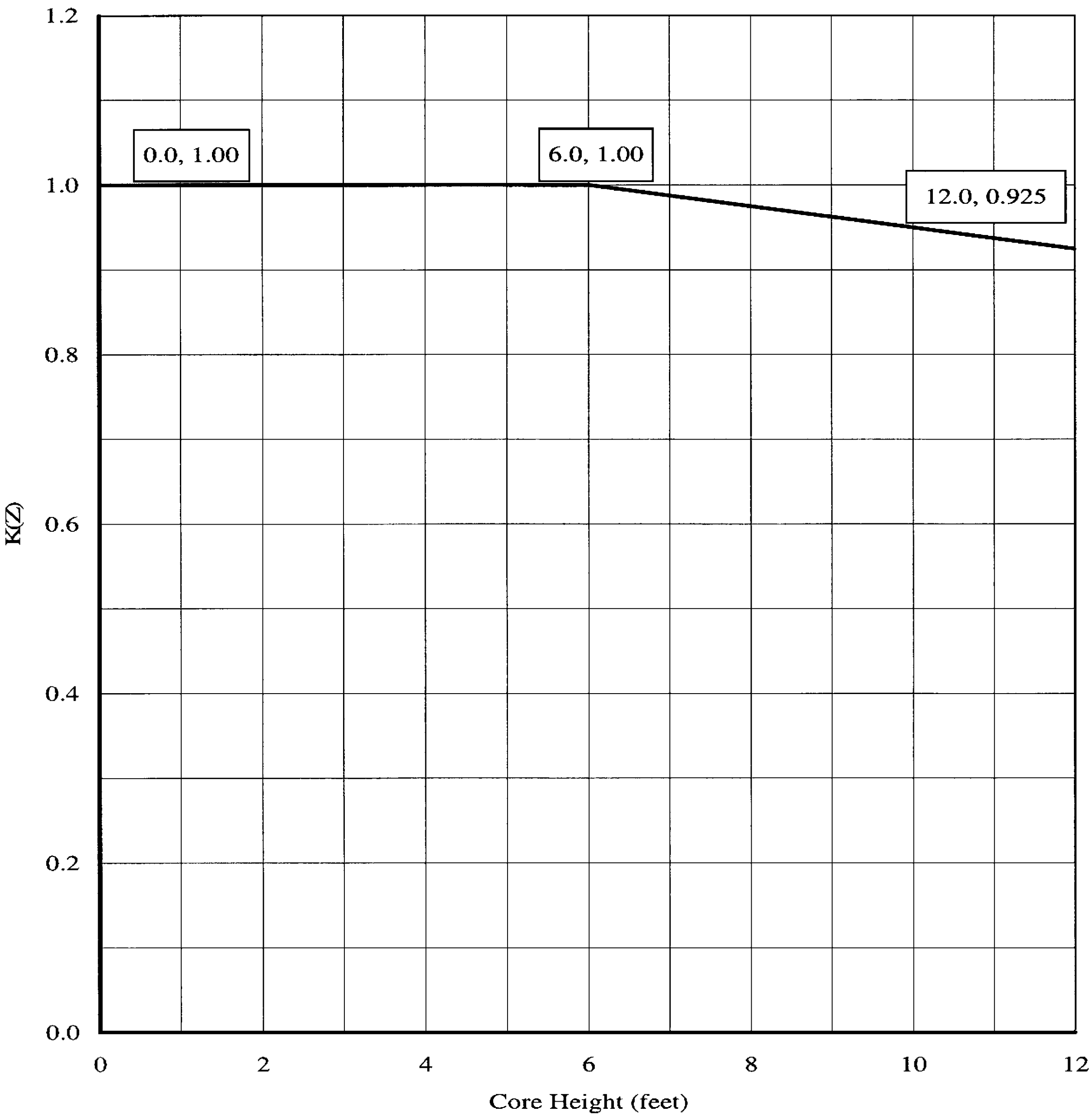

Figure 5.1-3 (Page 1 of 1)

F_QT NORMALIZED OPERATING ENVELOPE, K(Z)

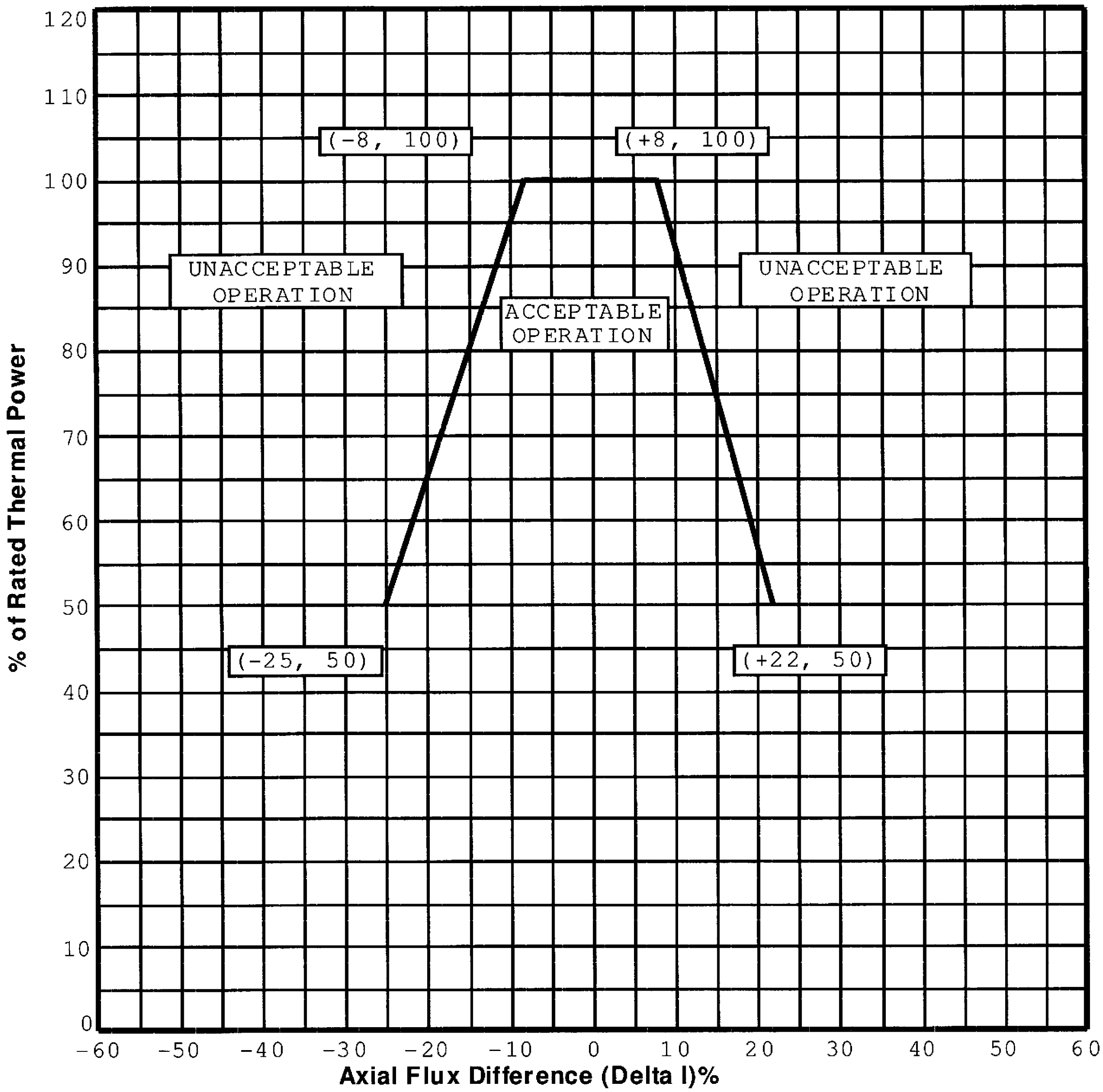

Figure 5.1-4 (Page 1 of 1)

AXIAL FLUX DIFFERENCE LIMITS AS A FUNCTION OF

PERCENT OF RATED THERMAL POWER FOR RAOC

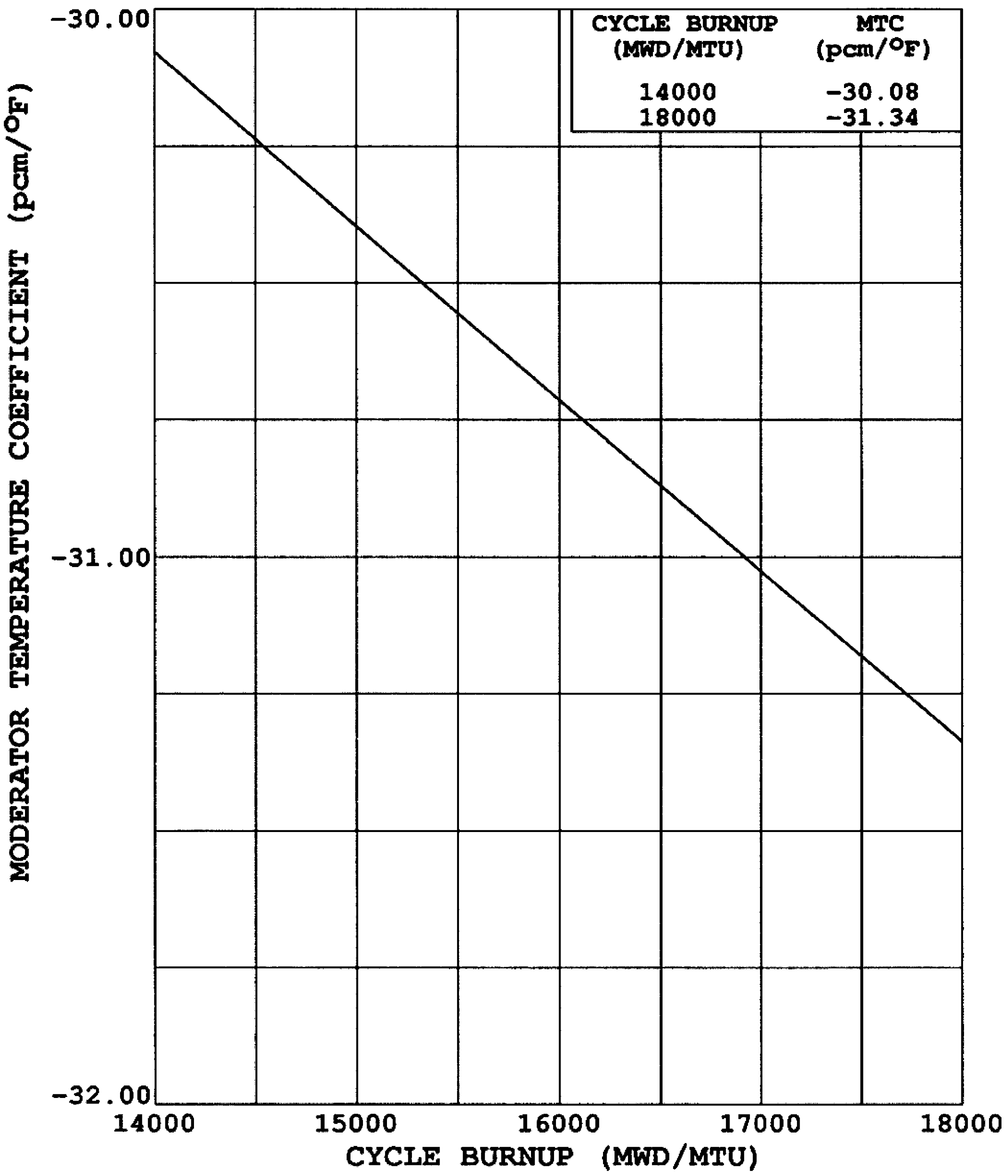

Figure 5.1-5 (Page 1 of 1)

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	1.1275	1.1787	1.2521	1.2179	1.2248
	9	10.5	1.1226	1.1755	1.2449	1.2119	1.2180
	10	10.3	1.1166	1.1701	1.2362	1.2077	1.2112
	11	10.1	1.1095	1.1630	1.2261	1.2056	1.2054
	12	9.9	1.1025	1.1608	1.2156	1.2087	1.1990
	13	9.7	1.0974	1.1611	1.2086	1.2095	1.1921
	14	9.5	1.0979	1.1596	1.2109	1.2083	1.1850
	15	9.3	1.1035	1.1543	1.2091	1.2057	1.1789
	16	9.1	1.1103	1.1501	1.2097	1.2029	1.1827
	17	8.9	1.1155	1.1467	1.2091	1.2028	1.1869
	18	8.7	1.1232	1.1523	1.2145	1.2064	1.1884
	19	8.5	1.1306	1.1580	1.2188	1.2156	1.1931
	20	8.3	1.1363	1.1618	1.2210	1.2218	1.2051
	21	8.1	1.1409	1.1640	1.2207	1.2256	1.2143
	22	7.9	1.1442	1.1650	1.2189	1.2275	1.2215
	23	7.6	1.1452	1.1636	1.2145	1.2267	1.2261
	24	7.4	1.1452	1.1612	1.2088	1.2243	1.2292
	25	7.2	1.1435	1.1567	1.2002	1.2187	1.2286
	26	7.0	1.1409	1.1511	1.1899	1.2109	1.2256
	27	6.8	1.1371	1.1443	1.1785	1.2025	1.2212
	28	6.6	1.1316	1.1360	1.1656	1.1924	1.2154
	29	6.4	1.1256	1.1269	1.1528	1.1808	1.2077
	30	6.2	1.1190	1.1169	1.1435	1.1678	1.1981
	31	6.0	1.1158	1.1104	1.1332	1.1538	1.1871
	32	5.8	1.1122	1.1040	1.1222	1.1391	1.1751

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	1.1083	1.1005	1.1107	1.1237	1.1616
	34	5.4	1.1091	1.1001	1.1021	1.1144	1.1455
	35	5.2	1.1150	1.1001	1.0975	1.1101	1.1357
	36	5.0	1.1217	1.1019	1.0954	1.1066	1.1315
	37	4.8	1.1281	1.1051	1.0926	1.1027	1.1259
	38	4.6	1.1342	1.1086	1.0898	1.0984	1.1199
	39	4.4	1.1401	1.1119	1.0868	1.0938	1.1132
	40	4.2	1.1455	1.1149	1.0838	1.0893	1.1064
	41	4.0	1.1503	1.1176	1.0809	1.0848	1.0996
	42	3.8	1.1552	1.1207	1.0775	1.0794	1.0914
	43	3.6	1.1596	1.1255	1.0740	1.0747	1.0830
	44	3.4	1.1660	1.1303	1.0704	1.0715	1.0757
	45	3.2	1.1740	1.1347	1.0697	1.0701	1.0748
	46	3.0	1.1796	1.1384	1.0704	1.0686	1.0808
	47	2.8	1.1971	1.1540	1.0757	1.0726	1.0933
	48	2.6	1.2239	1.1770	1.0888	1.0830	1.1069
	49	2.4	1.2498	1.1988	1.1038	1.0946	1.1211
	50	2.2	1.2762	1.2215	1.1190	1.1077	1.1357
	51	2.0	1.3026	1.2440	1.1338	1.1200	1.1492
	52	1.8	1.3285	1.2663	1.1482	1.1318	1.1618
	53	1.6	1.3523	1.2869	1.1619	1.1431	1.1741
	54	1.4	1.3739	1.3057	1.1743	1.1535	1.1855
*	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	1.2169
	9	10.5	1.1980
	10	10.3	1.1775
	11	10.1	1.1555
	12	9.9	1.1333
	13	9.7	1.1134
	14	9.5	1.1003
	15	9.3	1.0940
	16	9.1	1.0895
	17	8.9	1.0856
	18	8.7	1.0863
	19	8.5	1.0870
	20	8.3	1.0856
	21	8.1	1.0867
	22	7.9	1.0860
	23	7.6	1.0841
	24	7.4	1.0828
	25	7.2	1.0782
	26	7.0	1.0765
	27	6.8	1.0734
	28	6.6	1.0678
	29	6.4	1.0629
	30	6.2	1.0587
	31	6.0	1.0579
	32	5.8	1.0559

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	1.0541
	34	5.4	1.0579
	35	5.2	1.0650
	36	5.0	1.0731
	37	4.8	1.0816
	38	4.6	1.0901
	39	4.4	1.0992
	40	4.2	1.1080
	41	4.0	1.1170
	42	3.8	1.1253
	43	3.6	1.1336
	44	3.4	1.1438
	45	3.2	1.1554
	46	3.0	1.1647
	47	2.8	1.1858
	48	2.6	1.2161
	49	2.4	1.2458
	50	2.2	1.2766
	51	2.0	1.3076
	52	1.8	1.3379
	53	1.6	1.3662
	54	1.4	1.3923
*	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 - 450	1.0237
> 450	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.