FENOC™
FirstEnergy Nuclear Operating Company

Beaver Valley Power Station
P.O. Box 4
Shippingport, PA 15077

Eric A. Larson
Site Vice President

724-682-5234
Fax: 724-643-8069

December 28, 2015
L-15-376

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

SUBJECT:
Beaver Valley Power Station, Unit No. 1
Docket No. 50-334, License No. DPR-66
<u>Cycle 24-1 Core Operating Limits Report</u>

Pursuant to the requirements of Beaver Valley Power Station, Unit No. 1 Technical Specification 5.6.3, "CORE OPERATING LIMITS REPORT (COLR)," FirstEnergy Nuclear Operating Company hereby submits the COLR for Cycle 24-1. Technical Specification 5.6.3.d requires, in part, that the COLR be provided to the Nuclear Regulatory Commission upon issuance for any midcycle revision. The Cycle 24-1 COLR was made effective on December 3, 2015.

The COLR was revised for Cycle 24 to require that additional specified uncertainty be applied 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 between 50 and 75 percent of the total number of thimbles. When the number of measured thimbles is between 50 and 75 percent, at least 4 measured thimbles per core quadrant are also required.

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,

for EA Larson

Eric A. Larson

Enclosure:

Beaver Valley Power Station, Unit No. 1, Core Operating Limits Report, Cycle 24-1

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

Enclosure
L-15-376

Beaver Valley Power Station, Unit No. 1
Core Operating Limits Report, Cycle 24-1
(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 - 4.4 x 10^{-4} Δk/k/°F at RATED THERMAL POWER.

c. 300 ppm Surveillance Limit: (- 37 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 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 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 = 0.05 pcm/°F / ΔAFD

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

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(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: (- 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:

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

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

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

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

$ For Cycle 24 of Unit 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 ((75-T)/(75-50))*0.12 is added to the measurement uncertainty, 1.05, where T is the percentage of measured thimbles. This adjusted measurement uncertainty is then multiplied by 1.03 to obtain the total uncertainty to be applied. At least four 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 ($F^N_{\Delta H}$)

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

Where: $CF_{\Delta H} = 1.62$

$PF_{\Delta H} = 0.3$

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

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 1 and 2

a. Overtemperature ΔT Setpoint Parameter Values:

Parameter	Value
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)

$ For Cycle 24 of Unit 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 ((75-T)/(75-50))*0.06 is added to the standard uncertainty on $F^N_{\Delta H}$ of 1.04., where T is the percentage of measured thimbles. At least four 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 (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(ΔI) = 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	$K4 \leq 1.085$
Overpower ΔT reactor trip setpoint Tavg rate/lag coefficient	$K5 \geq 0.02/°F$ for increasing average temperature $K5 = 0/°F$ for decreasing average temperature
Overpower ΔT reactor trip setpoint Tavg heatup coefficient	$K6 \geq 0.0021/°F$ for $T > T''$ $K6 = 0/°F$ for $T \leq T''$
Tavg at RATED THERMAL POWER	$T'' \leq 577.9°F$(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

Parameter	Indicated Value
Reactor Coolant System Tavg	Tavg ≤ 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.

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(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√™ 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-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.

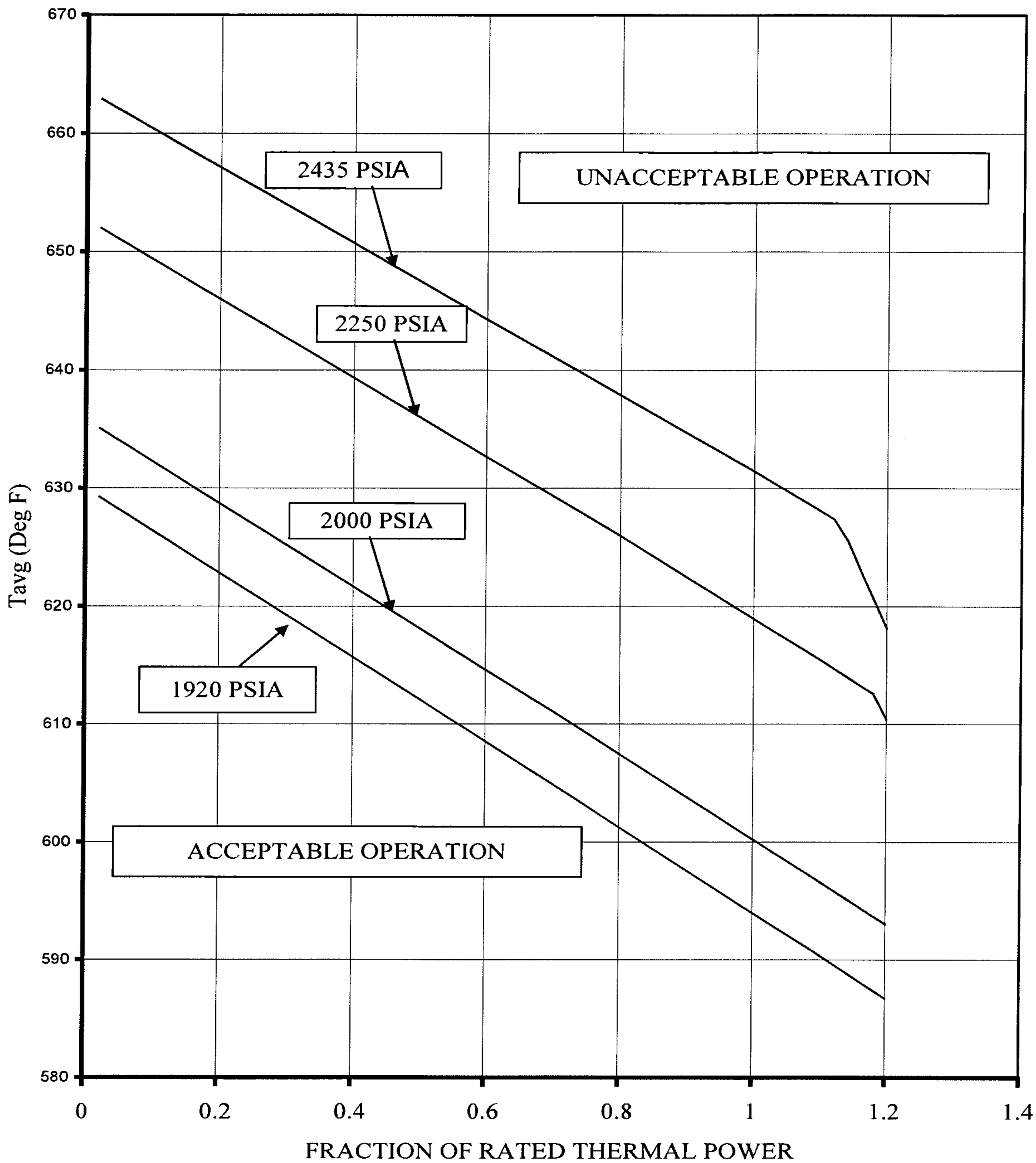

Figure 5.1-1 (Page 1 of 1)

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

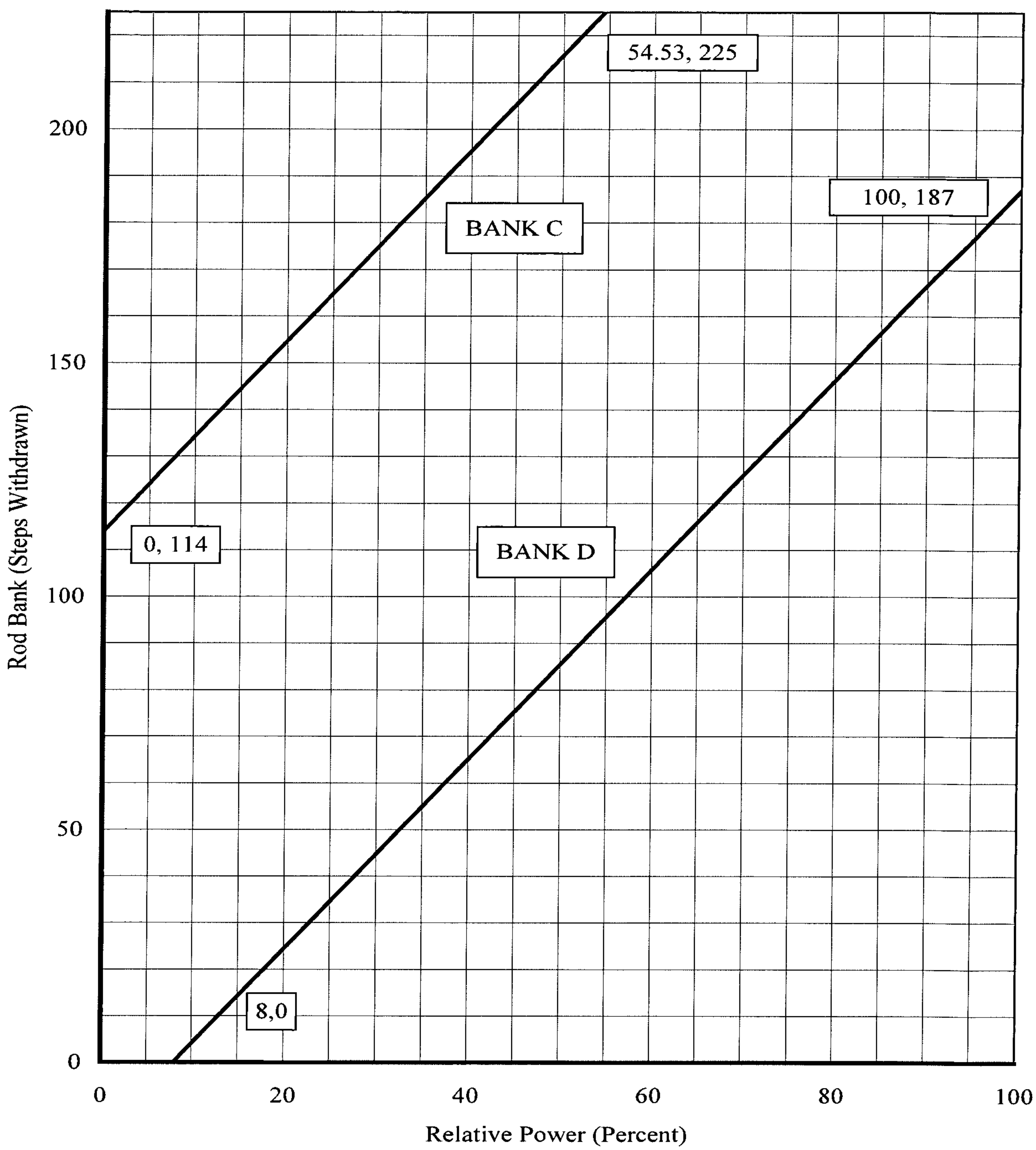

Figure 5.1-2 (Page 1 of 1)

CONTROL ROD INSERTION LIMITS

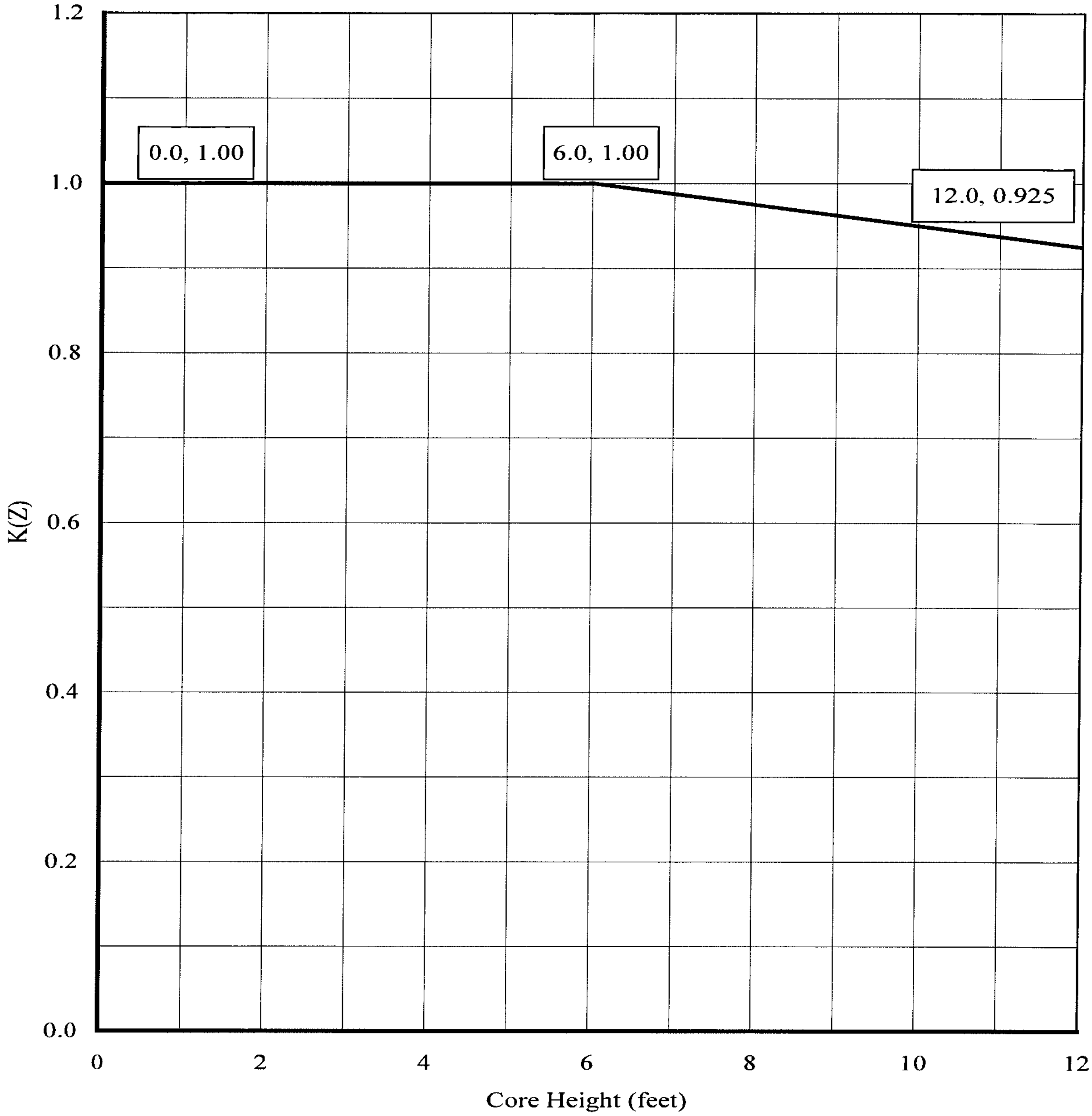

Figure 5.1-3 (Page 1 of 1)

$F_Q T$ NORMALIZED OPERATING ENVELOPE, K(Z)

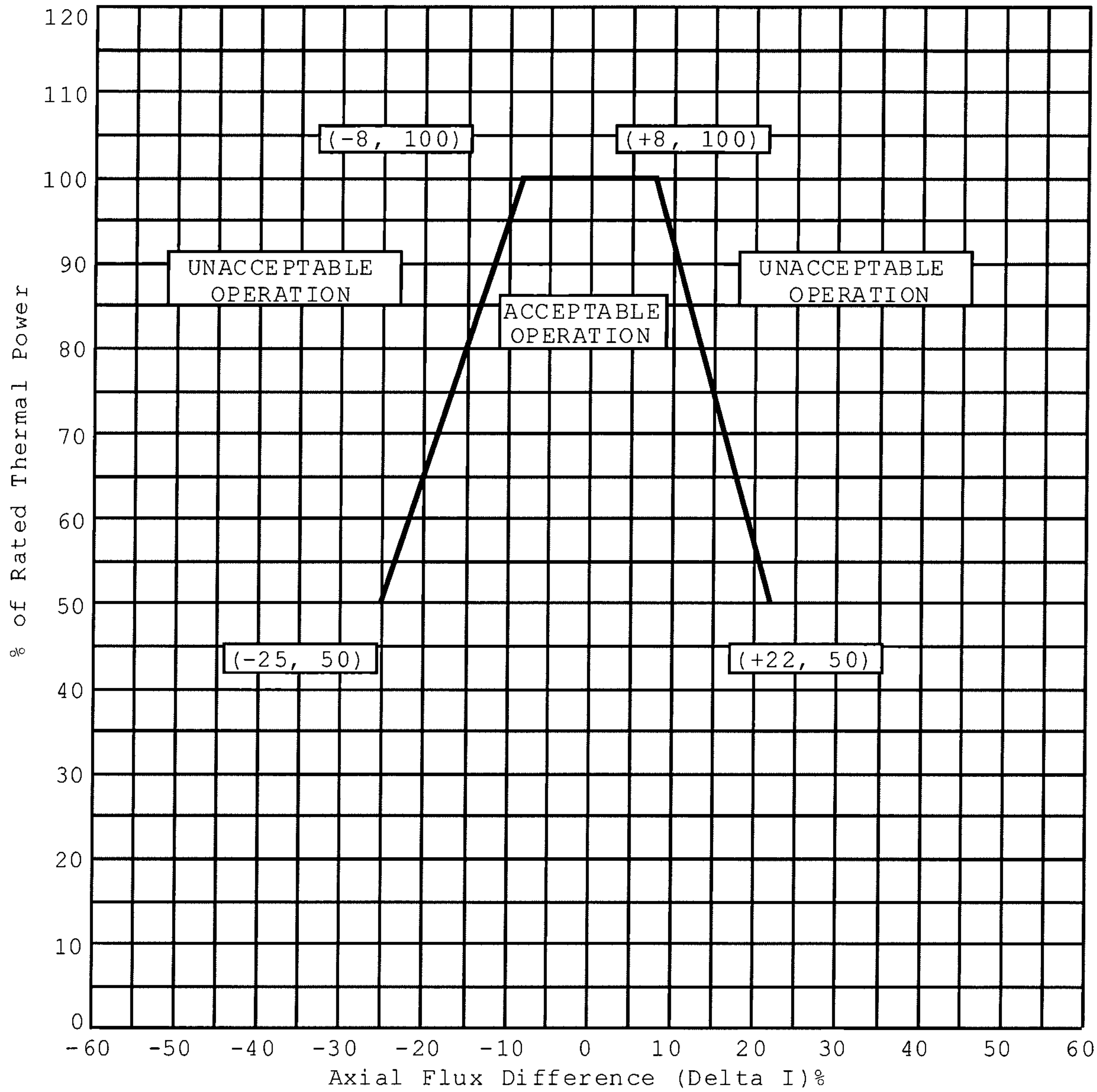

Figure 5.1-4 (Page 1 of 1)

AXIAL FLUX DIFFERENCE LIMITS AS A FUNCTION OF

PERCENT OF RATED THERMAL POWER FOR RAOC

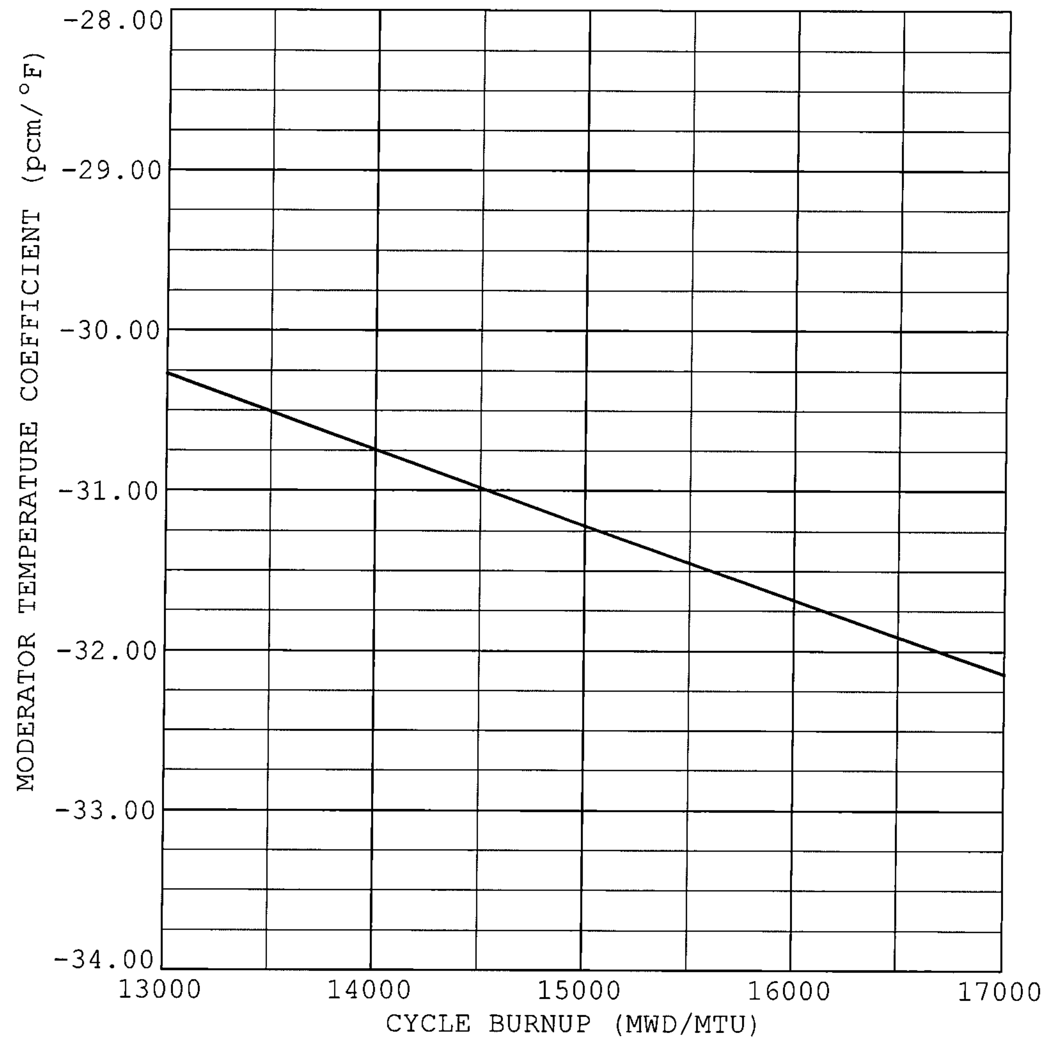

Figure 5.1-5 (Page 1 of 1)

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.