Tennessee Valley Authority, Post Office Box 2000, Soddy Daisy, Tennessee 37384-2000

May 27, 2015

10 CFR 50.4

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

Sequoyah Nuclear Plant, Unit 1
Facility Operating License No. DPR-77
NRC Docket No. 50-327

Subject: **Sequoyah Unit 1 Cycle 21 Core Operating Limits Report**

In accordance with Sequoyah Nuclear Plant (SQN) Unit 1 Technical Specification (TS) 6.9.1.14.c, enclosed is the Unit 1 Cycle 21 Core Operating Limits Report (COLR), Revision 0. In accordance with TS 6.9.1.14.c, the COLR is required to be provided to the Nuclear Regulatory Commission within 30 days after the cycle start-up (Mode 2) for each reload cycle. Sequoyah Unit 1 entered Mode 2 on May 15, 2015, for the current reload cycle.

There are no new regulatory commitments in this letter. If you have any questions, please contact Erin Henderson, SQN Site Licensing Manager at (423) 843-7170.

Respectfully,

Acting VP.

John T. Carlin
Site Vice President
Sequoyah Nuclear Plant

Enclosure
Sequoyah Unit 1 Cycle 21 Core Operating Limits Report

cc (Enclosure):
NRC Regional Administrator – Region II
NRC Senior Resident Inspector – SQN

A001
NRR

ENCLOSURE

SEQUOYAH UNIT 1 CYCLE 21
CORE OPERATING LIMITS REPORT

SEQUOYAH UNIT 1 CYCLE 21
CORE OPERATING LIMITS REPORT

REVISION 0

May 2015

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Revision 0

Pages affected All

Reason for Revision: Initial Issue

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Sequoyah Unit 1 Cycle 21 has been prepared in accordance with the requirements of Technical Specification (TS) 6.9.1.14.

The TSs affected by this Report are listed below:

TABLE 2.2-1	$f_1(\Delta I)$ trip reset function for OTΔT Trip (QTNL, QTPL) and rates of trip setpoint decrease per percent ΔI (QTNS, QTPS)
TABLE 2.2-1	$f_2(\Delta I)$ trip reset function for OPΔT Trip (QPNL, QPPL) and rates of trip setpoint decrease per percent ΔI (QPNS, QPPS)
3/4.1.1.3	Moderator Temperature Coefficient (MTC)
3/4.1.3.5	Shutdown Rod Insertion Limit
3/4.1.3.6	Control Rod Insertion Limits
3/4.2.1	Axial Flux Difference (AFD)
3/4.2.2	Heat Flux Hot Channel Factor ($F_Q(X,Y,Z)$)
3/4.2.3	Nuclear Enthalpy Rise Hot Channel Factor ($F_{\Delta H}(X,Y)$)

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 the NRC approved methodologies specified in TS 6.9.1.14. The versions of the topical reports which describe the methodologies used for this cycle are listed in Table 1.

The following abbreviations are used in this section:

BOL stands for Beginning of Cycle Life
ARO stands for All Rods Out
HZP stands for Hot Zero THERMAL POWER
EOL stands for End of Cycle Life
RTP stands for RATED THERMAL POWER

2.1 ***Moderator Temperature Coefficient – MTC (Specification 3/4.1.1.3)***

2.1.1 The MTC limits are:

The BOL/ARO/HZP MTC shall be less positive than 0 Δk/k/°F (BOL limit). With the measured value more positive than -0.05×10^{-5} Δk/k/°F, establish control rod withdrawal limits to ensure the MTC remains less positive than 0 Δk/k/°F for all times in core life.

The EOL/ARO/RTP MTC shall be less negative than or equal to -4.5×10^{-4} Δk/k/°F.

2.1.2 The 300 ppm surveillance limit is:

The measured 300 ppm/ARO/RTP MTC shall be less negative than or equal to -3.74×10^{-4} Δk/k/°F.

2.2 ***Shutdown Rod Insertion Limit (Specification 3/4.1.3.5)***

2.2.1 The shutdown rods shall be withdrawn to a position as defined below:

Cycle Burnup (MWd/mtU)	Steps Withdrawn
≥ 0	≥ 225 to ≤ 231

2.3 ***Control Rod Insertion Limits (Specification 3/4.1.3.6)***

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

2.4 ***Axial Flux Difference – AFD (Specification 3/4.2.1)***

2.4.1 The axial flux difference (AFD) limits (AFD^{Limit}) are provided in Figure 2.

2.5 *Heat Flux Hot Channel Factor – $F_Q(X,Y,Z)$ (Specification 3/4.2.2)*

$F_Q(X,Y,Z)$ shall be limited by the following relationships:

$$F_Q(X,Y,Z) \le \frac{F_Q^{RTP}}{P} * K(Z) \qquad \text{for } P > 0.5$$

$$F_Q(X,Y,Z) \le \frac{F_Q^{RTP}}{0.5} * K(Z) \qquad \text{for } P \le 0.5$$

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

2.5.1 $F_Q^{RTP} = 2.62$

2.5.2 K(Z) is provided in Figure 3.

The following parameters are required for core monitoring per the Surveillance Requirements of Specification 3/4.2.2:

2.5.3 $NSLOPE^{AFD} = 1.21$

where $NSLOPE^{AFD}$ = Negative AFD limit adjustment required to compensate for each 1% that $F_Q(X,Y,Z)$ exceeds BQDES.

2.5.4 $PSLOPE^{AFD} = 1.55$

where $PSLOPE^{AFD}$ = Positive AFD limit adjustment required to compensate for each 1% that $F_Q(X,Y,Z)$ exceeds BQDES.

2.5.5 $NSLOPE^{f2(\Delta I)} = 1.48$

where $NSLOPE^{f2(\Delta I)}$ = Adjustment to negative OPΔT $f_2(\Delta I)$ limit required to compensate for each 1% that $F_Q(X,Y,Z)$ exceeds BCDES.

2.5.6 $PSLOPE^{f2(\Delta I)} = 2.00$

where $PSLOPE^{f2(\Delta I)}$ = Adjustment to positive OPΔT $f_2(\Delta I)$ limit required to compensate for each 1% that $F_Q(X,Y,Z)$ exceeds BCDES.

2.5.7 BQNOM(X,Y,Z) = Nominal design peaking factor, increased by an allowance for the expected deviation between the nominal design power distribution and the measurement.

2.5.8 BQDES(X,Y,Z) = Maximum allowable design peaking factor which ensures that the F_Q (X,Y,Z) limit will be preserved for operation within the LCO limits, including allowances for calculational and measurement uncertainties.

2.5.9 BCDES(X,Y,Z) = Maximum allowable design peaking factor which ensures that the centerline fuel melt limit will be preserved for operation within the LCO limits, including allowances for calculational and measurement uncertainties.

BQNOM(X,Y,Z), BQDES(X,Y,Z), and BCDES(X,Y,Z) databases are provided for input to the plant power distribution analysis codes on a cycle-specific basis and are determined using the methodology for core limit generation described in the references in Specification 6.9.1.14.

2.5.10 The increase in F_Q^M(X,Y,Z) for compliance with the 4.2.2.2.e Surveillance Requirements is defined as follows.

For all cycle burnups, use 2.0%

2.6 *Nuclear Enthalpy Rise Hot Channel Factor - $F_{\Delta H}(X,Y)$ (Specification 3/4.2.3)*

$F_{\Delta H}(X,Y)$ shall be limited by the following relationship:

$$F_{\Delta H}(X,Y) \leq MAP(X,Y,Z) / AXIAL(X,Y)$$

2.6.1 MAP(X,Y,Z) is provided in Table 2.

AXIAL(X,Y) is the axial peak from the normalized axial power shape.

The following parameters are required for core monitoring per the Surveillance Requirements of Specification 3/4.2.3:

$$F\Delta HR^M(X,Y) \leq BHNOM(X,Y)$$

where $F\Delta HR^M(X,Y) = F_{\Delta H}{}^M (X,Y) / [MAP^M / AXIAL(X,Y)]$

$F_{\Delta H}{}^M$ (X,Y) is the measured radial peak at location X,Y.

MAP^M is the value of MAP(X,Y,Z) obtained from Table 2 for the measured peak.

2.6.2 BHNOM(X,Y) = Nominal design radial peaking factor, increased by an allowance for the expected deviation between the nominal design power distribution and the measurement.

2.6.3 BHDES(X,Y) = Maximum allowable design radial peaking factor which ensures that the $F_{\Delta H}$ (X,Y) limit will be preserved for operation within the LCO limits, including allowances for calculational and measurement uncertainties.

2.6.4 BRDES(X,Y) = Maximum allowable design radial peaking factor which ensures that the steady state DNBR limit will be preserved for operation within the LCO limits, including allowances for calculational and measurement uncertainties.

BHNOM(X,Y), BHDES(X,Y) and BRDES(X,Y) databases are provided for input to the plant power distribution analysis computer codes on a cycle-specific basis and are determined using the methodology for core limit generation described in the references in Specification 6.9.1.14.

2.6.5 RRH = 3.34 when $0.8 < P \leq 1.0$

RRH = 1.67 when $P \leq 0.8$

where RRH = Thermal power reduction required to compensate for each 1% that $F_{\Delta H}(X,Y)$ exceeds its limit.

P = Thermal Power / Rated Thermal Power

2.6.6 TRH = 0.0334 when $0.8 < P \leq 1.0$

TRH = 0.0167 when $P \leq 0.8$

Where TRH = Reduction in OTΔT K_1 setpoint required to compensate for each 1% that $F_{\Delta H}(X,Y)$ exceeds its limit.

P = Thermal Power / Rated Thermal Power

2.6.7 All cycle burnups shall use a 2% increase in $F_{\Delta H}^{M}$ (X,Y) for compliance with the 4.2.3.2.d.1 Surveillance Requirement.

3.0 REACTOR CORE PROTECTIVE LIMITS

3.1 *Trip Reset Term [$f_1(\Delta I)$] for Overtemperature Delta-T Trip (Specification 2.2.1)*

The following parameters are required to specify the power level-dependent $f_1(\Delta I)$ trip reset term limits for the Overtemperature Delta-T trip function:

3.1.1 QTNL = -20%

where QTNL = the maximum negative ΔI setpoint at rated thermal power at which the trip setpoint is not reduced by the axial power distribution.

3.1.2 QTPL = +5%

where QTPL = the maximum positive ΔI setpoint at rated thermal power at which the trip setpoint is not reduced by the axial power distribution.

3.1.3 QTNS = 2.50%

where QTNS = the percent reduction in Overtemperature Delta-T trip setpoint for each percent that the magnitude of ΔI exceeds its negative limit at rated thermal power (QTNL).

3.1.4 QTPS = 1.40%

where QTPS = the percent reduction in Overtemperature Delta-T trip setpoint for each percent that the magnitude of ΔI exceeds its positive limit at rated thermal power (QTPL).

3.2 *Trip Reset Term [$f_2(\Delta I)$] for Overpower Delta-T Trip (Specification 2.2.1)*

The following parameters are required to specify the power level-dependent $f_2(\Delta I)$ trip reset term limits for the Overpower Delta-T trip function:

3.2.1 QPNL = -25%

where QPNL = the maximum negative ΔI setpoint at rated thermal power at which the trip setpoint is not reduced by the axial power distribution.

3.2.2 QPPL = +25%

where QPPL = the maximum positive ΔI setpoint at rated thermal power at which the trip setpoint is not reduced by the axial power distribution.

3.2.3 QPNS = 1.70%

where QPNS = the percent reduction in Overpower Delta-T trip setpoint for each percent that the magnitude of ΔI exceeds its negative limit at rated thermal power (QPNL).

3.2.4 QPPS = 1.70%

where QPPS = the percent reduction in Overpower Delta-T trip setpoint for each percent that the magnitude of ΔI exceeds its positive limit at rated thermal power (QPPL).

Table 1

COLR Methodology Topical Reports

1. BAW-10180-A, Revision 1, "NEMO-Nodal Expansion Method Optimized," March 1993.

   (Methodology for Specification 3/4.1.1.3-Moderator Temperature Coefficient)

2. BAW-10169P-A, Revision 0, "RSG Plant Safety Analysis-B&W Safety Analysis Methodology for Recirculating Steam Generator Plants," October 1989.

   (Methodology for Specification 3/4.1.1.3-Moderator Temperature Coefficient)

3. BAW-10163P-A, Revision 0, "Core Operating Limit Methodology for Westinghouse-Designed PWRs," June 1989.

   (Methodology for Specifications 2.2.1-Reactor Trip Instrumentation Setpoints [$f_1(\Delta I)$, $f_2(\Delta I)$ limits], 3/4.1.3.5-Shutdown Rod Insertion Limit, 3/4.1.3.6-Control Rod Insertion Limits, 3/4.2.1-Axial Flux Difference, 3/4.2.2-Heat Flux Hot Channel Factor, 3/4.2.3-Nuclear Enthalpy Rise Hot Channel Factor)

4. EMF-2328(P)(A), "PWR Small Break LOCA Evaluation Model," March 2001.

   (Methodology for Specification 3/4.2.2-Heat Flux Hot Channel Factor)

5. BAW-10227P-A, Revision 1, "Evaluation of Advanced Cladding and Structural Material (M5) in PWR Reactor Fuel," June 2003.

   (Methodology for Specification 3/4.2.2-Heat Flux Hot Channel Factor)

6. BAW-10186P-A, Revision 2, "Extended Burnup Evaluation," June 2003.

   (Methodology for Specification 3/4.2.2-Heat Flux Hot Channel Factor)

7. EMF-2103P-A, Revision 0, "Realistic Large Break LOCA Methodology for Pressurized Water Reactors," April 2003.

   (Methodology for Specification 3/4.2.2-Heat Flux Hot Channel Factor)

8. BAW-10241P-A, Revision 1, "BHTP DNB Correlation Applied with LYNXT," July 2005.

   (Methodology for Specification 3/4.2.3-Enthalpy Rise Hot Channel Factor)

9. BAW-10199P-A, Revision 0, "The BWU Critical Heat Flux Correlations," August 1996.

   (Methodology for Specification 3/4.2.3-Enthalpy Rise Hot Channel Factor)

10. BAW-10189P-A, "CHF Testing and Analysis of the Mark-BW Fuel Assembly Design," January 1996.

    (Methodology for Specification 3/4.2.3-Enthalpy Rise Hot Channel Factor)

11. BAW-10159P-A, "BWCMV Correlation of Critical Heat Flux in Mixing Vane Grid Fuel Assemblies," August 1990.

    (Methodology for Specification 3/4.2.3-Enthalpy Rise Hot Channel Factor)

12. BAW-10231P-A, Revision 1, "COPERNIC Fuel Rod Design Computer Code," January 2004.

    (Methodology for Specification 2.2.1-Reactor Trip Instrumentation Setpoints)

Table 2

Maximum Allowable Peaking Limits MAP(X,Y,Z) for Operation

AXIAL(X,Y)	ELEVATION (ft)	MAP(X,Y,Z)	AXIAL(X,Y)	ELEVATION (ft)	MAP(X,Y,Z)
1.1	1	1.8128	1.4	1	2.5969
	2	1.8125		2	2.5380
	3	1.8122		3	2.4827
	4	1.8119		4	2.4411
	5	1.8115		5	2.4315
	6	1.8109		6	2.4800
	7	1.8106		7	2.5356
	8	1.8104		8	2.4447
	9	1.8098		9	2.3555
	10	1.8092		10	2.1738
	11	1.7599		11	2.0238
1.2	1	2.0671	1.5	1	2.6723
	2	2.0664		2	2.6061
	3	2.0656		3	2.5417
	4	2.0649		4	2.4913
	5	2.0642		5	2.4801
	6	2.0636		6	2.5380
	7	2.0624		7	2.6273
	8	2.0615		8	2.5311
	9	2.0457		9	2.4447
	10	1.9492		10	2.2772
	11	1.8589		11	2.0975
1.3	1	2.3433	1.6	1	2.7308
	2	2.3419		2	2.6605
	3	2.3412		3	2.5947
	4	2.3397		4	2.5371
	5	2.3389		5	2.5234
	6	2.3381		6	2.5906
	7	2.3357		7	2.7077
	8	2.3130		8	2.6117
	9	2.1886		9	2.5240
	10	2.0643		10	2.3758
	11	1.9439		11	2.1662

Table 2 (continued)

AXIAL(X,Y)	ELEVATION (ft)	MAP(X,Y,Z)
1.7	1	2.7664
	2	2.7083
	3	2.6380
	4	2.5791
	5	2.5639
	6	2.6359
	7	2.7795
	8	2.6870
	9	2.5798
	10	2.4726
	11	2.2304
1.8	1	2.7963
	2	2.7466
	3	2.6775
	4	2.6172
	5	2.6010
	6	2.6802
	7	2.8456
	8	2.7552
	9	2.6648
	10	2.5655
	11	2.2931
1.9	1	2.8235
	2	2.7739
	3	2.7125
	4	2.6523
	5	2.6328
	6	2.7200
	7	2.9065
	8	2.8193
	9	2.7288
	10	2.6384
	11	2.3482

AXIAL(X,Y)	ELEVATION (ft)	MAP(X,Y,Z)
>1.9	1	2.4339
	2	2.4060
	3	2.3856
	4	2.3423
	5	2.3114
	6	2.6006
	7	2.5003
	8	2.4004
	9	2.2989
	10	2.1483
	11	1.9630
2.1	1	2.5057
	2	2.4754
	3	2.4449
	4	2.3591
	5	2.4205
	6	2.7643
	7	2.6474
	8	2.5360
	9	2.4400
	10	2.3277
	11	2.0549
2.3	1	2.5380
	2	2.5216
	3	2.4619
	4	2.4294
	5	2.4290
	6	2.8222
	7	2.7334
	8	2.6234
	9	2.5186
	10	2.4215
	11	2.1250

Table 2 (continued)

AXIAL(X,Y)	ELEVATION (ft)	MAP(X,Y,Z)
2.5	1	2.6440
	2	2.5160
	3	2.5045
	4	2.4488
	5	2.5803
	6	2.9481
	7	2.8544
	8	2.7286
	9	2.6450
	10	2.5527
	11	2.1731
2.7	1	2.5554
	2	2.5529
	3	2.5197
	4	2.4375
	5	2.5643
	6	2.9839
	7	2.8837
	8	2.7939
	9	2.7040
	10	2.5997
	11	2.1995
2.9	1	2.4223
	2	2.5653
	3	2.5075
	4	2.3955
	5	2.7295
	6	3.0921
	7	3.0070
	8	2.8896
	9	2.8058
	10	2.6974
	11	2.2039

AXIAL(X,Y)	ELEVATION (ft)	MAP(X,Y,Z)
3.1	1	2.2448
	2	2.5535
	3	2.4678
	4	2.3229
	5	2.8913
	6	3.1515
	7	3.0181
	8	2.9699
	9	2.8941
	10	2.7819
	11	2.1866
3.3	1	2.0228
	2	2.5172
	3	2.4007
	4	2.2195
	5	3.0496
	6	3.2226
	7	3.1446
	8	3.0350
	9	2.9688
	10	2.8533
	11	2.1473
3.5	1	1.7563
	2	2.4566
	3	2.3062
	4	2.0854
	5	3.2045
	6	3.2929
	7	3.2627
	8	3.0846
	9	3.0299
	10	2.9117
	11	2.0862

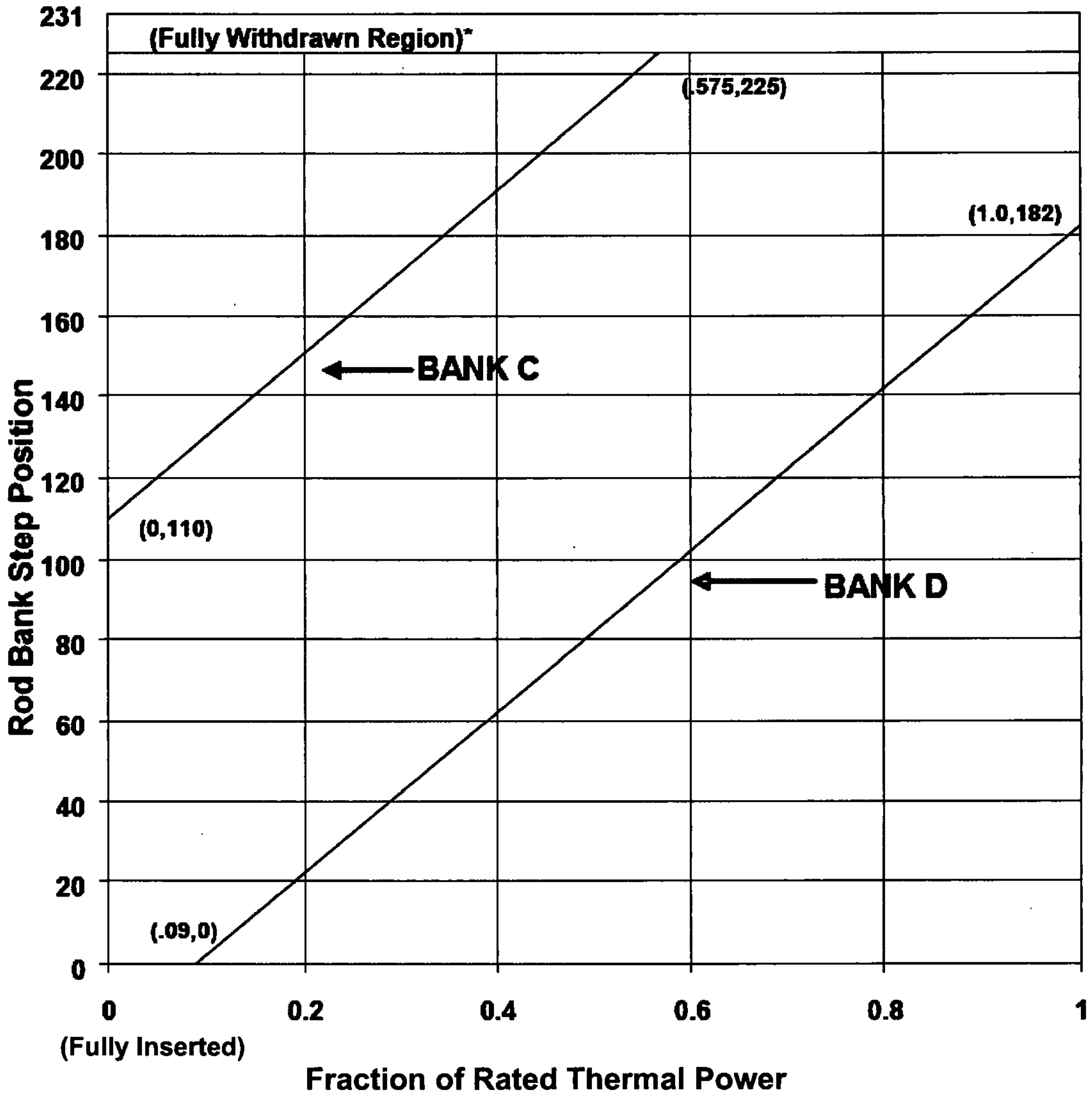

FIGURE 1
Rod Bank Insertion Limits Versus Thermal Power, Four Loop Operation

* Fully withdrawn region shall be the condition where shutdown and control banks are at a position within the interval of ≥225 and ≤231steps withdrawn, inclusive.

Fully withdrawn shall be the position as defined below,

Cycle Burnup (MWd/mtU)	Steps Withdrawn
≥ 0	≥ 225 to ≤ 231

This figure is valid for operation at a rated thermal power of 3455 MWth when the LEFM is in operation.

If the LEFM becomes inoperable, then prior to the next NIS calibration, the maximum allowable power level must be reduced by 1.3% in power, and the rod insertion limit lines must be increased by 3 steps withdrawn until the LEFM is returned to operation.

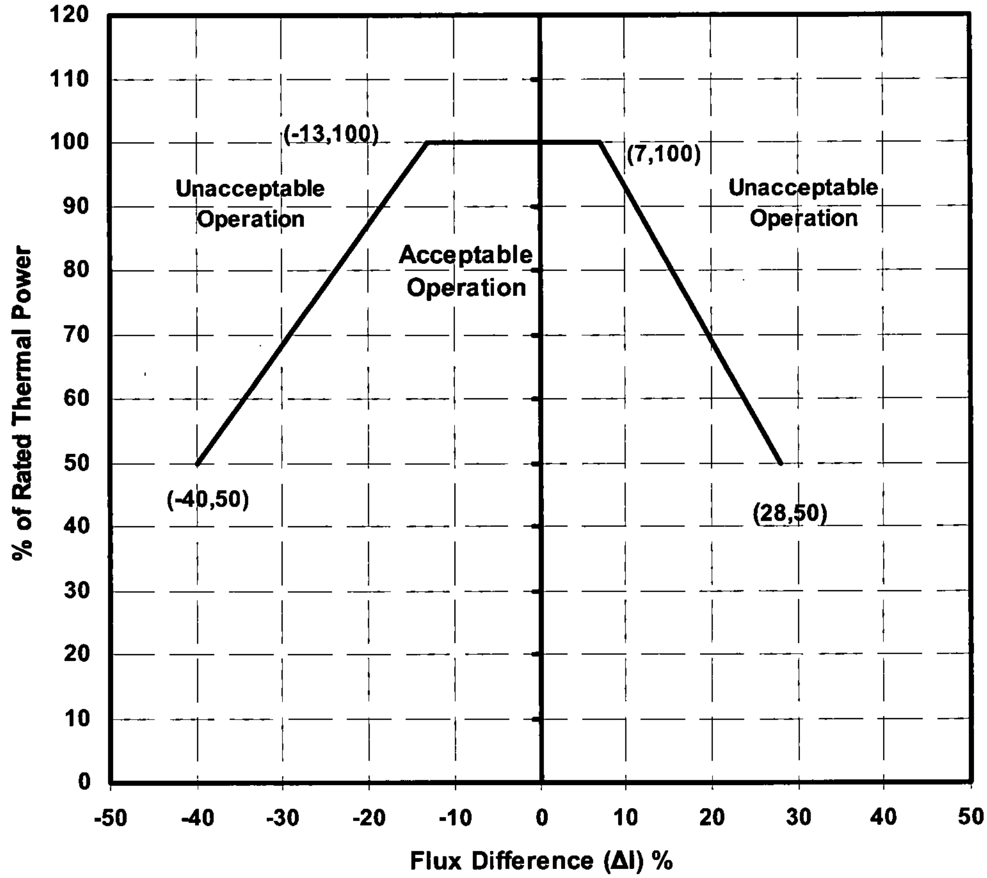

FIGURE 2

Axial Flux Difference Limits As A Function of Rated Thermal Power For Burnup Range 0 EFPD to EOL

This figure is valid for operation at a rated thermal power of 3455 MWth when the LEFM is in operation.

If the LEFM becomes inoperable, then prior to the next NIS calibration, the maximum allowable power level must be reduced by 1.3% in power, and the AFD limit lines must be made more restrictive by 1% in AFD until the LEFM is returned to operation.

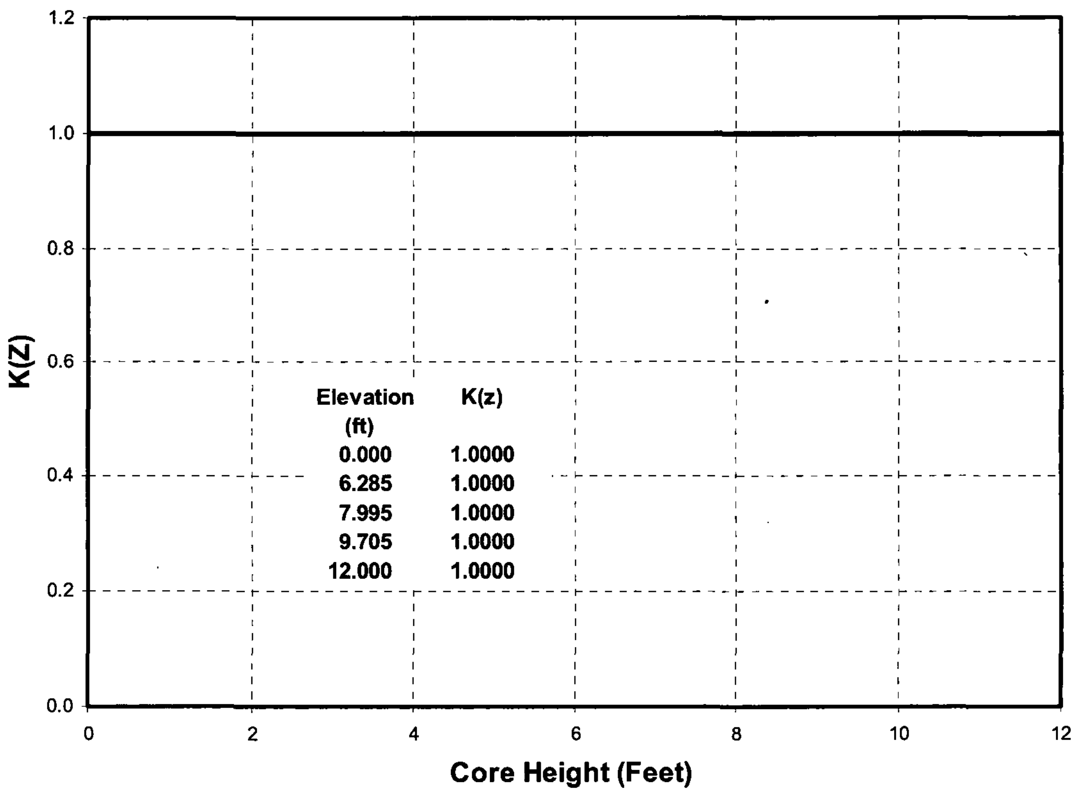

FIGURE 3

K(Z) - Normalized $F_Q(X,Y,Z)$ as a Function of Core Height