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

December 23, 2015

10 CFR 50.4

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

Sequoyah Nuclear Plant, Unit 2
Renewed Facility Operating License No. DPR-79
NRC Docket No. 50-328

Subject: **Sequoyah Unit 2 Cycle 21 Core Operating Limits Report**

In accordance with Sequoyah Nuclear Plant (SQN) Unit 2 Technical Specification (TS) 5.6.3.d, enclosed is the Unit 2 Cycle 21 Core Operating Limits Report (COLR), Revision 0 that was issued on November 27, 2015.

SQN has completed the transition from the Mark-BW fuel design to the Advanced W17 HTP fuel design in Unit 2. Accordingly, the COLR only includes core operating limits associated with the use of Advanced W17 HTP fuel. Limited Mark-BW fuel assemblies remain viable for use in Unit 2 core designs. Although a mixed core using Mark-BW fuel is not expected, future core designs will apply TS 5.6.3 for determining the core operating limits.

A001
NRR

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

Respectfully,

Christopher J. Schwarz
Site Vice President
Sequoyah Nuclear Plant

Enclosure
Sequoyah Unit 2 Cycle 21 Core Operating Limits Report

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

ENCLOSURE

SEQUOYAH UNIT 2 CYCLE 21
CORE OPERATING LIMITS REPORT

SEQUOYAH UNIT 2 CYCLE 21
CORE OPERATING LIMITS REPORT

REVISION 0

November 2015

Prepared by:

Kelly R. Kenner, PWR Fuel Engineering / 11/20/2015 Date

Christine A. Setter, PWR Fuel Engineering / 11/20/2015 Date

Verified by:

John E. Strange, PWR Fuel Engineering / 11/20/15 Date

Reviewed by:

Kathleen A. Cunningham, PWR Fuel Engineering Manager / 11-20-2015 Date

Brandon S. Catalanotto, Reactor Engineering Manager / 11-20-2015 Date

Approved by:

Thomas B Marshall

PORC Chairman / 11/27/2015 Date

MARK GIACOMI

Plant Manager / 11/27/2015 Date

Revision	Date of PORC Approval	Affected Pages	Reason for Revision
0	11/27/15	All	Initial issue.

1.0 CORE OPERATING LIMITS REPORT

This CORE OPERATING LIMITS REPORT (COLR) for Sequoyah Unit 2 Cycle 21 has been prepared in accordance with the requirements of Technical Specification (TS) 5.6.3.

The TSs affected by this Report are listed below:

TS Section	Technical Specification	COLR Parameter	COLR Section	COLR Page
3.1.1	SHUTDOWN MARGIN (SDM)	SDM	2.1	3
3.1.3	Moderator Temperature Coefficient (MTC)	BOL MTC Limit EOL MTC Limit 300 ppm Surveillance Limit 60 ppm Surveillance Limit	2.2.1 2.2.2 2.2.3 2.2.4	4 4 4 4
3.1.4	Rod Group Alignment Limits	SDM	2.1.3	3
3.1.5	Shutdown Bank Insertion Limits	Shutdown Bank Insertion Limits SDM	2.3 2.1.4	4 3
3.1.6	Control Bank Insertion Limits	Control Bank Insertion Limits SDM	2.4 2.1.5	5 3
3.1.8	PHYSICS TESTS Exceptions – MODE 2	SDM	2.1.6	3
3.2.1	Heat Flux Hot Channel Factor (F_Q(X,Y,Z))	F_Q^{RTP} K(Z) $NSLOPE^{AFD}$ $PSLOPE^{AFD}$ $NSLOPE^{f2(\Delta I)}$ $PSLOPE^{f2(\Delta I)}$ F_Q(X,Y,Z) Appropriate Factor ITS LCO 3.2.1 Required Action A.3	2.5.1 2.5.2 2.5.3 2.5.4 2.5.5 2.5.6 2.5.7 2.5.8	6 6 6 6 6 6 6 6
3.2.2	Nuclear Enthalpy Rise Hot Channel Factor ($F_{\Delta H}$(X,Y))	MAP(X,Y,Z) RRH TRH $F_{\Delta H}$(X,Y) Appropriate Factor ITS 3.2.2 Required Action A.4 ITS 3.2.2 Required Action B.1	2.6.1 2.6.2 2.6.3 2.6.4 2.6.5 2.6.6	6 6 6 7 7 7
3.2.3	AXIAL FLUX DIFFERENCE (AFD)	AFD Limits	2.7	7
3.3.1	Reactor Trip System (RTS) Instrumentation	QTNL, QTPL, QTNS, and QTPS QPNL, QPPL, QPNS, and QPPS	2.8.1 2.8.2	8 9
3.9.1	Boron Concentration	Refueling Boron Concentration	2.9	9
5.6.3	CORE OPERATING LIMITS REPORT (COLR)	Analytical Methods	2.0	3

2.0 OPERATING LIMITS

The cycle-specific parameter limits for the TS listed in section 1.0 are presented in the following subsections. These limits have been developed using the NRC approved methodologies specified in TS 5.6.3. 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
EOL stands for End of Cycle Life
RTP stands for RATED THERMAL POWER

2.1 SHUTDOWN MARGIN – SDM (TS 3.1.1, 3.1.4, 3.1.5, 3.1.6, 3.1.8)

2.1.1 For TS 3.1.1, SDM shall be ≥ 1.6 %Δk/k in MODE 2 with k_{eff} < 1.0, MODE 3 and MODE 4

2.1.2 For TS 3.1.1, SDM shall be ≥ 1.0 %Δk/k in MODE 5.

2.1.3 For TS 3.1.4, SDM shall be ≥ 1.6 %Δk/k in MODE 1 and MODE 2.

2.1.4 For TS 3.1.5, SDM shall be ≥ 1.6 %Δk/k in MODE 1 and MODE 2.

2.1.5 For TS 3.1.6, SDM shall be ≥ 1.6 %Δk/k in MODE 1 and MODE 2 with k_{eff} ≥ 1.0.

2.1.6 For TS 3.1.8, SDM shall be ≥ 1.6 %Δk/k in MODE 2.

2.2 Moderator Temperature Coefficient – MTC (TS 3.1.3)

2.2.1 The BOL MTC limit is:
less positive than 0.00×10^{-5} Δk/k/°F.

2.2.2 The EOL MTC limit is:
less negative than or equal to -4.50×10^{-4} Δk/k/°F.

2.2.3 The 300 ppm Surveillance limit is:
less negative than or equal to -3.75×10^{-4} Δk/k/°F.

2.2.4 The 60 ppm Surveillance limit is:
less negative than or equal to -4.15×10^{-4} Δk/k/°F.

2.3 Shutdown Bank Insertion Limits (TS 3.1.5)

2.3.1 Each shutdown bank shall be withdrawn to a position as defined below:

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

2.4 Control Bank Insertion Limits (TS 3.1.6)

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

2.4.2 Each control bank shall be considered fully withdrawn from the core at ≥ 225 steps.

2.4.3 The control banks shall be operated in sequence by withdrawal of Bank A, Bank B, Bank C, and Bank D. The control banks shall be sequenced in reverse order upon insertion.

2.4.4 Each control bank not fully withdrawn from the core shall be operated with the following overlap as a function of full out position.

Full Out Position (steps)	Bank Overlap (steps)	Bank Difference (steps)
225	97	128
226	98	128
227	99	128
228	100	128
229	101	128
230	102	128
231	103	128

2.5 Heat Flux Hot Channel Factor – $F_Q(X,Y,Z)$ (TS 3.2.1)

2.5.1 F_Q^{RTP} = 2.62

2.5.2 K(Z) is provided in Figure 2

2.5.3 $NSLOPE^{AFD}$ = 1.17

2.5.4 $PSLOPE^{AFD}$ = 1.55

2.5.5 $NSLOPE^{f2(\Delta I)}$ = 1.41

2.5.6 $PSLOPE^{f2(\Delta I)}$ = 2.20

2.5.7 The appropriate factor for increase in $F_Q^M(X,Y,Z)$ for compliance with SR 3.2.1.2 and SR 3.2.1.3 is specified as follows:

For all cycle burnups, use 2.0%

2.5.8 ITS LCO 3.2.1 Required Action A.3 reduces the Overpower Delta T Trip setpoints (value of K_4) at least 1% (in ΔT span) for each 1% that $F_Q^C(X,Y,Z)$ exceeds its limit.

2.6 Nuclear Enthalpy Rise Hot Channel Factor - $F_{\Delta H}(X,Y)$ (TS 3.2.2)

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

2.6.2 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

2.6.3 **TRH = 0.0334 when $0.8 < P \leq 1.0$**

TRH = 0.0167 when $P \leq 0.8$

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

P = THERMAL POWER / RATED THERMAL POWER

2.6.4 The appropriate factor for increase in $F\Delta H^{M}$ (X,Y) for compliance with SR 3.2.2.1 and SR 3.2.2.2 is specified as follows:

For all cycle burnups, use 2.0%

2.6.5 ITS 3.2.2 Required Action A.4 reduces the Overtemperature Delta T setpoint (K_1 term in Table 3.3.1-1) by ≥ TRH multiplied times the $F_{\Delta H}$ minimum margin.

2.6.6 ITS 3.2.2 Required Action B.1 reduces the Overtemperature Delta T setpoint (K_1 term in Table 3.3.1-1) by ≥ TRH multiplied times the $f_1(\Delta I)$ minimum margin.

2.7 Axial Flux Difference – AFD (TS 3.2.3)

2.7.1 The AFD limits are specified in Figure 3

2.8 Reactor Trip System Instrumentation (TS 3.3.1)

2.8.1 Trip Reset Term [$f_1(\Delta I)$] for Overtemperature Delta-T Trip

The following parameters are required to specify the power level-dependent $f_1(\Delta I)$ trip reset term limits for Table 3.3.1-1 (function 6), Overtemperature Delta-T trip function:

2.8.1.1 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.

2.8.1.2 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.

2.8.1.3 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).

2.8.1.4 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).

2.8.2 Trip Reset Term [$f_2(\Delta I)$] for Overpower Delta-T Trip

The following parameters are required to specify the power level-dependent $f_2(\Delta I)$ trip reset term limits for Table 3.3.1-1 (function 7), Overpower Delta-T trip function:

2.8.2.1 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.

2.8.2.2 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.

2.8.2.3 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).

2.8.2.4 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).

2.9 Boron Concentration (TS 3.9.1)

2.9.1 The refueling boron concentration shall be ≥ 2058 ppm.

Table 1

COLR Methodology Topical Reports

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

   (Methodology for TS 3.1.1-SHUTDOWN MARGIN, 3.1.3-Moderator Temperature Coefficient, 3.9.1-Boron Concentration)

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

   (Methodology for TS 3.1.3-Moderator Temperature Coefficient)

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

   (Methodology for TS 3.3.1-Reactor Trip System Instrumentation [$f_1(\Delta I)$, $f_2(\Delta I)$ limits], 3.1.5-Shutdown Bank Insertion Limits, 3.1.6-Control Bank Insertion Limits, 3.2.1-Heat Flux Hot Channel Factor, 3.2.2-Nuclear Enthalpy Rise Hot Channel Factor, 3.2.3-AXIAL FLUX DIFFERENCE)

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

   (Methodology for TS 3.2.1-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 TS 3.2.1-Heat Flux Hot Channel Factor)

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

   (Methodology for TS 3.2.1-Heat Flux Hot Channel Factor)

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

   (Methodology for TS 3.2.1-Heat Flux Hot Channel Factor)

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

   (Methodology for TS 3.2.2-Nuclear Enthalpy Rise Hot Channel Factor, 3.3.1-Reactor Trip System Instrumentation [$f_1(\Delta I)$ limits])

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

   (Methodology for TS 3.2.2-Nuclear Enthalpy Rise Hot Channel Factor, 3.3.1-Reactor Trip System Instrumentation [$f_1(\Delta I)$ limits])

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

    (Methodology for TS 3.2.2-Nuclear Enthalpy Rise Hot Channel Factor, 3.3.1-Reactor Trip System Instrumentation [$f_1(\Delta I)$ limits])

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

    (Methodology for TS 3.2.2-Nuclear Enthalpy Rise Hot Channel Factor, 3.3.1-Reactor Trip System Instrumentation [$f_1(\Delta I)$ limits])

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

    (Methodology for TS 3.3.1-Reactor Trip System Instrumentation [$f_2(\Delta I)$ limits])

Table 2

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

Advanced W17 HTP™ Fuel (TS 3.2.2)

AXIAL(X,Y)	Elevation (ft)	MAP(X,Y,Z)	AXIAL(X,Y)	Elevation (ft)	MAP(X,Y,Z)
1.1	1	1.8764	1.4	1	2.7078
	2	1.8761		2	2.6846
	3	1.8758		3	2.6349
	4	1.8755		4	2.5983
	5	1.8750		5	2.5933
	6	1.8746		6	2.6505
	7	1.8732		7	2.6394
	8	1.8731		8	2.5563
	9	1.8729		9	2.4572
	10	1.8733		10	2.2668
	11	1.8320		11	2.1190
1.2	1	2.1327	1.5	1	2.8223
	2	2.1321		2	2.7591
	3	2.1315		3	2.6985
	4	2.1306		4	2.6542
	5	2.1295		5	2.6482
	6	2.1290		6	2.7162
	7	2.1286		7	2.7495
	8	2.1274		8	2.6507
	9	2.1254		9	2.5578
	10	2.0247		10	2.3791
	11	1.9355		11	2.2011
1.3	1	2.4093	1.6	1	2.8935
	2	2.4077		2	2.8252
	3	2.4068		3	2.7571
	4	2.4063		4	2.7055
	5	2.4050		5	2.6985
	6	2.4043		6	2.7776
	7	2.4034		7	2.8428
	8	2.3923		8	2.7401
	9	2.3053		9	2.6471
	10	2.1479		10	2.4862
	11	2.0305		11	2.2766

Table 2 (continued)

AXIAL(X,Y)	Elevation (ft)	MAP(X,Y,Z)
1.7	1	2.9545
	2	2.8786
	3	2.8103
	4	2.7522
	5	2.7457
	6	2.8308
	7	2.9230
	8	2.8209
	9	2.7287
	10	2.5873
	11	2.3478
1.8	1	2.9942
	2	2.9271
	3	2.8570
	4	2.7942
	5	2.7875
	6	2.8823
	7	2.9967
	8	2.8980
	9	2.8027
	10	2.6853
	11	2.4156
1.9	1	3.0267
	2	2.9676
	3	2.8960
	4	2.8345
	5	2.8256
	6	2.9291
	7	3.0655
	8	2.9714
	9	2.8741
	10	2.7780
	11	2.4797

AXIAL(X,Y)	Elevation (ft)	MAP(X,Y,Z)
>1.9	1	2.6005
	2	2.5794
	3	2.5536
	4	2.5118
	5	2.4500
	6	2.4520
	7	2.6494
	8	2.5446
	9	2.4371
	10	2.2595
	11	2.0819
2.1	1	2.7049
	2	2.6623
	3	2.6375
	4	2.5288
	5	2.5460
	6	2.5252
	7	2.7990
	8	2.6963
	9	2.5830
	10	2.4527
	11	2.1796
2.3	1	2.7475
	2	2.7275
	3	2.6457
	4	2.6125
	5	2.5774
	6	2.5707
	7	2.9015
	8	2.7773
	9	2.6757
	10	2.4740
	11	2.2722

Table 2 (continued)

AXIAL(X,Y)	Elevation (ft)	MAP(X,Y,Z)
2.5	1	2.8372
	2	2.7099
	3	2.7081
	4	2.6340
	5	2.6483
	6	2.6284
	7	3.0303
	8	2.8965
	9	2.8111
	10	2.7019
	11	2.3542

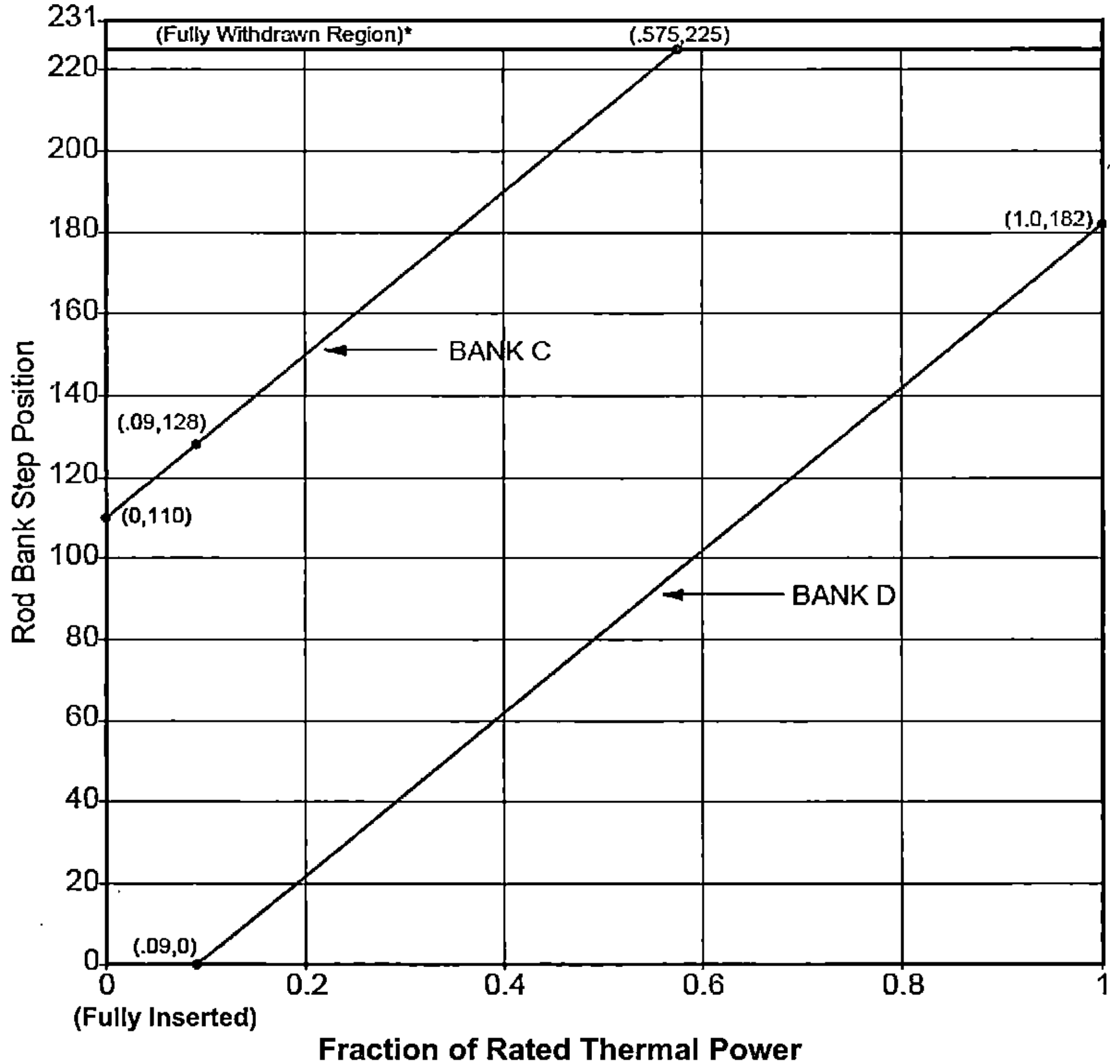

FIGURE 1

Rod Bank Insertion Limits Versus Thermal Power, Four Loop Operation (TS 3.1.6)

* 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.

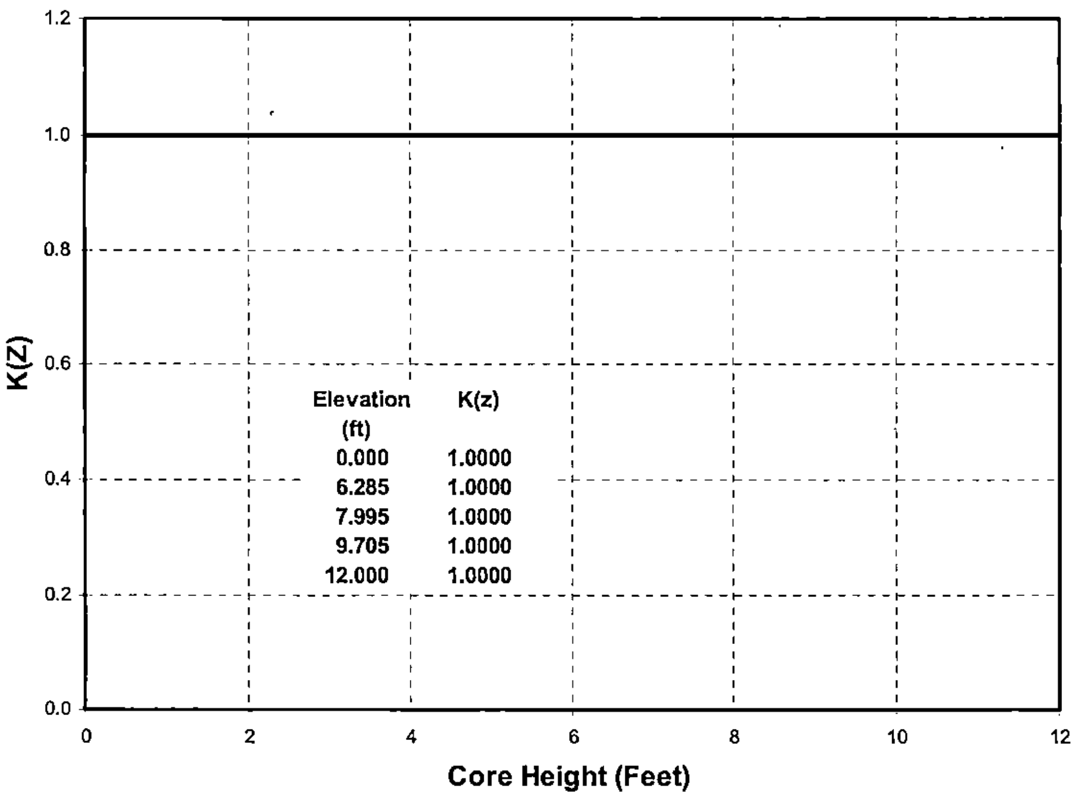

FIGURE 2

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

(TS 3.2.1)

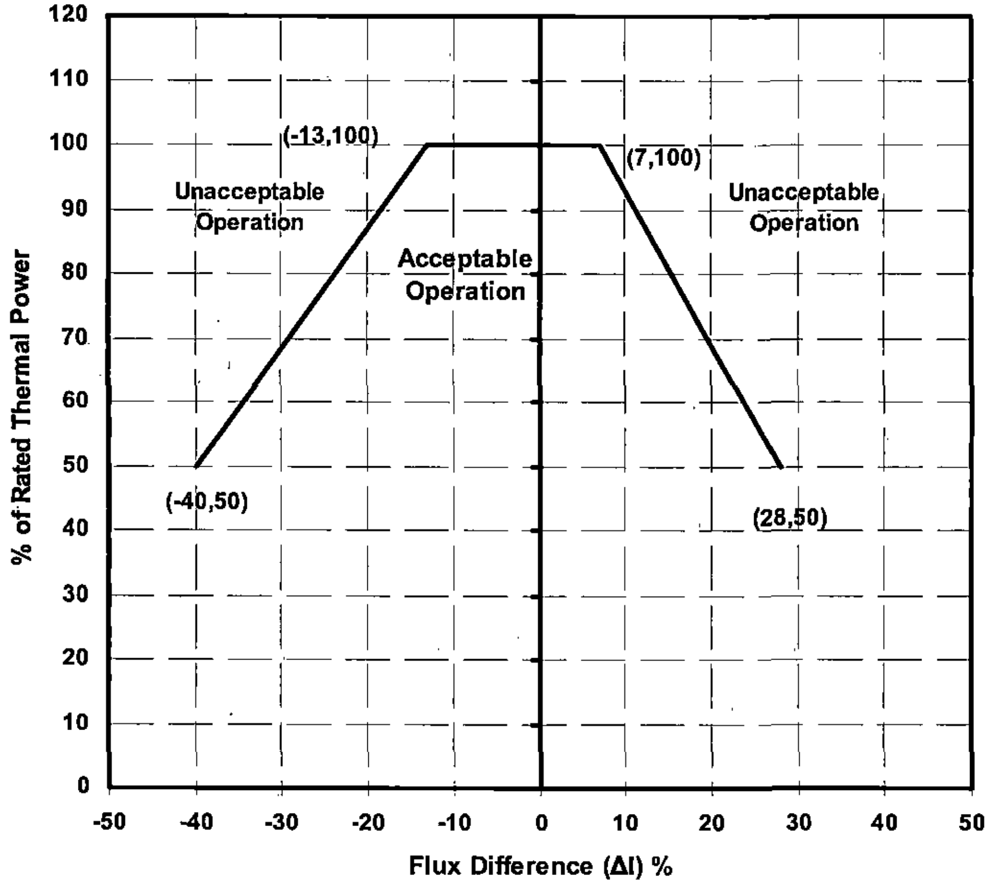

FIGURE 3

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

(TS 3.2.3)

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.