ENCLOSURE

# SEQUOYAH NUCLEAR PLANT UNIT 1 CYCLE 10

# CORE OPERATING LIMITS REPORT

REVISION 0

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# COLR FOR SEQUOYAH UNIT 1 CYCLE 10

## SEQUOYAH NUCLEAR PLANT UNIT 1, CYCLE 10

REVISION 0

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Revision 0

Pages affected ____

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## 1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Sequoyah Unit 1 Cycle 10 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 $f_1$ (ΔI) trip reset function for OTΔT Trip (QTNL, QTPL) and rates of trip setpoint decrease per percent ΔI (QTNS, QTPS)

TABLE 2.2.1 $f_2$ (ΔI) 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 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 BOL/ARO/HZP-MTC more positive than 0 Δk/k/°F (as-measured MTC limit), 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 $-4.5 \times 10^{-4}$ $\Delta k/k/^{\circ}F$.

2.1.2 The 300 ppm surveillance limit is:

The measured 300 ppm/ARO/RTP-MTC should be less negative than or equal to $-3.75 \times 10^{-4}$ $\Delta k/k/^{\circ}F$.

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2.2.1 The shutdown rods shall be withdrawn to a position as defined below: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 |
|---|---|
| $\leq$ 4,000 | $\geq$ 225 to $\leq$ 231 |
| > 4,000 to < 14,000 | $\geq$ 222 to $\leq$ 231 |
| $\geq$ 14,000 | $\geq$ 225 to $\leq$ 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 Figures 2a and 2b.

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:

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

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

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

2.5.1 $F_Q^{RTP}$ = 2.50 for Mark-BW fuel

$F_Q^{RTP}$ = 2.40 for Westinghouse fuel

2.5.2 K(Z) is provided in Figure 3 for Mark-BW fuel.

K(Z) is provided in Figure 4 for Westinghouse fuel.

**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 $PSLOPE^{AFD}$ = 1.68

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

2.5.5 $NSLOPE^{f_2(\Delta I)}$ = 1.38

where $NSLOPE^{f_2(\Delta I)}$ 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 $PSLOPE^{f_2(\Delta I)}$ = 2.40

where $PSLOPE^{f_2(\Delta I)}$ 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) data bases 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 cycle burnups ≤ 18569 MWd/MTU 2.0%

For cycle burnups > 18569 MWd/MTU 2.7%

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) ≤ MAP(X,Y,Z) / AXIAL(X,Y)

2.6.1 MAP(X,Y,Z) is provided in Table 1 for Mark-BW fuel and Westinghouse fuel.

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) ≤ BHNOM(X,Y)

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

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

$MAP^M$ is the value of MAP(X,Y,Z) obtained from Table 1 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) data bases 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 ≤ 1.0

RRH = 1.67 when P ≤ 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 = 0.034 when $0.8 < P \leq 1.0$

TRH = 0.017 when $P \leq 0.8$

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

2.6.7 All cycle burnups shall use a 2% increase in $F_{\Delta H}^{M}$ (X,Y) margin 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 $\Delta I$ 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 $\Delta I$ 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 $\Delta I$ exceeds its negative limit at rated thermal power (QPNL).

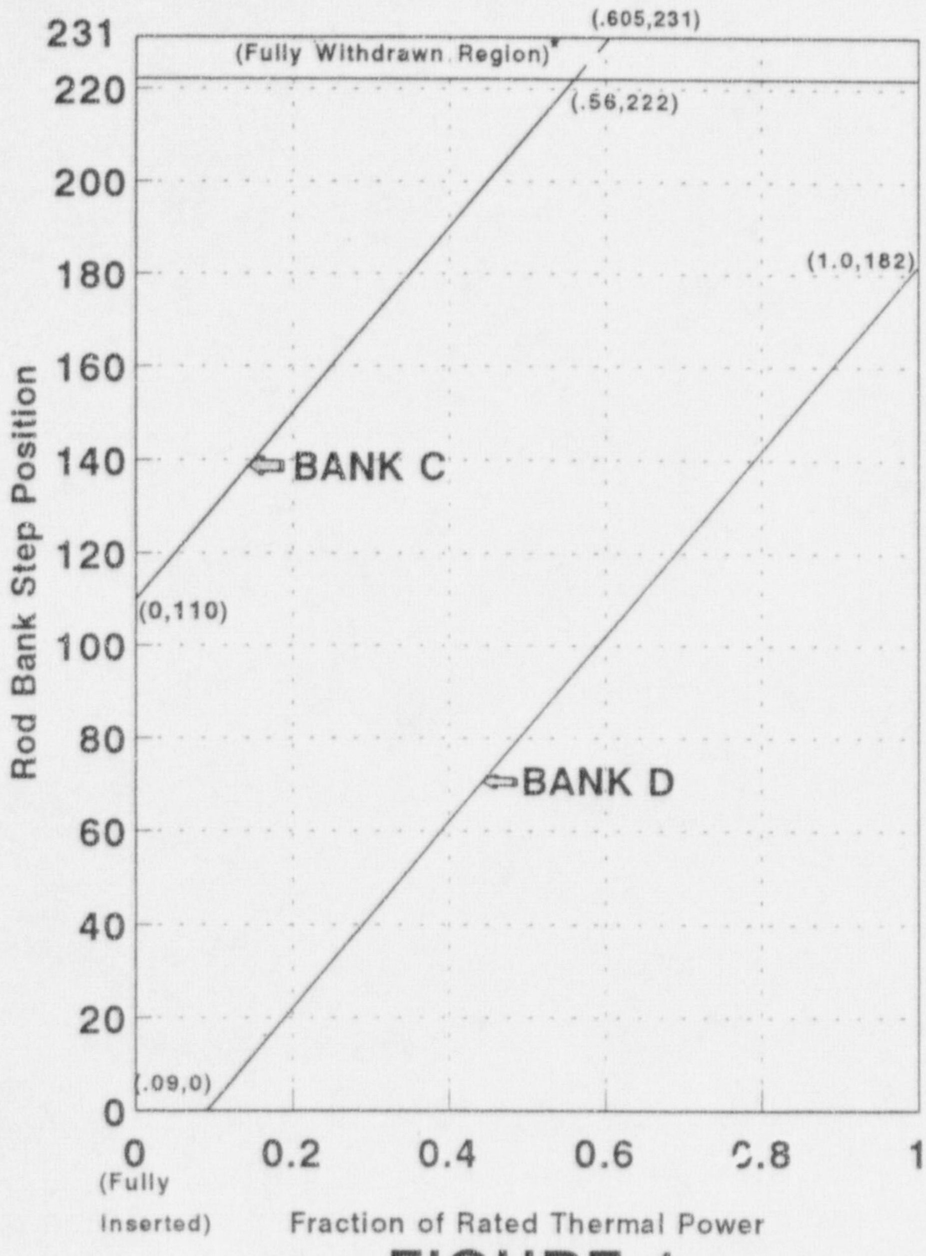
3.2.4 QPPS = 1.70%

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

Table 1

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

| Elevation (ft) | AXIAL (X,Y) | Mk-BW Fuel MAP (X,Y,Z) | W Fuel MAP (X,Y,Z) |
|---|---|---|---|
| 2 | 1.1 | 1.970 | 1.899 |
| 4 | | 1.966 | 1.897 |
| 6 | | 1.958 | 1.893 |
| 8 | | 1.945 | 1.881 |
| 10 | | 1.917 | 1.851 |
| 2 | 1.2 | 2.208 | 2.135 |
| 4 | | 2.197 | 2.131 |
| 6 | | 2.180 | 2.119 |
| 8 | | 2.150 | 2.092 |
| 10 | | 2.072 | 1.991 |
| 2 | 1.3 | 2.453 | 2.378 |
| 4 | | 2.434 | 2.372 |
| 6 | | 2.406 | 2.339 |
| 8 | | 2.315 | 2.219 |
| 10 | | 2.185 | 2.100 |
| 2 | 1.4 | 2.702 | 2.626 |
| 4 | | 2.672 | 2.570 |
| 6 | | 2.572 | 2.446 |
| 8 | | 2.429 | 2.320 |
| 10 | | 2.288 | 2.191 |
| 2 | 1.5 | 2.956 | 2.777 |
| 4 | | 2.826 | 2.664 |
| 6 | | 2.683 | 2.538 |
| 8 | | 2.529 | 2.405 |
| 10 | | 2.381 | 2.269 |
| 2 | 1.7 | 3.162 | 2.911 |
| 4 | | 3.007 | 2.804 |
| 6 | | 2.850 | 2.685 |
| 8 | | 2.690 | 2.542 |
| 10 | | 2.542 | 2.413 |
| 2 | 1.9 | 3.283 | 3.004 |
| 4 | | 3.133 | 2.916 |
| 6 | | 2.982 | 2.805 |
| 8 | | 2.821 | 2.659 |
| 10 | | 2.685 | 2.532 |



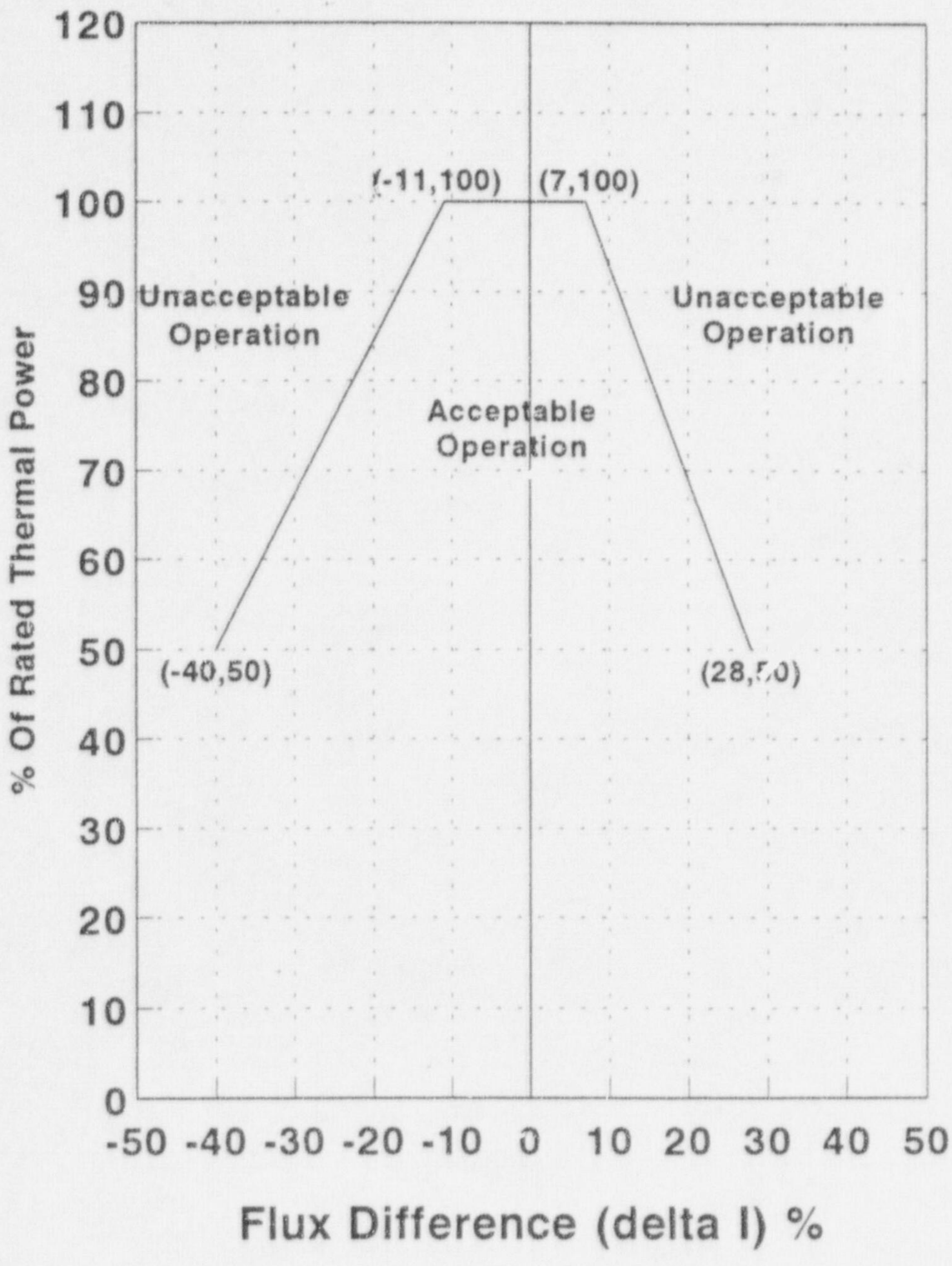

# FIGURE 1

## 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 ≥ 222 and ≤ 231 steps withdrawn, inclusive.

Fully withdrawn shall be the position as defined below,

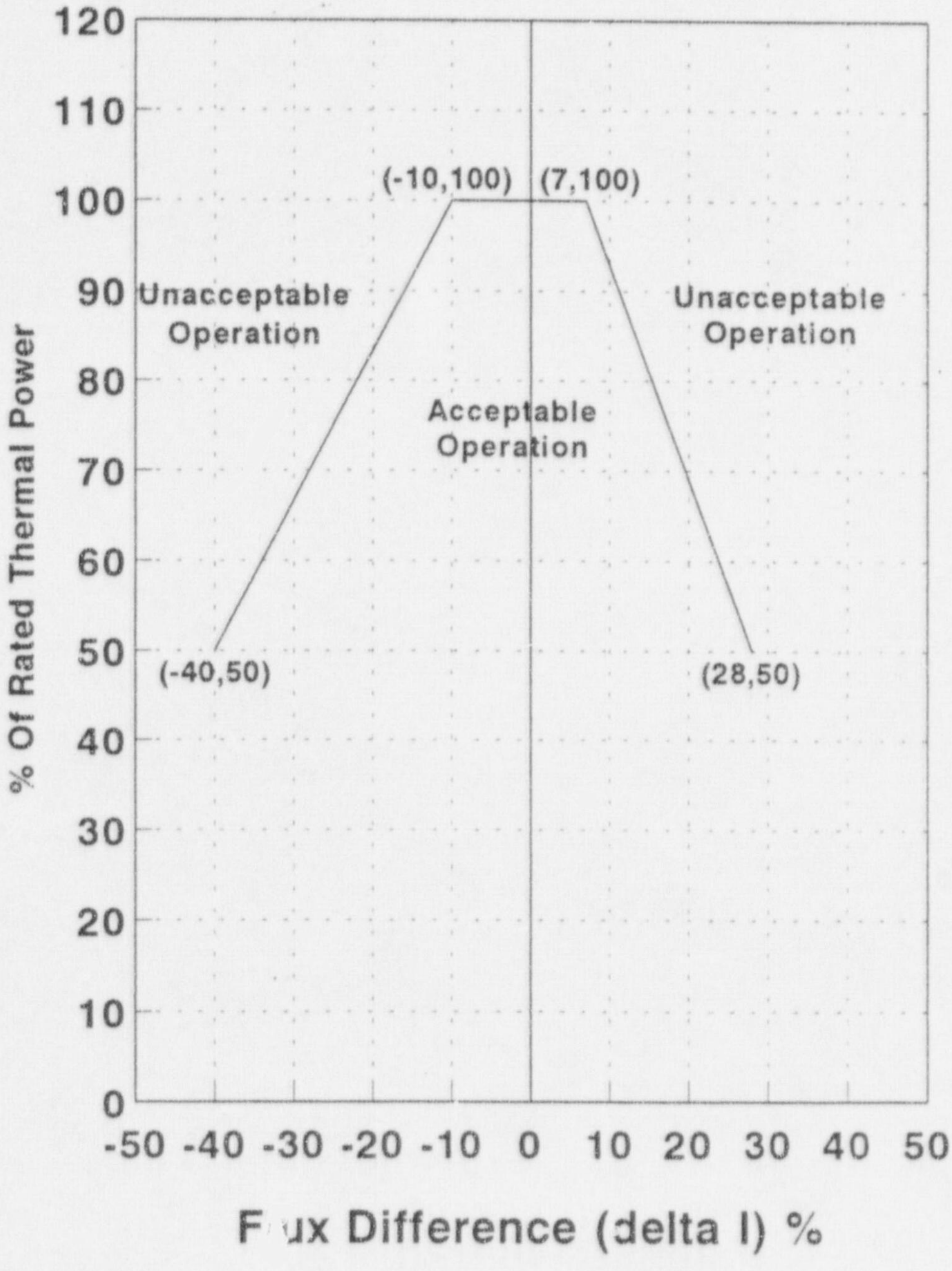
| Cycle Burnup (MWd/MTU) | Step Withdrawn |
|---|---|
| ≤ 4000 | ≥ 225 to ≤ 231 |
| > 4000 to < 14,000 | ≥ 222 to ≤ 231 |
| ≥ 14,000 | ≥ 225 to ≤ 231 |




# FIGURE 2a

## Axial Flux Difference Limits As A Function Of Rated Thermal Power

*For Operation From BOC to 10000+/-380 MWd/MTU*
*and*
*For Operation From 18569+/-380 MWd/MTU to EOC*




# FIGURE 2b

## Axial Flux Difference Limits As A Function Of Rated Thermal Power

*For Operation From 10000+/-380 MWd/MTU to 18569+/-380 MWd/MTU*

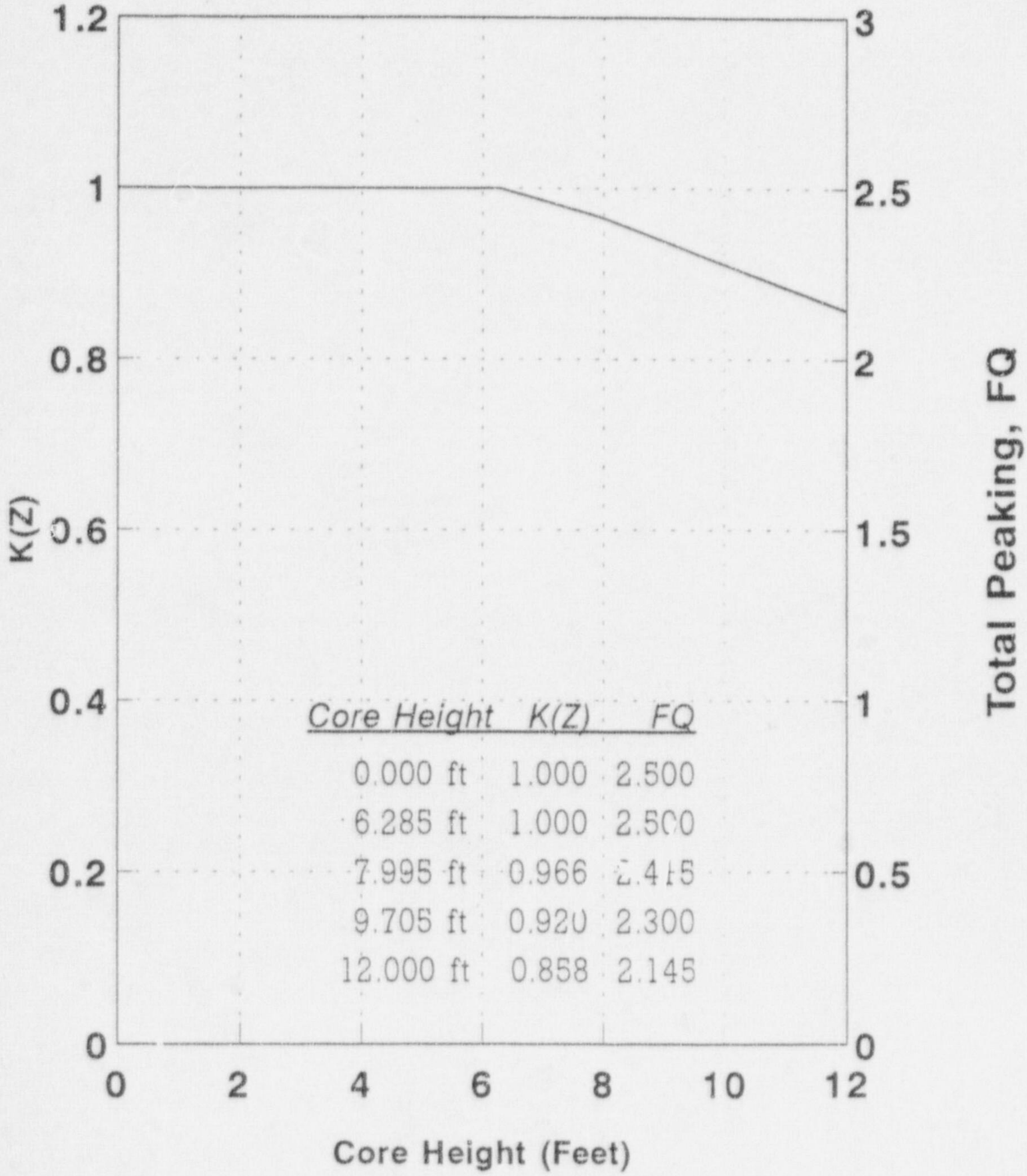
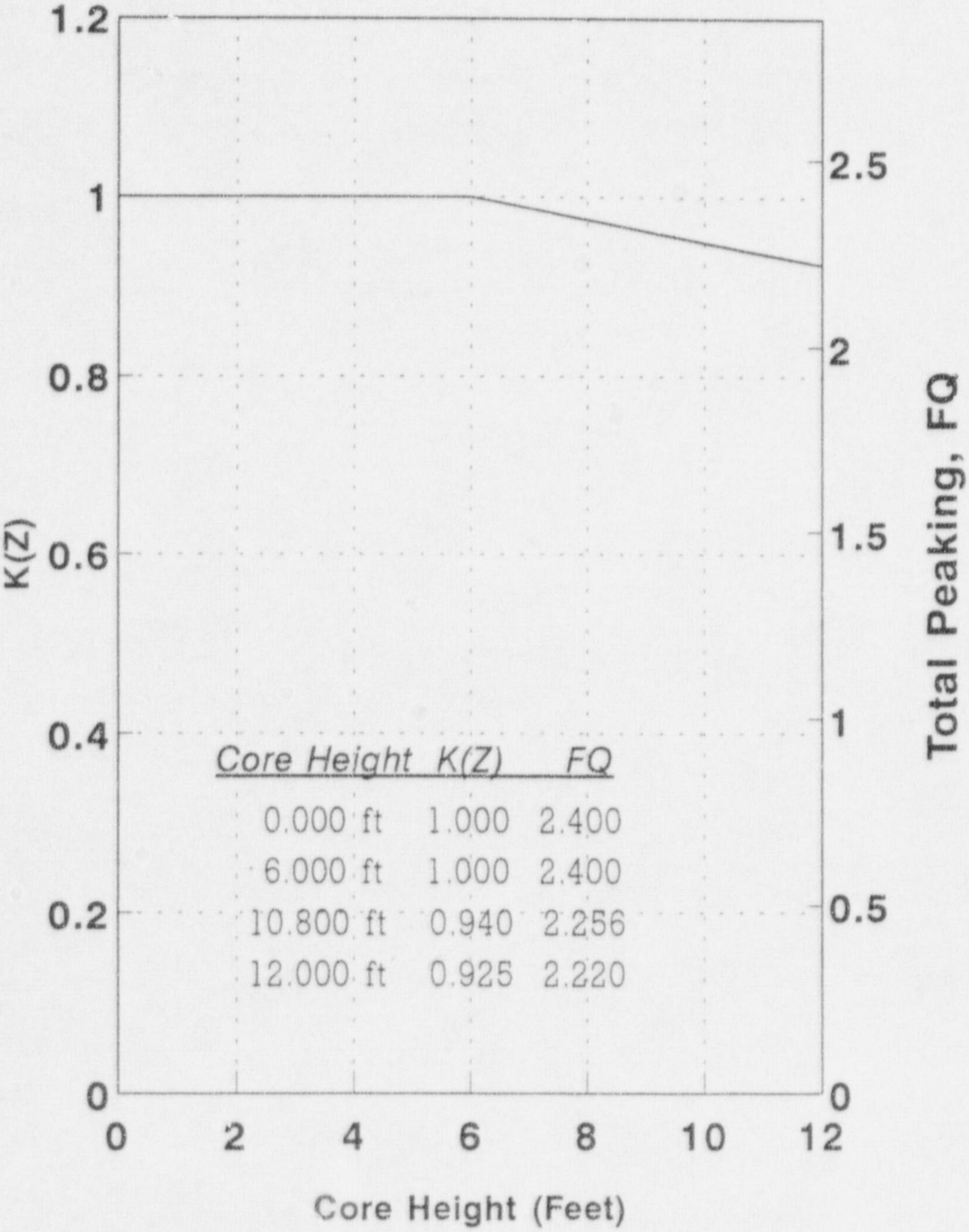



**FIGURE 3**

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

(Mark-BW Fuel)




| Core Height | K(Z) | FQ |
|---|---|---|
| 0.000 ft | 1.000 | 2.400 |
| 6.000 ft | 1.000 | 2.400 |
| 10.800 ft | 0.940 | 2.256 |
| 12.000 ft | 0.925 | 2.220 |

# FIGURE 4

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

(Westinghouse Fuel)