Catawba Unit 2 Cycle 7

Core Operating Limits Report

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Duke Power Company

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QA CONDITION 1

NOTE

This document does not contain information that affects the results and conclusions presented in the C2C7 Reload Report, Safety Analysis.

INSERTION SHEET

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pages 1-19, rev 2-4	pages 1-20, rev 5

REVISION LOG

Revision	Effective Date	Comment
Original Issue	15 February 1993	C2C6 COLR
Revision 1	14 April 1994	C2C6 COLR rev 1
Revision 2	19 May 1994	C2C7 COLR
Revision 3	24 October 1994	C2C7 COLR rev 1
Revision 4	12 April 1995	C2C7 COLR rev 2
Revision 5	28 September 1995	C2C7 COLR rev 3

1.0 Core Operating Limits Report

This Core Operating Limits Report (COLR) for Catawba Unit 2, Cycle 7 has been prepared in accordance with the requirements of Technical Specification 6.9.1.9.

The Technical Specifications affected by this report are listed below:

2.2.1	Reactor Trip System Instrumentation Setpoints
3/4.1.1.3	Moderator Temperature Coefficient
3/4.1.2.5	Borated Water Source - Shutdown
3/4.1.2.6	Borated Water Source - Operating
3/4.1.3.5	Shutdown Rod Insertion Limit
3/4.1.3.6	Control Rod Insertion Limit
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
3/4.3.3.11	Boron Dilution Mitigation System
3/4.5.1	Accumulators
3/4.5.4	Refueling Water Storage Tank
4.7.13.3	Standby Makeup Pump Water Supply - Boron Concentration
3/4.9.1	Refueling Operations - Boron Concentration
3/4.9.2	Instrumentation
3/4.9.12	Refueling Operations - Spent Fuel Pool Boron Concentration

1.1 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 NRC-approved methodologies specified in Technical Specification 6.9.1.9.

2.0 Reactor Trip System Instrumentation Setpoints (Specification 2.2.1)

2.1 Overtemperature ΔT Setpoint Parameter Values

Parameter	Value
Overtemperature ΔT reactor trip setpoint	$K_1 = 1.1953$
Overtemperature ΔT reactor trip heatup setpoint penalty coefficient	$K_2 = 0.03163/°F$
Overtemperature ΔT reactor trip depressurization setpoint penalty coefficient	$K_3 = 0.001414/psi$
Measured reactor vessel ΔT lead/lag time constants	$\tau_1 = 8$ sec. $\tau_2 = 3$ sec.
Measured ΔT lag time constant	$\tau_3 = 0$ sec.
Measured reactor vessel average temperature lead/lag time constants	$\tau_4 = 22$ sec. $\tau_5 = 4$ sec.
Measured reactor vessel average temperature lag time constant	$\tau_6 = 0$ sec.
$f_1(\Delta I)$ "positive" breakpoint	= 3.0% ΔI
$f_1(\Delta I)$ "negative" breakpoint	= -39.9% ΔI
$f_1(\Delta I)$ "positive" slope	= 1.525% ΔT_0/ % ΔI
$f_1(\Delta I)$ "negative" slope	= 3.910% ΔT_0/ % ΔI

2.2 Overpower ΔT Setpoint Parameter Values

Parameter	Value
Overpower ΔT reactor trip setpoint	$K_4 = 1.0819$
Overpower ΔT reactor trip heatup setpoint penalty coefficient (for $T > 590.8\ ^oF$)	$K_6 = 0.001291/^oF$
Overpower ΔT reactor trip heatup setpoint penalty coefficient (for $T \leq 590.8\ ^oF$)	$K_6 = 0.0/^oF$
Measured reactor vessel ΔT lead/lag time constants	$\tau_1 = 8$ sec. $\tau_2 = 3$ sec.
Measured ΔT lag time constant	$\tau_3 = 0$ sec.
Measured reactor vessel average temperature lag time constant	$\tau_6 = 0$ sec.
Measured reactor vessel average temperature rate-lag time constant	$\tau_7 = 10$ sec.
$f_2(\Delta I)$ "positive" breakpoint	$= 35.0\%\ \Delta I$
$f_2(\Delta I)$ "negative" breakpoint	$= -35.0\%\ \Delta I$
$f_2(\Delta I)$ "positive" slope	$= 7.0\%\ \Delta T_0/\ \%\ \Delta I$
$f_2(\Delta I)$ "negative" slope	$= 7.0\%\ \Delta T_0/\ \%\ \Delta I$

3.0 Moderator Temperature Coefficient (Specification 3/4.1.1.3)

3.0.1 The Moderator Temperature Coefficient (MTC) Limits are:

The MTC shall be less positive than the limits shown in Figure 1. The BOC, ARO, HZP MTC shall be less positive than $0.7 * 10^{-4}$ ΔK/K/°F.

The EOC, ARO, RTP MTC shall be less negative that $-4.1 * 10^{-4}$ ΔK/K/°F.

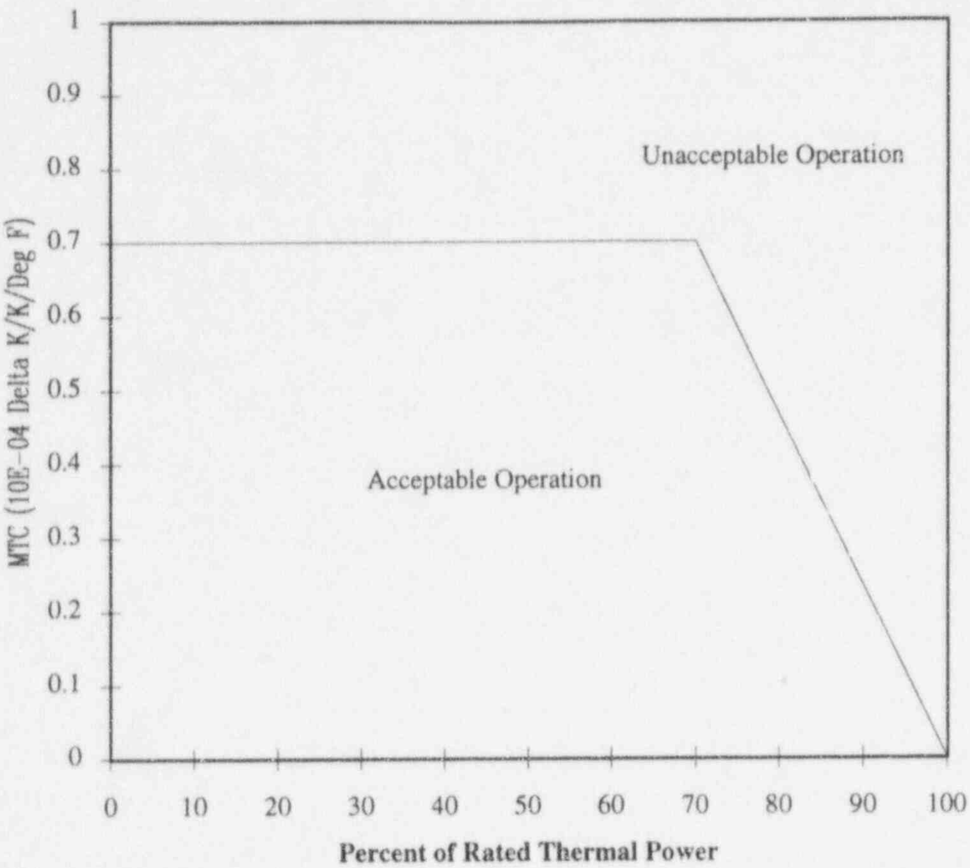
3.0.2 For the MTC Surveillance Limit:

The 300 PPM/ARO/RTP MTC should be less negative than or equal to $-3.2 * 10^{-4}$ ΔK/K/°F.

Where: BOC stands for Beginning of Cycle
EOC stands for End of Cycle
ARO stands for All Rods Out
HZP stands for Hot Zero (Thermal) Power
RTP stands for Rated Thermal Power

Figure 1

Moderator Temperature Coefficient Versus Percent of Rated Thermal Power



3.1 Borated Water Source - Shutdown (Specification 3/4.1.2.5)

3.1.1 Volume and boron concentrations for the Boric Acid Storage System and the Refueling Water Storage Tank (RWST) during modes 5 & 6:

Parameter	Limit
Boric Acid Storage System minimum boron concentration for LCO 3.1.2.5a	7,000 ppm
Boric Acid Storage System minimum contained water volume for LCO 3.1.2.5a	12,000 gallons
Boric Acid Storage System minimum water volume required to maintain SDM at 7,000 ppm	585 gallons
Refueling Water Storage Tank minimum boron concentration for LCO 3.1.2.5b	2,175 ppm
Refueling Water Storage Tank minimum contained water volume for LCO 3.1.2.5b	45,000 gallons
Refueling Water Storage Tank minimum water volume required to maintain SDM at 2,175 ppm	3,500 gallons

3.2 Borated Water Source - Operating (Specification 3/4.1.2.6)

3.2.1 Volume and boron concentrations for the Boric Acid Storage System and the Refueling Water Storage Tank (RWST) during modes 1, 2, 3, & 4:

Parameter	Limit
Boric Acid Storage System minimum boron concentration for LCO 3.1.2.6a	7,000 ppm
Boric Acid Storage System minimum contained water volume for LCO 3.1.2.6a	22,000 gallons
Boric Acid Storage System minimum water volume required to maintain SDM at 7,000 ppm	9,851 gallons
Refueling Water Storage Tank minimum boron concentration for LCO 3.1.2.6b	2,175 ppm
Refueling Water Storage Tank minimum contained water volume for LCO 3.1.2.6b	363,513 gallons
Refueling Water Storage Tank minimum water volume required to maintain SDM at 2,175 ppm	57,107 gallons

3.3 Shutdown Rod Insertion Limit (Specification 3/4.1.3.5)

3.3.1 The shutdown rods shall be withdrawn to at least 222 steps.

3.4 Control Rod Insertion Limits (Specification 3/4.1.3.6)

3.4.1 The control rod banks shall be limited to physical insertion as shown in Figure 2.

3.5 Axial Flux Difference (Specification 3/4.2.1)

3.5.1 The Axial Flux Difference (AFD) Limits are provided in Figure 3.

Figure 2

Control Rod Bank Insertion Limits Versus Percent of Rated Thermal Power

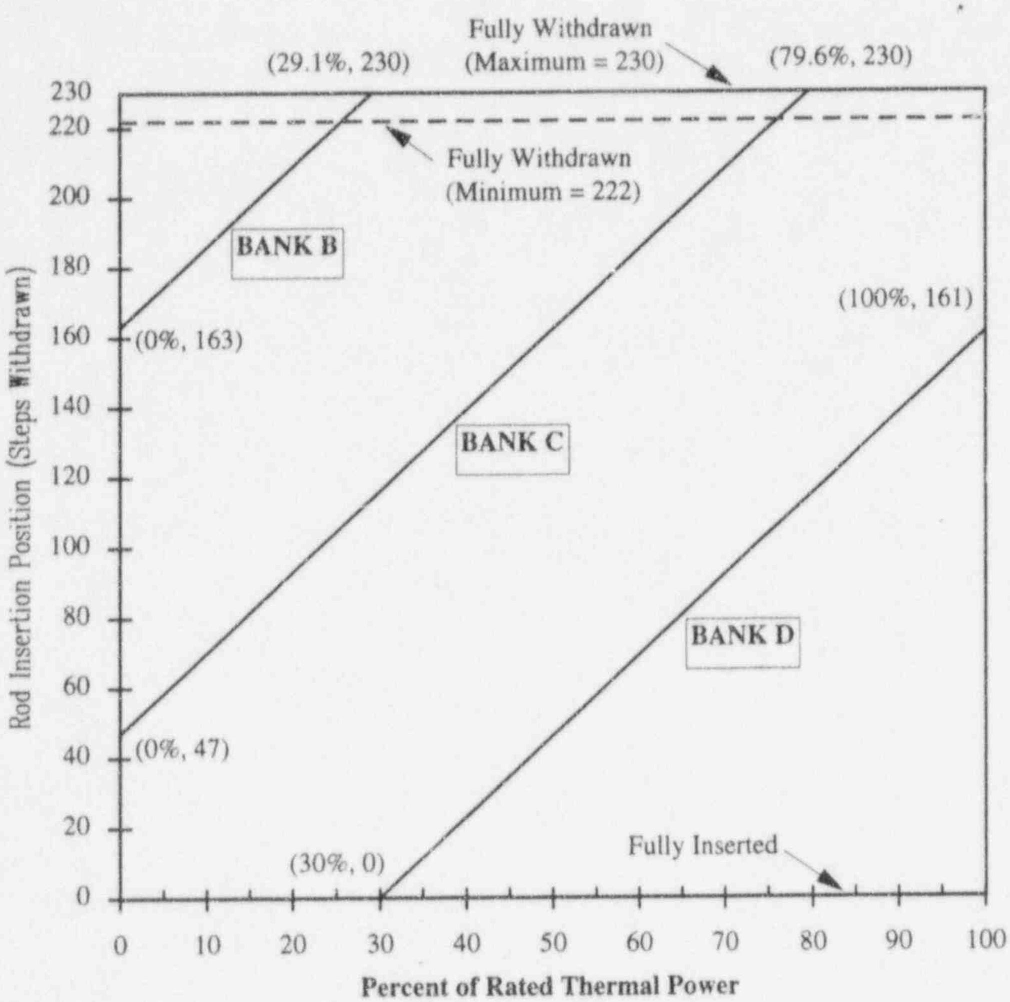
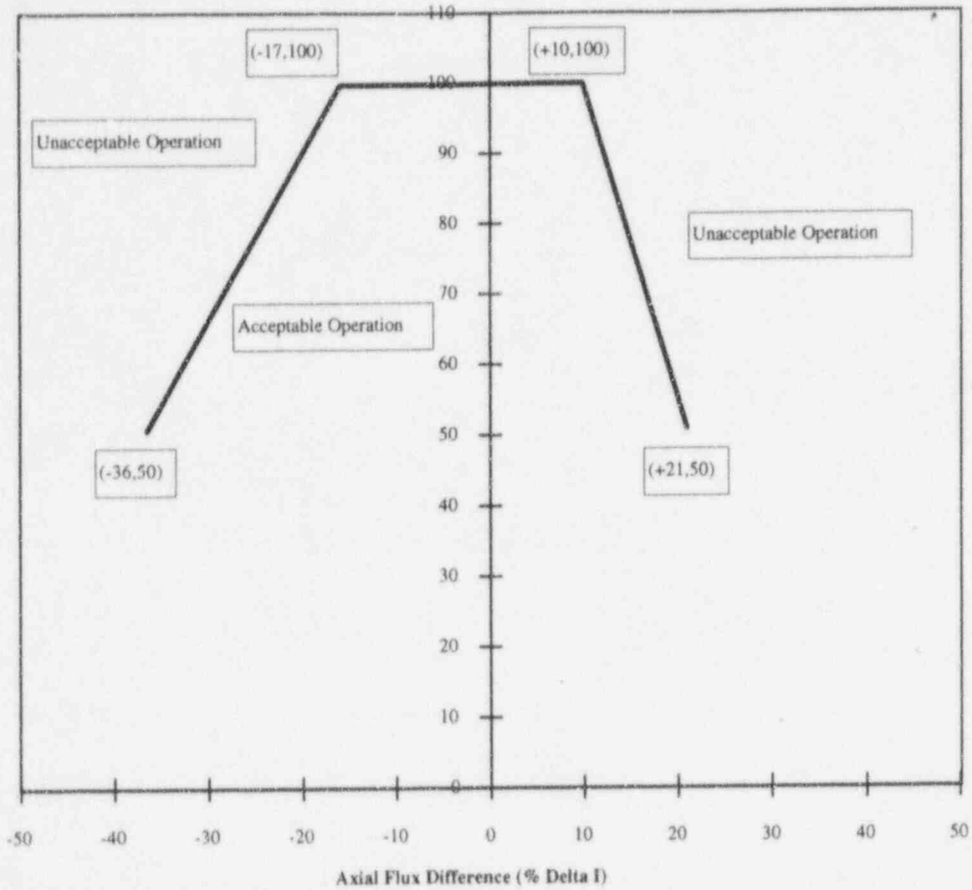


Figure 3

Percent of Rated Thermal Power Versus Axial Flux Difference Limits



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

3.6.1 $F_Q^{RTP} = 2.32$

3.6.2 K(Z) is provided in Figure 4 for Mark-BW fuel.

3.6.3 K(Z) is provided in Figure 5 for OFA fuel.

The following parameters are required for the Surveillance Requirements of T.S. 3/4.2.2:

3.6.4 $$[F_Q^L(X,Y,Z)]^{OP} = \frac{F_Q^D(X,Y,Z) * M_Q(X,Y,Z)}{UMT * MT * TILT}$$

where: $[F_Q^L(X,Y,Z)]^{OP}$ = cycle dependent maximum allowable design peaking factor which ensures that the $F_Q(X,Y,Z)$ limit will be preserved for operation within the LCO limits. $[F_Q^L(X,Y,Z)]^{OP}$ includes allowances for calculational and measurement uncertainties.

$F_Q^D(X,Y,Z)$ = the design power distribution for F_Q. $F_Q^D(X,Y,Z)$ is provided in Table 1, Appendix A for normal operation and Table 2, Appendix A for power escalation testing during initial startup.

$M_Q(X,Y,Z)$ = the margin remaining in core location X,Y,Z to the LOCA limit in the transient power distribution. $M_Q(X,Y,Z)$ is provided in Table 1, Appendix A for normal operation and Table 2, Appendix A for power escalation testing during initial startup.

UMT = Measurement Uncertainty, = 1.05.

MT = Engineering Hot Channel Factor, = 1.03.

TILT = Peaking penalty that accounts for allowable quadrant power tilt ratio of 1.02, = 1.035.

NOTE: $[F_Q^L(X,Y,Z)]^{OP}$ is the parameter identified as $F_Q^{MAX}(X,Y,Z)$ in DPC-NE-2011PA.

3.6.5 $[F_Q^L(X,Y,Z)]^{RPS} = \dfrac{F_Q^D(X,Y,Z) * M_C(X,Y,Z)}{UMT * MT * TILT}$

where: $[F_Q^L(X,Y,Z)]^{RPS}$ = cycle dependent maximum allowable design peaking factor which ensures that the centerline fuel melt limit will be preserved for all operation. $[F_Q^L(X,Y,Z)]^{RPS}$ includes allowances for calculational and measurement uncertainties.

$F_Q^D(X,Y,Z)$ = the design power distributions for F_Q. $F_Q^D(X,Y,Z)$ is provided in Table 1, Appendix A for normal operation and Table 2, Appendix A for power escalation testing during initial startup.

$M_C(X,Y,Z)$ = the margin remaining to the CFM limit in core location X,Y,Z from the transient power distribution. $M_C(X,Y,Z)$ calculations parallel the $M_Q(X,Y,Z)$ calculations described in DPC-NE-2011PA, except that the LOCA limit is replaced with the CFM limit. $M_C(X,Y,Z)$ is provided in Table 3, Appendix A for normal operation and Table 4, Appendix A for power escalation testing during initial startup.

UMT = Measurement Uncertainty, = 1.05.

MT = Engineering Hot Channel Factor, = 1.03.

TILT = Peaking penalty that accounts for allowable quadrant power tilt ratio of 1.02, = 1.035.

NOTE: $[F_Q^L(X,Y,Z)]^{RPS}$ is similar to the parameter identified as $F_Q^{MAX}(X,Y,Z)$ in DPC-NE-2011PA except that $M_C(X,Y,Z)$ replaces $M_Q(X,Y,Z)$.

3.6.6 KSLOPE = adjustment to the K_1 value from OTΔT required to compensate for each 1% that $[F_Q^L(X,Y,Z)]^{RPS}$ exceeds it limit, = 0.0725

Figure 4

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

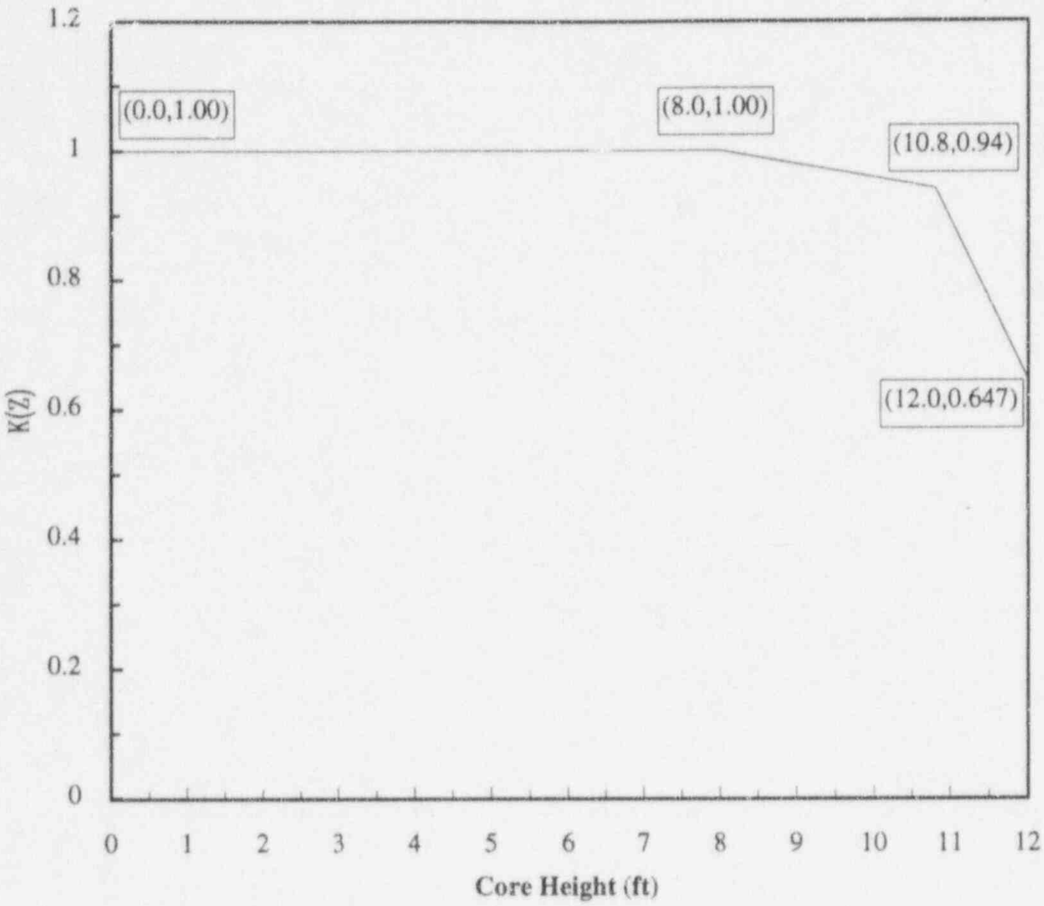
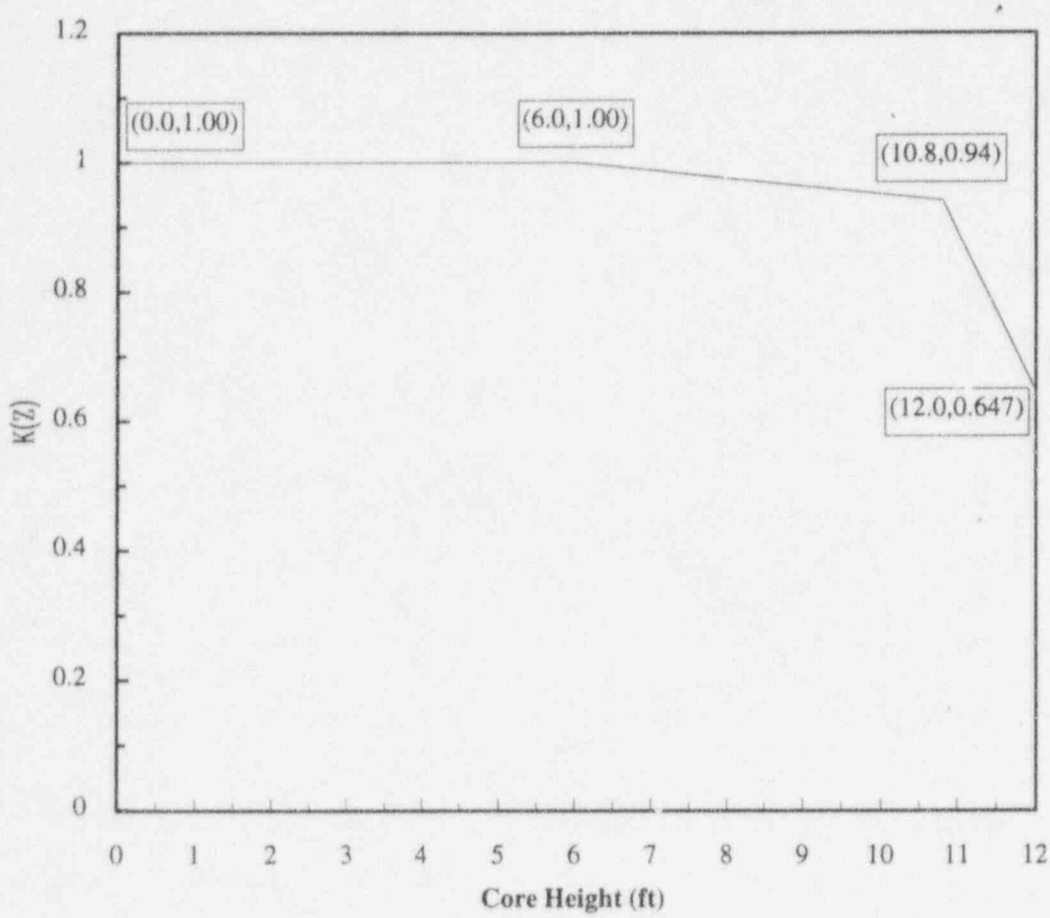


Figure 5

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



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

The following parameters are required for the LCO Requirements of T.S. 3/4.2.3:

3.7.1 $$[F^L_{\Delta H}(X,Y)]^{LCO} = MARP(X,Y) * \left[1.0 + \frac{1}{RRH} * (1.0 - P)\right]$$

where: MARP(X,Y) = Catawba 2 Cycle 7 Operating Limit Maximum Allowable Radial Peaks. (MARP(X,Y)) is provided in Table 7, Appendix A for non-axial blanket fuel and in Table 8, Appendix A for axial blanket fuel.

$$P = \frac{\text{Thermal Power}}{\text{Rated Thermal Power}}$$

RRH is defined in section 3.7.3

The following parameters are required for the Surveillance Requirements of T.S. 3/4.2.3:

3.7.2 $$[F^L_{\Delta H}(X,Y)]SURV = \frac{F^D_{\Delta H}(X,Y) \times M_{\Delta H}(X,Y)}{UMR \times TILT}$$

where: $[F^L_{\Delta H}(X,Y)]^{SURV}$ = cycle dependent maximum allowable design peaking factor which ensures that the $F_{\Delta H}(X,Y)$ limit will be preserved for operation within the LCO limits. $[F^L_{\Delta H}(X,Y)]^{SURV}$ includes allowances for calculational and measurement uncertainties.

$F^D_{\Delta H}(X,Y)$ = the design power distribution for $F_{\Delta H}$. $F^D_{\Delta H}(X,Y)$ is provided in Table 5, Appendix A for normal operation and Table 6, Appendix A for power escalation testing during initial startup.

$M_{\Delta H}(X,Y)$ = the margin remaining in core location X,Y to the Operational DNB limit in the transient power distribution. $M_{\Delta H}(X,Y)$ is provided in Table 5, Appendix A for normal operation and Table 6, Appendix A for power escalation testing during initial startup.

UMR = Uncertainty value for measured radial peaks, = 1.04.

TILT = Peaking penalty that accounts for allowable quadrant power tilt ratio of 1.02, = 1.035.

NOTE: $[F_{\Delta H}^{L}(X,Y)]^{SURV}$ is the parameter identified as $F_{\Delta H}^{MAX}(X,Y)$ in DPC-NE-2011PA.

3.7.3 RRH = Thermal Power reduction required to compensate for each 1% that $F_{\Delta H}(X,Y)$ exceeds its limit, = 3.34.

3.7.4 TRH = Reduction in OTΔT K_1 setpoint required to compensate for each 1% that $F_{\Delta H}(X,Y)$ exceeds its limit, = 0.04

3.8 Boron Dilution Mitigation System (Specification 3/4.3.3.11)

3.8.1 Reactor Water Makeup Pump flowrate limits:

Applicable Mode	Limit
Mode 3 or 4	≤ 150 gpm
Mode 5	≤ 70 gpm

3.9 Accumulators (Specification 3/4.5.1)

3.9.1 Boron concentration limits during modes 1, 2 and 3:

Parameter	Limits
Cold Leg Accumulator minimum boron concentration for LCO 3.5.1c	2,000 ppm
Cold Leg Accumulator maximum boron concentration for LCO 3.5.1c	2,275 ppm
Minimum Cold Leg Accumulator boron concentration required to ensure post-LOCA subcriticality	1,900 ppm

3.10 Refueling Water Storage Tank (Specification 3/4.5.4)

3.10.1 Boron concentration limits during modes 1, 2, 3 and 4:

Parameter	Limits
Refueling Water Storage Tank minimum boron concentration for LCO 3.5.4b	2,175 ppm
Refueling Water Storage Tank maximum boron concentration for LCO 3.5.4b	2,275 ppm

3.11 Instrumentation (Specification 3/4.9.2)

3.11.1 Reactor Makeup Water Pump Flowrate Limit:

Applicable Mode	Limits
Mode 6	$\leq$ 70 gpm

3.12 Refueling Operations - Boron Concentration (Specification 3/4.9.1)

3.12.1 Minimum boron concentrations for the filled portions of the Reactor Coolant System and the refueling canal. Applicable for mode 6 with the reactor vessel head closure bolts less than fully tensioned, or with the head removed.

Parameter	Limit
Refueling boron concentration for the filled portions of the Reactor Coolant System and the refueling canal, for LCO 3.9.1.b.	2175 ppm

3.13 Standby Makeup Pump Water Supply - Boron Concentration (Specification 4.7.13.3)

3.13.1 Minimum boron concentration limit for the spent fuel pool, or a contained borated water volume (meeting additional requirements of surveillance 4.7.13.3.a.2). Applicable for modes 1, 2, and 3.

Parameter	Limits
Spent fuel pool minimum boron concentration, for surveillance 4.7.13.3.a.1	2175 ppm
Contained borated water volume, for surveillance 4.7.13.3.a.2	2175 ppm

3.14 Refueling Operations - Spent Fuel Pool Boron Concentration (Specification 3/4.9.12)

3.14.1 Minimum boron concentration limits for spent fuel pool. Applicable when fuel is stored in the spent fuel pool.

Parameter	Limit
Spent fuel pool minimum boron concentration for LCO 3.9.12	2,175 ppm

* - Values provided as Tables in the Appendix to this document were generated in the C2C07 Maneuvering Analysis calculational file (CNC-1553.05-00-0177). The CNS Reactor Engineering Group will control this information via computer file(s) and should be contacted if there is a need to access this information.