Catawba Unit 1 Cycle 9

Core Operating Limits Report

September 1995

Duke Power Company

		Date
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QA Condition 1

The contents of this document have been reviewed to verify that no material herein either directly or indirectly changes the results and conclusions presented in the 10CFR50.59 Catawba 1 Cycle 9 Reload Safety Evaluation (CNC-1552.08-00-0236).

INSERTION SHEET FOR REVISION 8

Remove	Insert
Pages 1-19, rev 6-7	Pages 1-20, rev 8

REVISION LOG

Revision	Effective Date	Comment
Original Issue	September 8, 1992	C1C07 COLR
Revision 1	October 10, 1992	C1C07 COLR rev 1
Revision 2	December 1, 1993	C1C08 COLR
Revision 3	April 14, 1994	C1C08 COLR rev 1
Revision 4	October 24, 1994	C1C08 COLR rev 2
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Revision 6	February 15, 1995	C1C09 COLR
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Revision 8	September 28, 1995	C1C09 COLR rev 2

1.0 Core Operating Limits Report

This Core Operating Limits Report (COLR) 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:

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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)

2.0.1 Overtemperature ΔT Setpoint Parameter Values

Parameter	Value
Overtemperature ΔT reactor trip setpoint	$K_1 = 1.1954$
Overtemperature ΔT reactor trip heatup setpoint penalty coefficient	$K_2 = 0.03371/^{o}F$
Overtemperature ΔT reactor trip depressurization setpoint penalty coefficient	$K_3 = 0.001529/psi$
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.
Measure reactor vessel average temperature lag time constant	$\tau_6 = 0$ sec.
$f_1(\Delta I)$ "positive" breakpoint	= 8.0 %ΔI
$f_1(\Delta I)$ "negative" breakpoint	= -42.0 %ΔI
$f_1(\Delta I)$ "positive" slope	= 1.640 $\%\Delta T_0/\ \%\Delta I$
$f_1(\Delta I)$ "negative" slope	= 3.672 $\%\Delta T_0/\ \%\Delta I$

2.0.2 Overpower ΔT Setpoint Parameter Values

Parameter	Value
Overpower ΔT reactor trip setpoint	$K_4 = 1.0855$
Overpower ΔT reactor trip heatup setpoint penalty coefficient (for T > 590.8 °F)	$K_6 = 0.001262/^{o}F$
Overpower ΔT reactor trip heatup setpoint penalty coefficient (for T $\leq$ 590.8 °F)	$K_6 = 0.0/^{o}F$
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.
Measure reactor vessel average temperature lag time constant	$\tau_6 = 0$ sec.
Measure reactor vessel average temperature rate-lag time constant	$\tau_7 \geq 10$ sec.
$f_2(\Delta I)$ "positive" breakpoint	= 35.0 %ΔI
$f_2(\Delta I)$ "negative" breakpoint	= -35.0 %ΔI
$f_2(\Delta I)$ "positive" slope	= 7.0 $\%\Delta T_0/$ %ΔI
$f_2(\Delta I)$ "negative" slope	= 7.0 $\%\Delta T_0/$ %ΔI

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 0.7E-04 ΔK/K/°F.

The EOC, ARO, RTP MTC shall be less negative than -4.1E-04 ΔK/K/°F.

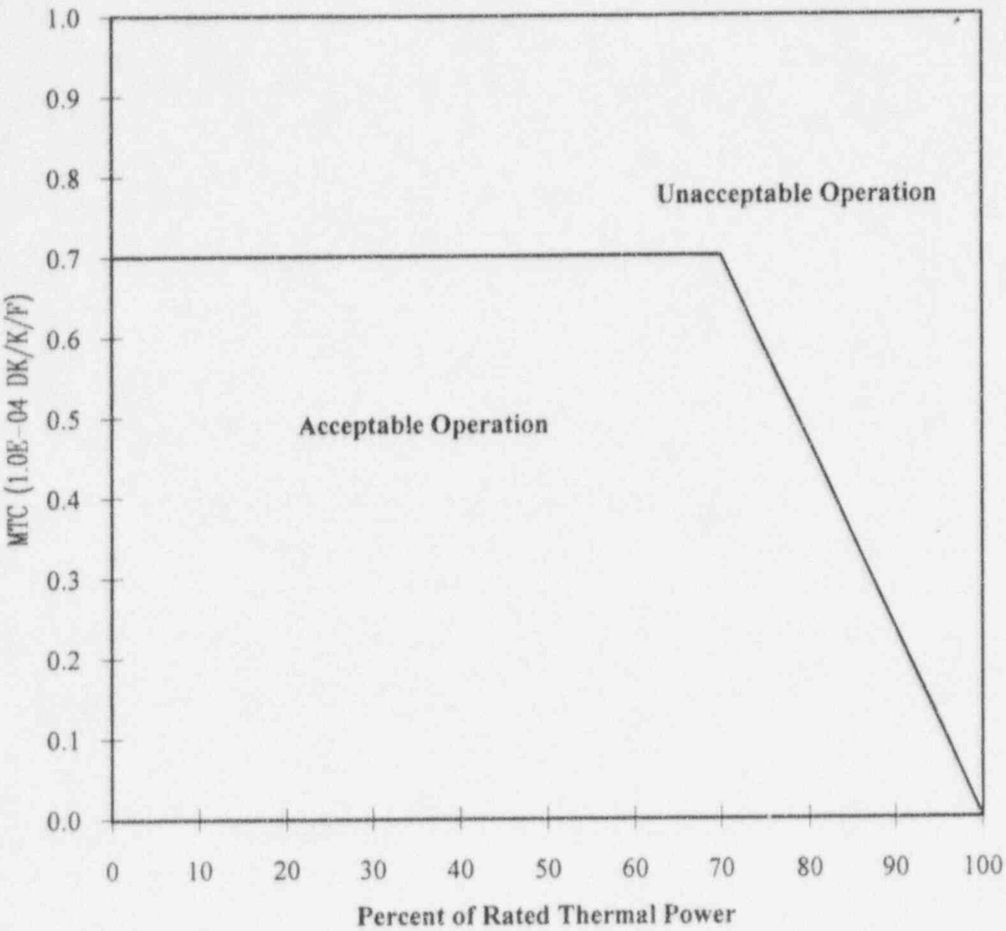
3.0.2 The MTC Surveillance Limit is:

The 300 PPM/ARO/ RTP MTC should be less negative than or equal to -3.2E-04 ΔK/K/°F.

where.
BOC = Beginning of Cycle
EOC = End of Cycle
ARO = All Rods Out
HZP = Hot Zero Thermal Power
RTP = Rated Thermal Power

Figure 1

Moderator Temperature Coefficient Versus Power Level



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 and 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	2,475 ppm
Refueling Water Storage Tank minimum contained borated water volume for LCO 3.1.2.5b	45,000 gallons
Refueling Water Storage Tank minimum water volume required to maintain SDM at 2,475 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, and 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	2,475 ppm
Refueling Water Storage Tank minimum contained borated water volume for LCO 3.1.2.6b	98,607 gallons
Refueling Water Storage Tank minimum water volume required to maintain SDM at 2,475 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 Rated Thermal Power

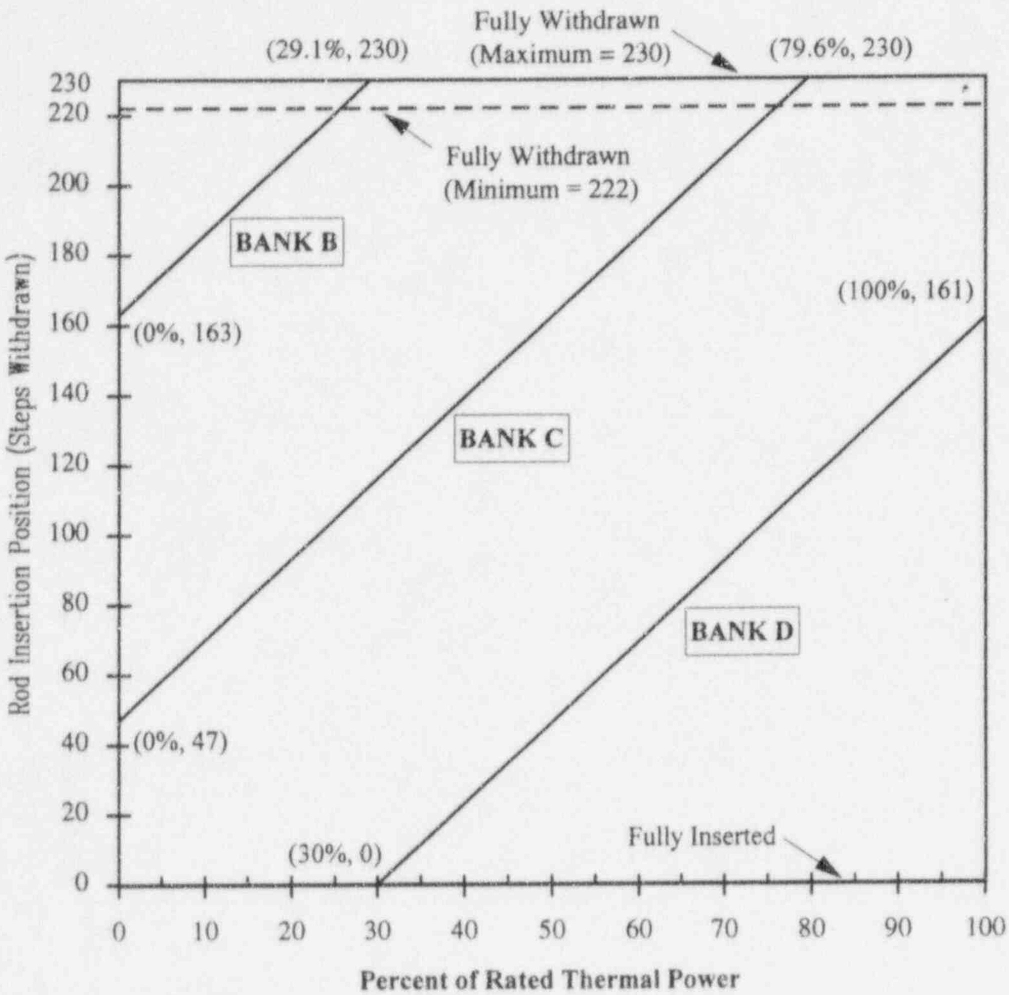
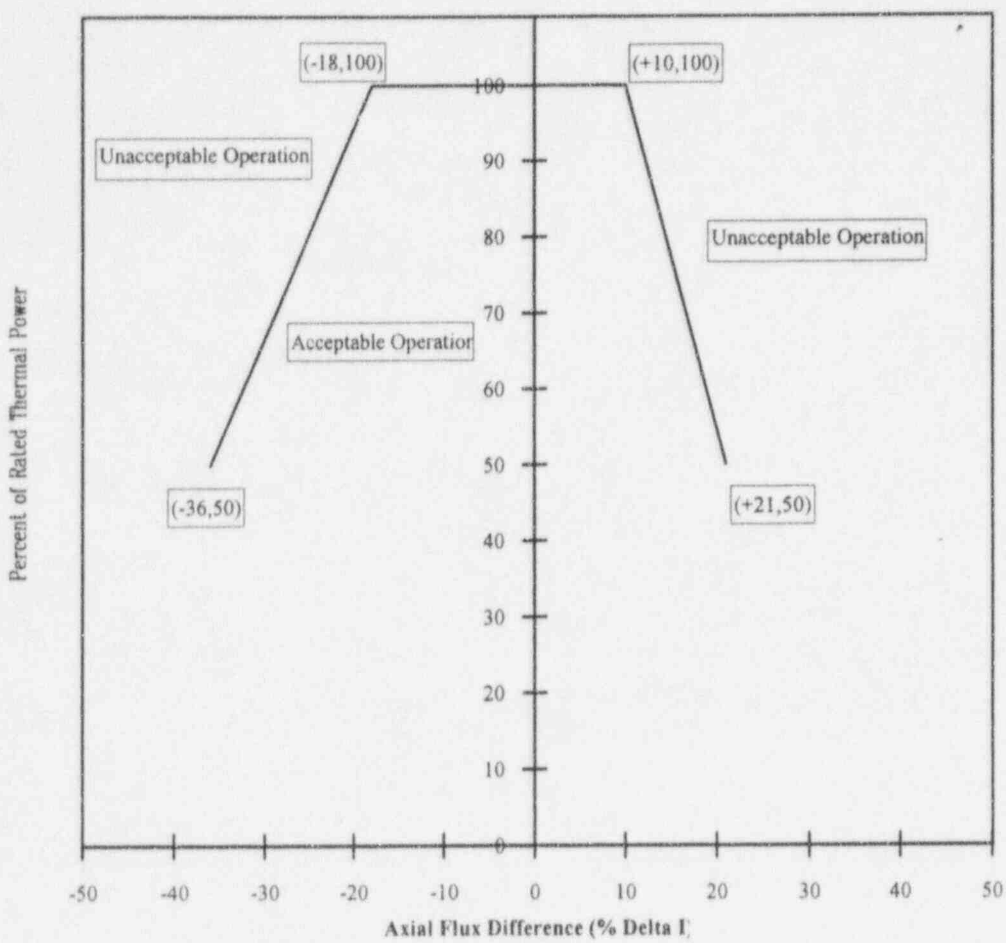


Figure 3

Axial Flux Difference Limits Versus Percent of Rated Thermal Power



3.6 Heat Flux Hot Channel Factor, FQ(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 MkBW fuel.

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

3.6.3 $[F_Q^L(X,Y,Z)]^{OP} = \dfrac{F_Q^D(X,Y,Z) * M_Q(X,Y,Z)}{UMT * MT * TILT}$

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 $[F_Q^L(X,Y,Z)]^{OP}$. $[F_Q^L(X,Y,Z)]^{OP}$ includes allowances for calculational and measurement uncertainties.

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

$M_Q(X,Y,Z)$ = 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 operating conditions and in Table 2, Appendix A for power escalation testing during initial startup operations.

UMT = Measurement Uncertainty (UMT = 1.05)

MT = Engineering Hot Channel Factor (MT = 1.03)

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

3.6.4 $[F_Q^L(X,Y,Z)]RPS = \dfrac{F_Q^D(X,Y,Z) * M_C(X,Y,Z)}{UMT * MT * TILT}$

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 operation within the LCO limits. $[F_Q^L(X,Y,Z)]^{RPS}$ includes allowances for calculational and measurement uncertainties.

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

$M_C(X,Y,Z)$ = 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 operating conditions and in Table 4, Appendix A for power escalation testing during initial startup operations.

UMT = Measurement Uncertainty (UMT = 1.05)

MT = Engineering Hot Channel Factor (MT = 1.03)

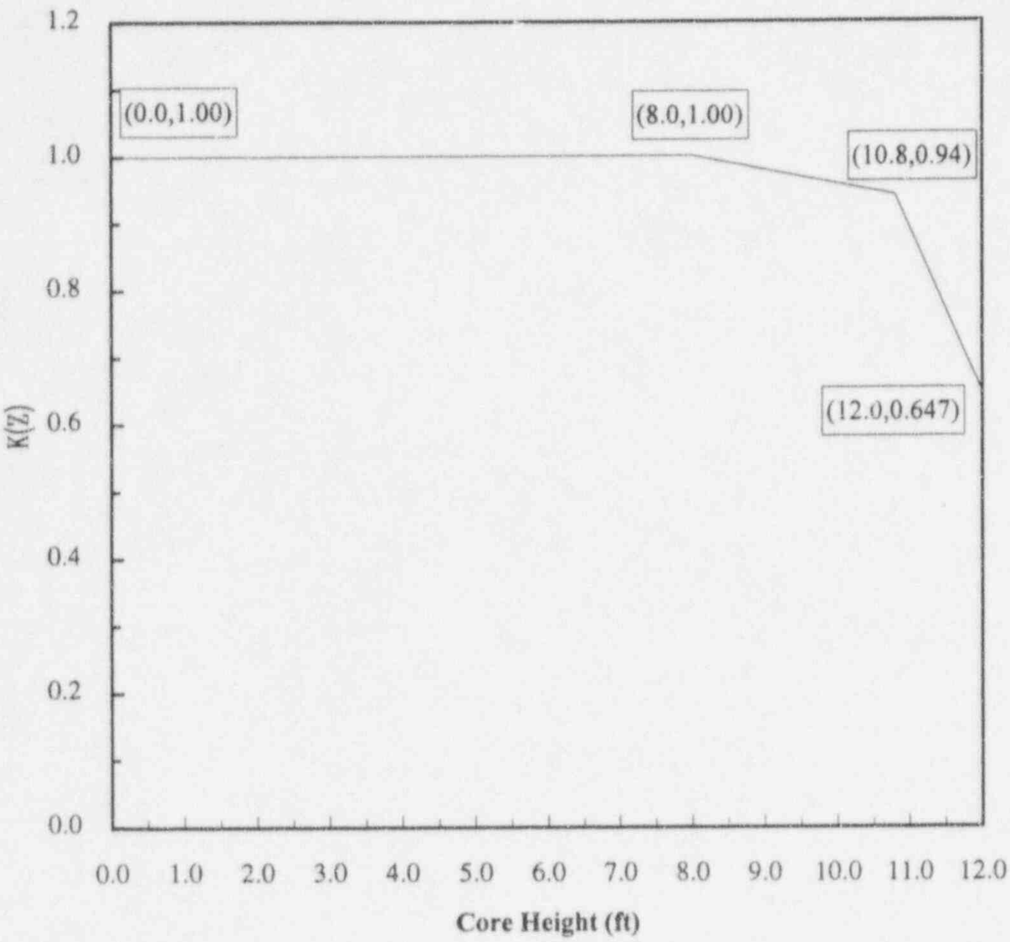
TILT = Peaking penalty that accounts for allowable quadrant power tilt ratio of 1.02. (TILT = 1.035)

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

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

Figure 4

K(Z), Normalized $F_Q(X,Y,Z)$ as a Function of Core Height for MkBW 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 $[F^{L}_{\Delta H}(X,Y)]^{LCO} = \text{MARP}(X,Y) * \left[1.0 + \frac{1}{\text{RRH}} * (1.0 - P)\right]$

where:

MARP(X,Y) = Cycle specific Operating Limit Maximum Allowable Radial Peaks. MARP(X,Y) radial peaking limits, provided in Table 7, Appendix A.

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

RRH = Defined in section 3.7.3

The following parameters are required for core monitoring per the Surveillance requirements of T.S. 3/4.2.3.

3.7.2 $[F^{L}_{\Delta H}(X,Y)]\text{SURV} = \frac{F^{D}_{\Delta H}(X,Y) \times M_{\Delta H}(X,Y)}{\text{UMR} \times \text{TILT}}$

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 uncertainty.

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

$M_{DH}(X,Y)$ = Margin remaining in core location X,Y relative 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 in Table 6, Appendix A for power escalation testing during initial startup operations.

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

TILT = Factor to account for a peaking increase due to the allowed quadrant tilt ratio of 1.02. (TILT = 1.035).

NOTE: $[F^L_{\Delta H}(X,Y)]^{SURV}$ is the parameter identified as $[F_{\Delta H}(X,Y)]^{MAX}$ 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 (RRH = 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 (TRH = 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	$\leq$ 150 gpm
Mode 5	$\leq$ 70 gpm

3.9 Accumulators (Specification 3/4.5.1)

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

Parameter	Limit
Cold Leg Accumulator minimum boron concentration for LCO 3.5.1c	2,375 ppm
Cold Leg Accumulator maximum boron concentration for LCO 3.5.1c	2,575 ppm
Minimum Cold Leg Accumulator boron concentration required to ensure post-LOCA subcriticality	2,250 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	Limit
Refueling Water Storage Tank minimum boron concentration for LCO 3.5.4b	2,475 ppm
Refueling Water Storage Tank maximum boron concentration for LCO 3.5.4b	2,575 ppm

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

3.11.1 Minimum boron concentrations for the filled portions of the Reactor Coolant System and 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 refueling canal for LCO 3.9.1.b.	2,475 ppm

3.12 Instrumentation (Specification 3/4.9.2)

3.12.1 Reactor Makeup Water Pump Flowrate Limit:

Applicable Mode	Limit
Mode 6	$\leq$ 70 gpm

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

3.13.1 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	2,475 ppm

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

3.14.1 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	Limit
Spent fuel pool minimum boron concentration for surveillance 4.7.13.3.a.1	2,475 ppm
Contained borated water volume for surveillance 4.7.13.3.a.2	2,475 ppm

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NOTE: Data contained in the Appendix of this document was generated in the Catawba 1 Cycle 9 Maneuvering Analysis calculational file, CNC-1553.05-00-0197. The Catawba Nuclear Engineering Section will control this information via computer file(s) and should be contacted if there is a need to access this information.