Catawba Unit 1 Cycle 11

Core Operating Limits Report
Revision 14

December 1998

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 or affects the results and conclusions presented in the 10CFR50.59 Catawba 1 Cycle 11 Reload Safety Evaluation.

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IMPLEMENTATION INSTRUCTIONS FOR REVISION 14

Revision 14 of the Catawba Unit 1 COLR updates this report to be compliant with the Improved Technical Specifications (ITS). This revision should be implemented concurrently with the release of ITS.

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REVISION LOG

Revision	Effective Date	Pages Affected	COLR
Original Issue	September 8, 1992	N/A	C1C07 COLR
Revision 1	October 10, 1992	N/A	C1C07 COLR rev 1
Revision 2	December 1, 1993	N/A	C1C08 COLR
Revision 3	April 14, 1994	N/A	C1C08 COLR rev 1
Revision 4	October 24, 1994	N/A	C1C08 COLR rev 2
Revision 5	November 30, 1994	N/A	C1C08 COLR rev 3
Revision 6	February 15, 1995	N/A	C1C09 COLR
Revision 7	April 12, 1995	N/A	C1C09 COLR rev 1
Revision 8	September 28, 1995	N/A	C1C09 COLR rev 2
Revision 9	August 2, 1996	N/A	C1C10 COLR
Revision 10	May 28, 1997	N/A	C1C10 COLR rev 1
Revision 11	July 1997	N/A	C1C10 COLR rev 2
Revision 12	November 1997	N/A	C1C11 COLR
Revision 13	August 1998	N/A	C1C11 COLR rev 1
Revision 14	December 1998	1-24	C1C11 COLR rev 2

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INSERTION SHEET FOR REVISION 14

Remove pages	Insert Rev. 14 pages
Pages 1-21	Pages 1-24

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1.0 Core Operating Limits Report

This Core Operating Limits Report (COLR) has been prepared in accordance with the requirements of the Technical Specification.

The Technical Specifications that reference this report are listed below:

TS Section	Technical Specifications	COLR Section	Page
3.1.1	Shutdown Margin	2.1	6
3.1.3	Moderator Temperature Coefficient	2.2	6
3.1.4	Shutdown Margin	2.1	6
3.1.5	Shutdown Margin	2.1	6
3.1.5	Shutdown Bank Insertion Limit	2.3	7
3.1.6	Shutdown Margin	2.1	6
3.1.6	Control Bank Insertion Limit	2.4	7
3.2.1	Heat Flux Hot Channel Factor	2.5	10
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3.3.9	Boron Dilution Mitigation System	2.9	20
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The Selected Licensee Commitments that reference this report are listed below:

SLC Section	Selected License Commitment	Section	Page
16.7-9.3	Standby Makeup Pump Water Supply	2.17	24
16.9-11	Borated Water Source – Shutdown	2.15	22
16.9-12	Borated Water Source – Operating	2.16	23

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 NRC approved methodologies specified in Technical Specification 5.6.5.

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2.1 Shutdown Margin - SDM (TS 3.1.1, TS 3.1.4, TS 3.1.5, TS 3.1.6)

2.1.1 For TS 3.1.1, shutdown margin shall be greater than or equal to 1.3% ΔK/K in mode 2 with Keff < 1.0 and in modes 3 and 4.

2.1.2 For TS 3.1.1, shutdown margin shall be greater than or equal to 1.0% ΔK/K in mode 5.

2.1.3 For TS 3.1.4, shutdown margin shall be greater than or equal to 1.3% ΔK/K in mode 1 and mode 2.

2.1.4 For TS 3.1.5, shutdown margin shall be greater than or equal to 1.3% ΔK/K in mode 1 and mode 2 with any control bank not fully inserted.

2.1.5 For TS 3.1.6, shutdown margin shall be greater than or equal to 1.3% ΔK/K in mode 1 and mode 2 with Keff ≥ 1.0.

2.2 Moderator Temperature Coefficient - MTC (TS 3.1.3)

2.2.1 The Moderator Temperature Coefficient (MTC) Limits are:

The MTC shall be less positive than the upper 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 the -4.1E-04 ΔK/K/°F lower MTC limit.

2.2.2 The 300 ppm MTC Surveillance Limit is:

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

2.2.3 The 60 PPM MTC Surveillance Limit is:

The 60 PPM ARO, equilibrium RTP MTC shall be less negative than or equal to -3.85E-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
PPM = Parts per million (Boron)

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2.3 Shutdown Bank Insertion Limit (TS 3.1.5)

2.3.1 Each shutdown bank shall be withdrawn to at least 226 steps.

2.4 Control Bank Insertion Limits (TS 3.1.6)

2.4.1 Control banks shall be within the insertion, sequence, and overlap limits shown in Figure 2.

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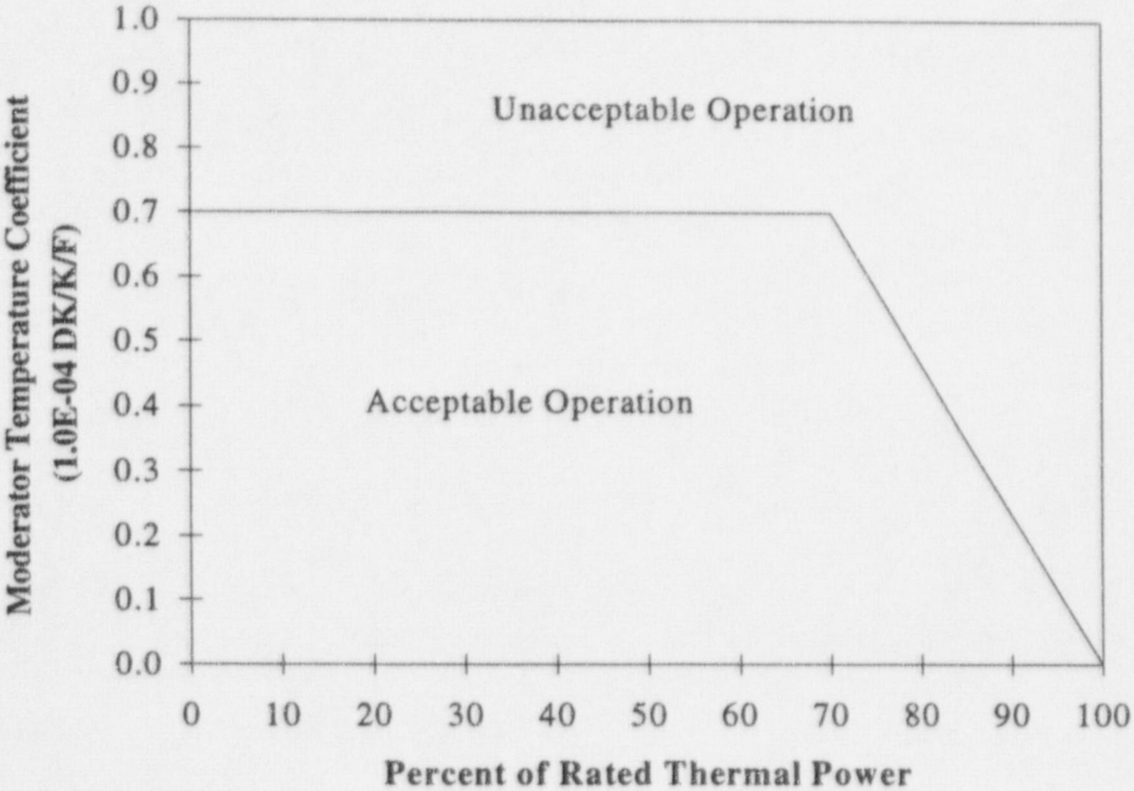
Figure 1
Moderator Temperature Coefficient Upper Limit Versus Power Level



NOTE: Compliance with Technical Specification 3.1.3 may require rod withdrawal limits. Refer to the Unit 1 ROD manual for details.

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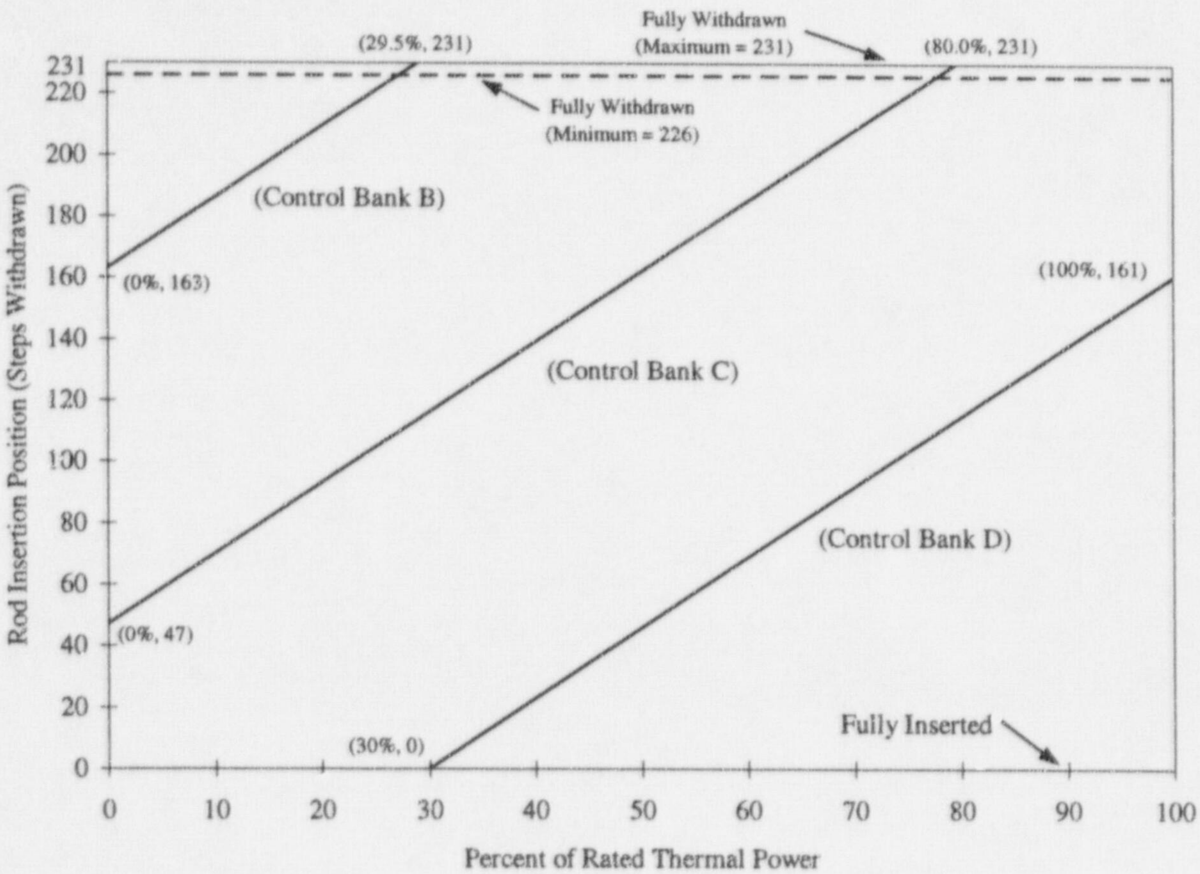
Figure 2

Control Bank Insertion Limits Versus Percent Rated Thermal Power



NOTE: Compliance with Technical Specification 3.1.3 may require rod withdrawal limits. Refer to the Unit 1 ROD manual for details.

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2.5 Heat Flux Hot Channel Factor - FQ(X,Y,Z) (TS 3.2.1)

2.5.1 $F_Q(X,Y,Z)$ steady-state limits are defined by the following relationships:

$$F_Q^{RTP} * K(Z)/P \qquad \text{for } P > 0.5$$
$$F_Q^{RTP} * K(Z)/0.5 \qquad \text{for } P \leq 0.5$$

where,

P = (Thermal Power)/(Rated Power)

Note: The measured $F_Q(X,Y,Z)$ shall be increased by 3% to account for manufacturing tolerances and 5% to account for measurement uncertainty when comparing against the limits. The manufacturing tolerance and measurement uncertainty are implicitly included in the F_Q surveillance limits as defined in COLR Sections 2.5.5 and 2.5.6.

2.5.2 $F_Q^{RTP} = 2.50 \times K(BU)$

2.5.3 K(Z) is the normalized FQ(X,Y,Z) as a function of core height for MkBW fuel and is provided in Figure 3.

2.5.4 K(BU) is the normalized FQ(X,Y,Z) as a function of burnup for MkBW fuel and is provided in Figure 4.

The following parameters are required for core monitoring per the Surveillance Requirements of Technical Specification 3.2.1:

2.5.5 $$[F_Q^L(X,Y,Z)]^{OP} = \frac{F_Q^D(X,Y,Z) * M_Q(X,Y,Z)}{UMT * MT * TILT}$$

where:

$[F_Q^L(X,Y,Z)]^{OP}$ = Cycle dependent maximum allowable design peaking factor that ensures that the $F_Q(X,Y,Z)$ LOCA limit is not exceeded for operation within the AFD, RIL, and QPTR limits. $F_Q^L(X,Y,Z)^{OP}$ includes allowances for calculational and measurement uncertainties.

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$F_Q^D(X,Y,Z)$ = 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 operation.

$M_Q(X,Y,Z)$ = 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 operation.

UMT = Total Peak 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.

2.5.6 $$[F_Q^L(X,Y,Z)]^{RPS} = \frac{F_Q^D(X,Y,Z) * M_C(X,Y,Z)}{UMT * MT * TILT}$$

where:

$[F_Q^L(X,Y,Z)]^{RPS}$ = Cycle dependent maximum allowable design peaking factor that ensures that the $F_Q(X,Y,Z)$ Centerline Fuel Melt (CFM) limit is not exceeded for operation within the AFD, RIL, and QPRT 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

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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 $M_C(X,Y,Z)$.

2.5.7 KSLOPE = 0.0725

where:

KSLOPE = the adjustment to the K_1 value from OTΔT trip setpoint required to compensate for each 1% that $F_Q^M(X,Y,Z)$ exceeds $F_Q^L(X,Y,Z)^{RPS}$.

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Figure 3

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

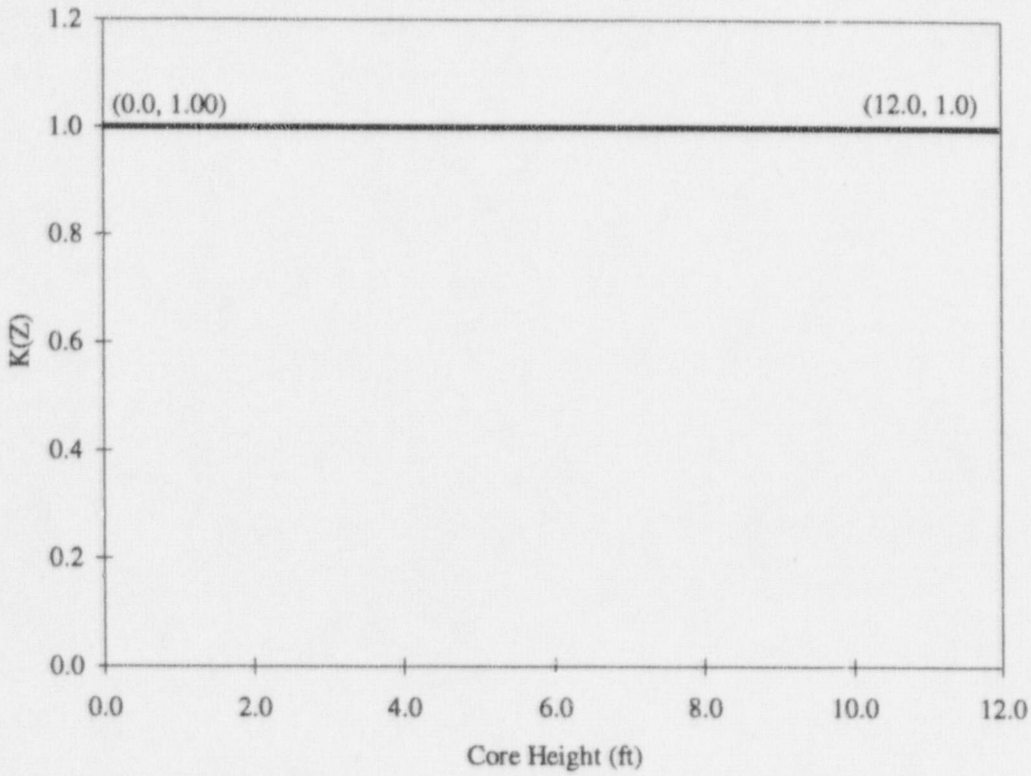

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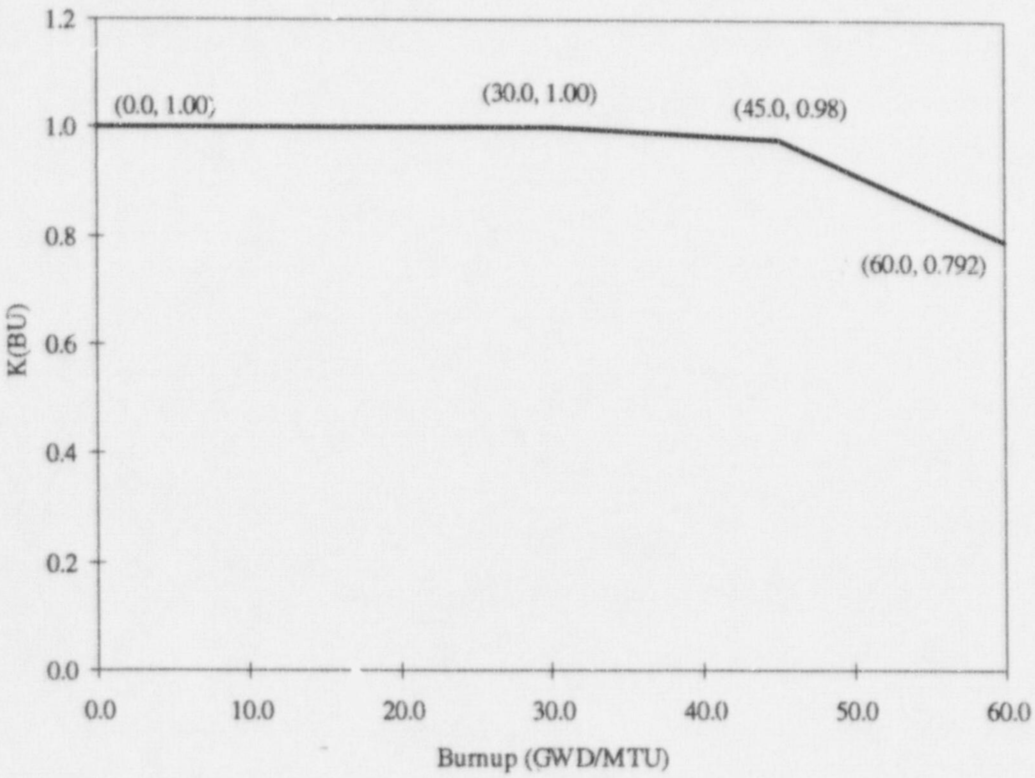
Figure 4

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



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

The $F_{\Delta H}$ steady-state limits referred to in Technical Specification 3.2.2 is defined by the following relationship.

2.6.1 $$[F^{L}_{\Delta H}(X,Y)]^{LCO} = MARP(X,Y) * \left[1.0 + \frac{1}{RRH} * (1.0 - P)\right]$$

where:

$[F^{L}_{\Delta H}(X,Y)]^{LCO}$ is defined as the steady-state, maximum allowed radial peak.

MARP(X,Y) = Cycle-specific operating limit Maximum Allowable Radial Peaks. MARP(X,Y) radial peaking limits are provided in Table 7, Appendix A.

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

RRH = Thermal Power reduction required to compensate for each 1% that the measured radial peak, $F^{M}_{\Delta H}(X,Y)$, exceeds the limit. (RRH = 3.34)

The following parameters are required for core monitoring per the Surveillance requirements of Technical Specification 3.2.2.

2.6.2 $$[F^{L}_{\Delta H}(X,Y)]^{SURV} = \frac{F^{D}_{\Delta H}(X,Y) \times M_{\Delta H}(X,Y)}{UMR \times TILT})$$

where:

$[F^{L}_{\Delta H}(X,Y)]^{SURV}$ = Cycle dependent maximum allowable design peaking factor that ensures that the $F_{\Delta H}(X,Y)$ limit is not exceeded for operation within the AFD, RIL, and QPRT 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 operation.

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$M_{\Delta H}(X,Y)$ = The margin remaining in core location X,Y relative to the Operational DNB limits 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 operation.

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

2.6.3 RRH = 3.34

where:

RRH = Thermal Power reduction required to compensate for each 1% that the measured radial peak, $F^{M}_{\Delta H}(X,Y)$ exceeds its limit.

2.6.4 TRH = 0.04

where:

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

2.7 Axial Flux Difference – AFD (TS 3.2.3)

2.7.1 The Axial Flux Difference (AFD) Limits are provided in Figure 5.

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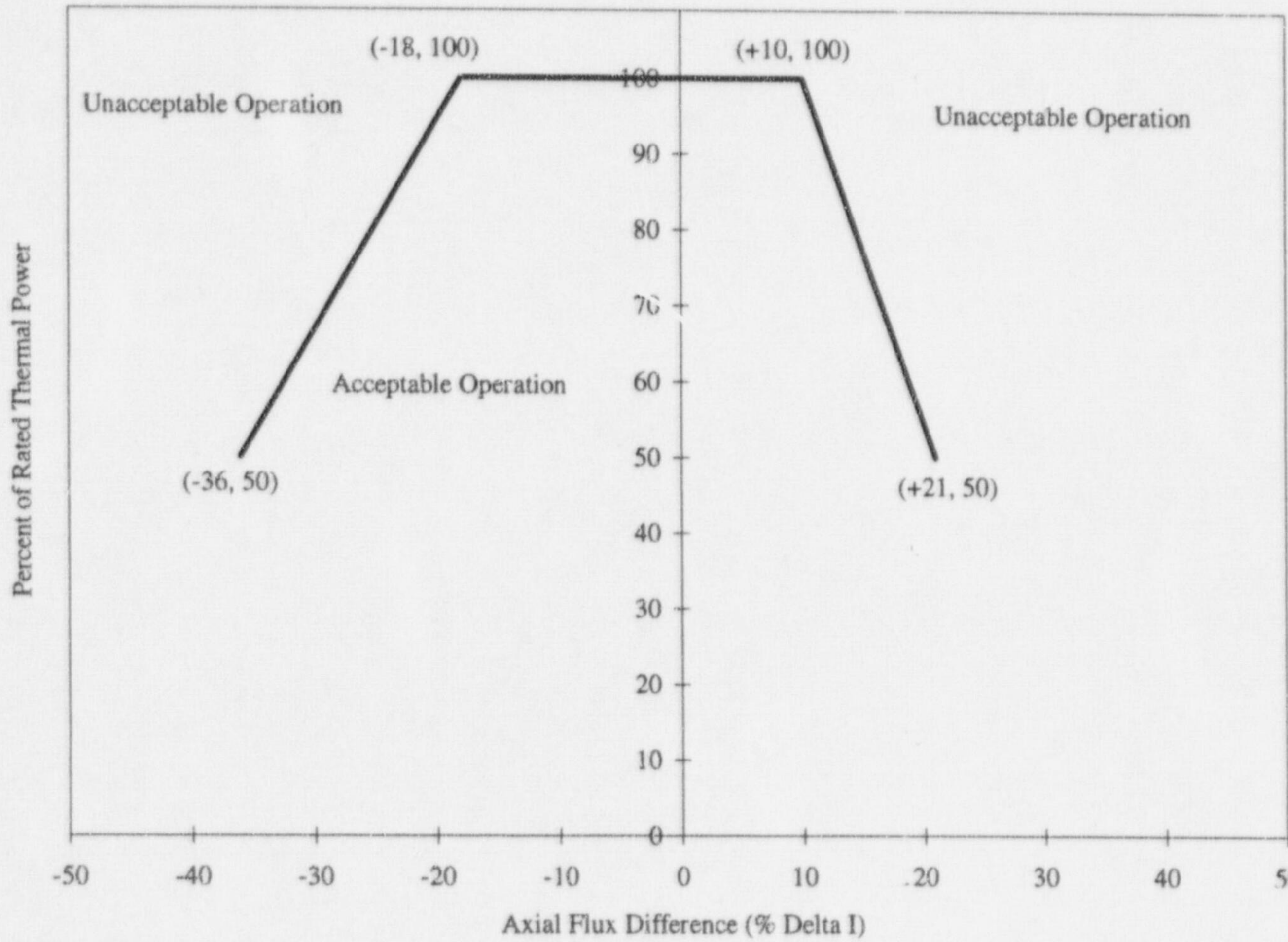
Figure 5

Percent of Rated Thermal Power Versus Percent Axial Flux Difference Limits



NOTE: Compliance with Technical Specification 3.2.1 may require more restrictive AFD limits. Refer to the Unit 1 ROD manual for operational AFD limits.

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2.8 Reactor Trip System Instrumentation Setpoints (TS 3.3.1) Table 3.3.1-1

2.8.1 Overtemperature ΔT Setpoint Parameter Values

Parameter	Value
Overtemperature ΔT reactor trip setpoint	$K_1 = 1.1978$
Overtemperature ΔT reactor trip heatup setpoint penalty coefficient	$K_2 = 0.03340/^oF$
Overtemperature ΔT reactor trip depressurization setpoint penalty coefficient	$K_3 = 0.001601/psi$
Time constants utilized in the lead-lag compensator for ΔT	$\tau_1 = 8$ sec. $\tau_2 = 3$ sec.
Time constant utilized in the lag compensator for ΔT	$\tau_3 = 0$ sec.
Time constants utilized in the lead-lag compensator for T_{avg}	$\tau_4 = 22$ sec. $\tau_5 = 4$ sec.
Time constant utilized in the measured T_{avg} lag compensator	$\tau_6 = 0$ sec.
$f_1(\Delta I)$ "positive" breakpoint	= 19.0 %ΔI
$f_1(\Delta I)$ "negative" breakpoint	= N/A*
$f_1(\Delta I)$ "positive" slope	= 1.769 $\%\Delta T_0/\ \%\Delta I$
$f_1(\Delta I)$ "negative" slope	= N/A*

* The $f_1(\Delta I)$ "negative" breakpoint and the $f_1(\Delta I)$ "negative" slope are not applicable since the $f_1(\Delta I)$ function is not required below the $f_1(\Delta I)$ "positive" breakpoint of 19.0% ΔI.

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2.8.2 Overpower ΔT Setpoint Parameter Values

Parameter	Value
Overpower ΔT reactor trip setpoint	$K_4 = 1.0864$
Overpower ΔT reactor trip heatup setpoint penalty coefficient (for T>T")	$K_6 = 0.001179/^oF$
Time constants utilized in the lead-lag compensator for ΔT	$\tau_1 = 8$ sec. $\tau_2 = 3$ sec.
Time constant utilized in the lag compensator for ΔT	$\tau_3 = 0$ sec.
Time constant utilized in the measured T_{avg} lag compensator	$\tau_6 = 0$ sec.
Time constant utilized in the rate-lag controller for T_{avg}	$\tau_7 = 10$ 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 $\%\Delta T_0/\ \%\Delta I$
$f_2(\Delta I)$ "negative" slope	= 7.0 $\%\Delta T_0/\ \%\Delta I$

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2.9 Boron Dilution Mitigation System (TS 3.3.9)

2.9.1 Reactor Makeup Water Pump flowrate limits:

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

2.10 Accumulators (TS 3.5.1)

2.10.1 Boron concentration limits during modes 1 and 2, and mode 3 with RCS pressure >1000 psi:

Parameter	Limit
Cold Leg Accumulator minimum boron concentration.	2,575 ppm
Cold Leg Accumulator maximum boron concentration.	2,975 ppm

2.11 Refueling Water Storage Tank - RWST (TS 3.5.4)

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

Parameter	Limit
Refueling Water Storage Tank minimum boron concentration.	2,775 ppm
Refueling Water Storage Tank maximum boron concentration.	2,975 ppm

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2.12 Spent Fuel Pool Boron Concentration (TS 3.7.15)

2.12.1 Minimum boron concentration limit for the spent fuel pool. Applicable when fuel assemblies are stored in the spent fuel pool.

Parameter	Limit
Spent fuel pool minimum boron concentration.	2,775 ppm

2.13 Refueling Operations - Boron Concentration (TS 3.9.1)

2.13.1 Minimum boron concentration limit for the filled portions of the Reactor Coolant System, refueling canal, and refueling cavity for mode 6 conditions. The minimum boron concentration limit and plant refueling procedures ensure that the Keff of the core will remain within the mode 6 reactivity requirement of Keff $\leq$ 0.95.

Parameter	Limit
Minimum Boron concentration of the Reactor Coolant System, the refueling canal, and the refueling cavity.	2,775 ppm

2.14 Refueling Operations - Instrumentation (TS 3.9.2)

2.14.1 Reactor Makeup Water Pump Flowrate Limit:

Applicable Mode	Limit
Mode 6	$\leq$ 70 gpm

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2.15 Borated Water Source – Shutdown (SLC 16.9-11)

2.15.1 Volume and boron concentrations for the Boric Acid Storage System and the Refueling Water Storage Tank (RWST) during mode 4 with any RCS cold leg temperature $\leq 285^{\circ}$F, and modes 5 and 6.

Parameter	Limit
Boric Acid Storage System minimum contained borated water volume	12,000 gallons
Boric Acid Storage System minimum boron concentration	7,000 ppm
Boric Acid Storage System minimum water volume required to maintain SDM at 7,000 ppm	585 gallons
Refueling Water Storage Tank minimum contained borated water volume	45,000 gallons
Refueling Water Storage Tank minimum boron concentration	2,775 ppm
Refueling Water Storage Tank minimum water volume required to maintain SDM at 2,775 ppm	3,500 gallons

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2.16 Borated Water Source - Operating (SLC 16.9-12)

2.16.1 Volume and boron concentrations for the Boric Acid Storage System and the Refueling Water Storage Tank (RWST) during modes 1, 2, 3, and mode 4 with all RCS cold leg temperatures $> 285^{O}$F.

Parameter	Limit
Boric Acid Storage System minimum contained borated water volume	24,000 gallons
Boric Acid Storage System minimum boron concentration	7,000 ppm
Boric Acid Storage System minimum water volume required to maintain SDM at 7,000 ppm	11,851 gallons
Refueling Water Storage Tank minimum contained borated water volume	98,607 gallons
Refueling Water Storage Tank minimum boron concentration	2,775 ppm
Refueling Water Storage Tank minimum water volume required to maintain SDM at 2,775 ppm	57,107 gallons

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2.17 Standby Makeup Pump Water Supply - Boron Concentration (SLC-16.7-9.3)

2.17.1 Minimum boron concentration limit for the spent fuel pool. Applicable for modes 1, 2, and 3.

Parameter	Limit
Spent fuel pool minimum boron concentration for surveillance SLC-16.7-9.3.	2,775 ppm

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NOTE: Data contained in the Appendix to this document was generated in the Catawba 1 Cycle 11 Maneuvering Analysis calculation file, CNC-1553.05-00-0266. The Plant Nuclear Engineering Section will control this information via computer file(s) and should be contacted if there is a need to access this information.