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RA-22-0097

March 24, 2022

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

Subject: Duke Energy Carolinas, LLC (Duke Energy)  
Catawba Nuclear Station, Unit 2  
Facility Operating License Number NPF-52  
Docket Number 50-414  
Core Operating Limits Report (COLR) for Unit 2 Cycle 25 Reload Core, Rev. 2

Pursuant to Catawba Technical Specification 5.6.5.d, please find attached an information copy of the subject revised (Revision 2) COLR. Revisions to this COLR are indicated by revision bars in the margin of the document.

The power distribution monitoring factors from Appendix A of Revision 0 remain valid and are not transmitted as part of Revision 2.

This letter and enclosed COLR do not contain any regulatory commitments.

Please direct any questions or concerns to Ari Tuckman, Regulatory Affairs, at (803) 701-3771.

Sincerely,

A handwritten signature in black ink that reads 'Tom Simril'.

Tom Simril  
Vice President, Catawba Nuclear Station

Enclosure (Catawba Unit 2 Cycle 25 COLR, Rev. 2)

U.S. Nuclear Regulatory Commission  
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**Enclosure**

**Catawba Unit 2 Cycle 25 COLR, Rev. 2  
(paper COLR excluding Attachment A)**

**Catawba 2 Cycle 25**  
**Core Operating Limits Report**  
**Revision 2**

**March 2022**

Reference: CNC-1553.05-00-0699, Rev. 2

Reload 50.59 #: 02366211

$\tau_3$  and  $\tau_6$  AD #: 02403794

K4 and K5 AD #: 02414325



**QA Condition 1**

The information presented in this report has been prepared and issued in accordance with Catawba Technical Specification 5.6.5.

## Catawba 2 Cycle 25 Core Operating Limits Report

### Implementation Instructions for Revision 2

#### Revision Description and CR Tracking

Revision 2 of the Catawba 2 Cycle 25 COLR contains limits specific to the reload core.

NCR 02409929 documents spurious OPΔT alarms in Reactor Coolant System Loop 2B due to noisy setpoints from a failing RTD. The change in the nominal OPΔT K4 and K5 settings are intended to reduce the frequency of OPΔT alarms and gain margin to OPΔT trip signals when Maintenance is performing work in other channels for NIS Power Range or 7300 OPΔT / OTΔT / Tav<sub>g</sub> and Pressurizer Pressure loops. This will reduce risk of inadvertent trip during planned or unplanned work. This revision supports a mid-cycle change in the nominal OPΔT K4 and K5 for increasing Tav<sub>g</sub> settings in Section 2.9.2. All licensed reload analyses were evaluated for the K4 and K5 change per AD-NF-ALL-0807, Reload Design Process.

The power distribution factors from Appendix A of Revision 0 remain valid and are not transmitted as part of Revision 2.

#### Implementation Schedule

The Catawba 2 Cycle 25 COLR requires the reload 50.59 (AR #02366211) be approved prior to implementation. Revision 2 requires Applicability Determination 02414325 be approved to allow implementation of the revised K4 and K5 setting values. Previous COLR revisions support the current licensing basis of the operating core until the mid-cycle changes to nominal OPΔT K4 and K5 are implemented. Catawba Nuclear Station Engineering Change (EC) EVAL 420258 evaluates site impacts and implementation actions associated with the changes to K4 and K5.

The Catawba 2 Cycle 25 COLR will cease to be effective during NO MODE between cycles 25 and 26.

#### Data files to be Implemented

No data files are transmitted as part of this document.

#### Additional Information

A review was performed by Safety Analysis for COLR Section 2.9.

CNS Reactor Engineering performed a site impact review in accordance with AD-NF-ALL-0807 and AD-NF-NGO-0214.

CNS I&C Engineering performed an inspection.

**Catawba 2 Cycle 25 Core Operating Limits Report**

## REVISION LOG

<b><u>Revision</u></b>	<b><u>Effective Date</u></b>	<b><u>Pages Affected</u></b>	<b><u>COLR</u></b>
0	March 2021	1-31, Appendix A*	C2C25 COLR, Rev. 0
1	November 2021	1-3, 23, 24	C2C25 COLR, Rev. 1
2	March 2022	1-3, 24	C2C25 COLR, Rev. 2

\* Appendix A contains power distribution monitoring factors used in Technical Specification Surveillance and is not uploaded as part of the EI body. However, Appendix A is uploaded into the document management system, for ease of transmittal to the NRC.

## Catawba 2 Cycle 25 Core Operating Limits Report

### 1.0 Core Operating Limits Report

This Core Operating Limits Report (COLR) has been prepared in accordance with requirements of Technical Specification 5.6.5. Technical Specifications that reference this report are listed below along with the NRC approved analytical methods used to develop and/or determine COLR parameters identified in Technical Specifications.

TS Section	Technical Specifications	COLR Parameter	COLR Section	NRC Approved Methodology (Section 1.1 Number)
2.1.1	Reactor Core Safety Limits	RCS Temperature and Pressure Safety Limits	2.1	6, 7, 8, 9, 10, 12, 15, 16, 19, 20
3.1.1	Shutdown Margin	Shutdown Margin	2.2	6, 7, 8, 12, 14, 15, 16, 19, 20
3.1.3	Moderator Temperature Coefficient	MTC	2.3	6, 7, 8, 14, 16, 18
3.1.4	Rod Group Alignment Limits	Shutdown Margin	2.2	6, 7, 8, 12, 14, 15, 16, 19, 20
3.1.5	Shutdown Bank Insertion Limit	Shutdown Margin Rod Insertion Limits	2.2 2.4	2, 4, 6, 7, 8, 9, 10 12, 14, 15, 16, 19, 20
3.1.6	Control Bank Insertion Limit	Shutdown Margin Rod Insertion Limits	2.2 2.5	2, 4, 6, 7, 8, 9, 10 12, 14, 15, 16, 19, 20
3.1.8	Physics Tests Exceptions	Shutdown Margin	2.2	6, 7, 8, 12, 14, 15, 16, 19, 20
3.2.1	Heat Flux Hot Channel Factor	F <sub>Q</sub> AFD OTAT Penalty Factors	2.6 2.8 2.9 2.6	2, 4, 6, 7, 8, 9, 10, 12, 15, 16, 19, 20
3.2.2	Nuclear Enthalpy Rise Hot Channel Factor	FAH Penalty Factors	2.7 2.7	2, 4, 6, 7, 8, 9, 10 12, 15, 16, 19, 20
3.2.3	Axial Flux Difference	AFD	2.8	2, 4, 6, 7, 8, 15, 16
3.3.1	Reactor Trip System Instrumentation	OTAT OPAT	2.9 2.9	6, 7, 8, 9, 10, 12 15, 16, 19, 20
3.3.9	Boron Dilution Mitigation System	Reactor Makeup Water Flow Rate	2.10	6, 7, 8, 14, 16
3.4.1	RCS Pressure, Temperature and Flow limits for DNB	RCS Pressure, Temperature and Flow	2.11	6, 7, 8, 9, 10, 12, 19, 20
3.5.1	Accumulators	Max and Min Boron Conc.	2.12	6, 7, 8, 14, 16
3.5.4	Refueling Water Storage Tank	Max and Min Boron Conc.	2.13	6, 7, 8, 14, 16
3.7.15	Spent Fuel Pool Boron Concentration	Min Boron Concentration	2.14	6, 7, 8, 14, 16
3.9.1	Refueling Operations - Boron Concentration	Min Boron Concentration	2.15	6, 7, 8, 14, 16
5.6.5	Core Operating Limits Report (COLR)	Analytical Methods	1.1	None

The Selected Licensee Commitments that reference this report are listed below

SLC Section	Selected Licensee Commitment	COLR Parameter	COLR Section	NRC Approved Methodology (Section 1.1 Number)
16.7-9	Standby Shutdown System	Standby Makeup Pump Water Supply	2.16	6, 7, 8, 14, 16
16.9-11	Boration Systems – Borated Water Source – Shutdown	Borated Water Volume and Conc. for BAT/RWST	2.17	6, 7, 8, 14, 16
16.9-12	Boration Systems – Borated Water Source – Operating	Borated Water Volume and Conc. for BAT/RWST	2.18	6, 7, 8, 14, 16

## Catawba 2 Cycle 25 Core Operating Limits Report

### 1.1 Analytical Methods

Analytical methods used to determine core operating limits for parameters identified in Technical Specifications and previously reviewed and approved by the NRC as specified in Technical Specification 5.6.5 are as follows.

1. WCAP-9272-P-A, "Westinghouse Reload Safety Evaluation Methodology," (W Proprietary).

Revision 0

Report Date: July 1985

**Not Used**

2. WCAP-10054-P-A, "Westinghouse Small Break ECCS Evaluation Model using the NOTRUMP Code," (W Proprietary).

Revision 0

Report Date: August 1985

Addendum 2, "Addendum to the Westinghouse Small Break ECCS Evaluation Model Using the NOTRUMP Code: Safety Injection into the Broken Loop and COSI Condensation Model," (W Proprietary). (Referenced in Duke Letter DPC-06-101)

Revision 1

Report Date: July 1997

3. WCAP-10266-P-A, "The 1981 Version Of Westinghouse Evaluation Model Using BASH Code," (W Proprietary).

Revision 2

Report Date: March 1987

**Not Used**

4. WCAP-12945-P-A, Volume 1 and Volumes 2-5, "Code Qualification Document for Best-Estimate Loss of Coolant Analysis," (W Proprietary).

Revision: Volume 1 (Revision 2) and Volumes 2-5 (Revision 1)

Report Date: March 1998

5. BAW-10168P-A, "B&W Loss-of-Coolant Accident Evaluation Model for Recirculating Steam Generator Plants," (B&W Proprietary).

Revision 1

SER Date: January 22, 1991

Revision 2

SER Dates: August 22, 1996 and November 26, 1996.

Revision 3

SER Date: June 15, 1994.

**Not Used**



## Catawba 2 Cycle 25 Core Operating Limits Report

### 1.1 Analytical Methods (continued)

6. DPC-NE-3000-PA, "Thermal-Hydraulic Transient Analysis Methodology," (Duke Energy Proprietary).  
Revision 5a  
Report Date: October 2012
7. DPC-NE-3001-PA, "Multidimensional Reactor Transients and Safety Analysis Physics Parameter Methodology," (Duke Energy Proprietary).  
Revision 1  
Report Date: March 2015
8. DPC-NE-3002-A, "UFSAR Chapter 15 System Transient Analysis Methodology"  
Revision 4c  
Report Date: January 2019
9. DPC-NE-2004P-A, "Duke Power Company McGuire and Catawba Nuclear Stations Core Thermal-Hydraulic Methodology using VIPRE-01," (Duke Energy Proprietary).  
Revision 2a  
Report Date: December 2008
10. DPC-NE-2005P-A, "Thermal Hydraulic Statistical Core Design Methodology," (Duke Energy Proprietary).  
Revision 5  
Report Date: March 2016
11. DPC-NE-2008-PA, "Fuel Mechanical Reload Analysis Methodology Using TACO3," (Duke Energy Proprietary).  
Revision 0  
Report Date: April 1995  
**Not Used**
12. DPC-NE-2009-P-A, "Westinghouse Fuel Transition Report," (Duke Energy Proprietary).  
Revision 3c  
Report Date: March 2017
13. DPC-NE-1004-A, "Nuclear Design Methodology Using CASMO-3/SIMULATE-3P."  
Revision 1a  
Report Date: January 2009  
**Not Used**

## Catawba 2 Cycle 25 Core Operating Limits Report

### 1.1 Analytical Methods (continued)

14. DPC-NF-2010-A, "Nuclear Physics Methodology for Reload Design."  
Revision 2a  
Report Date: December 2009
15. DPC-NE-2011-PA, "Nuclear Design Methodology for Core Operating Limits of Westinghouse Reactors," (Duke Energy Proprietary).  
Revision 1a  
Report Date: June 2009
16. DPC-NE-1005-PA, "Nuclear Design Methodology Using CASMO-4 / SIMULATE-3 MOX," (Duke Energy Proprietary).  
Revision 1  
Report Date: November 2008
17. BAW-10231P-A, "COPERNIC Fuel Rod Design Computer Code" (Framatome ANP Proprietary)  
Revision 1  
SER Date: January 14, 2004  
**Not Used**
18. DPC-NE-1007-PA, "Conditional Exemption of the EOC MTC Measurement Methodology," (Duke Energy and W Proprietary)  
Revision 0  
Report Date: April 2015
19. WCAP-12610-P-A, "VANTAGE+ Fuel Assembly Reference Core Report," (W Proprietary).  
Revision 0  
Report Date: April 1995
20. WCAP-12610-P-A & CENPD-404-P-A, Addendum 1-A, "Optimized ZIRLO™," (W Proprietary).  
Revision 0  
Report Date: July 2006

## Catawba 2 Cycle 25 Core Operating Limits Report

### 2.0 Operating Limits

Cycle-specific parameter limits for specifications listed in Section 1.0 are presented in the following subsections. These limits have been developed using NRC approved methodologies specified in Section 1.1.

#### 2.1 Reactor Core Safety Limits (TS 2.1.1)

Reactor Core Safety Limits are shown in Figure 1.

#### 2.2 Shutdown Margin - SDM (TS 3.1.1, TS 3.1.4, TS 3.1.5, TS 3.1.6, TS 3.1.8)

**2.2.1** For TS 3.1.1, SDM shall be  $\geq 1.3\% \Delta K/K$  in MODE 2 with  $K_{\text{eff}} < 1.0$  and in MODES 3 and 4.

**2.2.2** For TS 3.1.1, SDM shall be  $\geq 1.0\% \Delta K/K$  in MODE 5.

**2.2.3** For TS 3.1.4, SDM shall be  $\geq 1.3\% \Delta K/K$  in MODE 1 and MODE 2.

**2.2.4** For TS 3.1.5, SDM shall be  $\geq 1.3\% \Delta K/K$  in MODE 1 and MODE 2 with any control bank not fully inserted.

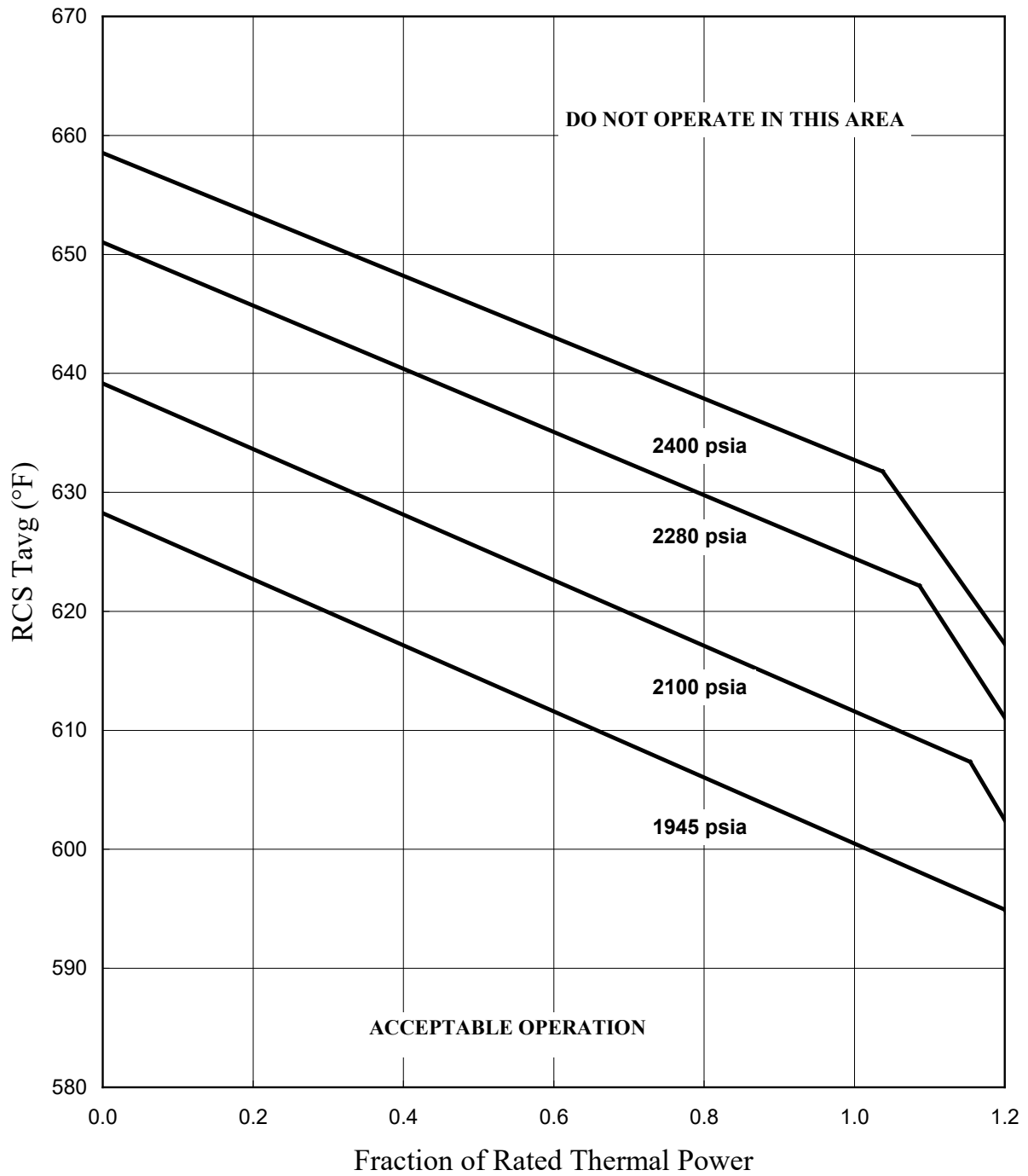
**2.2.5** For TS 3.1.6, SDM shall be  $\geq 1.3\% \Delta K/K$  in MODE 1 and MODE 2 with  $K_{\text{eff}} \geq 1.0$ .

**2.2.6** For TS 3.1.8, SDM shall be  $\geq 1.3\% \Delta K/K$  in MODE 2 during PHYSICS TESTS.

### Catawba 2 Cycle 25 Core Operating Limits Report

Figure 1

#### Reactor Core Safety Limits Four Loops in Operation



## Catawba 2 Cycle 25 Core Operating Limits Report

### 2.3 Moderator Temperature Coefficient - MTC (TS 3.1.3)

#### 2.3.1 Moderator Temperature Coefficient (MTC) Limits are:

MTC shall be less positive than the upper limits shown in Figure 2.

BOC, ARO, HZP MTC shall be less positive than  $0.7E-04 \Delta K/K/^{\circ}F$ .

EOC, ARO, RTP MTC shall be less negative than the  $-4.3E-04 \Delta K/K/^{\circ}F$  lower MTC limit.

#### 2.3.2 300 ppm MTC Surveillance Limit is:

Measured 300 ppm ARO, equilibrium RTP MTC shall be less negative than or equal to  $-3.65E-04 \Delta K/K/^{\circ}F$ .

#### 2.3.3 The Revised Predicted near-EOC 300 ppm ARO RTP MTC shall be calculated using the procedure contained in DPC-NE-1007-PA.

If the Revised Predicted MTC is less negative than or equal to the 300 ppm SR 3.1.3.2 Surveillance Limit, and all benchmark data contained in the surveillance procedure is satisfied, then an MTC measurement in accordance with SR 3.1.3.2 is not required to be performed.

#### 2.3.4 60 ppm MTC Surveillance Limit is:

Measured 60 ppm ARO, equilibrium RTP MTC shall be less negative than or equal to  $-4.125E-04 \Delta K/K/^{\circ}F$ .

Where:

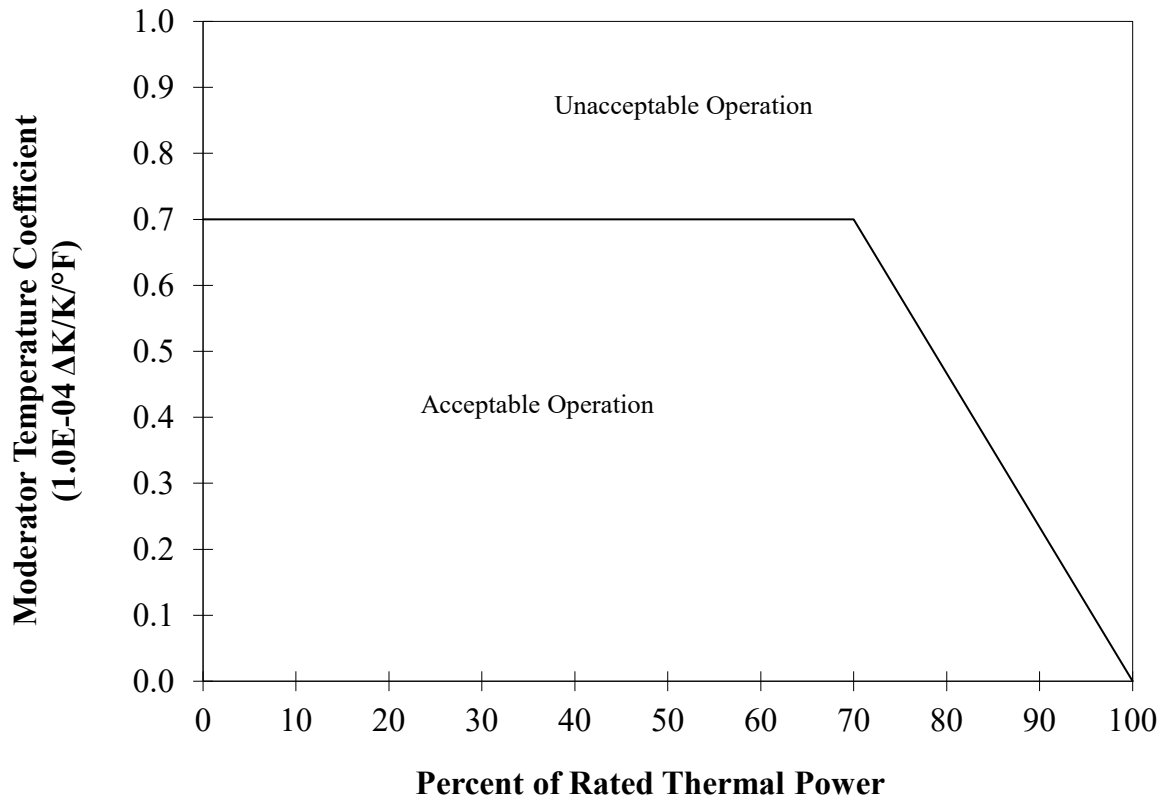
- BOC = Beginning of Cycle (burnup corresponding to most positive MTC)
- EOC = End of Cycle
- ARO = All Rods Out
- HZP = Hot Zero Thermal Power
- RTP = Rated Thermal Power
- ppm = Parts per million (Boron)

### 2.4 Shutdown Bank Insertion Limit (TS 3.1.5)

#### 2.4.1 Each shutdown bank shall be withdrawn to at least 222 steps. Shutdown banks are withdrawn in sequence and with no overlap.

### 2.5 Control Bank Insertion Limits (TS 3.1.6)

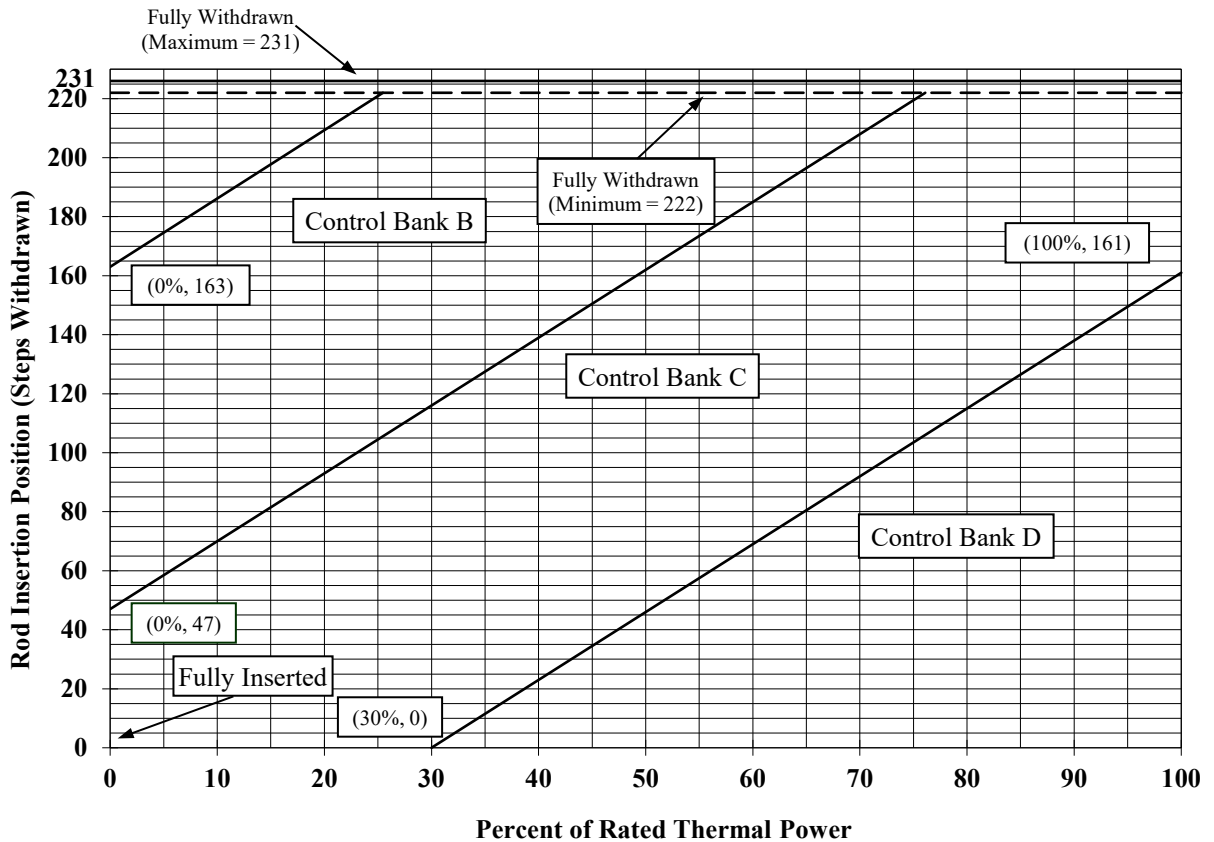
#### 2.5.1 Control banks shall be within the insertion, sequence, and overlap limits shown in Figure 3. Specific control bank withdrawal and overlap limits as a function of the fully withdrawn position are shown in Table 1.

**Catawba 2 Cycle 25 Core Operating Limits Report****Figure 2****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 2 ROD manual for details.

## Catawba 2 Cycle 25 Core Operating Limits Report

**Figure 3**  
**Control Bank Insertion Limits Versus Percent Rated Thermal Power**



The Rod Insertion Limits (RIL) for Control Bank D (CD), Control Bank C (CC), and Control Bank B (CB) can be calculated by:

$$\text{Bank CD RIL} = 2.3(P) - 69 \quad \{30 \leq P \leq 100\}$$

$$\text{Bank CC RIL} = 2.3(P) + 47 \quad \{0 \leq P \leq 76.1\} \text{ for CC RIL} = 222 \quad \{76.1 < P \leq 100\}$$

$$\text{Bank CB RIL} = 2.3(P) + 163 \quad \{0 \leq P \leq 25.7\} \text{ for CB RIL} = 222 \quad \{25.7 < P \leq 100\}$$

where  $P = \% \text{ of Rated Thermal Power}$

**NOTE:** Compliance with Technical Specification 3.1.3 may require rod withdrawal limits. Refer to the Unit 2 ROD manual for details.

## Catawba 2 Cycle 25 Core Operating Limits Report

### Table 1

<b>Control Bank Withdrawal Sequence Equation</b>			
<b>Control Bank A</b>	<b>Control Bank B</b>	<b>Control Bank C</b>	<b>Control Bank D</b>
0 Start	0	0	0
116	0 Start	0	0
CBA Stop	CBA - 116	0	0
CBA	116	0 Start	0
CBA	CBB Stop	CBB - 116	0
CBA	CBB	116	0 Start
CBA	CBB	CBC	CBC - 116

Where:

*CBA* = Fully withdrawn position of Control Bank A

*CBB* = Fully withdrawn position of Control Bank B

*CBC* = Fully withdrawn position of Control Bank C

Allowed Control Bank Fully Withdrawn Positions Range from 223 Steps to 231 Steps for frequent RCCA Reposition Required per CNEI-0400-091, Rev. 6, "RCCA Axial Repositioning Schedule for Catawba Nuclear Station."



## Catawba 2 Cycle 25 Core Operating Limits Report

### 2.6 Heat Flux Hot Channel Factor - $F_Q(X,Y,Z)$ (TS 3.2.1)

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

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

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

where,

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

Note: 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 LCO limits. The manufacturing tolerance and measurement uncertainty are implicitly included in the  $F_Q$  surveillance limits as defined in COLR Sections 2.6.5 and 2.6.6.

2.6.2  $F_Q^{RTP} = 2.70 \times K(\text{BU})$

2.6.3  $K(Z)$  is the normalized  $F_Q(X,Y,Z)$  as a function of core height.  $K(Z)$  for Westinghouse RFA fuel is provided in Figure 4.

2.6.4  $K(\text{BU})$  is the normalized  $F_Q(X,Y,Z)$  as a function of burnup.  $F_Q^{RTP}$  with the  $K(\text{BU})$  penalty for Westinghouse RFA fuel is analytically confirmed in cycle-specific reload calculation.  $K(\text{BU})$  is set to 1.0 at all burnups.

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

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

where:

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

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

$F_Q^D(X,Y,Z)$  = Design power distribution for  $F_Q$ .  $F_Q^D(X,Y,Z)$  is provided in Appendix Table A-1 for normal operating conditions and in Appendix Table A-4 for power escalation testing during initial startup operation.

## Catawba 2 Cycle 25 Core Operating Limits Report

$M_Q(X,Y,Z)$  = 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 Appendix Table A-1 for normal operating conditions and in Appendix Table A-4 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 to account for allowable quadrant power tilt ratio of 1.02. (TILT = 1.035)

$$2.6.6 \quad [F_Q^L(X,Y,Z)]^{RPS} = \frac{F_Q^D(X,Y,Z) * M_C(X,Y,Z)}{UMT * MT * TILT}$$

where:

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

$F_Q^D(X,Y,Z)$  = Defined in Section 2.6.5.

$M_C(X,Y,Z)$  = Margin remaining to the CFM limit in core location X,Y,Z from the transient power distribution.  $M_C(X,Y,Z)$  is provided in Appendix Table A-2 for normal operating conditions and in Appendix Table A-5 for power escalation testing during initial startup operations.

UMT = Defined in Section 2.6.5.

MT = Defined in Section 2.6.5.

TILT = Defined in Section 2.6.5.

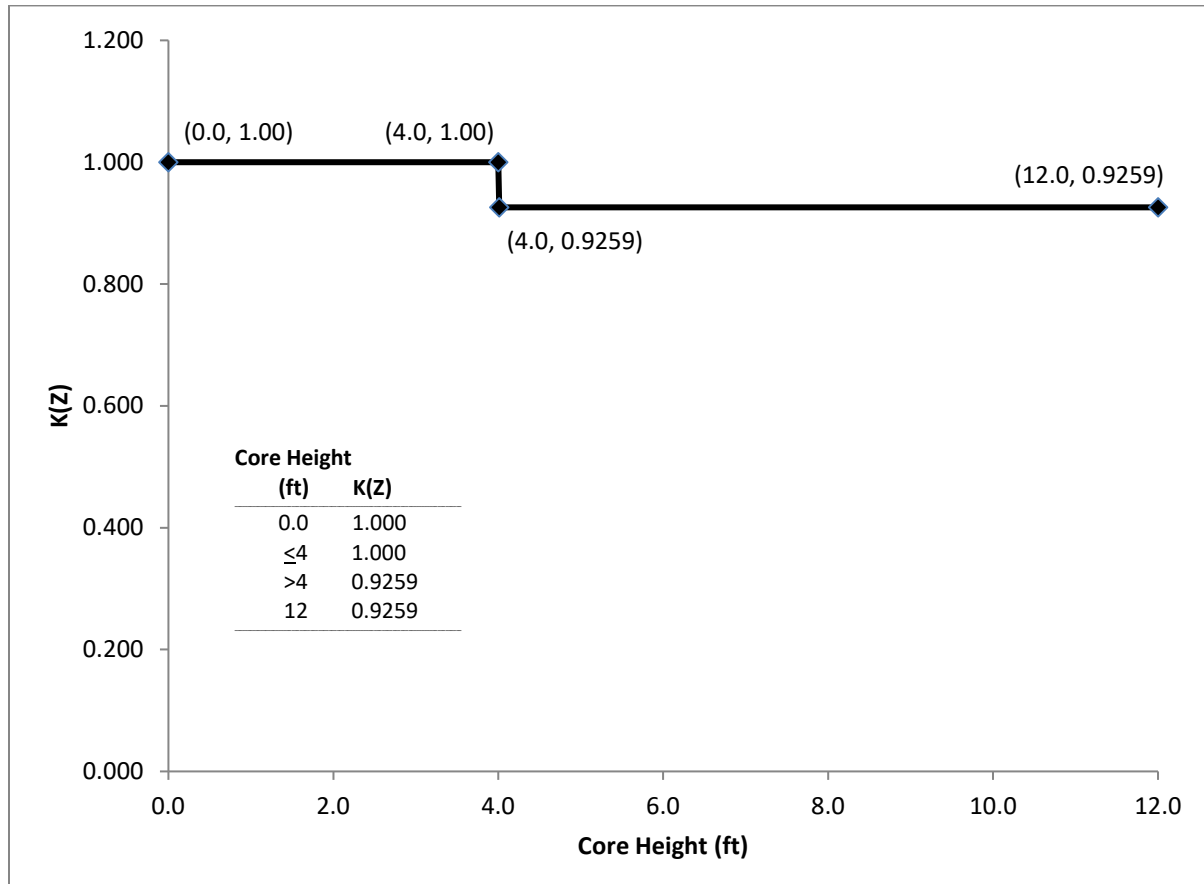
## Catawba 2 Cycle 25 Core Operating Limits Report

**2.6.7**  $KSLOPE = 0.0725$

where:

$KSLOPE$  = adjustment to  $K_1$  value from  $OT\Delta T$  trip setpoint required to compensate for each 1% measured  $F_Q^M(X,Y,Z)$  exceeds  $[F_Q^L(X,Y,Z)]^{RPS}$ .

**2.6.8**  $F_Q(X,Y,Z)$  Penalty Factors for Technical Specification Surveillances 3.2.1.2 and 3.2.1.3 are provided in Table 2.

**Catawba 2 Cycle 25 Core Operating Limits Report****Figure 4** **$K(Z)$ , Normalized  $F_Q(X,Y,Z)$  as a Function of Core Height for RFA Fuel**

## Catawba 2 Cycle 25 Core Operating Limits Report

### Table 2

#### F<sub>Q</sub>(X,Y,Z) and F<sub>ΔH</sub>(X,Y) Penalty Factors For Tech Spec Surveillances 3.2.1.2, 3.2.1.3 and 3.2.2.2

Burnup (EFPD)	F <sub>Q</sub> (X,Y,Z) Penalty Factor(%)	F <sub>ΔH</sub> (X,Y) Penalty Factor (%)
4	2.00	2.00
12	2.00	2.00
25	2.00	2.00
50	2.00	2.00
75	2.00	2.00
100	2.00	2.00
125	2.00	2.00
150	2.00	2.00
175	2.00	2.00
200	2.00	2.00
225	2.00	2.00
250	2.00	2.00
275	2.00	2.00
300	2.00	2.00
325	2.00	2.00
350	2.00	2.00
375	2.00	2.00
400	2.00	2.00
425	2.00	2.00
450	2.00	2.00
460	2.00	2.00
476	2.00	2.00
486	2.00	2.00
496	2.00	2.00
506	2.00	2.00

**Note:** Linear interpolation is adequate for intermediate cycle burnups. All cycle burnups outside the range of the table shall use a 2% penalty factor for both F<sub>Q</sub>(X,Y,Z) and F<sub>ΔH</sub>(X,Y) for compliance with Tech Spec Surveillances 3.2.1.2, 3.2.1.3 and 3.2.2.2.

## Catawba 2 Cycle 25 Core Operating Limits Report

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

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

$$2.7.1 \quad [F_{\Delta H}^L(X,Y)]^{LCO} = \text{MARP}(X,Y) * \left[ 1.0 + \frac{1}{\text{RRH}} * (1.0 - P) \right]$$

where:

$[F_{\Delta H}^L(X,Y)]^{LCO}$  is the steady-state, maximum allowed radial peak and includes allowances for calculation/measurement uncertainty.

$\text{MARP}(X,Y) =$  Cycle-specific operating limit Maximum Allowable Radial Peaks.  $\text{MARP}(X,Y)$  radial peaking limits are provided in Table 3.

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

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

$$(\text{RRH} = 3.34, 0.0 < P \leq 1.0)$$

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

$$2.7.2 \quad [F_{\Delta H}^L(X,Y)]^{SURV} = \frac{F_{\Delta H}^D(X,Y) * M_{\Delta H}(X,Y)}{\text{UMR} * \text{TILT}}$$

where:

$[F_{\Delta H}^L(X,Y)]^{SURV} =$  Cycle dependent maximum allowable design peaking factor that ensures  $F_{\Delta H}(X,Y)$  limit is not exceeded for operation within AFD, RIL, and QPTR limits.  $F_{\Delta H}^L(X,Y)^{SURV}$  includes allowances for calculation and measurement uncertainty.

$F_{\Delta H}^D(X,Y) =$  Design power distribution for  $F_{\Delta H}$ .  $F_{\Delta H}^D(X,Y)$  is provided in Appendix Table A-3 for normal operation and in Appendix Table A-6 for power escalation testing during initial startup operation.

## Catawba 2 Cycle 25 Core Operating Limits Report

$M_{\Delta H}(X,Y)$  = 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 Appendix Table A-3 for normal operation and in Appendix Table A-6 for power escalation testing during initial startup operation.

UMR = Uncertainty value for measured radial peaks (UMR = 1.0). UMR is 1.0 since a factor of 1.04 is implicitly included in the variable  $M_{\Delta H}(X,Y)$ .

TILT = Defined in Section 2.6.5.

**2.7.3** RRH is defined in Section 2.7.1.

**2.7.4** TRH = 0.04

where:

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

**2.7.5**  $F_{\Delta H}(X,Y)$  Penalty Factors for Technical Specification Surveillance 3.2.2.2 are provided in Table 2.

## **2.8 Axial Flux Difference – AFD (TS 3.2.3)**

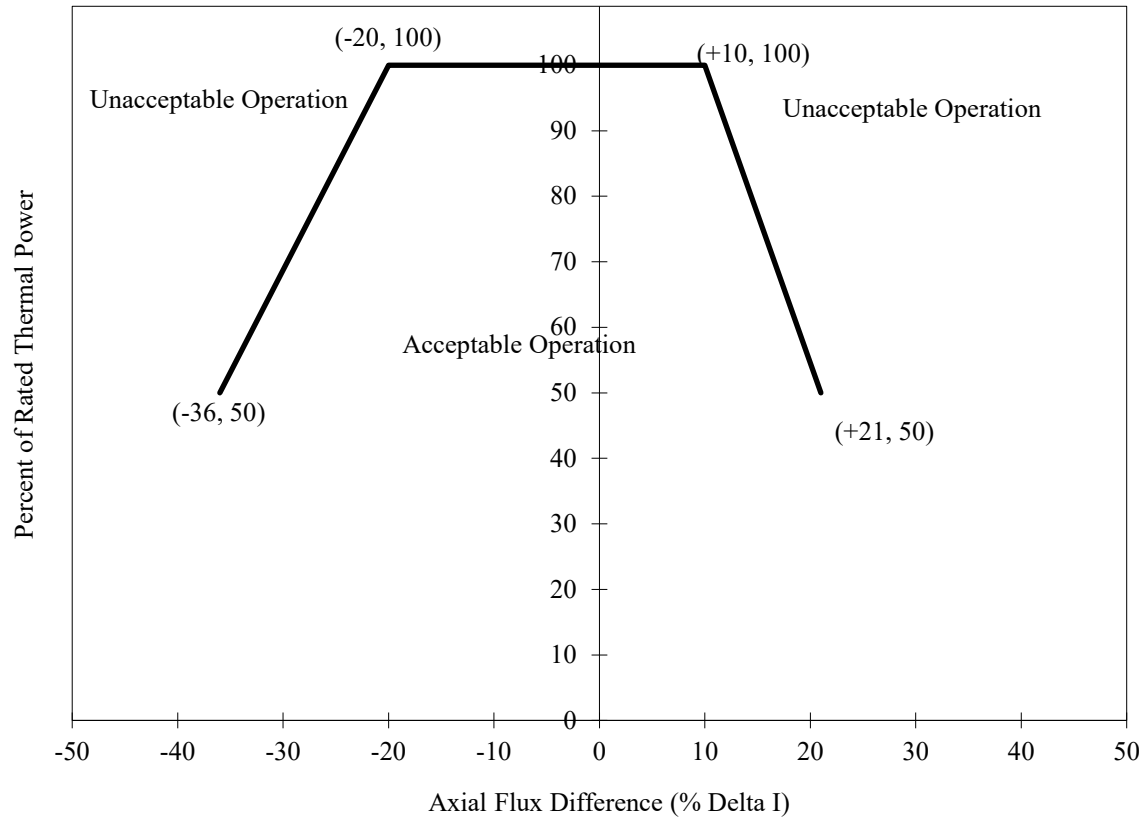
**2.8.1** Axial Flux Difference (AFD) Limits are provided in Figure 5.

## Catawba 2 Cycle 25 Core Operating Limits Report

**Table 3**  
**Maximum Allowable Radial Peaks (MARPs)**  
**RFA Steady State Limiting Value Between**  
**Loss of Flow Accident (LOFA) MARPs and  $F\Delta H_{LOCA}$**

Core Height (ft)	Axial Peak												
	1.05	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.1	3	3.25
0.12	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.3151	1.2461
1.20	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.3007	1.2235
2.40	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.4633	1.4616
3.60	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.4675	1.3874
4.80	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.2987	1.2579
6.00	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.3293	1.2602
7.20	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.5982	1.2871	1.2195
8.40	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6010	1.5127	1.2182	1.1578
9.60	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.5808	1.5301	1.4444	1.1431	1.0914
10.80	1.6058	1.6058	1.6058	1.6058	1.6058	1.6058	1.5743	1.5573	1.5088	1.4624	1.3832	1.1009	1.0470
11.40	1.6058	1.6058	1.6058	1.6058	1.6057	1.5826	1.5289	1.5098	1.4637	1.4218	1.3458	1.0670	1.0142



**Catawba 2 Cycle 25 Core Operating Limits Report****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 2 ROD manual for operational AFD limits.

## Catawba 2 Cycle 25 Core Operating Limits Report

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

#### 2.9.1 Overtemperature $\Delta T$ Setpoint Parameter Values

<u>Parameter</u>	<u>Nominal Value</u>
Nominal $T_{avg}$ at RTP	$T' \leq 590.8 \text{ }^\circ\text{F}$
Nominal RCS Operating Pressure	$P' = 2235 \text{ psig}$
Overtemperature $\Delta T$ reactor trip setpoint	$K_1 = 1.1953$
Overtemperature $\Delta T$ reactor trip heatup setpoint penalty coefficient	$K_2 = 0.03163/^\circ\text{F}$
Overtemperature $\Delta T$ reactor trip depressurization setpoint penalty coefficient	$K_3 = 0.001414/\text{psi}$
Time constants utilized in the lead-lag compensator for $\Delta T$	$\tau_1 = 8 \text{ sec.}$ $\tau_2 = 3 \text{ sec.}$
Time constant utilized in the lag compensator for $\Delta T$	$\tau_3 \leq 1.8 \text{ sec.}$
Time constants utilized in the lead-lag compensator for $T_{avg}$	$\tau_4 = 22 \text{ sec.}$ $\tau_5 = 4 \text{ sec.}$
Time constant utilized in the measured $T_{avg}$ lag compensator	$\tau_6 \leq 1.8 \text{ sec.}$
$f_1(\Delta I)$ "positive" breakpoint	$= 3.0 \text{ } \%\Delta I$
$f_1(\Delta I)$ "negative" breakpoint	$= \text{N/A}^*$
$f_1(\Delta I)$ "positive" slope	$= 1.525 \text{ } \%\Delta T_0 / \%\Delta I$
$f_1(\Delta I)$ "negative" slope	$= \text{N/A}^*$

- \*  $f_1(\Delta I)$  negative breakpoints and slopes for OT $\Delta T$  are less restrictive than OP $\Delta T$   $f_2(\Delta I)$  negative breakpoint and slope. Therefore, during a transient which challenges negative imbalance limits, OP $\Delta T$   $f_2(\Delta I)$  limits will result in a reactor trip before OT $\Delta T$   $f_1(\Delta I)$  limits are reached. This makes implementation of an OT $\Delta T$   $f_1(\Delta I)$  negative breakpoint and slope unnecessary.

## Catawba 2 Cycle 25 Core Operating Limits Report

### 2.9.2 Overpower $\Delta T$ Setpoint Parameter Values

<u>Parameter</u>	<u>Nominal Value</u>
Nominal Tavg at RTP	$T'' \leq 590.8 \text{ } ^\circ\text{F}$
Overpower $\Delta T$ reactor trip setpoint	$K_4 \leq 1.0909$
Overpower $\Delta T$ reactor trip penalty	$K_5 \geq 0.0 \text{ } / \text{ } ^\circ\text{F}$ for increasing Tavg $K_5 = 0.00 \text{ } / \text{ } ^\circ\text{F}$ for decreasing Tavg
Overpower $\Delta T$ reactor trip heatup setpoint penalty coefficient	$K_6 = 0.001291 / ^\circ\text{F}$ for $T > T''$ $K_6 = 0.0 \text{ } / ^\circ\text{F}$ for $T \leq T''$
Time constants utilized in the lead-lag compensator for $\Delta T$	$\tau_1 = 8 \text{ sec.}$ $\tau_2 = 3 \text{ sec.}$
Time constant utilized in the lag compensator for $\Delta T$	$\tau_3 \leq 1.8 \text{ sec.}$
Time constant utilized in the measured T <sub>avg</sub> lag compensator	$\tau_6 \leq 1.8 \text{ sec.}$
Time constant utilized in the rate-lag controller for T <sub>avg</sub>	$\tau_7 = 10 \text{ sec.}$
f <sub>2</sub> ( $\Delta I$ ) "positive" breakpoint	$= 35.0 \text{ } \% \Delta I$
f <sub>2</sub> ( $\Delta I$ ) "negative" breakpoint	$= -35.0 \text{ } \% \Delta I$
f <sub>2</sub> ( $\Delta I$ ) "positive" slope	$= 7.0 \text{ } \% \Delta T_0 / \% \Delta I$
f <sub>2</sub> ( $\Delta I$ ) "negative" slope	$= 7.0 \text{ } \% \Delta T_0 / \% \Delta I$

## Catawba 2 Cycle 25 Core Operating Limits Report

### 2.10 Boron Dilution Mitigation System (TS 3.3.9)

2.10.1 Reactor Makeup Water Pump flow rate limits:

<u>Applicable Mode</u>	<u>Limit</u>
MODE 3	$\leq 80$ gpm
MODE 4 or 5	$\leq 70$ gpm

### 2.11 RCS Pressure, Temperature and Flow Limits for DNB (TS 3.4.1)

RCS pressure, temperature and flow limits for DNB are shown in Table 4.

### 2.12 Accumulators (TS 3.5.1)

2.12.1 Boron concentration limits during MODES 1 and 2, and MODE 3 with RCS pressure >1000 psi:

<u>Parameter</u>	<u>Applicable Burnup</u>	<u>Limit</u>
Accumulator <b>minimum</b> boron concentration.	0 - 200 EFPD	2,500 ppm
Accumulator <b>minimum</b> boron concentration.	200.1 - 300 EFPD	2,500 ppm
Accumulator <b>minimum</b> boron concentration.	300.1 - 400 EFPD	2,328 ppm
Accumulator <b>minimum</b> boron concentration.	400.1 - 496 EFPD	2,179 ppm
Accumulator <b>minimum</b> boron concentration.	496.1 - 506 EFPD	2,040 ppm
Accumulator <b>maximum</b> boron concentration.	0 - 506 EFPD	3,075 ppm

## Catawba 2 Cycle 25 Core Operating Limits Report

### Table 4

#### Reactor Coolant System DNB Parameters

PARAMETER	INDICATION	No. Operable CHANNELS	LIMITS
1. Indicated RCS Average Temperature	meter	4	$\leq 589.6$ °F
	meter	3	$\leq 589.3$ °F
	computer	4	$\leq 590.1$ °F
	computer	3	$\leq 589.9$ °F
2. Indicated Pressurizer Pressure	meter	4	$\geq 2209.8$ psig
	meter	3	$\geq 2212.1$ psig
	computer	4	$\geq 2205.8$ psig
	computer	3	$\geq 2207.5$ psig
3. RCS Total Flow Rate			$\geq 387,000$ gpm

## Catawba 2 Cycle 25 Core Operating Limits Report

### 2.13 Refueling Water Storage Tank - RWST (TS 3.5.4)

#### 2.13.1 Boron concentration limits during MODES 1, 2, 3, and 4:

<u>Parameter</u>	<u>Limit</u>
RWST minimum boron concentration.	2,700 ppm
RWST maximum boron concentration.	3,075 ppm

### 2.14 Spent Fuel Pool Boron Concentration (TS 3.7.15)

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

<u>Parameter</u>	<u>Limit</u>
Spent fuel pool minimum boron concentration.	2,700 ppm

### 2.15 Refueling Operations - Boron Concentration (TS 3.9.1)

#### 2.15.1 Minimum boron concentration limit for 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 core $K_{\text{eff}}$ remains within MODE 6 reactivity requirement of $K_{\text{eff}} \leq 0.95$ .

<u>Parameter</u>	<u>Limit</u>
Minimum boron concentration of the Reactor Coolant System, the refueling canal, and the refueling cavity.	2,700 ppm

## Catawba 2 Cycle 25 Core Operating Limits Report

### 2.16 Standby Shutdown System - (SLC-16.7-9)

**2.16.1** Minimum boron concentration limit for the spent fuel pool required for Standby Makeup Pump Water Supply. Applicable for MODES 1, 2, and 3.

<u>Parameter</u>	<u>Limit</u>
Spent fuel pool minimum boron concentration for TR 16.7-9-3.	2,700 ppm

### 2.17 Borated Water Source – Shutdown (SLC 16.9-11)

**2.17.1** Volume and boron concentrations for the Boric Acid Tank (BAT) and the Refueling Water Storage Tank (RWST) during MODE 4 with any RCS cold leg temperature  $\leq 210^{\circ}\text{F}$ , and MODES 5 and 6.

<u>Parameter</u>	<u>Limit</u>
BAT minimum boron concentration	7,000 ppm
Volume of 7,000 ppm boric acid solution required to maintain SDM at 68 °F	2000 gallons

**NOTE: When cycle burnup is > 438 EFPD, Figure 6 may be used to determine required BAT minimum level.**

BAT Minimum Shutdown Volume (Includes the additional volumes listed in SLC 16.9-11)	13,086 gallons (14.9% level)
RWST minimum boron concentration	2,700 ppm
Volume of 2,700 ppm boric acid solution required to maintain SDM at 68 °F	7,000 gallons
RWST Minimum Shutdown Volume (Includes the additional volumes listed in SLC 16.9-11)	48,500 gallons (8.7% level)

## Catawba 2 Cycle 25 Core Operating Limits Report

### 2.18 Borated Water Source - Operating (SLC 16.9-12)

**2.18.1** Volume and boron concentrations for the Boric Acid Tank (BAT) and the Refueling Water Storage Tank (RWST) during MODES 1, 2, and 3 and MODE 4 with all RCS cold leg temperatures > 210 °F \*.

**\* NOTE: The SLC 16.9-12 applicability is down to MODE 4 temperatures of > 210°F. The minimum volumes calculated support cooldown to 200°F to satisfy UFSAR Chapter 9 requirements.**

<u>Parameter</u>	<u>Limit</u>
BAT minimum boron concentration	7,000 ppm
Volume of 7,000 ppm boric acid solution required to maintain SDM at 210°F	13,500 gallons

**NOTE: When cycle burnup is > 438 EFPD, Figure 6 may be used to determine required BAT minimum level.**

BAT Minimum Shutdown Volume (Includes the additional volumes listed in SLC 16.9-12)	25,200 gallons (45.8% level)
RWST minimum boron concentration	2,700 ppm
Volume of 2,700 ppm boric acid solution required to maintain SDM at 210 °F	57,107 gallons
RWST Minimum Shutdown Volume (Includes the additional volumes listed in SLC 16.9-12)	98,607 gallons (22.0% level)



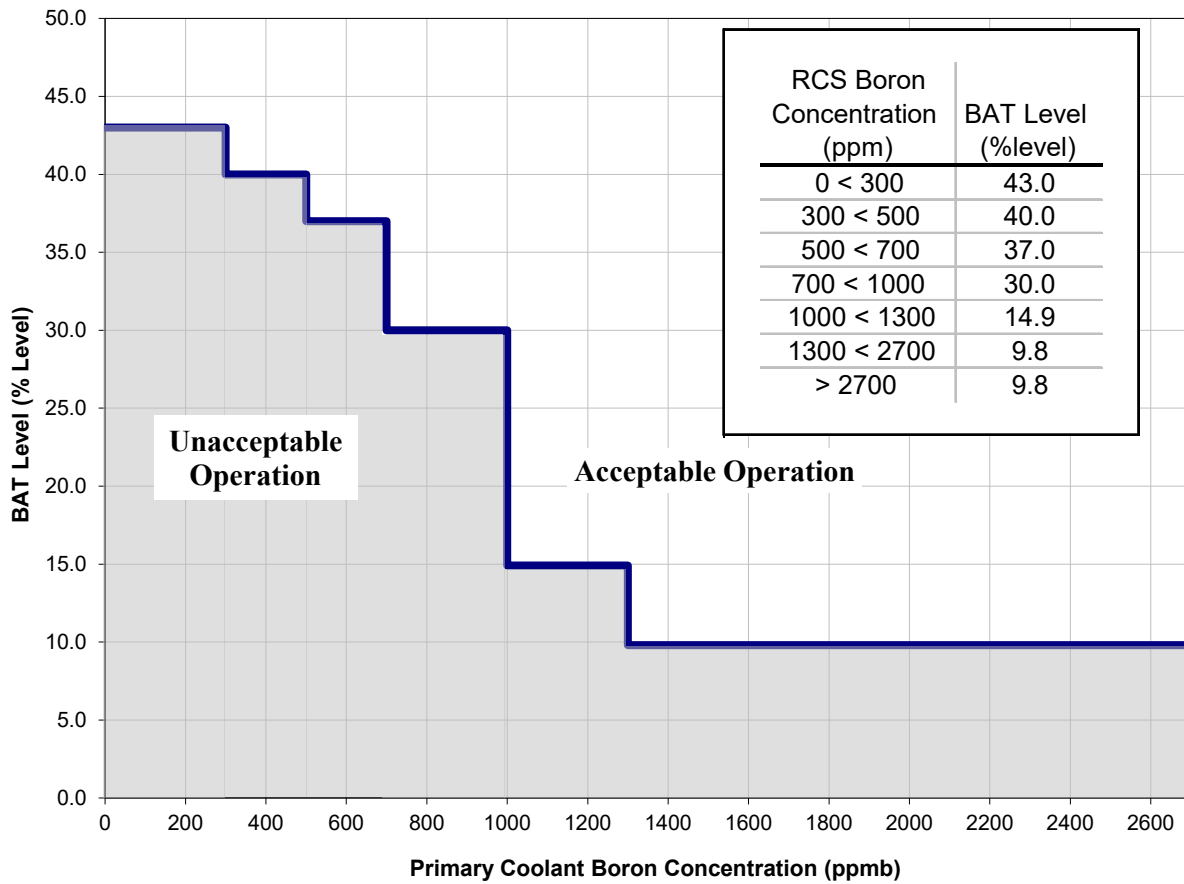
**Catawba 2 Cycle 25 Core Operating Limits Report**

**Figure 6**

**Boric Acid Storage Tank Indicated Level Versus  
Primary Coolant Boron Concentration**

**(Valid When Cycle Burnup is > 438 EFPD)**

**This figure includes additional volumes listed in SLC 16.9-11 and 16.9-12**



## Catawba 2 Cycle 25 Core Operating Limits Report

### Appendix A

#### Power Distribution Monitoring Factors

Appendix A contains power distribution monitoring factors used in Technical Specification Surveillance. This data was generated in the Catawba 2 Cycle 25 Maneuvering Analysis calculation file, CNC-1553.05-00-0696, Rev 0. Due to the size of the monitoring factor data, Appendix A is controlled electronically within the Duke document management system and is not included in the Duke internal copies of the COLR. The Plant Reactor Engineering section will control this information via computer file(s) and should be contacted if there is a need to access this information.

Appendix A is available to be transmitted to the NRC.

<b>Filename</b>	<b>Checksum / File Size</b>
c2c25_AppendixA.pdf	2502569615 / 3149024