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A Duke Energy Company

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March 27, 2003

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555-0001

Subject: Duke Energy Corporation
Catawba Nuclear Station Unit 2
Docket No.: 50-414
Core Operating Limits Report for Catawba Unit 2
Cycle 13 Revision 22

Attached, pursuant to Catawba Technical Specification 5.6.5, is an information copy of the Core Operating Limits Report (COLR) for Catawba Unit 2 Cycle 13. The COLR Appendix A is included with the letter to the NRC Document Control Desk as an electronic file.

The attachment and electronic file do not contain any new commitments.

Please direct any questions or concerns to George Strickland at (803) 831-3585.

Sincerely,

G. R. Peterson

Attachment

A001

xc w/att: L. A. Reyes, Regional Administrator Region II

R. E. Martin, NRR Senior Project Manager

E. F. Guthrie, Catawba NRC Senior Resident

# Catawba Unit 2 Cycle 13

# Core Operating Limits Report
# Revision 22

## February 2003

Duke Power Company

| | | Date |
|---|---|---|
| Prepared By: | [signature] | 2/26/2003 |
| Checked By: | Nicholas R Hueger | 2/26/03 |
| Checked By: | Stephen D. Sing | 2/26/03 |
| Approved By: | [signature] | 2/26/03 |

**QA Condition 1**

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

**INSPECTION OF ENGINEERING INSTRUCTIONS**

Inspection Waived By: P. M. Abraham (Sponsor) Date: 2/26/2003

<u>CATAWBA</u>

| | Inspection Waived | | |
|---|---|---|---|
| MCE (Mechanical & Civil) | ☑ | Inspected By/Date: | |
| RES (Electrical Only) | ☑ | Inspected By/Date: | |
| RES (Reactor) | ☑ | Inspected By/Date: | |
| MOD | ☑ | Inspected By/Date: | |
| Other ( ____________ ) | ☐ | Inspected By/Date: | |

<u>OCONEE</u>

| | Inspection Waived | | |
|---|---|---|---|
| MCE (Mechanical & Civil) | ☐ | Inspected By/Date: | |
| RES (Electrical Only) | ☐ | Inspected By/Date: | |
| RES (Reactor) | ☐ | Inspected By/Date: | |
| MOD | ☐ | Inspected By/Date: | |
| Other ( ____________ ) | ☐ | Inspected By/Date: | |

<u>MCGUIRE</u>

| | Inspection Waived | | |
|---|---|---|---|
| MCE (Mechanical & Civil) | ☐ | Inspected By/Date: | |
| RES (Electrical Only) | ☐ | Inspected By/Date: | |
| RES (Reactor) | ☐ | Inspected By/Date: | |
| MOD | ☐ | Inspected By/Date: | |
| Other ( ____________ ) | ☐ | Inspected By/Date: | |

**Catawba 2 Cycle 13 Core Operating Limits Report**

IMPLEMENTATION INSTRUCTIONS FOR REVISION 22

Revision 22 of the Catawba Unit 2 COLR contains limits specific to the Catawba 2 Cycle 13 reload core and may become effective any time during NO MODE between Cycles 12 and 13.

This revision must become effective prior to entering MODE 6 which starts Cycle 13.

# Catawba 2 Cycle 13 Core Operating Limits Report

## REVISION LOG

| Revision | Effective Date | Pages Affected | COLR |
|---|---|---|---|
| Revisions 1-13 | N/A | N/A | C2C06 – C2C09 |
| Revision 14 | August 1998 | N/A | C2C10 COLR |
| Revision 15 | October 1998 | N/A | C2C10 COLR rev 1 |
| Revision 16 | December 1998 | N/A | C2C10 COLR rev 2 |
| Revision 17 | February 2000 | N/A | C2C11 COLR |
| Revision 18 | February 2001 | N/A | C2C11 COLR rev 1 |
| Revision 19 | September 2001 | ALL | C2C12 COLR |
| Revision 20 | September 2001 | 1,2,3,4,25,26,27 | C2C12 COLR rev 1 |
| Revision 21 | July 2002 | 1-4, 5a, 5b, 5c | C2C12 COLR rev 2 |
| Revision 22 | February 2003 | All | C2C13 COLR |

## Catawba 2 Cycle 13 Core Operating Limits Report

### INSERTION SHEET FOR REVISION 22

| Remove pages | Insert Rev. 22 pages |
|---|---|
| All | 1-30 |
| | Appendix A*, 1-312 |

* Appendix A contains power distribution monitoring factors used in Technical Specification Surveillance. Appendix A is only included on CD with the COLR copy sent to the NRC.

# Catawba 2 Cycle 13 Core Operating Limits Report

## 1.0 Core Operating Limits Report

This Core Operating Limits Report (COLR) has been prepared in accordance with the requirements of the Technical Specification 5.6.5.

The Technical Specifications that reference this report are listed below:

| Tech Spec Section | Technical Specifications | COLR Parameter | COLR Section | COLR Page |
|---|---|---|---|---|
| 3.1.1 | Shutdown Margin | Shutdown Margin | 2.1 | 9 |
| 3.1.3 | Moderator Temperature Coefficient | MTC | 2.2 | 9 |
| 3.1.4 | Rod Group Alignment Limits | Shutdown Margin | 2.1 | 9 |
| 3.1.5 | Shutdown Bank Insertion Limit | Shutdown Margin | 2.1 | 9 |
| | | Rod Insertion Limits | 2.3 | 10 |
| 3.1.6 | Control Bank Insertion Limit | Shutdown Margin | 2.1 | 9 |
| | | Rod Insertion Limits | 2.4 | 10 |
| 3.1.8 | Physics Tests Exceptions | Shutdown Margin | 2.1 | 9 |
| 3.2.1 | Heat Flux Hot Channel Factor | $F_Q$ | 2.5 | 14 |
| | | AFD | 2.7 | 21 |
| | | OTΔT | 2.8 | 24 |
| | | Penalty Factors | 2.5 | 16 |
| 3.2.2 | Nuclear Enthalpy Rise Hot Channel Factor | FΔH | 2.6 | 20 |
| | | Penalty Factors | 2.6 | 21 |
| 3.2.3 | Axial Flux Difference | AFD | 2.7 | 21 |
| 3.3.1 | Reactor Trip System Instrumentation | OTΔT | 2.8 | 24 |
| | | OPΔT | 2.8 | 25 |
| 3.3.9 | Boron Dilution Mitigation System | Reactor Makeup Water Flow Rate | 2.9 | 26 |
| 3.5.1 | Accumulators | Max and Min Boron Conc. | 2.10 | 26 |
| 3.5.4 | Refueling Water Storage Tank | Max and Min Boron Conc.. | 2.11 | 26 |
| 3.7.15 | Spent Fuel Pool Boron Concentration | Min Boron Concentration | 2.12 | 27 |
| 3.9.1 | Refueling Operations - Boron Concentration | Min Boron Concentration | 2.13 | 27 |
| 3.9.2 | Refueling Operations – Nuclear Instrumentation | Reactor Makeup Water Flow Rate | 2.14 | 27 |
| 5.6.5 | Core Operating Limits Report (COLR) | Analytical Methods | 1.1 | 6 |

The Selected License Commitments that reference this report are listed below:

| SLC Section | Selected Licensing Commitment | COLR Parameter | COLR Section | COLR Page |
|---|---|---|---|---|
| 16.7-9.3 | Standby Shutdown System | Standby Makeup Pump Water Supply | 2.15 | 28 |
| 16 9-11 | Boration Systems – Borated Water Source – Shutdown | Borated Water Volume and Conc. for BAT/RWST | 2.16 | 28 |
| 16.9-12 | Boration Systems – Borated Water Source – Operating | Borated Water Volume and Conc. for BAT/RWST | 2.17 | 29 |

## Catawba 2 Cycle 13 Core Operating Limits Report

### 1.1 Analytical Methods

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

1. WCAP-9272-P-A, "WESTINGHOUSE RELOAD SAFETY EVALUATION METHODOLOGY," (W Proprietary).

   Revision 0
   Report Date: July 1985
   **Not Used for C2C13**

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

   Revision 0
   Report Date: August 1985

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 for C2C13**

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 for C2C13**

## Catawba 2 Cycle 13 Core Operating Limits Report

### 1.1 Analytical Methods (continued)

6. DPC-NE-3000PA, "Thermal-Hydraulic Transient Analysis Methodology," (DPC Proprietary).

   Revision 2
   SER Date: October 14, 1998

7. DPC-NE-3001PA, "Multidimensional Reactor Transients and Safety Analysis Physics Parameter Methodology," (DPC Proprietary).

   Revision 0
   Report Date: November 1991

8. DPC-NE-3002A, "FSAR Chapter 15 System Transient Analysis Methodology".

   Revision 4
   SER Date: April 6, 2001

9. DPC-NE-2004P-A, "Duke Power Company McGuire and Catawba Nuclear Stations Core Thermal-Hydraulic Methodology using VIPRE-01," (DPC Proprietary).

   Revision 1
   SER Date: February 20, 1997

10. DPC-NE-2005P-A, "Thermal Hydraulic Statistical Core Design Methodology," (DPC Proprietary).

    Revision 1
    SER Date: November 7, 1996

11. DPC-NE-2008P-A, "Fuel Mechanical Reload Analysis Methodology Using TACO3," (DPC Proprietary).

    Revision 0
    SER Date: April 3, 1995

12. DPC-NE-2009-P-A, "Westinghouse Fuel Transition Report," (DPC Proprietary).

    Revision 2
    SER Date: December 18, 2002

13. DPC-NE-1004A, "Nuclear Design Methodology Using CASMO-3/SIMULATE-3P."

    Revision 1
    SER Date: April 26, 1996

# Catawba 2 Cycle 13 Core Operating Limits Report

## 1.1 Analytical Methods (continued)

14. DPC-NF-2010A, "Duke Power Company McGuire Nuclear Station Catawba Nuclear Station Nuclear Physics Methodology for Reload Design."

    Revision 1
    SER Date: October 1, 2002

15. DPC-NE-2011PA, "Duke Power Company Nuclear Design Methodology for Core Operating Limits of Westinghouse Reactors," (DPC Proprietary).

    Revision 1
    SER Date: October 1, 2002

# Catawba 2 Cycle 13 Core Operating Limits Report

## 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.

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

**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.

**2.1.6** For TS 3.1.8, shutdown margin shall be greater than or equal to 1.3% ΔK/K in mode 2 during Physics Testing.

## 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.

**Catawba 2 Cycle 13 Core Operating Limits Report**

**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 (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)

**2.3 Shutdown Bank Insertion Limit (TS 3.1.5)**

**2.3.1** Each shutdown bank shall be withdrawn to at least 226 steps. Shutdown banks are withdrawn in sequence and with no overlap.

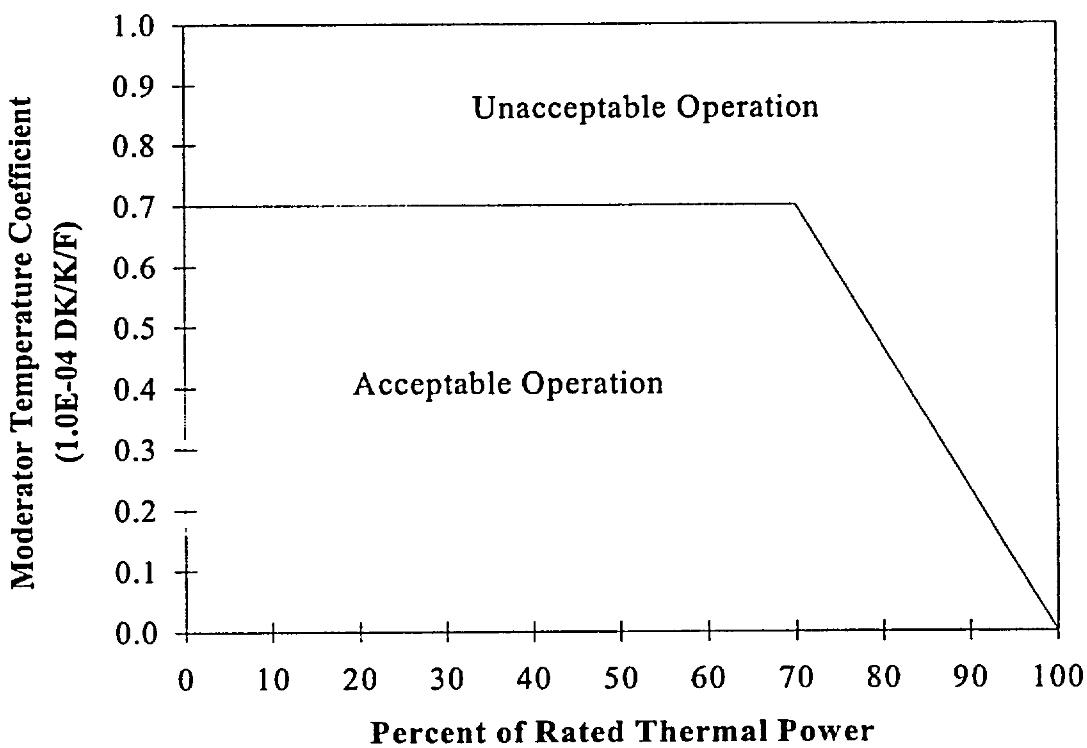
**2.4 Control Bank Insertion Limits (TS 3.1.6)**

**2.4.1** Control banks shall be within the insertion, sequence, and overlap limits shown in Figure 2. Specific control bank withdrawal and overlap limits as a function of the fully withdrawn position are shown in Table 1.

## Catawba 2 Cycle 13 Core Operating Limits Report

### Figure 1

### Moderator Temperature Coefficient Upper Limit Versus Power Level

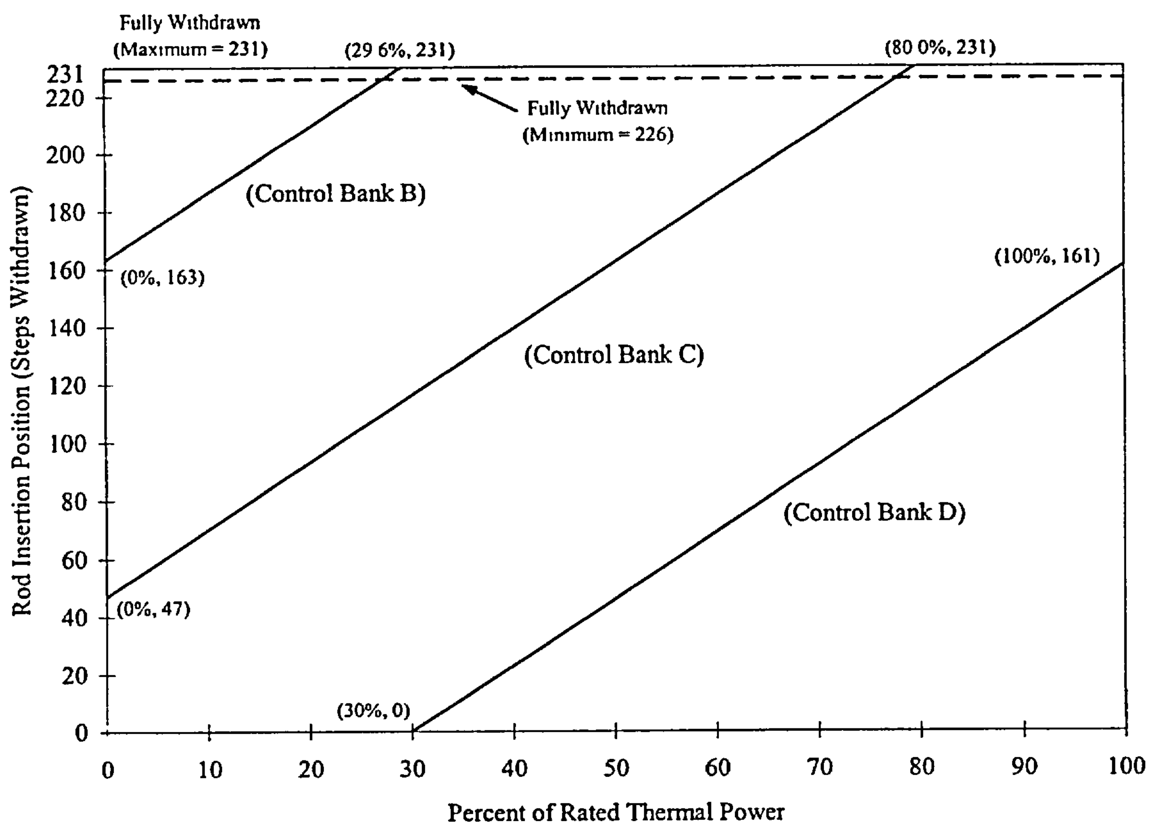



**NOTE:** Compliance with Technical Specification 3.1.3 may require rod withdrawal limits. Refer to the Unit 2 ROD manual for details.

## Catawba 2 Cycle 13 Core Operating Limits Report

### 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 2 ROD manual for details.

# Catawba 2 Cycle 13 Core Operating Limits Report

## Table 1
## Control Bank Withdrawal Steps and Sequence

**Fully Withdrawn at 226 Steps**

| Control Bank A | Control Bank B | Control Bank C | Control Bank D |
|---|---|---|---|
| 0 Start | 0 | 0 | 0 |
| 116 | 0 Start | 0 | 0 |
| 226 Stop | 110 | 0 | 0 |
| 226 | 116 | 0 Start | 0 |
| 226 | 226 Stop | 110 | 0 |
| 226 | 226 | 116 | 0 Start |
| 226 | 226 | 226 Stop | 110 |

**Fully Withdrawn at 227 Steps**

| Control Bank A | Control Bank B | Control Bank C | Control Bank D |
|---|---|---|---|
| 0 Start | 0 | 0 | 0 |
| 116 | 0 Start | 0 | 0 |
| 227 Stop | 111 | 0 | 0 |
| 227 | 116 | 0 Start | 0 |
| 227 | 227 Stop | 111 | 0 |
| 227 | 227 | 116 | 0 Start |
| 227 | 227 | 227 Stop | 111 |

**Fully Withdrawn at 228 Steps**

| Control Bank A | Control Bank B | Control Bank C | Control Bank D |
|---|---|---|---|
| 0 Start | 0 | 0 | 0 |
| 116 | 0 Start | 0 | 0 |
| 228 Stop | 112 | 0 | 0 |
| 228 | 116 | 0 Start | 0 |
| 228 | 228 Stop | 112 | 0 |
| 228 | 228 | 116 | 0 Start |
| 228 | 228 | 228 Stop | 112 |

**Fully Withdrawn at 229 Steps**

| Control Bank A | Control Bank B | Control Bank C | Control Bank D |
|---|---|---|---|
| 0 Start | 0 | 0 | 0 |
| 116 | 0 Start | 0 | 0 |
| 229 Stop | 113 | 0 | 0 |
| 229 | 116 | 0 Start | 0 |
| 229 | 229 Stop | 113 | 0 |
| 229 | 229 | 116 | 0 Start |
| 229 | 229 | 229 Stop | 113 |

**Fully Withdrawn at 230 Steps**

| Control Bank A | Control Bank B | Control Bank C | Control Bank D |
|---|---|---|---|
| 0 Start | 0 | 0 | 0 |
| 116 | 0 Start | 0 | 0 |
| 230 Stop | 114 | 0 | 0 |
| 230 | 116 | 0 Start | 0 |
| 230 | 230 Stop | 114 | 0 |
| 230 | 230 | 116 | 0 Start |
| 230 | 230 | 230 Stop | 114 |

**Fully Withdrawn at 231 Steps**

| Control Bank A | Control Bank B | Control Bank C | Control Bank D |
|---|---|---|---|
| 0 Start | 0 | 0 | 0 |
| 116 | 0 Start | 0 | 0 |
| 231 Stop | 115 | 0 | 0 |
| 231 | 116 | 0 Start | 0 |
| 231 | 231 Stop | 115 | 0 |
| 231 | 231 | 116 | 0 Start |
| 231 | 231 | 231 Stop | 115 |

## Catawba 2 Cycle 13 Core Operating Limits Report

### 2.5 Heat Flux Hot Channel Factor - $F_Q(X,Y,Z)$ (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 for $P > 0.5$
$F_Q^{RTP}$ *K(Z)/0.5 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 $F_Q(X,Y,Z)$ as a function of core height. K(Z) for MkBW fuel is provided in Figure 3, and the K(Z) for Westinghouse RFA fuel is provided in Figure 4.

**2.5.4** K(BU) is the normalized $F_Q(X,Y,Z)$ as a function of burnup. K(BU) for both MkBW fuel and Westinghouse RFA fuel is 1.0 at all burnups.

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.

**Catawba 2 Cycle 13 Core Operating Limits Report**

$F_Q^D$(X,Y,Z) = Design power distribution for $F_Q$. $F_Q^D$(X,Y,Z) is provided in Table 4, Appendix A, for normal operating conditions and in Table 7, 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 4, Appendix A for normal operating conditions and in Table 7, 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)

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 5, Appendix A for normal operating conditions and in Table 8, Appendix A for power escalation testing during initial startup operations.

**Catawba 2 Cycle 13 Core Operating Limits Report**

$M_C(X,Y,Z)$ = 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 Table 5, Appendix A for normal operating conditions and in Table 8, 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)

**2.5.7** KSLOPE = 0.0725

where:

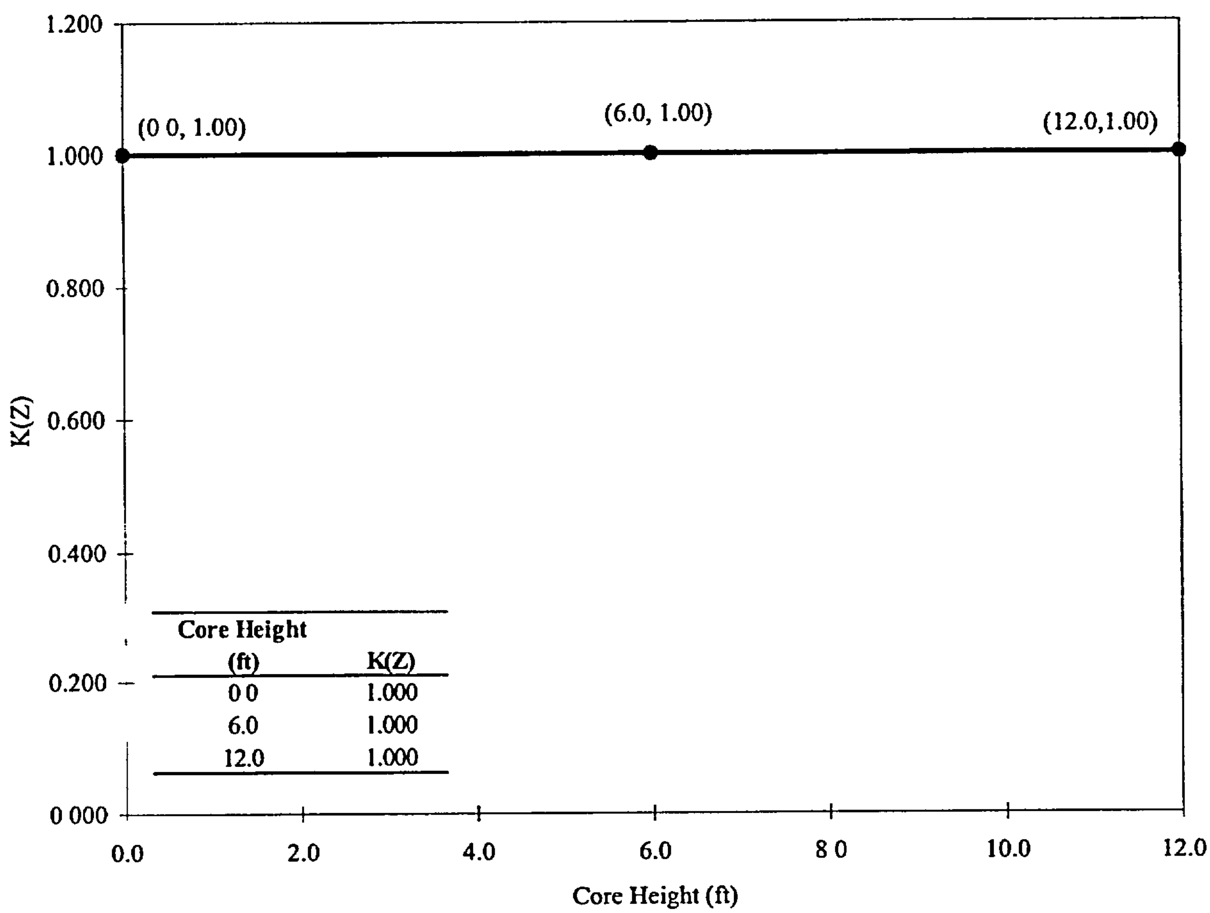
KSLOPE = the adjustment to the $K_1$ value from OTΔT trip setpoint required to compensate for each 1% that $F_Q^M$ (X,Y,Z) exceeds $F_Q^L$ $(X,Y,Z)^{RPS}$.

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

# Catawba 2 Cycle 13 Core Operating Limits Report

## Figure 3

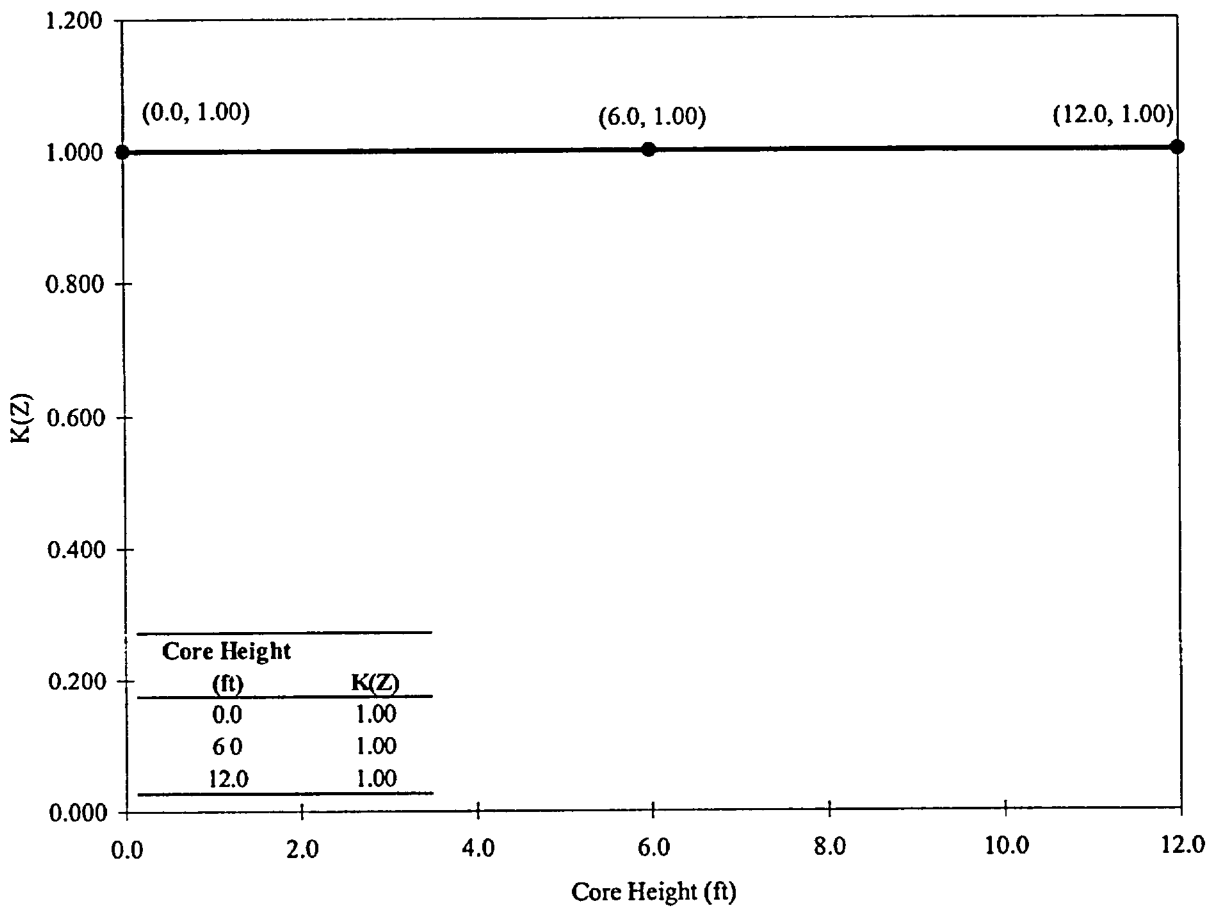
## K(Z), Normalized $F_Q(X,Y,Z)$ as a Function of Core Height for MkBW Fuel



## Catawba 2 Cycle 13 Core Operating Limits Report

### Figure 4

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




| Core Height (ft) | K(Z) |
|---|---|
| 0.0 | 1.00 |
| 6 0 | 1.00 |
| 12.0 | 1.00 |

# Catawba 2 Cycle 13 Core Operating Limits Report

## Table 2

### $F_Q(X,Y,Z)$ and $F_{\Delta H}(X,Y)$ Penalty Factors For Tech Spec Surveillances 3.2.1.2, 3.2.1.3 and 3.2.2.2

| Burnup (EFPD) | $F_Q(X,Y,Z)$ Penalty Factor(%) | $F_{\Delta H}(X,Y)$ 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 |
| 475 | 2.00 | 2.00 |
| 500 | 2.00 | 2.00 |
| 509 | 2.00 | 2.00 |
| 524 | 2.00 | 2.00 |
| 534 | 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 $F_Q(X,Y,Z)$ and $F_{\Delta H}(X,Y)$ for compliance with the Tech Spec Surveillances 3.2.1.2, 3.2.1.3 and 3.2.2.2.

**Catawba 2 Cycle 13 Core Operating Limits Report**

## 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. $[F^L_{\Delta H}(X,Y)]^{LCO}$ includes allowances for calculation/measurement uncertainty.

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

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

RRH = Thermal Power reduction required to compensate for each 1% that the measured radial peak, $F^M_{\Delta H}(X,Y)$, exceeds the limit. ($RRH = 3.34,\ 0.0 < P \le 1.0$)

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 6, Appendix A for normal operation and in Table 9,

**Catawba 2 Cycle 13 Core Operating Limits Report**

Appendix A for power escalation testing during initial startup operation.

$M_{\Delta H}(X,Y)$ = 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 6, Appendix A for normal operation and in Table 9, Appendix A for power escalation testing during initial startup operation.

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

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

**2.6.3** RRH = 3.34

where:

RRH = Thermal Power reduction required to compensate for each 1% that the measured radial peak, $F_{\Delta H}^{M}(X,Y)$ exceeds its limit. $(0 < P \leq 1.0)$

**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.

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

## 2.7 Axial Flux Difference – AFD (TS 3.2.3)

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

## Catawba 2 Cycle 13 Core Operating Limits Report

### Table 3
### Maximum Allowable Radial Peaks (MARPS)

MkBW Fuel MARPs

| Height | Axial Peak | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (ft) | 1.05 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | 2.1 | 3.0 | 3.25 |
| 0.12 | 1.678 | 1.708 | 1.772 | 1.829 | 1.878 | 1.922 | 1.852 | 1.798 | 1.714 | 1.636 | 1.535 | 1.211 | 1.147 |
| 1.20 | 1.675 | 1.706 | 1.766 | 1.821 | 1.867 | 1.886 | 1.829 | 1.806 | 1.731 | 1.655 | 1.540 | 1.182 | 1.117 |
| 2.40 | 1.679 | 1.708 | 1.763 | 1.815 | 1.853 | 1.841 | 1.786 | 1.769 | 1.711 | 1.655 | 1.557 | 1.168 | 1.106 |
| 3.60 | 1.682 | 1.709 | 1.760 | 1.804 | 1.812 | 1.797 | 1.743 | 1.722 | 1.669 | 1.619 | 1.556 | 1.202 | 1.131 |
| 4.80 | 1.684 | 1.708 | 1.754 | 1.792 | 1.766 | 1.750 | 1.699 | 1.681 | 1.630 | 1.581 | 1.516 | 1.232 | 1.186 |
| 6.00 | 1.686 | 1.708 | 1.745 | 1.761 | 1.715 | 1.703 | 1.654 | 1.638 | 1.590 | 1.544 | 1.476 | 1.206 | 1.156 |
| 7.20 | 1.686 | 1.704 | 1.733 | 1.714 | 1.666 | 1.649 | 1.603 | 1.587 | 1.542 | 1.503 | 1.438 | 1.177 | 1.127 |
| 8.40 | 1.681 | 1.692 | 1.702 | 1.660 | 1.612 | 1.595 | 1.549 | 1.537 | 1.494 | 1.454 | 1.387 | 1.145 | 1.100 |
| 9.60 | 1.673 | 1.677 | 1.651 | 1.601 | 1.558 | 1.544 | 1.502 | 1.491 | 1.450 | 1.413 | 1.350 | 1.121 | 1.076 |
| 10.80 | 1.662 | 1.649 | 1.603 | 1.550 | 1.503 | 1.491 | 1.448 | 1.441 | 1.404 | 1.369 | 1.307 | 1.086 | 1.043 |
| 12.00 | 1.636 | 1.608 | 1.553 | 1.505 | 1.456 | 1.446 | 1.408 | 1.403 | 1.370 | 1.340 | 1.286 | 1.072 | 1.027 |

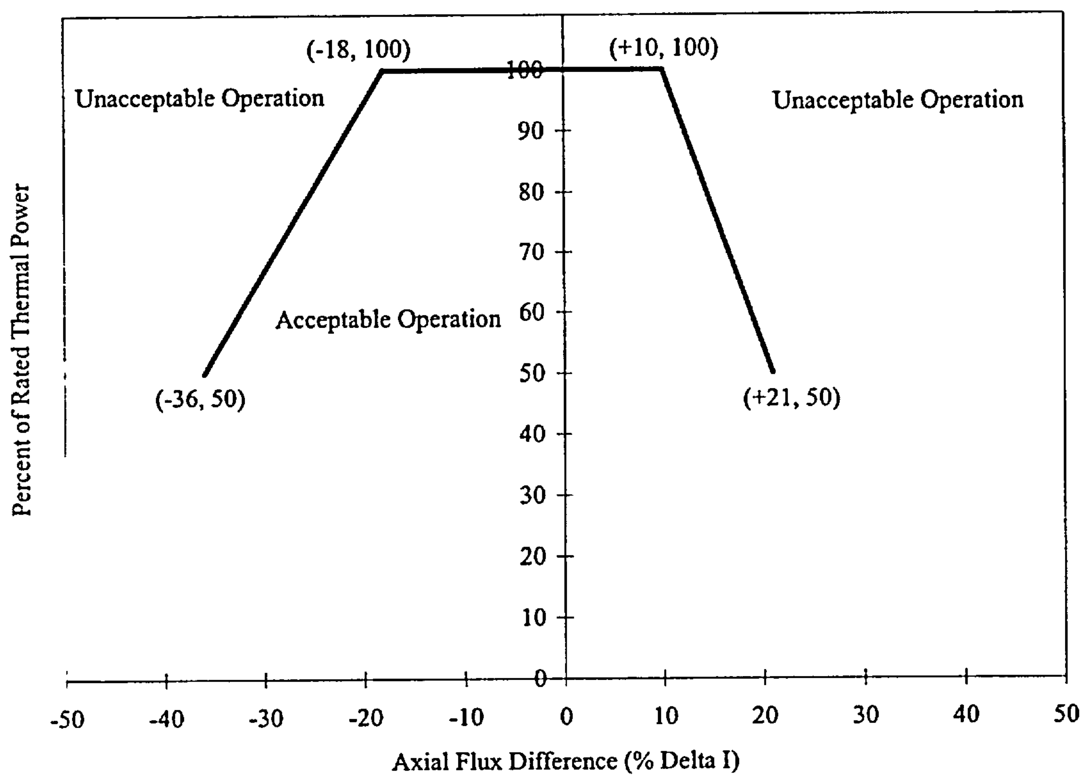
RFA Fuel MARPs

| Height | Axial Peak | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (ft) | 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 | 1.847 | 1.882 | 1.947 | 1.992 | 1.974 | 2.068 | 2.09 | 2.049 | 1.972 | 1.9 | 1.778 | 1.315 | 1.246 |
| 1.20 | 1.843 | 1.879 | 1.938 | 1.992 | 1.974 | 2.068 | 2.054 | 2.012 | 1.935 | 1.862 | 1.785 | 1.301 | 1.224 |
| 2.40 | 1.846 | 1.876 | 1.931 | 1.981 | 1.974 | 2.068 | 2.025 | 1.981 | 1.903 | 1.832 | 1.757 | 1.468 | 1.456 |
| 3.60 | 1.843 | 1.869 | 1.92 | 1.964 | 1.974 | 2.068 | 2.005 | 1.968 | 1.892 | 1.82 | 1.716 | 1.471 | 1.431 |
| 4.80 | 1.838 | 1.868 | 1.906 | 1.945 | 1.974 | 2.006 | 1.945 | 1.925 | 1.862 | 1.802 | 1.725 | 1.326 | 1.285 |
| 6.00 | 1.834 | 1.856 | 1.891 | 1.921 | 1.946 | 1.934 | 1.878 | 1.863 | 1.802 | 1.747 | 1.673 | 1.384 | 1.317 |
| 7.20 | 1.828 | 1.845 | 1.871 | 1.893 | 1.887 | 1.872 | 1.809 | 1.787 | 1.732 | 1.681 | 1.618 | 1.316 | 1.277 |
| 8.40 | 1.823 | 1.829 | 1.847 | 1.857 | 1.816 | 1.795 | 1.739 | 1.722 | 1.675 | 1.63 | 1.551 | 1.247 | 1.211 |
| 9.60 | 1.814 | 1.812 | 1.809 | 1.792 | 1.738 | 1.724 | 1.678 | 1.665 | 1.621 | 1.578 | 1.492 | 1.191 | 1.137 |
| 10.80 | 1.798 | 1.784 | 1.761 | 1.738 | 1.697 | 1.682 | 1.626 | 1.605 | 1.558 | 1.512 | 1.43 | 1.149 | 1.097 |
| 11.40 | 1.789 | 1.765 | 1.725 | 1.684 | 1.632 | 1.614 | 1.569 | 1.557 | 1.51 | 1.466 | 1.392 | 1.113 | 1.06 |

## Catawba 2 Cycle 13 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 13 Core Operating Limits Report**

## 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 | Nominal Value |
|---|---|
| Overtemperature ΔT reactor trip setpoint | $K_1 = 1.1953$ |
| Overtemperature ΔT reactor trip heatup setpoint penalty coefficient | $K_2 = 0.03163/^oF$ |
| Overtemperature ΔT reactor trip depressurization setpoint penalty coefficient | $K_3 = 0.001414/psi$ |
| Time constants utilized in the lead-lag compensator for ΔT | $\tau_1 = 8$ sec.<br>$\tau_2 = 3$ 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.<br>$\tau_5 = 4$ sec. |
| Time constant utilized in the measured $T_{avg}$ lag compensator | $\tau_6 = 0$ 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 $\%\Delta T_0/ \%\Delta I$ |
| $f_1(\Delta I)$ "negative" slope | = 3.910 $\%\Delta T_0/ \%\Delta I$ |

## Catawba 2 Cycle 13 Core Operating Limits Report

**2.8.2** Overpower ΔT Setpoint Parameter Values

| Parameter | Nominal Value |
|---|---|
| Overpower ΔT reactor trip setpoint | $K_4 = 1.0819$ |
| Overpower ΔT reactor trip heatup setpoint penalty coefficient (for T>T") | $K_6 = 0.001291/^{o}F$ |
| Time constants utilized in the lead-lag compensator for ΔT | $\tau_1 = 8$ sec.<br>$\tau_2 = 3$ 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 %$\Delta T_0$/ %ΔI |
| $f_2(\Delta I)$ "negative" slope | = 7.0 %$\Delta T_0$/ %ΔI |

## Catawba 2 Cycle 13 Core Operating Limits Report

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

**2.9.1** Reactor Makeup Water Pump flow rate 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. | 2,500 ppm |
| Cold Leg Accumulator maximum boron concentration. | 3,075 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. | 2,700 ppm |
| Refueling Water Storage Tank maximum boron concentration. | 3,075 ppm |

## Catawba 2 Cycle 13 Core Operating Limits Report

### 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. | 2,700 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. | 2,700 ppm |

### 2.14 Refueling Operations - Nuclear Instrumentation (TS 3.9.2)

**2.14.1** Reactor Makeup Water Pump Flow rate Limit:

| Applicable Mode | Limit |
|---|---|
| Mode 6 | $\leq$ 70 gpm |

**Catawba 2 Cycle 13 Core Operating Limits Report**

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

2.15.1 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. | 2,700 ppm |

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

**2.16.1** 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 $\leq 285^{\circ}$F, and Modes 5 and 6.

| Parameter | Limit |
|---|---|
| Boric Acid Tank minimum boron concentration | 7,000 ppm |
| Volume of 7,000 ppm boric acid solution required to maintain SDM at 68°F | 2,000 gallons |
| Boric Acid Tank Minimum Contained Shutdown Volume (Includes the additional volumes listed in SLC 16.9-11) | 13,086 gallons (14.9%) |

**NOTE: When cycle burnup is > 450 EFPD, Figure 6 may be used to determine the required Boric Acid Tank Minimum Level.**

| Parameter | Limit |
|---|---|
| Refueling Water Storage Tank minimum boron concentration | 2,700 ppm |
| Volume of 2,700 ppm boric acid solution required to maintain SDM at 68 °F | 7,000 gallons |
| Refueling Water Storage Tank Minimum Contained Shutdown Volume (Includes the additional volumes listed in SLC 16.9-11) | 48,500 gallons (8.7%) |

**Catawba 2 Cycle 13 Core Operating Limits Report**

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

**2.17.1** 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 > 285°F.

| Parameter | Limit |
|---|---|
| Boric Acid Tank minimum boron concentration | 7,000 ppm |
| Volume of 7,000 ppm boric acid solution required to maintain SDM at 285°F | 13,500 gallons |
| Boric Acid Tank Minimum Contained Shutdown Volume (Includes the additional volumes listed in SLC 16.9-12) | 25,200 gallons (45.8%) |

**NOTE: When cycle burnup is > 450 EFPD, Figure 6 may be used to determine the required Boric Acid Tank Minimum Level.**

| | |
|---|---|
| Refueling Water Storage Tank minimum boron concentration | 2,700 ppm |
| Volume of 2,700 ppm boric acid solution required to maintain SDM at 285 °F | 57,107 gallons |
| Refueling Water Storage Tank Minimum Contained Shutdown Volume (Includes the additional volumes listed in SLC 16.9-12) | 98,607 gallons (22.0%) |

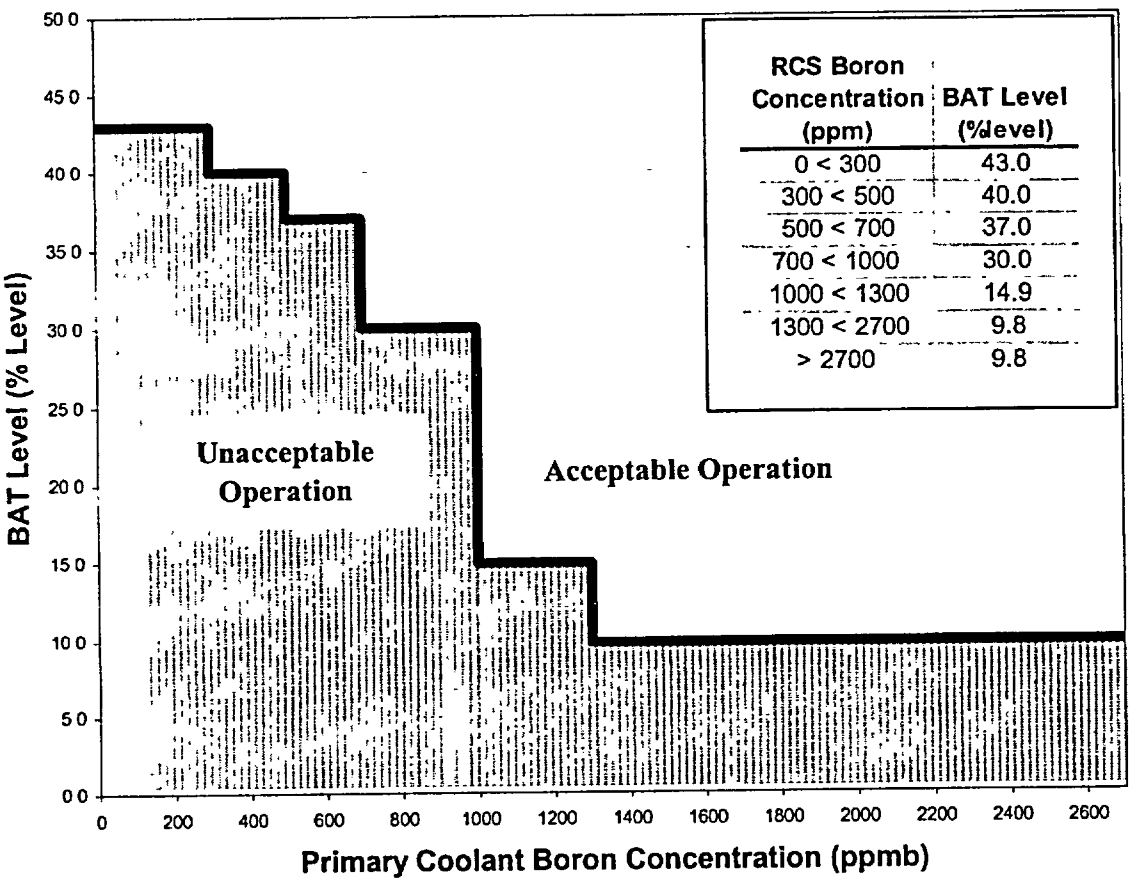
## Catawba 2 Cycle 13 Core Operating Limits Report

### Figure 6

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

**(Valid when the cycle burnup is greater than 450 EFPD)**

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




| RCS Boron Concentration (ppm) | BAT Level (%level) |
|---|---|
| 0 < 300 | 43.0 |
| 300 < 500 | 40.0 |
| 500 < 700 | 37.0 |
| 700 < 1000 | 30.0 |
| 1000 < 1300 | 14.9 |
| 1300 < 2700 | 9.8 |
| > 2700 | 9.8 |

Catawba 2 Cycle 13 Core Operating Limits Report

# Appendix A

# Catawba 2 Cycle 13 Monitoring Factors

**NOTE:** Data contained in Appendix A was generated in the Catawba 2 Cycle 13 Maneuvering Analysis calculation file, CNC-1553.05-00-0372. 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.