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U. S. Nuclear Regulatory Commission  
Document Control Desk  
Washington, D.C. 20555

Subject: Duke Energy Carolinas, LLC (Duke)  
McGuire Nuclear Station  
Docket No. 50-370  
Unit 2, Cycle 22, Revision 0  
Core Operating Limits Report

Pursuant to McGuire Technical Specification (TS) 5.6.5.d, please find enclosed the McGuire Unit 2 Cycle 22, Revision 0, Core Operating Limits Report (COLR).

Questions regarding this submittal should be directed to Kay Crane, McGuire Regulatory Affairs at (980) 875-4306.

Steven D. Capps

Attachment

A001  
NR2

U. S. Nuclear Regulatory Commission  
October 4, 2012  
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cc: Mr. Jon H. Thompson, Project Manager  
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bx: RGC File  
ECO50-ELL  
Master File

**McGuire Unit 2 Cycle 22**

**Core Operating Limits Report  
Revision 0**

**July 2012**

Calculation Number: MCC-1553.05-00-0564, Revision 0

Duke Energy Carolinas, LLC

		Date
Prepared By:	<u>David F. Bots</u>	<u>7/25/12</u>
Checked By:	<u>Nicholas R. Hager</u>	<u>7/25/12</u>
Checked By:	<u>Nathan S. Huffman</u> (Sections 2.1 and 2.9 - 2.17)	<u>7/25/12</u>
Approved By:	<u>RC Hawley</u>	<u>7/25/2012</u>

**QA Condition 1**

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

**McGuire 2 Cycle 22 Core Operating Limits Report**

**INSPECTION OF ENGINEERING INSTRUCTIONS**

Inspection Waived By: RC Hawley Date: 7/25/2012  
(Sponsor)

<u>CATAWBA</u>		
	Inspection Waived	
MCE (Mechanical & Civil)	<input type="checkbox"/>	Inspected By/Date: _____
RES (Electrical Only)	<input type="checkbox"/>	Inspected By/Date: _____
RES (Reactor)	<input type="checkbox"/>	Inspected By/Date: _____
MOD	<input type="checkbox"/>	Inspected By/Date: _____
Other ( _____ )	<input type="checkbox"/>	Inspected By/Date: _____

<u>OCONEE</u>		
	Inspection Waived	
MCE (Mechanical & Civil)	<input type="checkbox"/>	Inspected By/Date: _____
RES (Electrical Only)	<input type="checkbox"/>	Inspected By/Date: _____
RES (Reactor)	<input type="checkbox"/>	Inspected By/Date: _____
MOD	<input type="checkbox"/>	Inspected By/Date: _____
Other ( _____ )	<input type="checkbox"/>	Inspected By/Date: _____

<u>MCGUIRE</u>		
	Inspection Waived	
MCE (Mechanical & Civil)	<input checked="" type="checkbox"/>	Inspected By/Date: _____
RES (Electrical Only)	<input checked="" type="checkbox"/>	Inspected By/Date: _____
RES (Reactor)	<input checked="" type="checkbox"/>	Inspected By/Date: _____
MOD	<input checked="" type="checkbox"/>	Inspected By/Date: _____
Other ( _____ )	<input type="checkbox"/>	Inspected By/Date: _____

## **McGuire 2 Cycle 22 Core Operating Limits Report**

### **Implementation Instructions For Revision 0**

#### **Revision Description and PIP Tracking**

Revision 0 of the McGuire Unit 2 Cycle 22 COLR contains limits specific to the reload core. The revision is applicable for Unit 2 operation with or without implementation of the measurement uncertainty recapture (MUR) power uprate.

There is no PIP associated with this revision.

#### **Implementation Schedule**

Revision 0 may become effective any time during No MODE between cycles 21 and 22, but must become effective prior to entering MODE 6 which starts cycle 22. The McGuire Unit 2 Cycle 22 COLR will cease to be effective during No MODE between cycles 22 and 23.

#### **Data files to be Implemented**

No data files are transmitted as part of this document.

**McGuire 2 Cycle 22 Core Operating Limits Report****REVISION LOG**

<u>Revision</u>	<u>Effective Date</u>	<u>Pages Affected</u>	<u>COLR</u>
0	July 2012	1-32, Appendix A*	M2C22 COLR, Rev. 0

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

## McGuire 2 Cycle 22 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 Technical Specification 5.6.5. The Technical Specifications that reference the COLR are summarized below.

<u>TS Number</u>	<u>Technical Specifications</u>	<u>COLR Parameter</u>	<u>COLR Section</u>	<u>EI Page</u>
2.1.1	Reactor Core Safety Limits	RCS Temperature and Pressure Safety Limits	2.1	9
3.1.1	Shutdown Margin	Shutdown Margin	2.2	9
3.1.3	Moderator Temperature Coefficient	MTC	2.3	11
3.1.4	Rod Group Alignment Limits	Shutdown Margin	2.2	9
3.1.5	Shutdown Bank Insertion Limits	Shutdown Margin	2.2	9
3.1.5	Shutdown Bank Insertion Limits	Shutdown Bank Insertion Limit	2.4	11
3.1.6	Control Bank Insertion Limits	Shutdown Margin	2.2	9
3.1.6	Control Bank Insertion Limits	Control Bank Insertion Limit	2.5	15
3.1.8	Physics Tests Exceptions	Shutdown Margin	2.2	9
3.2.1	Heat Flux Hot Channel Factor	F <sub>q</sub> , AFD, OTAT and Penalty Factors	2.6	15
3.2.2	Nuclear Enthalpy Rise Hot Channel Factor	F $\Delta$ H, AFD and Penalty Factors	2.7	20
3.2.3	Axial Flux Difference	AFD	2.8	21
3.3.1	Reactor Trip System Instrumentation Setpoints	OTAT and OPAT Constants	2.9	24
3.4.1	RCS Pressure, Temperature, and Flow DNB limits	RCS Pressure, Temperature and Flow	2.10	26
3.5.1	Accumulators	Max and Min Boron Conc.	2.11	26
3.5.4	Refueling Water Storage Tank	Max and Min Boron Conc.	2.12	26
3.7.14	Spent Fuel Pool Boron Concentration	Min Boron Concentration	2.13	28
3.9.1	Refueling Operations – Boron Concentration	Min Boron Concentration	2.14	28
5.6.5	Core Operating Limits Report (COLR)	Analytical Methods	1.1	6

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

<u>SLC Number</u>	<u>Selected Licensing Commitment</u>	<u>COLR Parameter</u>	<u>COLR Section</u>	<u>EI Page</u>
16.9.14	Borated Water Source – Shutdown	Borated Water Volume and Conc. for BAT/RWST	2.15	29
16.9.11	Borated Water Source – Operating	Borated Water Volume and Conc. for BAT/RWST	2.16	30
16.9.7	Standby Shutdown System	Standby Makeup Pump Water Supply	2.17	30



## McGuire 2 Cycle 22 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 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

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

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

Revision 4a

Report Date: July 2009

## McGuire 2 Cycle 22 Core Operating Limits Report

### 1.1 Analytical Methods (continued)

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

Revision 0a

Report Date: May 2009

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

Revision 4b

Report Date: September 2010

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

Revision 2a

Report Date: December 2008

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

Revision 4a

Report Date: December 2008

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

Revision 1a

Report Date: December 2008

**Not Used**

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

Revision 3a

Report Date: September 2011

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

Revision 1a

Report Date: January 2009

**Not Used**

## McGuire 2 Cycle 22 Core Operating Limits Report

### 1.1 Analytical Methods (continued)

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

Revision 2a

Report Date: December 2009

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

Revision 1a

Report Date: June 2009

16. DPC-NE-1005-PA, "Nuclear Design Methodology Using CASMO-4 / SIMULATE-3 MOX," (DPC Proprietary).

Revision 1

Report Date: November 12, 2008

## McGuire 2 Cycle 22 Core Operating Limits Report

### 2.0 Operating Limits

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

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

2.1.1 The 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 and 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 MODES 1 and 2.

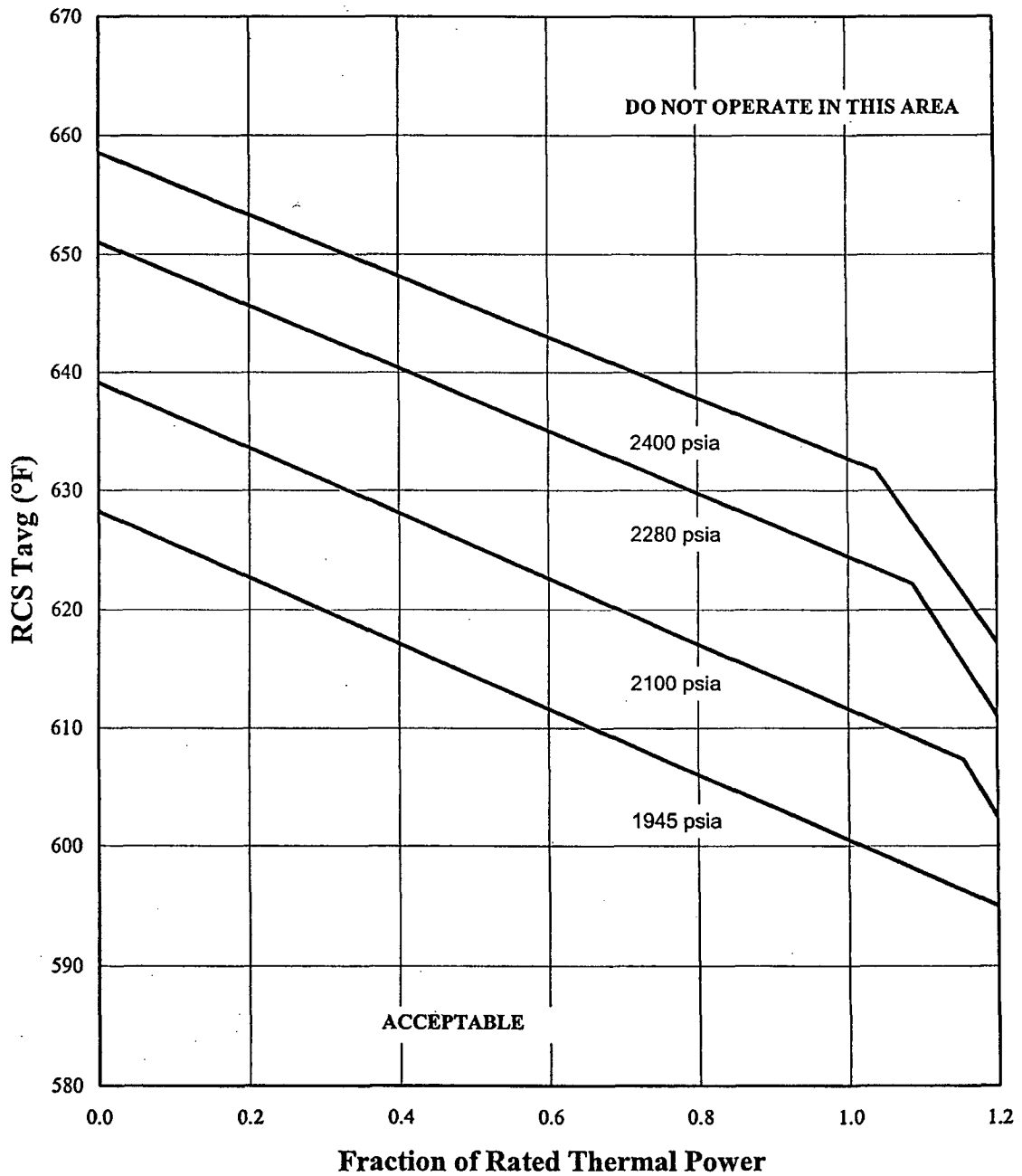
2.2.4 For TS 3.1.5, SDM shall be  $\geq 1.3\% \Delta K/K$  in MODE 1 and MODE 2 with any control bank not fully inserted.

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.

### McGuire 2 Cycle 22 Core Operating Limits Report

**Figure 1**  
**Reactor Core Safety Limits**  
**Four Loops in Operation**



## McGuire 2 Cycle 22 Core Operating Limits Report

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

#### 2.3.1 The 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 60 PPM MTC Surveillance Limit is:

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 the most positive MTC)  
              EOC = End of Cycle  
              ARO = All Rods Out  
              HZP = Hot Zero Power  
              RTP = Rated Thermal Power  
              PPM = Parts per million (Boron)

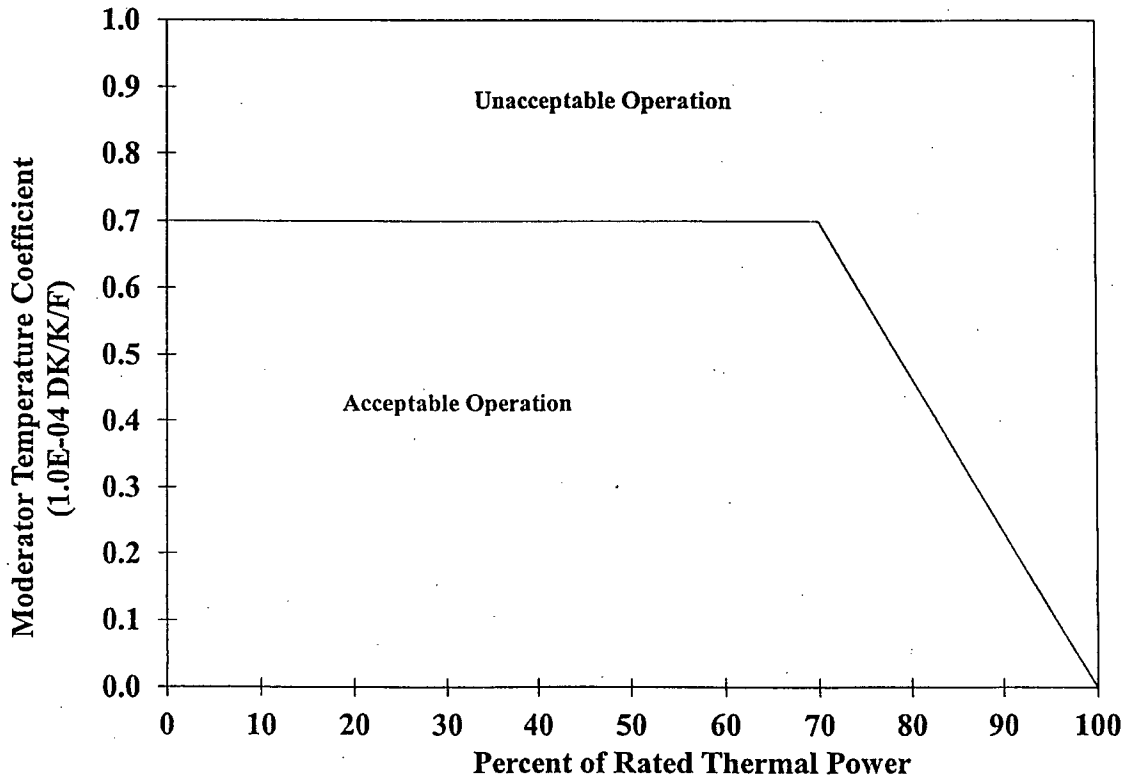
### 2.4 Shutdown Bank Insertion Limit (TS 3.1.5)

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

### McGuire 2 Cycle 22 Core Operating Limits Report

Figure 2

Moderator Temperature Coefficient Upper Limit Versus Power Level

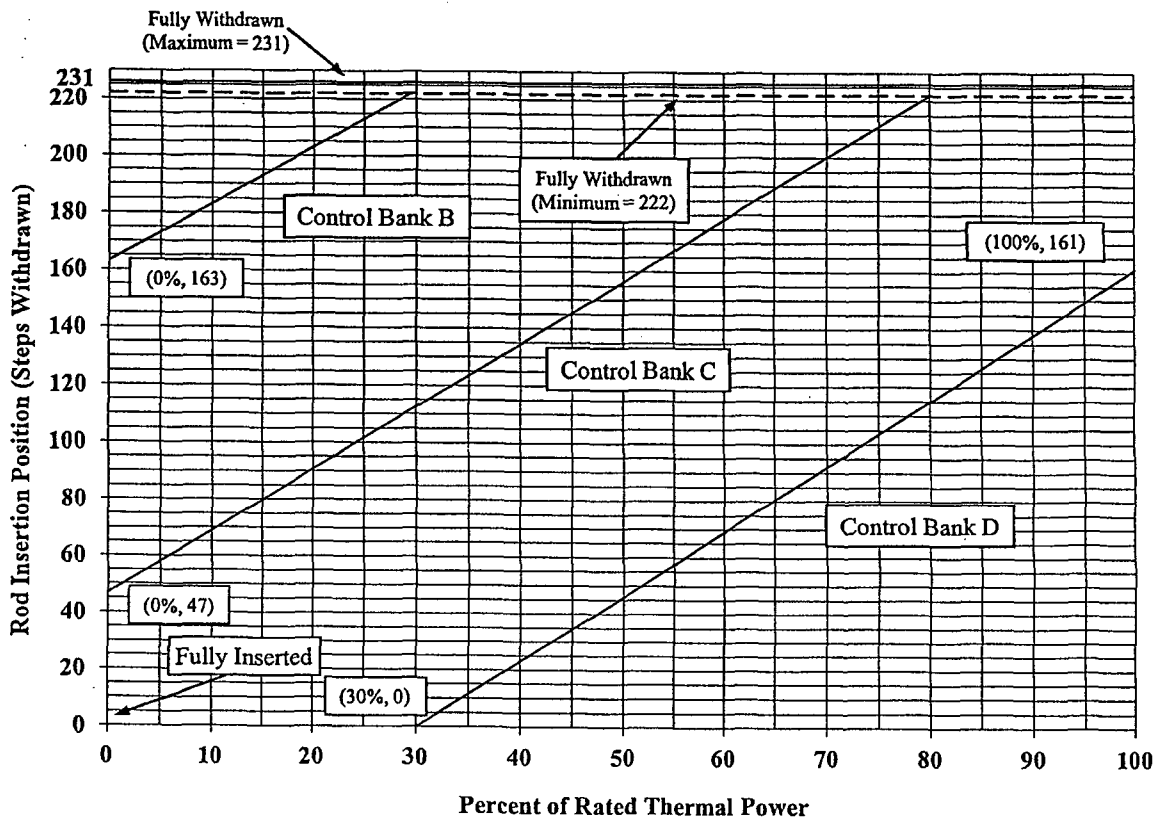


NOTE: Compliance with Technical Specification 3.1.3 may require rod withdrawal limits. Refer to OP/2/A/6100/22 Unit 2 Data Book for details.

## McGuire 2 Cycle 22 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  $P = \% \text{Rated Thermal Power}$

**NOTE:** Compliance with Technical Specification 3.1.3 may require rod withdrawal limits. Refer to OP/2/A/6100/22 Unit 2 Data Book for details.



## McGuire 2 Cycle 22 Core Operating Limits Report

**Table 1**  
**RCCA Withdrawal Steps and Sequence**

Fully Withdrawn at 222 Steps				Fully Withdrawn at 223 Steps			
Control Bank A	Control Bank B	Control Bank C	Control Bank D	Control Bank A	Control Bank B	Control Bank C	Control Bank D
0 Start	0	0	0	0 Start	0	0	0
116	0 Start	0	0	116	0 Start	0	0
222 Stop	106	0	0	223 Stop	107	0	0
222	116	0 Start	0	223	116	0 Start	0
222	222 Stop	106	0	223	223 Stop	107	0
222	222	116	0 Start	223	223	116	0 Start
222	222	222 Stop	106	223	223	223 Stop	107

Fully Withdrawn at 224 Steps				Fully Withdrawn at 225 Steps			
Control Bank A	Control Bank B	Control Bank C	Control Bank D	Control Bank A	Control Bank B	Control Bank C	Control Bank D
0 Start	0	0	0	0 Start	0	0	0
116	0 Start	0	0	116	0 Start	0	0
224 Stop	108	0	0	225 Stop	109	0	0
224	116	0 Start	0	225	116	0 Start	0
224	224 Stop	108	0	225	225 Stop	109	0
224	224	116	0 Start	225	225	116	0 Start
224	224	224 Stop	108	225	225	225 Stop	109

Fully Withdrawn at 226 Steps				Fully Withdrawn at 227 Steps			
Control Bank A	Control Bank B	Control Bank C	Control Bank D	Control Bank A	Control Bank B	Control Bank C	Control Bank D
0 Start	0	0	0	0 Start	0	0	0
116	0 Start	0	0	116	0 Start	0	0
226 Stop	110	0	0	227 Stop	111	0	0
226	116	0 Start	0	227	116	0 Start	0
226	226 Stop	110	0	227	227 Stop	111	0
226	226	116	0 Start	227	227	116	0 Start
226	226	226 Stop	110	227	227	227 Stop	111

Fully Withdrawn at 228 Steps				Fully Withdrawn at 229 Steps			
Control Bank A	Control Bank B	Control Bank C	Control Bank D	Control Bank A	Control Bank B	Control Bank C	Control Bank D
0 Start	0	0	0	0 Start	0	0	0
116	0 Start	0	0	116	0 Start	0	0
228 Stop	112	0	0	229 Stop	113	0	0
228	116	0 Start	0	229	116	0 Start	0
228	228 Stop	112	0	229	229 Stop	113	0
228	228	116	0 Start	229	229	116	0 Start
228	228	228 Stop	112	229	229	229 Stop	113

Fully Withdrawn at 230 Steps				Fully Withdrawn at 231 Steps			
Control Bank A	Control Bank B	Control Bank C	Control Bank D	Control Bank A	Control Bank B	Control Bank C	Control Bank D
0 Start	0	0	0	0 Start	0	0	0
116	0 Start	0	0	116	0 Start	0	0
230 Stop	114	0	0	231 Stop	115	0	0
230	116	0 Start	0	231	116	0 Start	0
230	230 Stop	114	0	231	231 Stop	115	0
230	230	116	0 Start	231	231	116	0 Start
230	230	230 Stop	114	231	231	231 Stop	115

## McGuire 2 Cycle 22 Core Operating Limits Report

### 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.

### 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:

$$\begin{aligned} F_Q^{RTP} * K(Z) / P & \quad \text{for } P > 0.5 \\ F_Q^{RTP} * K(Z) / 0.5 & \quad \text{for } P \leq 0.5 \end{aligned}$$

where,

$$P = (\text{Thermal Power}) / (\text{Rated Power})$$

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 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. The  $K(Z)$  function 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 calculations.  $K(\text{BU})$  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  $F_Q^L(X,Y,Z)^{OP} = \frac{F_Q^D(X,Y,Z) * M_Q(X,Y,Z)}{UMT * MT * TILT}$

## McGuire 2 Cycle 22 Core Operating Limits Report

where:

$F_Q^L(X,Y,Z)^{OP}$  = Cycle dependent maximum allowable design peaking factor that ensures  $F_Q(X,Y,Z)$  LOCA limit will be preserved for operation within the LCO 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.

$M_Q(X,Y,Z)$  = 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 the  $F_Q(X,Y,Z)$  Centerline Fuel Melt (CFM) limit will be preserved for operation within the LCO limits.  $F_Q^L(X,Y,Z)^{RPS}$  includes allowances for calculation and measurement uncertainties.

$F_Q^D(X,Y,Z)$  = Design power distributions 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.

### McGuire 2 Cycle 22 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 Appendix Table A-2 for normal operating conditions and in Appendix Table A-5 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)

#### 2.6.7 KSLOPE = 0.0725

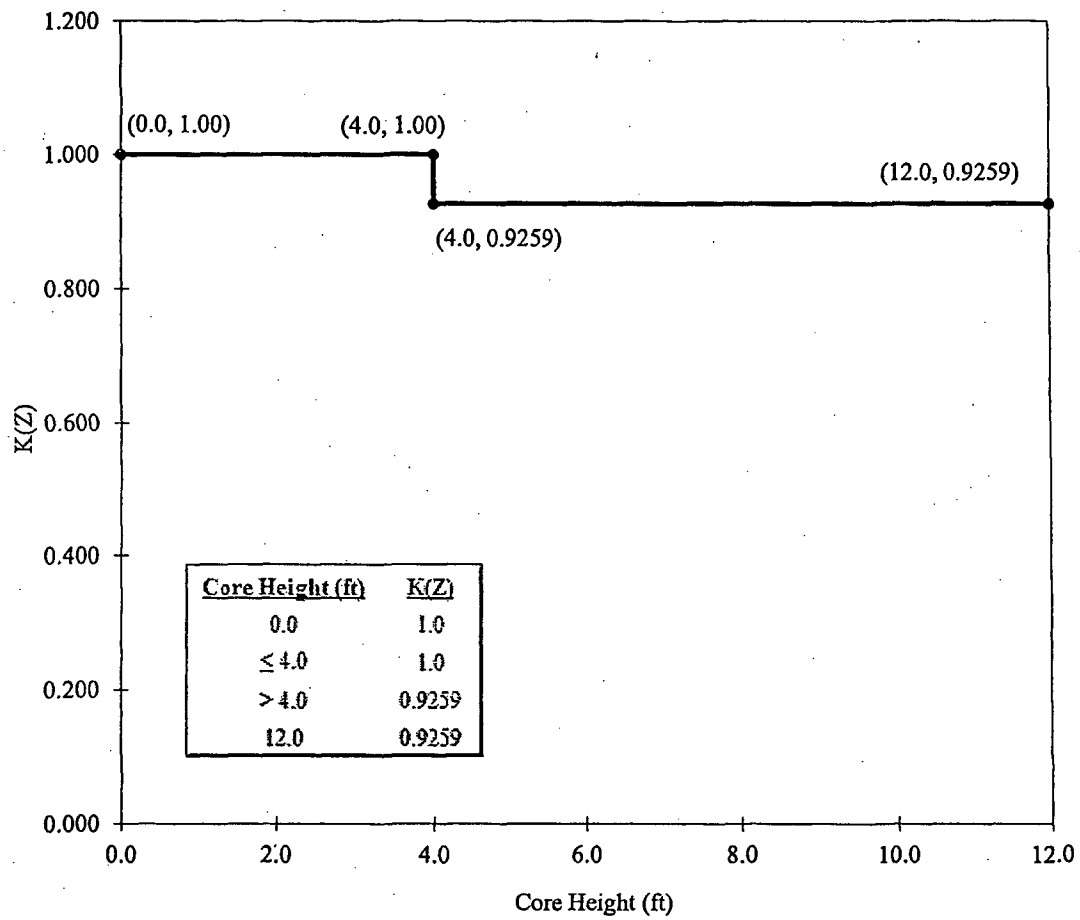
where:

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

#### 2.6.8 $F_Q(X,Y,Z)$ penalty factors for Technical Specification Surveillances 3.2.1.2 and 3.2.1.3 are provided in Table 2.

**McGuire 2 Cycle 22 Core Operating Limits Report**

**Figure 4**  
**K(Z), Normalized  $F_0(X,Y,Z)$  as a Function of**  
**Core Height for Westinghouse RFA Fuel**



## McGuire 2 Cycle 22 Core Operating Limits Report

### Table 2

#### $F_Q(X,Y,Z)$ and $F_{\Delta H}(X,Y)$ Penalty Factors

For Technical Specification Surveillance's 3.2.1.2, 3.2.1.3 and 3.2.2.2

<u>Burnup (EFPD)</u>	<u><math>F_Q(X,Y,Z)</math> Penalty Factor (%)</u>	<u><math>F_{\Delta H}(X,Y)</math> Penalty Factor (%)</u>
0	2.00	2.00
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
435	2.00	2.00
460	2.00	2.00
468	2.00	2.00
478	2.00	2.00
493	2.00	2.00
503	2.00	2.00

**Note:** Linear interpolation is adequate for intermediate cycle burnups. All cycle burnups outside of 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 Technical Specification Surveillances 3.2.1.2, 3.2.1.3 and 3.2.2.2.

## McGuire 2 Cycle 22 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 is 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% that the measured radial peak,  $F_{\Delta H}^M(X,Y)$ , exceeds its limit.  $\text{RRH}$  also is used to scale the  $\text{MARP}$  limits as a function of power per the  $[F_{\Delta H}^L(X,Y)]^{LCO}$  equation. ( $\text{RRH} = 3.34$  ( $0.0 < P \leq 1.0$ ))

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

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

where:

$F_{\Delta H}^L(X,Y)^{SURV}$  = Cycle dependent maximum allowable design peaking factor that ensures the  $F_{\Delta H}(X,Y)$  limit will be preserved for operation within the LCO limits.  $F_{\Delta H}^L(X,Y)^{SURV}$  includes allowances for calculation/measurement uncertainty.

## McGuire 2 Cycle 22 Core Operating Limits Report

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

$M_{\Delta H}(X,Y)$  = 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 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 = Peaking penalty to account for allowable quadrant power tilt ratio of 1.02 (TILT = 1.035).

### 2.7.3 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. ( $0 < P \leq 1.0$ )

### 2.7.4 TRH = 0.04

where:

TRH = Reduction in the OTAT  $K_1$  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 The Axial Flux Difference (AFD) Limits are provided in Figure 5.



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

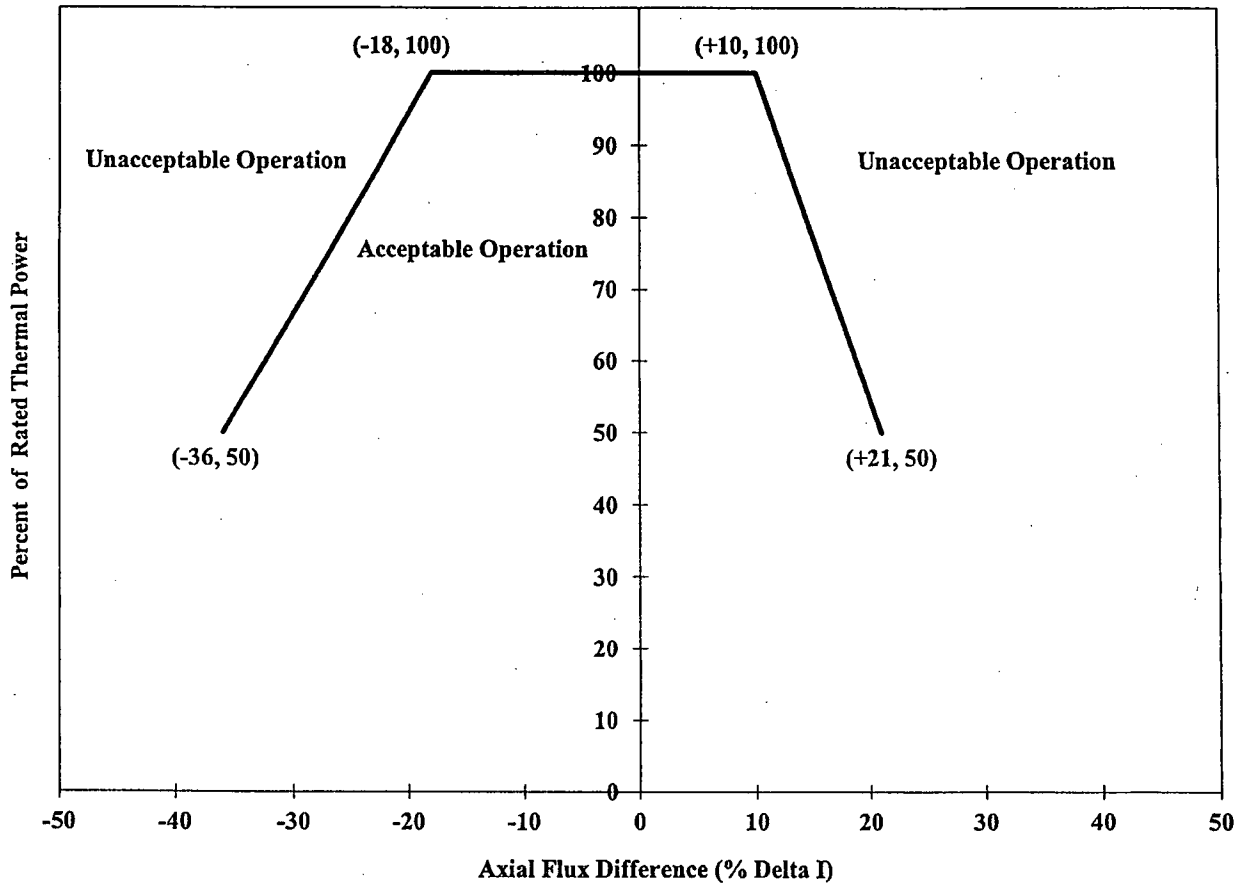
### RFA MARPS

<b>Core Ht (ft.)</b>	<b>Axial Peak</b>												
	<b><u>1.05</u></b>	<b><u>1.1</u></b>	<b><u>1.2</u></b>	<b><u>1.3</u></b>	<b><u>1.4</u></b>	<b><u>1.5</u></b>	<b><u>1.6</u></b>	<b><u>1.7</u></b>	<b><u>1.8</u></b>	<b><u>1.9</u></b>	<b><u>2.1</u></b>	<b><u>3.0</u></b>	<b><u>3.25</u></b>
<b>0.12</b>	1.809	1.855	1.949	1.995	1.974	2.107	2.050	2.009	1.933	1.863	1.778	1.315	1.246
<b>1.2</b>	1.810	1.854	1.940	1.995	1.974	2.107	2.019	1.978	1.901	1.831	1.785	1.301	1.224
<b>2.4</b>	1.809	1.853	1.931	1.978	1.974	2.074	1.995	1.952	1.876	1.805	1.732	1.463	1.462
<b>3.6</b>	1.810	1.851	1.920	1.964	1.974	2.050	1.966	1.926	1.852	1.786	1.700	1.468	1.387
<b>4.8</b>	1.810	1.851	1.906	1.945	1.974	2.006	1.944	1.923	1.854	1.784	1.671	1.299	1.258
<b>6.0</b>	1.810	1.851	1.892	1.921	1.946	1.934	1.880	1.863	1.802	1.747	1.671	1.329	1.260
<b>7.2</b>	1.807	1.844	1.872	1.893	1.887	1.872	1.809	1.787	1.733	1.681	1.598	1.287	1.220
<b>8.4</b>	1.807	1.832	1.845	1.857	1.816	1.795	1.736	1.709	1.654	1.601	1.513	1.218	1.158
<b>9.6</b>	1.807	1.810	1.809	1.791	1.738	1.718	1.657	1.635	1.581	1.530	1.444	1.143	1.091
<b>10.8</b>	1.798	1.787	1.761	1.716	1.654	1.632	1.574	1.557	1.509	1.462	1.383	1.101	1.047
<b>11.4</b>	1.789	1.765	1.725	1.665	1.606	1.583	1.529	1.510	1.464	1.422	1.346	1.067	1.014

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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 OP/2/A/6100/22 Unit 2 Data Book for more details.

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### 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>Value</u>
Nominal $T_{avg}$ at RTP	$T' \leq 585.1^\circ\text{F}$
Nominal RCS Operating Pressure	$P' = 2235 \text{ psig}$
Overtemperature $\Delta T$ reactor trip setpoint <sup>++</sup>	$K_1 \leq 1.1978$
Overtemperature $\Delta T$ reactor trip heatup setpoint penalty coefficient	$K_2 = 0.0334/^\circ\text{F}$
Overtemperature $\Delta T$ reactor trip depressurization setpoint penalty coefficient	$K_3 = 0.001601/\text{psi}$
Time constants utilized in the lead-lag compensator for $\Delta T$	$\tau_1 \geq 8 \text{ sec.}$ $\tau_2 \leq 3 \text{ sec.}$
Time constant utilized in the lag compensator for $\Delta T$	$\tau_3 \leq 2 \text{ sec.}$
Time constants utilized in the lead-lag compensator for $T_{avg}$	$\tau_4 \geq 28 \text{ sec.}$ $\tau_5 \leq 4 \text{ sec.}$
Time constant utilized in the measured $T_{avg}$ lag compensator	$\tau_6 \leq 2 \text{ sec.}$
$f_1(\Delta I)$ "positive" breakpoint	$= 19.0 \% \Delta I$
$f_1(\Delta I)$ "negative" breakpoint	$= \text{N/A}^*$
$f_1(\Delta I)$ "positive" slope	$= 1.769 \% \Delta T_0 / \% \Delta I$
$f_1(\Delta I)$ "negative" slope	$= \text{N/A}^*$

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

<sup>++</sup>  $\Delta T_0$  is assumed to be renormalized to 100% RTP following the MUR power uprate.

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

<u>Parameter</u>	<u>Value</u>
Nominal $T_{avg}$ at RTP	$T'' \leq 585.1^\circ\text{F}$
Overpower $\Delta T$ reactor trip setpoint <sup>++</sup>	$K_4 \leq 1.0864$
Overpower $\Delta T$ reactor trip Penalty	$K_5 = 0.02/^\circ\text{F}$ for increasing $T_{avg}$ $K_5 = 0.0$ for decreasing $T_{avg}$
Overpower $\Delta T$ reactor trip heatup setpoint penalty coefficient	$K_6 = 0.001179/^\circ\text{F}$ for $T > T''$ $K_6 = 0.0$ for $T \leq T''$
Time constants utilized in the lead-lag compensator for $\Delta T$	$\tau_1 \geq 8$ sec. $\tau_2 \leq 3$ sec.
Time constant utilized in the lag compensator for $\Delta T$	$\tau_3 \leq 2$ sec.
Time constant utilized in the measured $T_{avg}$ lag compensator	$\tau_6 \leq 2$ sec.
Time constant utilized in the rate-lag controller for $T_{avg}$	$\tau_7 \geq 5$ sec.
$f_2(\Delta I)$ "positive" breakpoint	$= 35.0 \% \Delta I$
$f_2(\Delta I)$ "negative" breakpoint	$= -35.0 \% \Delta I$
$f_2(\Delta I)$ "positive" slope	$= 7.0 \% \Delta T_0 / \% \Delta I$
$f_2(\Delta I)$ "negative" slope	$= 7.0 \% \Delta T_0 / \% \Delta I$

<sup>++</sup>  $\Delta T_0$  is assumed to be renormalized to 100% RTP following the MUR power uprate.

## McGuire 2 Cycle 22 Core Operating Limits Report

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

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

### 2.11 Accumulators (TS 3.5.1)

2.11.1 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	2,475 ppm
Accumulator <b>minimum</b> boron concentration.	200.1 - 250 EFPD	2,408 ppm
Accumulator <b>minimum</b> boron concentration.	250.1 - 300 EFPD	2,346 ppm
Accumulator <b>minimum</b> boron concentration.	300.1 - 350 EFPD	2,277 ppm
Accumulator <b>minimum</b> boron concentration.	350.1 - 400 EFPD	2,207 ppm
Accumulator <b>minimum</b> boron concentration.	400.1 - 450 EFPD	2,142 ppm
Accumulator <b>minimum</b> boron concentration.	450.1 - 493 EFPD	2,075 ppm
Accumulator <b>minimum</b> boron concentration.	493.1 - 503 EFPD	2,017 ppm
Accumulator <b>maximum</b> boron concentration.	0 - 503 EFPD	2,875 ppm

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

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

<u>Parameter</u>	<u>Limit</u>
RWST minimum boron concentration.	2,675 ppm
RWST maximum boron concentration.	2,875 ppm

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### Table 4

#### Reactor Coolant System DNB Parameters

Parameter	Indication	No. Operable Channels	Limits
1. Indicated RCS Average Temperature	meter	4	$\leq 587.2$ °F
	meter	3	$\leq 586.9$ °F
	computer	4	$\leq 587.7$ °F
	computer	3	$\leq 587.5$ °F
2. Indicated Pressurizer Pressure	meter	4	$\geq 2219.8$ psig
	meter	3	$\geq 2222.1$ psig
	computer	4	$\geq 2215.8$ psig
	computer	3	$\geq 2217.5$ psig
3. RCS Total Flow Rate			$\geq 388,000$ gpm

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### 2.13 Spent Fuel Pool Boron Concentration (TS 3.7.14)

2.13.1 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.	2,675 ppm

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

2.14.1 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 core  $K_{eff}$  remains within MODE 6 reactivity requirement of  $K_{eff} \leq 0.95$ .

<u>Parameter</u>	<u>Limit</u>
Minimum boron concentration of the Reactor Coolant System, the refueling canal, and the refueling cavity.	2,675 ppm

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### 2.15 Borated Water Source – Shutdown (SLC 16.9.14)

2.15.1 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  $\leq 300$  °F and MODES 5 and 6.

<u>Parameter</u>	<u>Limit</u>
BAT minimum contained borated water volume	10,599 gallons 13.6% Level

Note: When cycle burnup is  $> 460$  EFPD, Figure 6 may be used to determine required BAT minimum level.

BAT minimum boron concentration	7,000 ppm
BAT minimum water volume required to maintain SDM at 7,000 ppm	2,300 gallons
RWST minimum contained borated water volume	47,700 gallons 41 inches
RWST minimum boron concentration	2,675 ppm
RWST minimum water volume required to maintain SDM at 2,675 ppm	8,200 gallons



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### 2.16 Borated Water Source - Operating (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 MODES 1, 2, 3, and MODE 4 with all RCS cold leg temperature > 300 °F.

<u>Parameter</u>	<u>Limit</u>
BAT minimum contained borated water volume	22,049 gallons 38.0% Level

Note: When cycle burnup is > 460 EFPD, Figure 6 may be used to determine required BAT minimum level.

BAT minimum boron concentration	7,000 ppm
BAT minimum water volume required to maintain SDM at 7,000 ppm	13,750 gallons
RWST minimum contained borated water volume	96,607 gallons 103.6 inches
RWST minimum boron concentration	2,675 ppm
RWST maximum boron concentration (TS 3.5.4)	2,875 ppm
RWST minimum water volume required to maintain SDM at 2,675 ppm	57,107 gallons

### 2.17 Standby Shutdown System - (SLC-16.9.7)

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

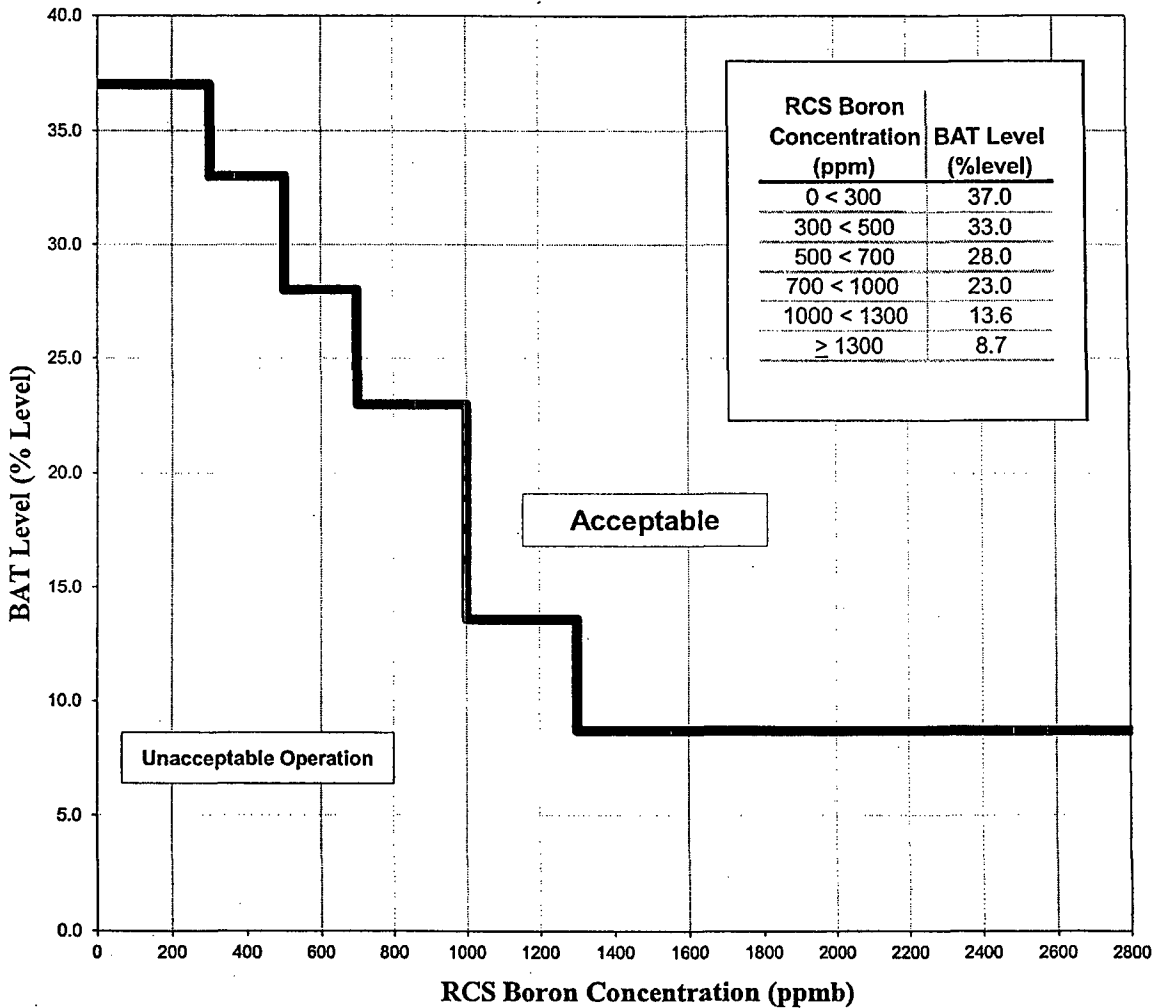
<u>Parameter</u>	<u>Limit</u>
Spent fuel pool minimum boron concentration for TR 16.9.7.2.	2,675 ppm

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Figure 6  
Boric Acid Storage Tank Indicated Level Versus  
RCS Boron Concentration

(Valid When Cycle Burnup is > 460 EFPD)

This figure includes additional volumes listed in SLC 16.9.14 and 16.9.11



## McGuire 2 Cycle 22 Core Operating Limits Report

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**NOTE:** Appendix A contains power distribution monitoring factors used in Technical Specification Surveillance. This data was generated in the McGuire 2 Cycle 22 Maneuvering Analysis calculation file, MCC-1553.05-00-0560. Due to the size of the monitoring factor data, Appendix A is controlled electronically within Duke and is not included in the Duke internal copies of the COLR. 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.

Appendix A is included in the COLR copy transmitted to the NRC.