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September 28, 2005

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

Subject: McGuire Nuclear Station,  
Docket Nos. 50-369  
Unit 1, Cycle 18, Revision 28  
Core Operating Limits Report (COLR)

Pursuant to McGuire Technical Specification 5.6.5.d, please find enclosed the McGuire Unit 1 Cycle 18 Core Operating Limits Report (COLR).

Questions regarding this submittal should be directed to Kay Crane, McGuire Regulatory Compliance at (704) 875-4306.



Gary R. Peterson

Attachment

A001

U. S. Nuclear Regulatory Commission

September 28, 2005

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cc: Mr. S. E. Peters, Project Manager  
U.S. Nuclear Regulatory Commission  
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Washington, D.C. 20555

Mr. W. D. Travers, Regional Administrator  
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Mr. Joe Brady  
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McGuire Nuclear Station

**McGuire Unit 1 Cycle 18**  
**Core Operating Limits Report**  
**Revision 28**

**August 2005**

Calculation Number: MCC-1553.05-00-0428

**Duke Power Company**

		Date
Prepared By:	<u>N. Charles R. Hager</u>	<u>08/22/05</u>
Checked By:	<u>T. P. Phelan</u>	<u>08/22/05</u>
Checked By:	<u>M. J. Bayne</u> (Sections 2.2 and 2.10 – 2.17)	<u>8/30/05</u>
Approved By:	<u>Stephen P. Schultz</u>	<u>08/31/05</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 1 Cycle 18 Core Operating Limits Report

INSPECTION OF ENGINEERING INSTRUCTIONS

Inspection Waived By: Stephen P. Pellety  
(Sponsor)

Date: 08/31/2005

CATAWBA

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: _____

OCONEE

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: _____

MCGUIRE

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 1 Cycle 18 Core Operating Limits Report**

### **Implementation Instructions for Revision 28**

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

Revision 28 of the McGuire Unit 1 COLR contains limits specific to the McGuire 1 Cycle 18 reload core. There is no PIP associated with this revision.

#### **Implementation Schedule**

Revision 28 may become effective as follows:

1. Upon implementation of a change to Technical Specification 5.6.5.b to include DPC-NE-1005PA in the core operating limits approved methodologies reference list, and
2. Any time during No MODE between Cycles 17 and 18 but must become effective prior to entering MODE 6 which starts Cycle 18.

This revision replaces the current revisions (MCEI-0400-46, Rev. 27).

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

No data files are transmitted as part of this document.

#### **Insertion/Deletion Instructions**

<b>Remove</b>	<b>Insert</b>
pages 1- 32, of rev 27 (including Appendix A*)	pages 1- 32 of rev 28 (including Appendix A*)

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

## McGuire 1 Cycle 18 Core Operating Limits Report

### REVISION LOG

<u>Revision</u>	<u>Effective Date</u>	<u>Effective Pages</u>	<u>COLR</u>
Revisions 0-3	Superseded	N/A	M1C09
Revisions 4-8	Superseded	N/A	M1C10
Revisions 9-11	Superseded	N/A	M1C11
Revisions 12-15	Superseded	N/A	M1C12
Revisions 16-17	Superseded	N/A	M1C13
Revision 18-20	Superseded	N/A	M1C14
Revision 21-23	Superseded	N/A	M1C15
Revision 24-26	Superseded	N/A	M1C16
Revision 27	March 12, 2004	1 - 32	M1C17 (Original Issue)
Revision 28	August 31, 2005	1 - 32	M1C18 (Original Issue)

## McGuire 1 Cycle 18 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 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>
1.1	Requirements for Operational Mode 6	Mode 6 Definition	2.1	9
2.1.1	Reactor Core Safety Limits	RCS Temperature and Pressure Safety Limits	2.2	9
3.1.1	Shutdown Margin	Shutdown Margin	2.3	9
3.1.3	Moderator Temperature Coefficient	MTC	2.4	11
3.1.4	Rod Group Alignment Limits	Shutdown Margin	2.3	9
3.1.5	Shutdown Bank Insertion Limits	Shutdown Margin	2.3	9
3.1.5	Shutdown Bank Insertion Limits	Shutdown Bank Insertion Limit	2.5	11
3.1.6	Control Bank Insertion Limits	Shutdown Margin	2.3	9
3.1.6	Control Bank Insertion Limits	Control Bank Insertion Limit	2.6	11
3.1.8	Physics Test Exceptions	Shutdown Margin	2.3	9
3.2.1	Heat Flux Hot Channel Factor	Fq, AFD, OTΔT and Penalty Factors	2.7	15
3.2.2	Nuclear Enthalpy Rise Hot Channel Factor	FΔH, AFD and Penalty Factors	2.8	20
3.2.3	Axial Flux Difference	AFD	2.9	21
3.3.1	Reactor Trip System Instrumentation Setpoint	OTΔT and OPΔT Constants	2.10	24
3.4.1	RCS Pressure, Temperature and Flow limits for DNB	RCS Pressure, Temperature and Flow	2.11	26
3.5.1	Accumulators	Max and Min Boron Conc.	2.12	26
3.5.4	Refueling Water Storage Tank	Max and Min Boron Conc.	2.13	26
3.7.14	Spent Fuel Pool Boron Concentration	Min Boron Concentration	2.14	28
3.9.1	Refueling Operations – Boron Concentration	Min Boron Concentration	2.15	28

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	2.16	29
16.9-11	Borated Water Source – Operating	Borated Water Volume and Conc. for BAT/RWST	2.17	30

## McGuire 1 Cycle 18 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 as follows.

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

Revision 0  
Report Date: July 1985  
Not Used for M1C18

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

Revision 0  
Report Date: August 1985  
Note: Amendments to this report are included in Ref. 12

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 M1C18

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 M1C18

## McGuire 1 Cycle 18 Core Operating Limits Report

### 1.1 Analytical Methods (continued)

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

Revision 3  
SER Date: September 24, 2003

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

Revision 0  
Report Date: November 1991 (Republished December 2000)

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 3  
SER Date: September 16, 2002

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

Revision 0  
SER Date: April 3, 1995  
Not Used for M1C18

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  
Not Used for M1C18

## **McGuire 1 Cycle 18 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 2

SER Date: June 24, 2003

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

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

Revision 0

SER Date: August 20, 2004

## **McGuire 1 Cycle 18 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 Section 1.1.

#### **2.1 Requirements for Operational Mode 6**

The following condition is required for operational mode 6.

**2.1.1** The Reactivity Condition requirement for operational mode 6 is that  $k_{eff}$  must be less than, or equal to 0.95.

#### **2.2 Reactor Core Safety Limits (TS 2.1.1)**

**2.2.1** The Reactor Core Safety Limits are shown in Figure 1.

#### **2.3 Shutdown Margin - SDM (TS 3.1.1, TS 3.1.4, TS 3.1.5, TS 3.1.6 and TS 3.1.8)**

**2.3.1** For TS 3.1.1, SDM shall be  $\geq 1.3\% \Delta K/K$  in mode 2 with  $k_{eff} < 1.0$  and in modes 3 and 4.

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

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

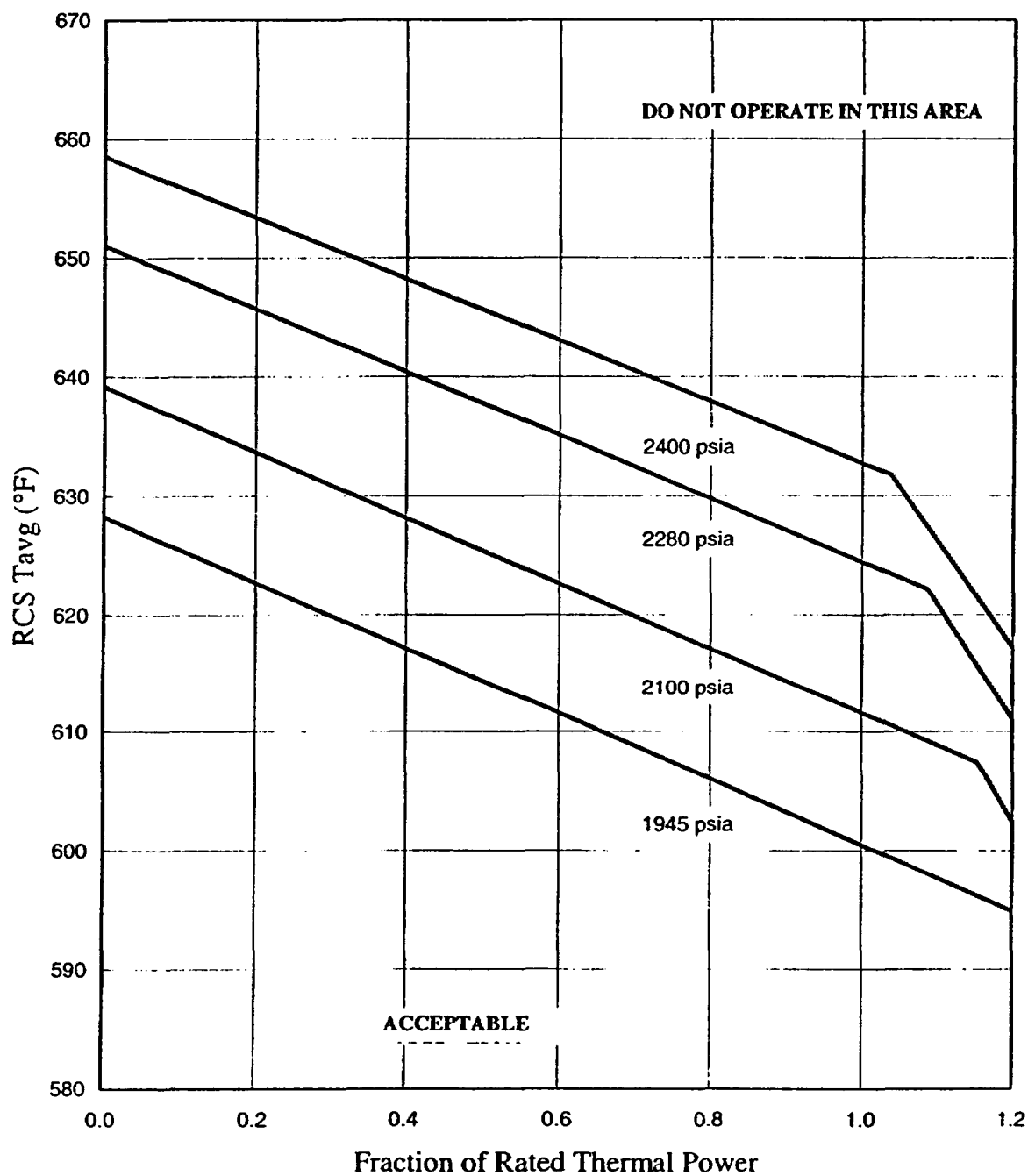
**2.3.4** For TS 3.1.5, SDM shall be  $\geq 1.3\% \Delta K/K$  in mode 1 and mode 2 with any control bank not fully inserted.

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

**2.3.6** For TS 3.1.8, SDM shall be  $\geq 1.3\% \Delta K/K$  in mode 2 during Physics Testing.

## McGuire 1 Cycle 18 Core Operating Limits Report

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



## McGuire 1 Cycle 18 Core Operating Limits Report

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

#### 2.4.1 The Moderator Temperature Coefficient (MTC) Limits are:

The MTC shall be less positive than the upper limits shown in Figure 2. The BOC, ARO, HZP MTC shall be less positive than  $0.7\text{E-}04 \Delta\text{K/K/}^\circ\text{F}$ .

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

#### 2.4.2 The 300 PPM MTC Surveillance Limit is:

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

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

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

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)

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

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

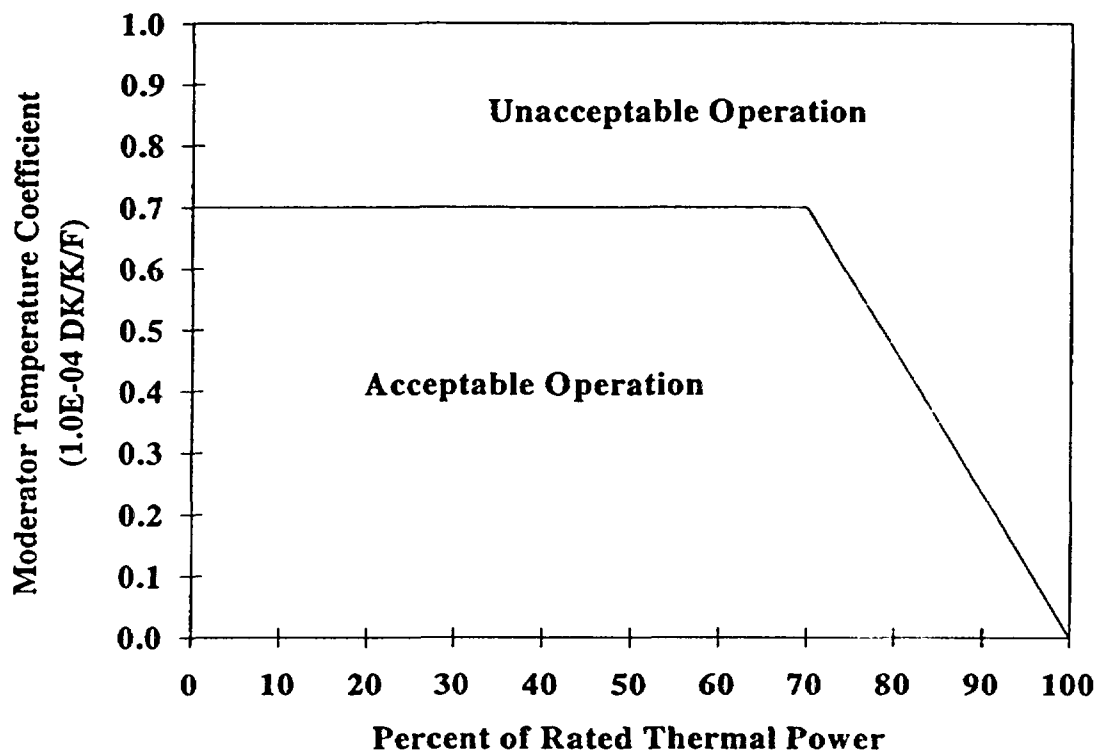
### 2.6 Control Bank Insertion Limits (TS 3.1.6)

2.6.1 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.

## McGuire 1 Cycle 18 Core Operating Limits Report

Figure 2

### Moderator Temperature Coefficient Upper Limit Versus Power Level

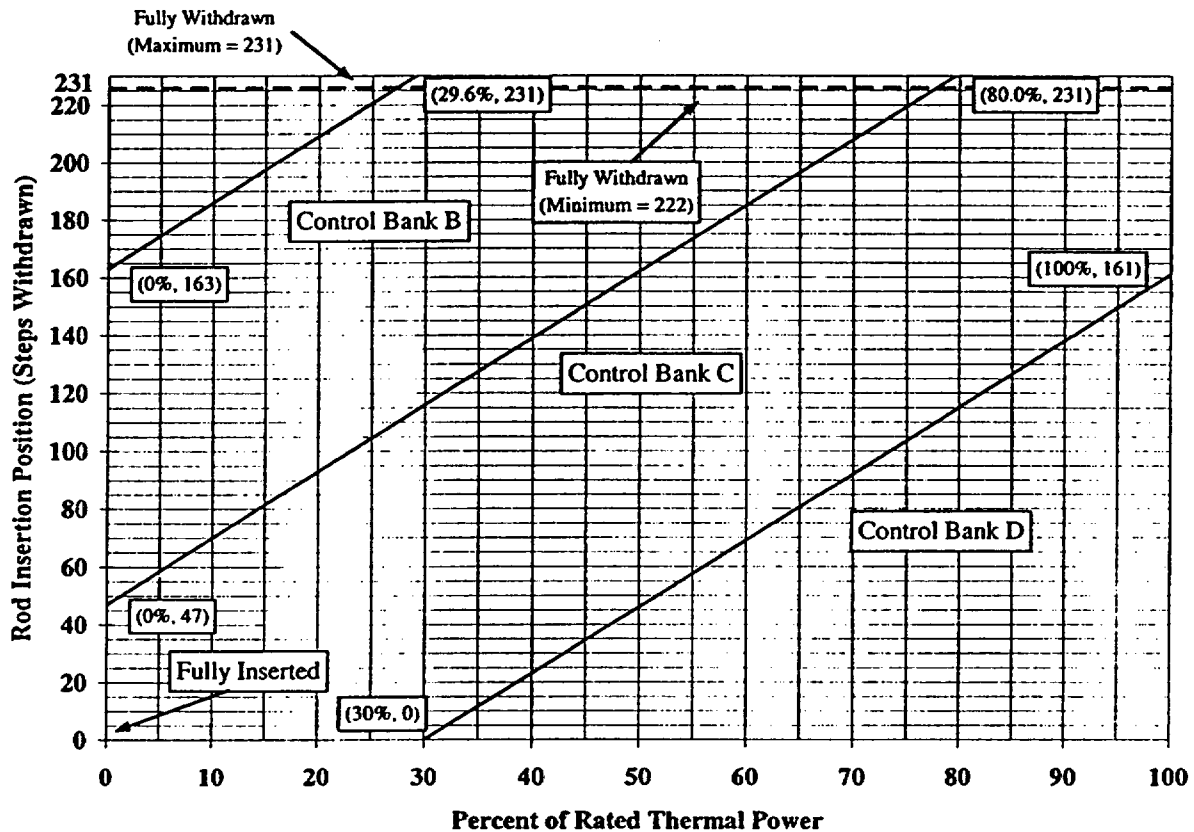


**NOTE:** Compliance with Technical Specification 3.1.3 may require rod withdrawal limits.  
Refer to OP/1/A/6100/22 Unit 1 Data Book for details.

## McGuire 1 Cycle 18 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:

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

$$\text{Bank CC RIL} = 2.3(P) + 47 \quad \{0 \leq P \leq 80\}$$

$$\text{Bank CB RIL} = 2.3(P) + 163 \quad \{0 \leq P \leq 29.6\}$$

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

**NOTE:** Compliance with Technical Specification 3.1.3 may require rod withdrawal limits. Refer to OP/1/A/6100/22 Unit 1 Data Book for details.

## McGuire 1 Cycle 18 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 1 Cycle 18 Core Operating Limits Report

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

2.7.1  $F_Q(X,Y,Z)$  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 LCO limits. The manufacturing tolerance and measurement uncertainty are implicitly included in the  $F_Q$  surveillance limits as defined in COLR Sections 2.7.5 and 2.7.6.

2.7.2  $F_Q^{RTP} = 2.60 \times K(\text{BU})$

2.7.3  $K(Z)$  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.

2.7.4  $K(\text{BU})$  is the normalized  $F_Q(X,Y,Z)$  as a function of burnup.  $K(\text{BU})$  for Westinghouse RFA fuel is 1.0 for all burnups.

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

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

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 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 A-1 for normal operating conditions and in

## McGuire 1 Cycle 18 Core Operating Limits Report

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 that accounts for the peaking increase from an allowable quadrant power tilt ratio of 1.02. (TILT = 1.035)

$$2.7.6 \quad F_Q^L(X,Y,Z)^{RPS} = \frac{F_Q^D(X,Y,Z) * M_C(X,Y,Z)}{UMT * MT * TILT}$$

where:

$F_Q^L(X,Y,Z)^{RPS}$  = Cycle dependent maximum allowable design peaking factor that ensures that 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.

$M_C(X,Y,Z)$  = 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.

## McGuire 1 Cycle 18 Core Operating Limits Report

UMT = Total Peak Measurement Uncertainty (UMT = 1.05)

MT = Engineering Hot Channel Factor (MT = 1.03)

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

### 2.7.7 KSLOPE = 0.0725

where:

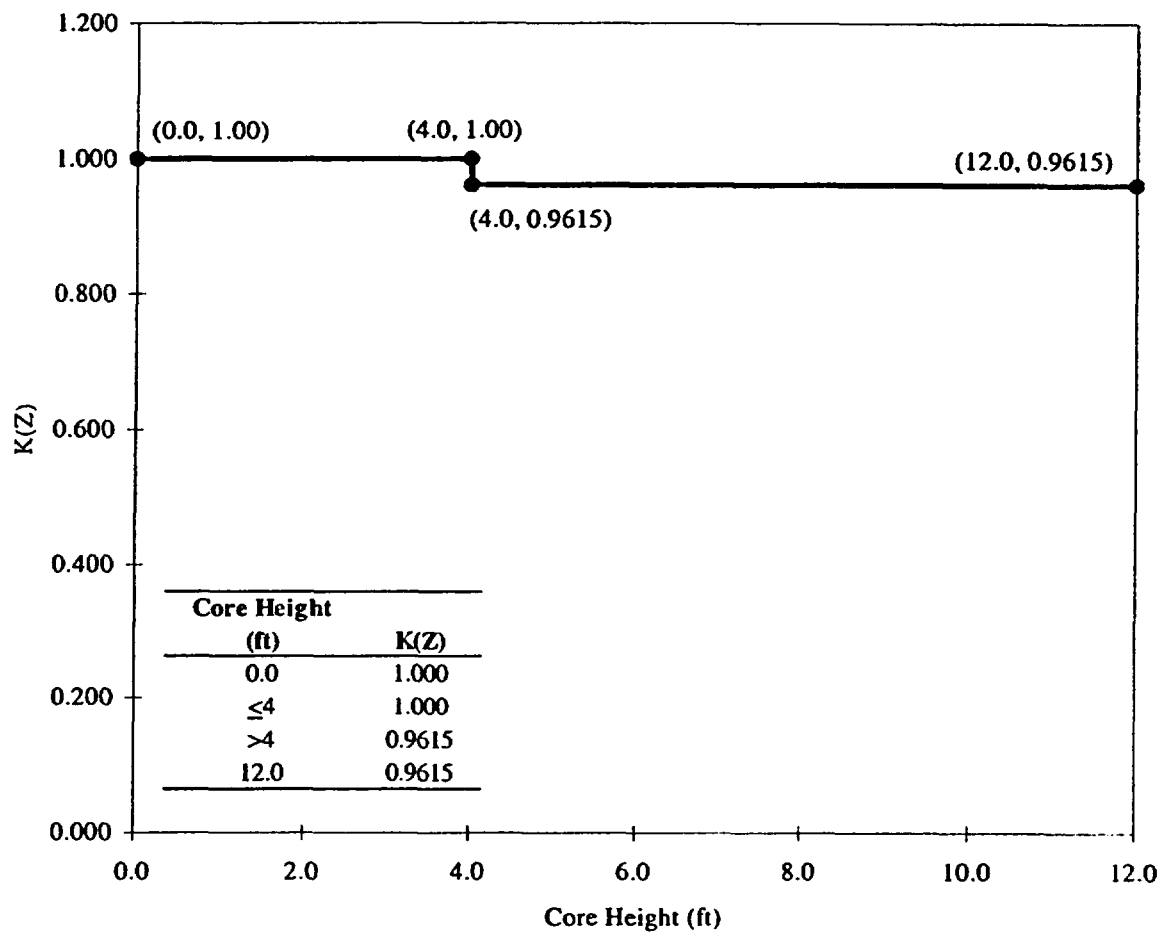
KSLOPE is the adjustment to the  $K_1$  value from OTAT trip setpoint required to compensate for each 1% that  $F_Q^M(X,Y,Z)$  exceeds  $F_Q^L(X,Y,Z)^{RPS}$ .

### 2.7.8 $F_Q(X,Y,Z)$ penalty factors for Technical Specification Surveillance's 3.2.1.2 and 3.2.1.3 are provided in Table 2.

# McGuire 1 Cycle 18 Core Operating Limits Report

Figure 4

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



## McGuire 1 Cycle 18 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**

<b><u>Burnup (EFPD)</u></b>	<b><u><math>F_Q(X,Y,Z)</math> Penalty Factor (%)</u></b>	<b><u><math>F_{\Delta H}(X,Y,Z)</math> Penalty Factor (%)</u></b>
0	2.00	2.00
4	2.00	2.00
12	2.00	2.00
25	2.00	2.00
50	2.02	2.00
75	2.00	2.00
100	2.48	2.00
125	3.26	2.00
150	2.54	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
510	2.00	2.00
525	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 1 Cycle 18 Core Operating Limits Report

### 2.8 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.

$$2.8.1 \quad F_{\Delta H}^L(X,Y)^{LCO} = \text{MARP}(X,Y) * \left[ 1.0 + \frac{1}{\text{RRH}} * (1.0 - P) \right]$$

where:

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

$F_{\Delta H}^L(X,Y)^{LCO}$  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 the 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.

$$2.8.2 \quad F_{\Delta H}^L(X,Y)^{SURV} = \frac{F_{\Delta H}^D(X,Y) \times M_{\Delta H}(X,Y)}{\text{UMR} \times \text{TILT}}$$

where:

$F_{\Delta H}^L(X,Y)^{SURV} =$  Cycle dependent maximum allowable design peaking factor that ensures that 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.

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$F_{\Delta H}^D(X,Y)$  = Design radial 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.

$M_{\Delta H}(X,Y)$  = 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 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 the peaking increase for an allowable quadrant power tilt ratio of 1.02, (TILT = 1.035).

### 2.8.3 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. ( $0 < P \leq 1.0$ )

### 2.8.4 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.

2.8.5  $F_{\Delta H}(X,Y)$  penalty factors for Technical Specification Surveillance 3.2.2.2 are provided in Table 2.

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

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

# McGuire 1 Cycle 18 Core Operating Limits Report

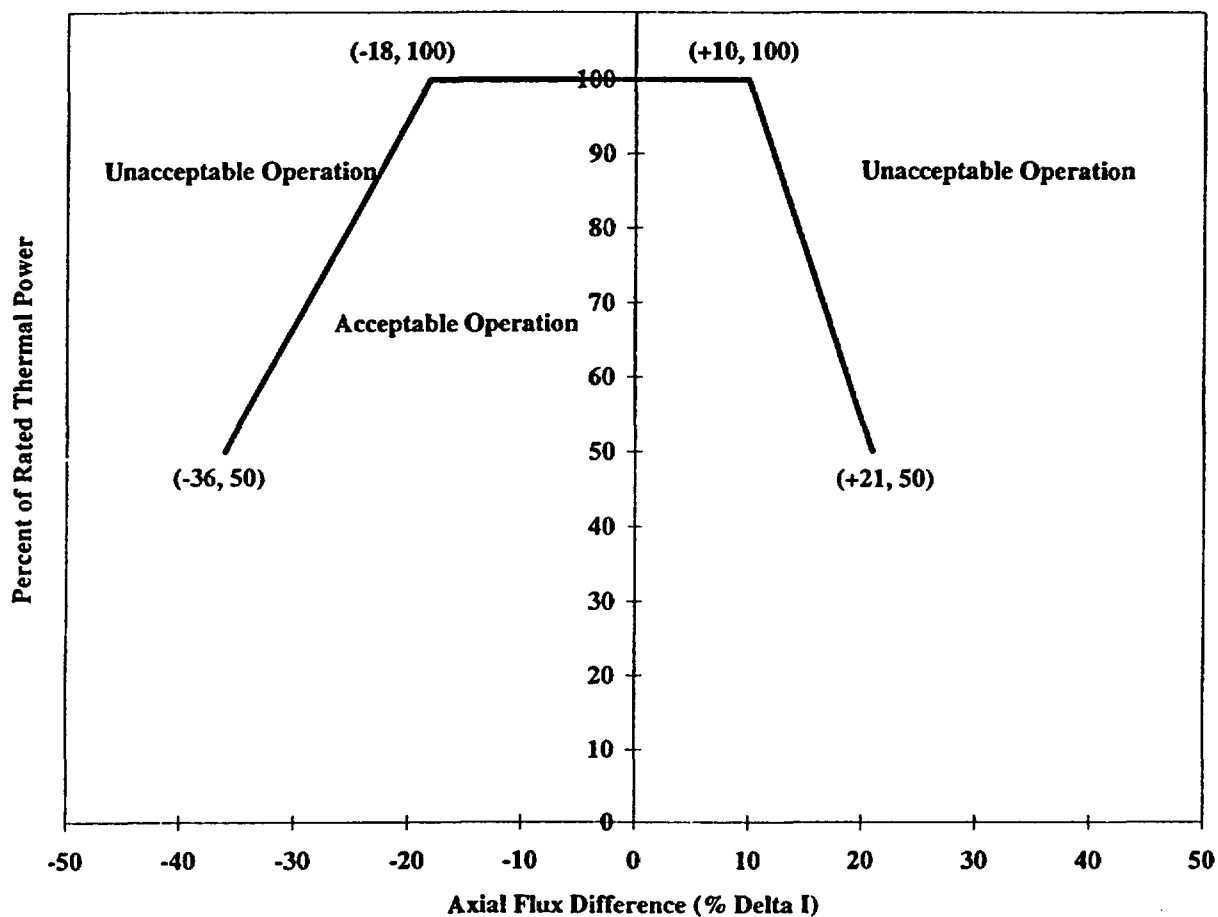
**Table 3**  
**Maximum Allowable Radial Peaks (MARPs)**  
**(Applicable for RFA Fuel)**

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	3.0	3.25
0.12	1.847	1.882	1.947	1.992	1.974	2.107	2.050	2.009	1.933	1.863	1.778	1.315	1.246
1.20	1.843	1.879	1.938	1.992	1.974	2.107	2.019	1.978	1.901	1.831	1.785	1.301	1.224
2.40	1.846	1.876	1.931	1.981	1.974	2.084	1.994	1.952	1.876	1.805	1.732	1.476	1.462
3.60	1.843	1.869	1.920	1.964	1.974	2.065	1.988	1.951	1.874	1.801	1.701	1.467	1.453
4.80	1.838	1.868	1.906	1.945	1.974	2.006	1.945	1.922	1.862	1.800	1.718	1.329	1.288
6.00	1.834	1.856	1.891	1.921	1.946	1.934	1.880	1.863	1.802	1.747	1.673	1.383	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	1.318	1.277
8.40	1.823	1.829	1.847	1.857	1.816	1.795	1.739	1.722	1.675	1.630	1.551	1.247	1.209
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	1.430	1.149	1.096
11.40	1.789	1.765	1.725	1.684	1.632	1.614	1.569	1.557	1.510	1.466	1.392	1.113	1.060

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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/1/A/6100/22 Unit 1 Data Book of more details.

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

#### 2.10.1 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	$K_1 \leq 1.1978$
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 slopes for OT $\Delta T$  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 an OT $\Delta T$   $f_1(\Delta I)$  negative breakpoint and slope unnecessary.

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### 2.10.2 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	$K_4 \leq 1.0864$
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 $\Delta T$	$\tau_1 \geq 8 \text{ sec.}$ $\tau_2 \leq 3 \text{ sec.}$
Time constant utilized in the lag compensator for $\Delta T$	$\tau_3 \leq 2 \text{ sec.}$
Time constant utilized in the measured $T_{avg}$ lag compensator	$\tau_6 \leq 2 \text{ sec.}$
Time constant utilized in the rate-lag controller for $T_{avg}$	$\tau_7 \geq 5 \text{ sec.}$
$f_2(\Delta I)$ "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	$= 7.0 \% \Delta T_0 / \% \Delta I$

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

2.11.1 The 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>Limit</u>
Cold Leg Accumulator minimum boron concentration.	2,475 ppm
Cold Leg Accumulator maximum boron concentration.	2,875 ppm

### 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>
Refueling Water Storage Tank minimum boron concentration.	2,675 ppm
Refueling Water Storage Tank 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	$\leq 587.2\text{ }^{\circ}\text{F}$
	meter	3	$\leq 586.9\text{ }^{\circ}\text{F}$
	computer	4	$\leq 587.7\text{ }^{\circ}\text{F}$
	computer	3	$\leq 587.5\text{ }^{\circ}\text{F}$
	meter	4	$\geq 2219.8\text{ psig}$
	meter	3	$\geq 2222.1\text{ psig}$
2. Indicated Pressurizer Pressure	meter	4	$\geq 2219.8\text{ psig}$
	meter	3	$\geq 2222.1\text{ psig}$
	computer	4	$\geq 2215.8\text{ psig}$
	computer	3	$\geq 2217.5\text{ psig}$
3. RCS Total Flow Rate			$\geq 388,000\text{ gpm}$

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

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.	2,675 ppm

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

2.15.1 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  $K_{eff} \leq 0.95$ .

<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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### 2.16 Borated Water Source – Shutdown (SLC 16.9-14)

**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  $\leq 300$  °F and modes 5 and 6.

<u>Parameter</u>	<u>Limit</u>
Boric Acid Tank minimum contained borated water volume	10,599 gallons 13.6% Level
<div style="border: 1px solid black; padding: 5px;"> <p>Note: When cycle burnup is &gt; 455 EFPD, Figure 6 may be used to determine the required BAT minimum level.</p> </div>	
Boric Acid Tank minimum boron concentration	7,000 ppm
Boric Acid Tank minimum water volume required to maintain SDM at 7,000 ppm	2,300 gallons
Refueling Water Storage Tank minimum contained borated water volume	47,700 gallons 41 inches
Refueling Water Storage Tank minimum boron concentration	2,675 ppm
Refueling Water Storage Tank minimum water volume required to maintain SDM at 2,675 ppm	8,200 gallons

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### 2.17 Borated Water Source - Operating (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 modes 1, 2, 3, and mode 4 with all RCS cold leg temperatures > 300°F.

<u>Parameter</u>	<u>Limit</u>
Boric Acid Tank minimum contained borated water volume	22,049 gallons 38.0% Level
<div style="border: 1px solid black; padding: 5px;"> <p>Note: When cycle burnup is &gt; 455 EFPD, Figure 6 may be used to determine the required BAT minimum level.</p> </div>	
Boric Acid Tank minimum boron concentration	7,000 ppm
Boric Acid Tank minimum water volume required to maintain SDM at 7,000 ppm	13,750 gallons
Refueling Water Storage Tank minimum contained borated water volume	96,607 gallons 103.6 inches
Refueling Water Storage Tank minimum boron concentration	2,675 ppm
Refueling Water Storage Tank maximum boron concentration (TS 3.5.4)	2875 ppm
Refueling Water Storage Tank minimum water volume required to maintain SDM at 2,675 ppm	57,107 gallons

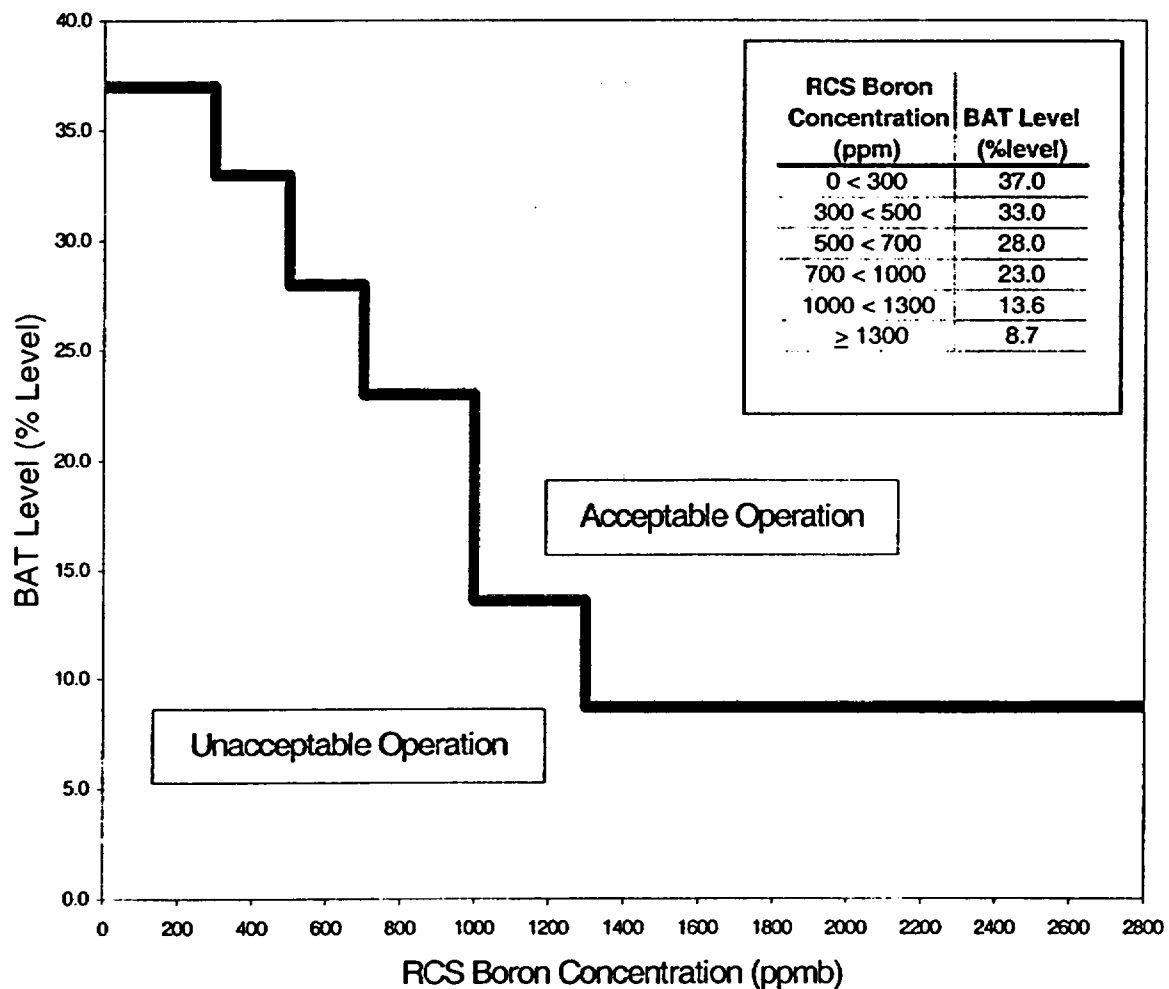
## McGuire 1 Cycle 18 Core Operating Limits Report

Figure 6

### Boric Acid Storage Tank Indicated Level Versus RCS Boron Concentration

(Valid When Cycle Burnup is > 455 EFPD)

This figure includes additional volumes listed in SLC 16.9-14 and 16.9-11



## McGuire 1 Cycle 18 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 1 Cycle 18 Maneuvering Analysis calculation file, MCC-1553.05-00-0416. 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.