



Tennessee Valley Authority, Post Office Box 2000, Decatur, Alabama 35609-2000

January 31, 2020

10 CFR 50.4

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

Browns Ferry Nuclear Plant, Unit 1  
Renewed Facility Operating License No. DPR-33  
NRC Docket No. 50-259

Subject: **Browns Ferry Nuclear Plant, Unit 1 Core Operating Limits Report for Cycle 13 Operation, Revision 1**

Reference: Letter from TVA to NRC, "Browns Ferry Nuclear Plant, Unit 1 Core Operating Limits Report for Cycle 13 Operation, Revision 0," dated October 24, 2018.

In accordance with the requirements of Technical Specification 5.6.5.d, the Tennessee Valley Authority (TVA) is submitting the Browns Ferry Nuclear Plant (BFN), Unit 1, Cycle 13, Core Operating Limits Report (COLR), Revision 1. Revision 0 of the BFN, Unit 1, Cycle 13, COLR (Reference) included all modes of operation (Modes 1 through 5). Revision 1 of the BFN, Unit 1, Cycle 13, COLR addresses operation in the Maximum Extended Load Line Limit Analysis Plus (MELLLA+) domain for the remainder of the current cycle.

There are no new commitments contained in this letter. If you have any questions please contact Jamie L. Paul at (256) 729-2636.

Respectfully,

A handwritten signature in black ink, appearing to read "S. M. Bono", is written over a circular stamp. The signature is fluid and stylized.

S. M. Bono  
Site Vice President

Enclosure: Core Operating Limits Report, (120% OLTP, MELLLA+), for Cycle 13 Operation TVA-COLR-BF1C13, Revision 1

U.S. Nuclear Regulatory Commission  
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cc: (w/ Enclosure)

NRC Regional Administrator - Region II  
NRC Senior Resident Inspector - Browns Ferry Nuclear Plant  
NRC Project Manager - Browns Ferry Nuclear Plant

**Enclosure  
Tennessee Valley Authority  
Browns Ferry Nuclear Plant  
Unit 1**

**Core Operating Limits Report, (120% OLTP, MELLLA+), for Cycle 13 Operation  
TVA COLR-BF1C13, Revision 1**

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**(See Attached)**



EDMS L94 200113 800  
QA Document  
BFE-4349, Revision 1

## Reactor Engineering and Fuels - BWRFE

1101 Market Street, Chattanooga, TN 37402

# Browns Ferry Unit 1 Cycle 13

## Core Operating Limits Report, (120% OLTP, MELLLA+)

**TVA-COLR-BF1C13** Revision 1 (Final)  
(Revision Log, Page v)


January 2020

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## Revision Log

Number	Page	Description
1-R1	vi-vii	Updated nomenclature pages for new items.
2-R1	viii	Updated References 1 and 4
3-R1	ix-x	Added New Reference (26) for the DSS-CD topical report supporting MELLLA+. Other References incremented by +1 for renumbering. Updated References 27-30. Removed Reference 31.
4-R1	1	In Section 1.2, the Oscillation Power Range Monitor (OPRM) Setpoint is no longer applicable for MELLLA+ operation. This part has been more generically renamed Hydraulic Stability Protection
5-R1	11-18	Updated Figures 3.3-3.10 as needed for new information
6-R1	20	In Section 4.2.3, exposure dependent limits updated as needed.
7-R1	23-32	Updated Tables 4.2-4.9 as needed.
8-R1	33-34	Re-write of Section 5 for DSS-CD stability change. Tables 5.1, 5.2, and 5.3 are new information supporting MELLLA+
9-R1	35	Updated to include two loop settings, clarify definitions
10-R1	38	Added clarifying note regarding limit applicability for mode 3, 4, & 5 activity.
11-R1	A1-A3	New material supporting MELLLA+
0-R0	All	New document.





## Nomenclature

ABSP	Automatic Backup Stability Protection
APLHGR	Average Planar LHGR
APRM	Average Power Range Monitor
AREVA NP	Vendor (Framatome, Siemens)
BOC	Beginning of Cycle
BSP	Backup Stability Protection
BWR	Boiling Water Reactor
CAVEX	Core Average Exposure
CD	Coast Down
CMSS	Core Monitoring System Software
COLR	Core Operating Limits Report
CPR	Critical Power Ratio
CRWE	Control Rod Withdrawal Error
CSDM	Cold SDM
DIVOM	Delta CPR over Initial CPR vs. Oscillation Magnitude
DSS-CD	Detect and Suppress Solution – Confirmation Density
EOC	End of Cycle
EOCLB	End-of-Cycle Licensing Basis
EOOS	Equipment OOS
EPU	Extended Power Uprate (120% OLTP)
FFTR	Final Feedwater Temperature Reduction
FFWTR	Final Feedwater Temperature Reduction
FHOOS	Feedwater Heaters OOS
ft	Foot: English unit of measure for length
GNF	Vendor (General Electric, Global Nuclear Fuels)
GWd	Giga Watt Day
HTSP	High TSP
ICA	Interim Corrective Action
ICF	Increased Core Flow (beyond rated)
IS	In-Service
kW	kilo watt: SI unit of measure for power.
LCO	License Condition of Operation
LFWH	Loss of Feedwater Heating
LHGRFAC	LHGR Multiplier (Power or Flow dependent)
LPRM	Low Power Range Monitor
LRNB	Generator Load Reject, No Bypass




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MAPFAC	MAPLHGR multiplier (Power or Flow dependent)
MBSP	Manual Backup Stability Protection
MCPR	Minimum CPR
MELLLA	Maximum Extended Load Line Limit Analysis
MELLLA+	Maximum Extended Load Line Limit Analysis Plus
MSRV	Moisture Separator Reheater Valve
MSRVOOS	MSRV OOS
MTU	Metric Ton Uranium
MWd/MTU	Mega Watt Day per Metric Ton Uranium
NEOC	Near EOC
NRC	United States Nuclear Regulatory Commission
NSS	Nominal Scram Speed
NTSP	Nominal TSP
OLMCPR	MCPR Operating Limit
OLTP	Original Licensed Thermal Power
OOS	Out-Of-Service
OPRM	Oscillation Power Range Monitor
OSS	Optimum Scram Speed
PBDA	Period Based Detection Algorithm
Pbypass	Power, below which TSV Position and TCV Fast Closure Scrams are Bypassed
PLU	Power Load Unbalance
PLUOOS	PLU OOS
PRNM	Power Range Neutron Monitor
RBM	Rod Block Monitor
RCPOOS	Recirculation Pump OOS (SLO)
RDF	Rated Drive Flow
RPS	Reactor Protection System
RPT	Recirculation Pump Trip
RPTOOS	RPT OOS
RTP	Rated Thermal Power
SDM	Shutdown Margin
SLMCPR	MCPR Safety Limit
SLO	Single Loop Operation
TBV	Turbine Bypass Valve
TBVIS	TBV IS
TBVOOS	Turbine Bypass Valves OOS
TIP	Transversing In-core Probe
TIPOOS	TIP OOS
TLO	Two Loop Operation
TSP	Trip Setpoint
TSSS	Technical Specification Scram Speed
TVA	Tennessee Valley Authority

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#### Setpoint References

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## 1 Introduction

In anticipation of cycle startup, it is necessary to describe the expected limits of operation.

### 1.1 Purpose

The primary purpose of this document is to satisfy requirements identified by unit technical specification section 5.6.5. This document may be provided, upon final approval, to the NRC..

### 1.2 Scope

This document will discuss the following areas:

- Average Planar Linear Heat Generation Rate (APLHGR) Limit  
(Technical Specifications 3.2.1 and 3.7.5)  
Applicability: Mode 1,  $\geq 23\%$  RTP (Technical Specifications definition of RTP)
- Linear Heat Generation Rate (LHGR) Limit  
(Technical Specification 3.2.3, 3.3.4.1, and 3.7.5)  
Applicability: Mode 1,  $\geq 23\%$  RTP (Technical Specifications definition of RTP)
- Minimum Critical Power Ratio Operating Limit (OLMCPR)  
(Technical Specifications 3.2.2, 3.3.4.1, 3.7.5 and Table 3.3.2.1-1)  
Applicability: Mode 1,  $\geq 23\%$  RTP (Technical Specifications definition of RTP)
- Thermal-Hydraulic Stability Protection  
(Technical Specification Table 3.3.1.1)  
Applicability: Mode 1,  $\geq$  (as specified in Technical Specifications Table 3.3.1.1-1)
- Average Power Range Monitor (APRM) Flow Biased Rod Block Trip Setting  
(Technical Requirements Manual Section 5.3.1 and Table 3.3.4-1)  
Applicability: Mode 1,  $\geq$  (as specified in Technical Requirements Manuals Table 3.3.4-1)
- Rod Block Monitor (RBM) Trip Setpoints and Operability  
(Technical Specification Table 3.3.2.1-1)  
Applicability: Mode 1,  $\geq$  % RTP as specified in Table 3.3.2.1-1 (TS definition of RTP)
- Shutdown Margin (SDM) Limit  
(Technical Specification 3.1.1)  
Applicability: All Modes

### 1.3 Fuel Loading

The core will contain previously exposed Framatome, Inc., ATRIUM-10, along with fresh and exposed ATRIUM-10XM. Nuclear fuel types used in the core loading are shown in Table 1.1. The core shuffle and final loading were explicitly evaluated for BOC cold shutdown margin performance as documented per Reference 5.



Table 1.1 Nuclear Fuel Types \*

Fuel Description	Original Cycle	Number of Assemblies	Nuclear Fuel Type (NFT)	Fuel Names (Range)
ATRIUM-10 A10-3840B-14GV80-FAB	11	49	23	FAB301-FAB500
ATRIUM-10 A10-4117B-13GV70-FAB	11	72	24	FAB501-FAB572
ATRIUM-10 A10-4112B-15GV70-FAB	11	31	25	FAB573-FAB608
ATRIUM-10XM XMLC-4102B-11GV70-FAC-B	12	40	26	FAC701-FAC740
ATRIUM-10XM XMLC-3969B-13GV80-FAC-C	12	128	27	FAC741-FAC868
ATRIUM-10XM XMLC-3948B-13GV70-FAC-B	12	112	28	FAC869-FAC980
ATRIUM-10XM XMLC-3967B-15GV80-FAD-B	13	164	29	FAD001-FAD164
ATRIUM-10XM XMLC-3945B-14GV80-FAD-C	13	72	30	FAD165-FAD236
ATRIUM-10XM XMLC-3951B-14GV80-FAD-C	13	40	31	FAD237-FAD276
ATRIUM-10XM XMLC-4091B-13GV80-FAD-B	13	56	32	FAD277-FAD332

## 1.4 Acceptability

Limits discussed in this document were generated based on NRC approved methodologies per References 6 through 25.

\* The table identifies the expected fuel type breakdown in anticipation of final core loading. The final composition of the core depends upon uncertainties during the outage such as discovering a failed fuel bundle, or other bundle damage. Minor core loading changes, due to unforeseen events, will conform to the safety and monitoring requirements identified in this document.



## 2 APLHGR Limits

### (Technical Specifications 3.2.1 & 3.7.5)

The APLHGR limit is determined by adjusting the rated power APLHGR limit for off-rated power, off-rated flow, and SLO conditions. The most limiting of these is then used as follows:

$$\text{APLHGR limit} = \text{MIN} ( \text{APLHGR}_P , \text{APLHGR}_F, \text{APLHGR}_{\text{SLO}} )$$

where:

APLHGR <sub>P</sub>	off-rated power APLHGR limit	$[\text{APLHGR}_{\text{RATED}} * \text{MAPFAC}_P]$
APLHGR <sub>F</sub>	off-rated flow APLHGR limit	$[\text{APLHGR}_{\text{RATED}} * \text{MAPFAC}_F]$
APLHGR <sub>SLO</sub>	SLO APLHGR limit	$[\text{APLHGR}_{\text{RATED}} * \text{SLO Multiplier}]$

### 2.1 Rated Power and Flow Limit: APLHGR<sub>RATED</sub>

The rated conditions APLHGR for all fuel are identified per Reference 1. The rated conditions APLHGR for ATRIUM-10 fuel are shown in Figure 2.1. The rated conditions APLHGR for ATRIUM-10XM are shown in Figure 2.2.

### 2.2 Off-Rated Power Dependent Limit: APLHGR<sub>P</sub>

Reference 1 does not specify a power dependent APLHGR. Therefore, MAPFAC<sub>P</sub> is set to a value of **1.0**.

#### 2.2.1 Startup without Feedwater Heaters

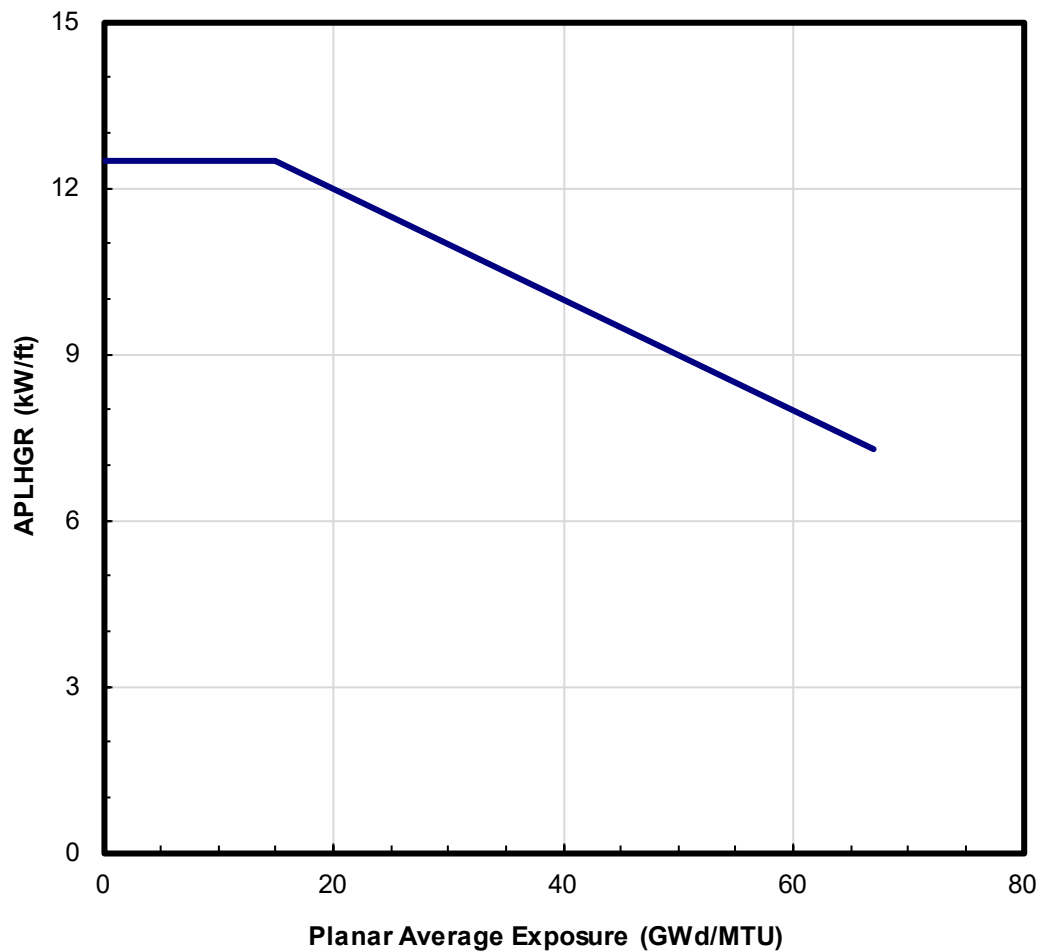
There is a range of operation during startup when the feedwater heaters are not placed into service until after the unit has reached a significant operating power level. No additional power dependent limitation is required.

### 2.3 Off-Rated Flow Dependent Limit: APLHGR<sub>F</sub>

Reference 1 does not specify a flow dependent APLHGR. Therefore, MAPFAC<sub>F</sub> is set to a value of **1.0**.

### 2.4 Single Loop Operation Limit: APLHGR<sub>SLO</sub>

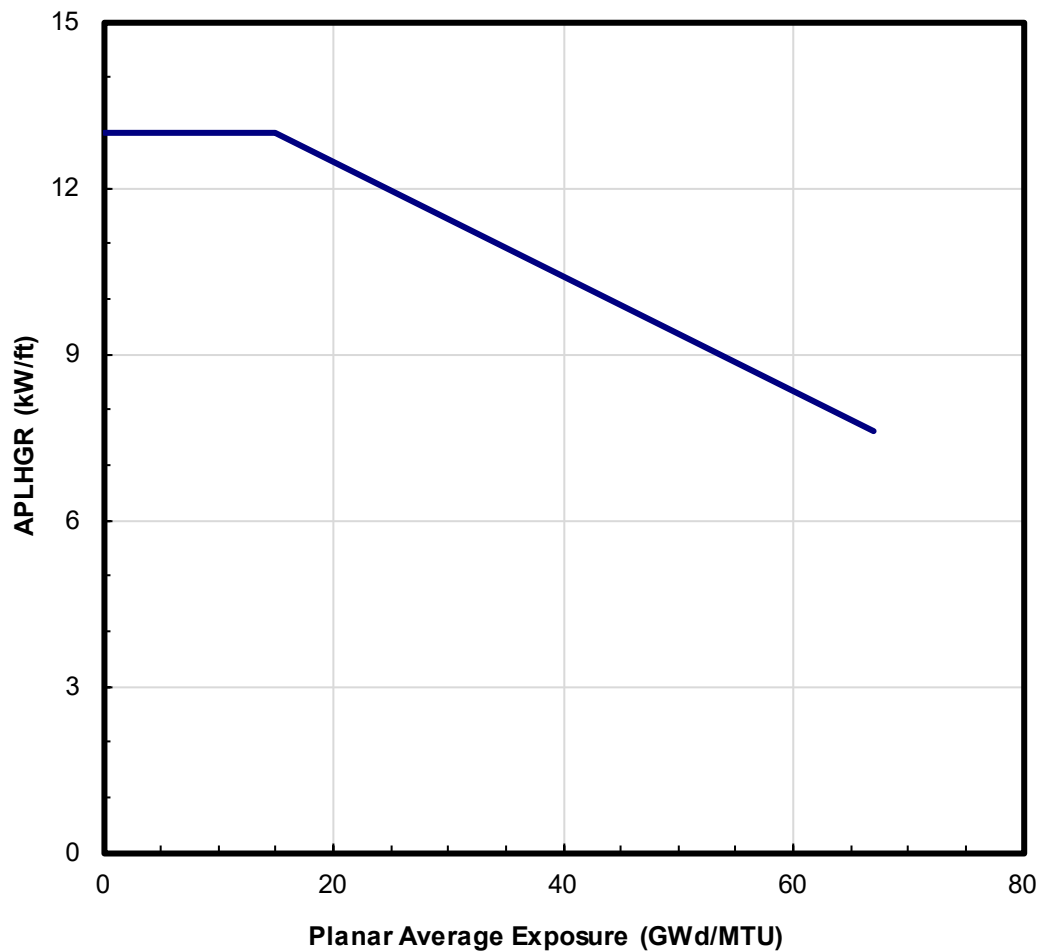
The single loop operation multiplier for ATRIUM-10 and ATRIUM-10XM fuel is **0.85**, per Reference 1.



Planar Avg. Exposure (GWd/MTU)	APLHGR Limit (kW/ft)
0.0	12.5
15.0	12.5
67.0	7.3

Figure 2.1 APLHGR<sub>RATED</sub> for ATRIUM-10 Fuel





Planar Avg. Exposure (GWd/MTU)	APLHGR Limit (kW/ft)
0.0	13.0
15.0	13.0
67.0	7.6

Figure 2.2 APLHGR<sub>RATED</sub> for ATRIUM-10XM Fuel



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## 2.5 Equipment Out-Of-Service Corrections

The limits shown in Figure 2.1 and Figure 2.2 are applicable for operation with all equipment In-Service as well as the following Equipment Out-Of-Service (EOOS) options; including combinations of the options.

In-Service	All equipment In-Service *
RPTOOS	EOC-Recirculation Pump Trip Out-Of-Service
TBVOOS	Turbine Bypass Valve(s) Out-Of-Service
PLUOOS	Power Load Unbalance Out-Of-Service
FHOOS (or FFWTR)	Feedwater Heaters Out-Of-Service or Final Feedwater Temperature Reduction
RCPOOS	One Recirculation Pump Out-Of-Service

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\* All equipment service conditions assume 1 SRVOOS.



### 3 LHGR Limits

(Technical Specification 3.2.3, 3.3.4.1, & 3.7.5)

The LHGR limit is determined by adjusting the rated power LHGR limit for off-rated power and off-rated flow conditions. The most limiting of these is then used as follows:

$$\text{LHGR limit} = \text{MIN} ( \text{LHGR}_P, \text{LHGR}_F )$$

where:

$\text{LHGR}_P$	off-rated power LHGR limit	$[\text{LHGR}_{\text{RATED}} * \text{LHGRFAC}_P]$
$\text{LHGR}_F$	off-rated flow LHGR limit	$[\text{LHGR}_{\text{RATED}} * \text{LHGRFAC}_F]$

#### 3.1 Rated Power and Flow Limit: $\text{LHGR}_{\text{RATED}}$

The rated conditions LHGR for all fuel are identified per Reference 1. The rated conditions LHGR for ATRIUM-10 are shown in Figure 3.1. The rated conditions LHGR for ATRIUM-10XM fuel is shown in Figure 3.2. The LHGR limit is consistent with References 2 and 3.

#### 3.2 Off-Rated Power Dependent Limit: $\text{LHGR}_P$

LHGR limits are adjusted for off-rated power conditions using the  $\text{LHGRFAC}_P$  multiplier provided in Reference 1. The multiplier is split into two sub cases: turbine bypass valves in and out-of-service. The base case multipliers are shown in Figure 3.3 and Figure 3.4.

##### 3.2.1 Startup without Feedwater Heaters

There is a range of operation during startup when the feedwater heaters are not placed into service until after the unit has reached a significant operating power level. Additional limits are shown in Figure 3.7 through Figure 3.10, based on temperature conditions identified in Table 3.1.

Table 3.1 Startup Feedwater Temperature Basis

Power (% Rated)	Temperature	
	Range 1	Range 2
	(°F)	(°F)
23	155.0	150.0
30	162.0	157.0
40	172.0	167.0
50	182.0	177.0



### 3.3 Off-Rated Flow Dependent Limit: LHGR<sub>F</sub>

LHGR limits are adjusted for off-rated flow conditions using the LHGRFAC<sub>F</sub> multiplier provided in Reference 1. Multipliers are shown in Figure 3.5 through Figure 3.6.

### 3.4 Equipment Out-Of-Service Corrections

The limits shown in Figure 3.1 and Figure 3.2 are applicable for operation with all equipment In-Service as well as the following Equipment Out-Of-Service (EOOS) options; including combinations of the options. \*

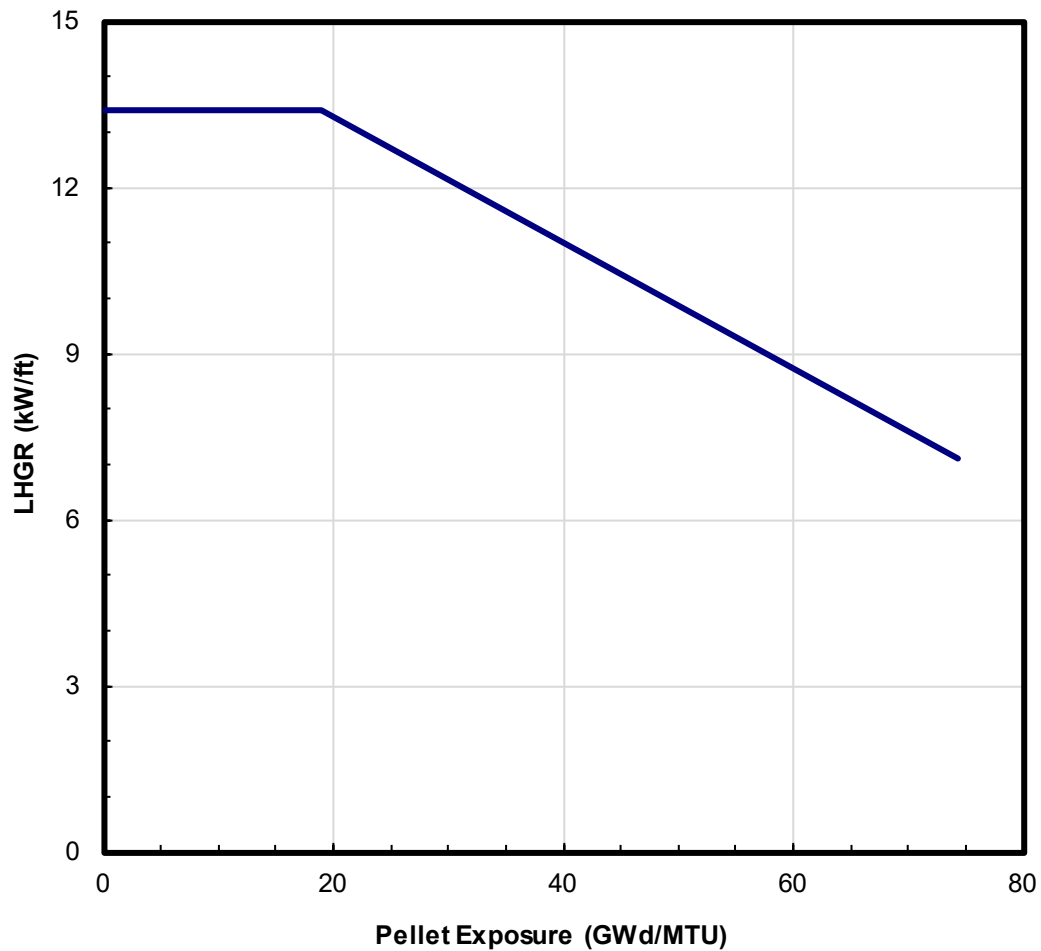
In-Service	All equipment In-Service
RPTOOS	EOC-Recirculation Pump Trip Out-Of-Service
TBVOOS	Turbine Bypass Valve(s) Out-Of-Service
PLUOOS	Power Load Unbalance Out-Of-Service
FHOOS (or FFWTR)	Feedwater Heaters Out-Of-Service or Final Feedwater Temperature Reduction
RCPOOS	One Recirculation Pump Out-Of-Service

Off-rated power corrections shown in Figure 3.3 and Figure 3.4 are dependent on operation of the Turbine Bypass Valve system. For this reason, separate limits are to be applied for TBVIS or TBVOOS operation. The limits have no dependency on RPTOOS, PLUOOS, FHOOS/FFWTR, or SLO.

Off-rated flow corrections shown in Figure 3.5 and Figure 3.6 are bounding for all EOOS conditions.

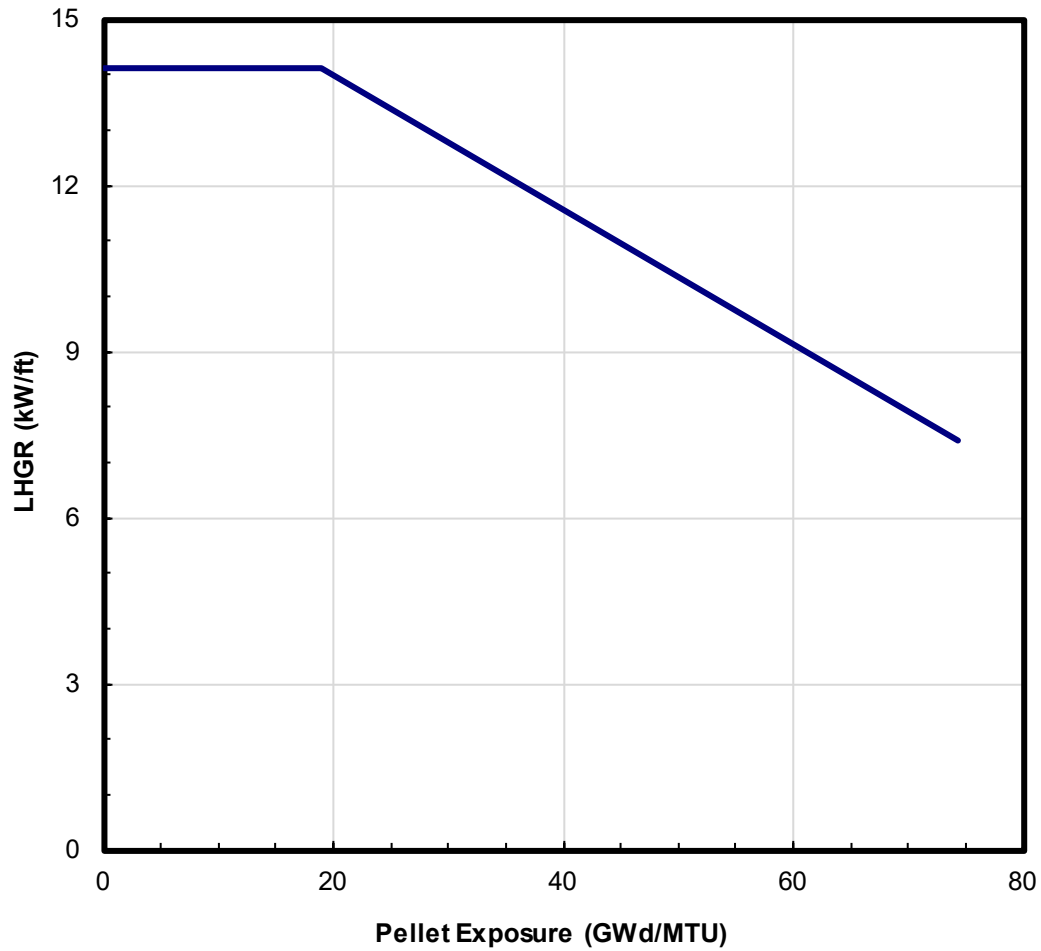
Off-rated power corrections shown in Figure 3.7 through Figure 3.10 are also dependent on operation of the Turbine Bypass Valve system. In this case, limits support FHOOS operation during startup. These limits have no dependency on RPTOOS, PLUOOS, or SLO.

\* All equipment service conditions assume 1 SRVOOS.



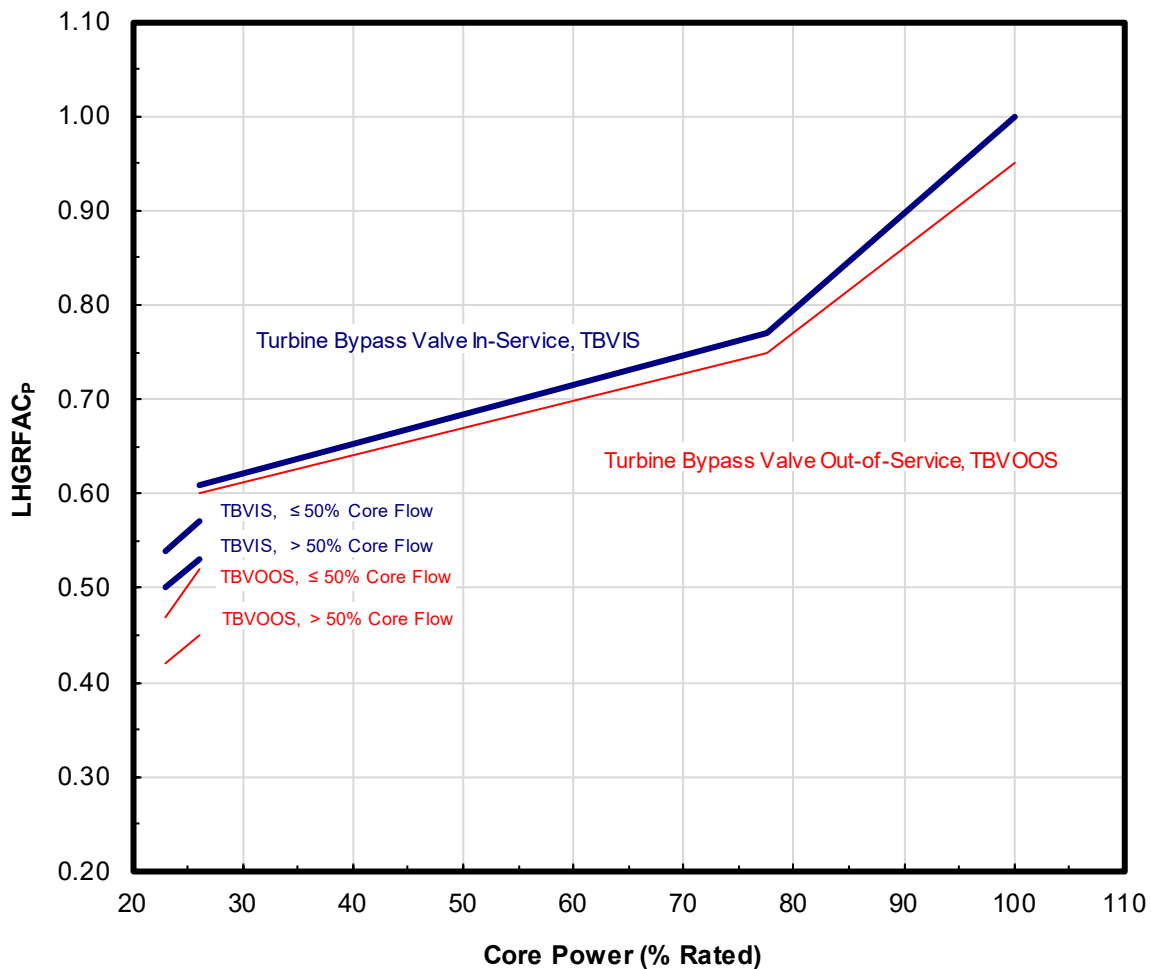
Pellet Exposure (GWd/MTU)	LHGR Limit (kW/ft)
0.0	13.4
18.9	13.4
74.4	7.1

Figure 3.1 LHGR<sub>RATED</sub> for ATRIUM-10 Fuel



Pellet Exposure (GWd/MTU)	LHGR Limit (kW/ft)
0.0	14.1
18.9	14.1
74.4	7.4

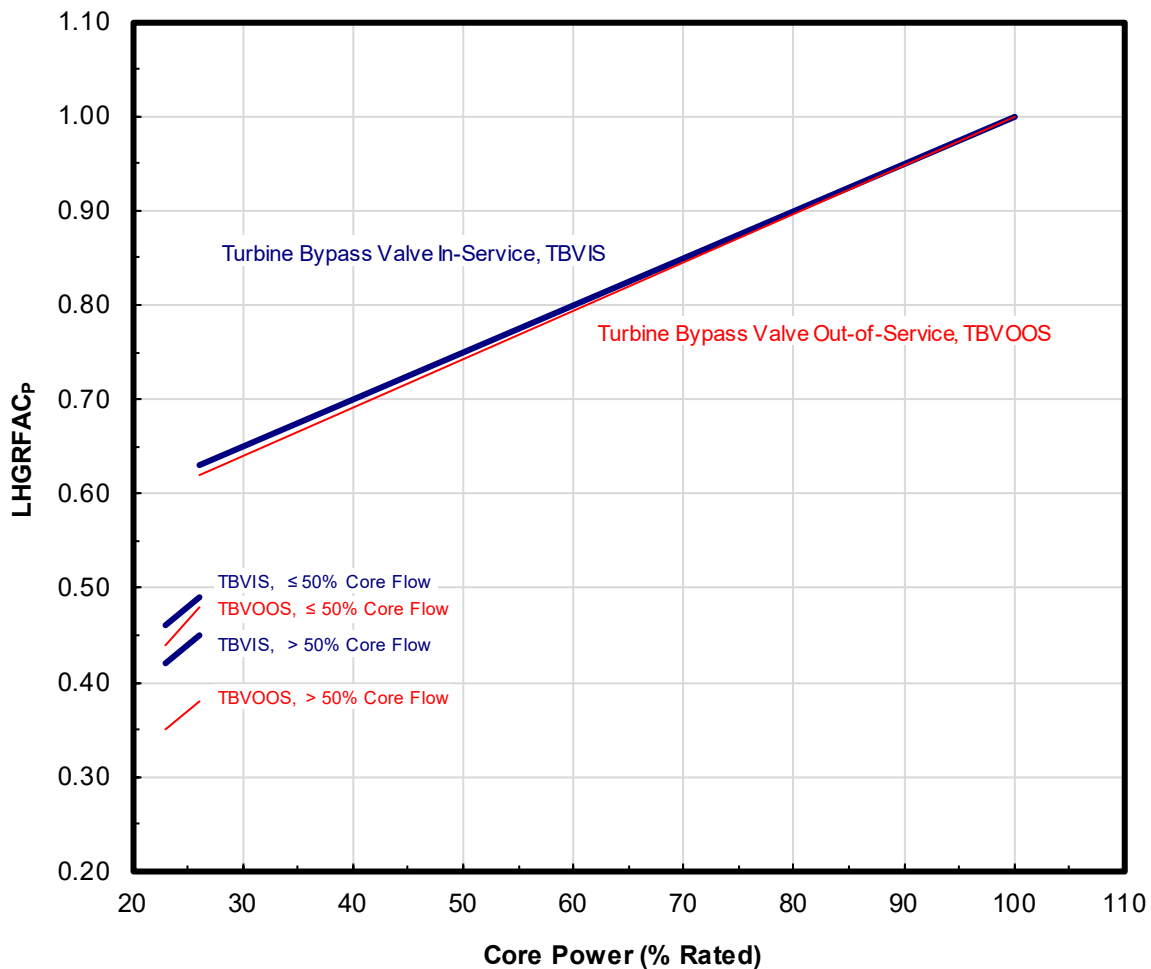
Figure 3.2 LHGR<sub>RATED</sub> for ATRIUM-10XM Fuel



<i>Turbine Bypass In-Service</i>	
Core Power	LHGRFAC <sub>p</sub>
(% Rated)	
100.0	1.00
77.6	0.77
26.0	0.61
Core Flow > 50% Rated	
26.0	0.53
23.0	0.50
Core Flow ≤ 50% Rated	
26.0	0.57
23.0	0.54

<i>Turbine Bypass Out-of-Service</i>	
Core Power	LHGRFAC <sub>p</sub>
(% Rated)	
100.0	0.95
77.6	0.75
26.0	0.60
Core Flow > 50% Rated	
26.0	0.45
23.0	0.42
Core Flow ≤ 50% Rated	
26.0	0.52
23.0	0.47

Figure 3.3 Base Operation LHGRFAC<sub>p</sub> for ATRIUM-10 Fuel  
(Independent of other EOOS conditions)

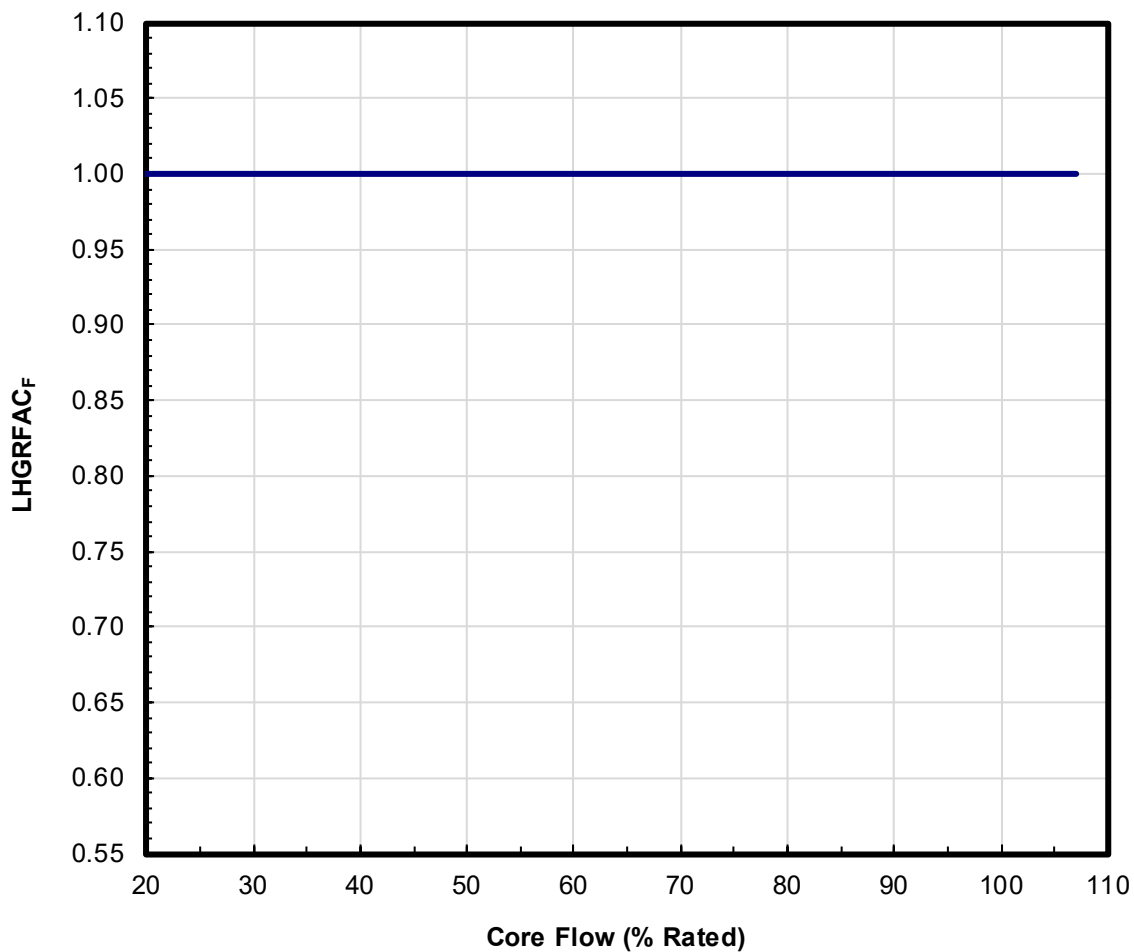


<i>Turbine Bypass In-Service</i>	
<b>Core Power</b>	<b>LHGRFAC<sub>p</sub></b>
<b>(% Rated)</b>	
100.0	1.00
26.0	0.63
<b>Core Flow &gt; 50% Rated</b>	
26.0	0.45
23.0	0.42
<b>Core Flow ≤ 50% Rated</b>	
26.0	0.49
23.0	0.46

<i>Turbine Bypass Out-of-Service</i>	
<b>Core Power</b>	<b>LHGRFAC<sub>p</sub></b>
<b>(% Rated)</b>	
100.0	1.00
26.0	0.62
<b>Core Flow &gt; 50% Rated</b>	
26.0	0.38
23.0	0.35
<b>Core Flow ≤ 50% Rated</b>	
26.0	0.48
23.0	0.44

Figure 3.4 Base Operation LHGRFAC<sub>p</sub> for ATRIUM-10XM Fuel  
(Independent of other EOOS conditions)

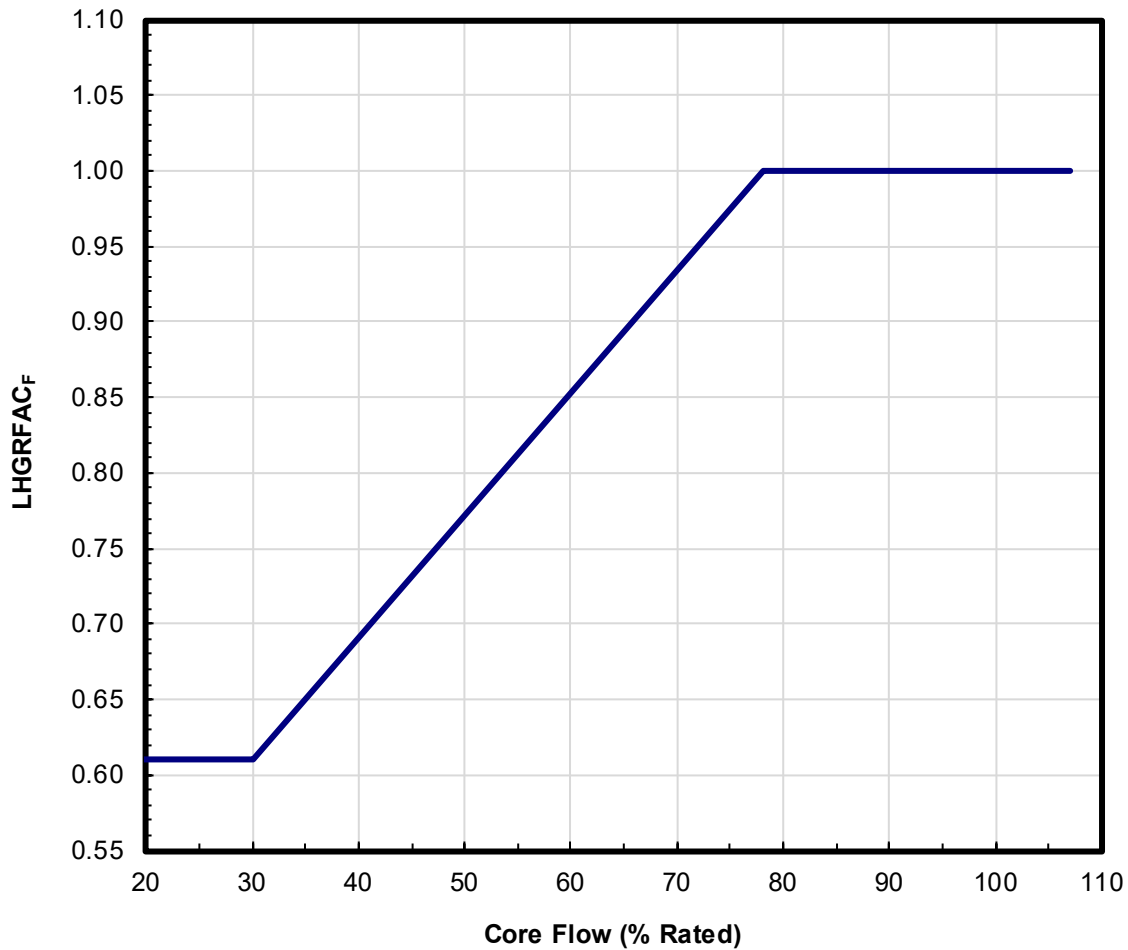




Core Flow (% Rated)	LHGRFAC <sub>F</sub>
0.0	1.00
30.0	1.00
107.0	1.00

Figure 3.5 LHGRFAC<sub>F</sub> for ATRIUM-10 Fuel  
(Values bound all EOOS conditions)

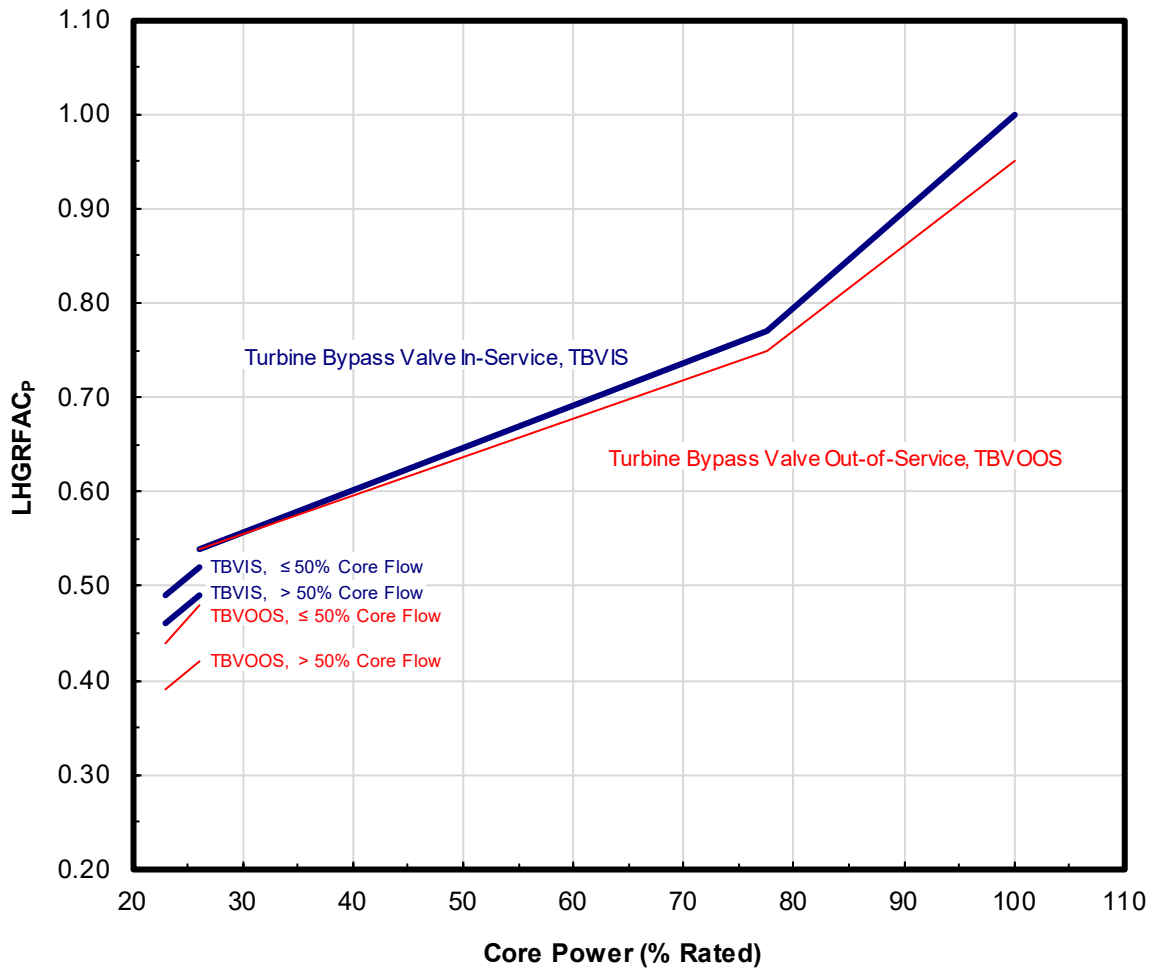
(107.0% maximum core flow line is used to support 105% rated flow operation, ICF)



Core Flow (% Rated)	LHGRFAC <sub>F</sub>
0.0	0.61
30.0	0.61
78.1	1.00
107.0	1.00

Figure 3.6 LHGRFAC<sub>F</sub> for ATRIUM-10XM Fuel  
(Values bound all EOOS conditions)

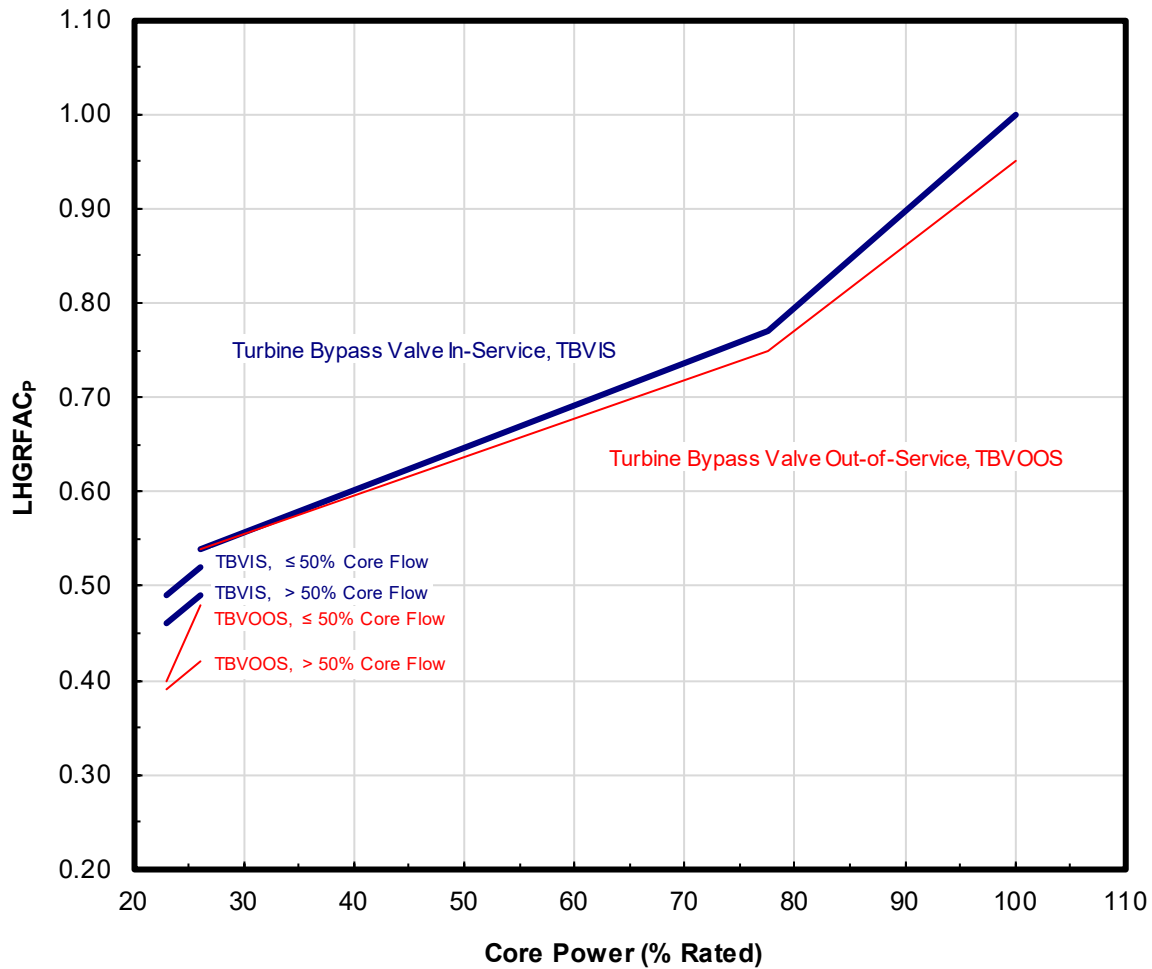
(107.0% maximum core flow line is used to support 105% rated flow operation, ICF)



Turbine Bypass In-Service	
Core Power (% Rated)	LHGRFAC <sub>p</sub>
100.0	1.00
77.6	0.77
26.0	0.54
Core Flow > 50% Rated	
26.0	0.49
23.0	0.46
Core Flow ≤ 50% Rated	
26.0	0.52
23.0	0.49

Turbine Bypass Out-of-Service	
Core Power (% Rated)	LHGRFAC <sub>p</sub>
100.0	0.95
77.6	0.75
26.0	0.54
Core Flow > 50% Rated	
26.0	0.42
23.0	0.39
Core Flow ≤ 50% Rated	
26.0	0.48
23.0	0.44

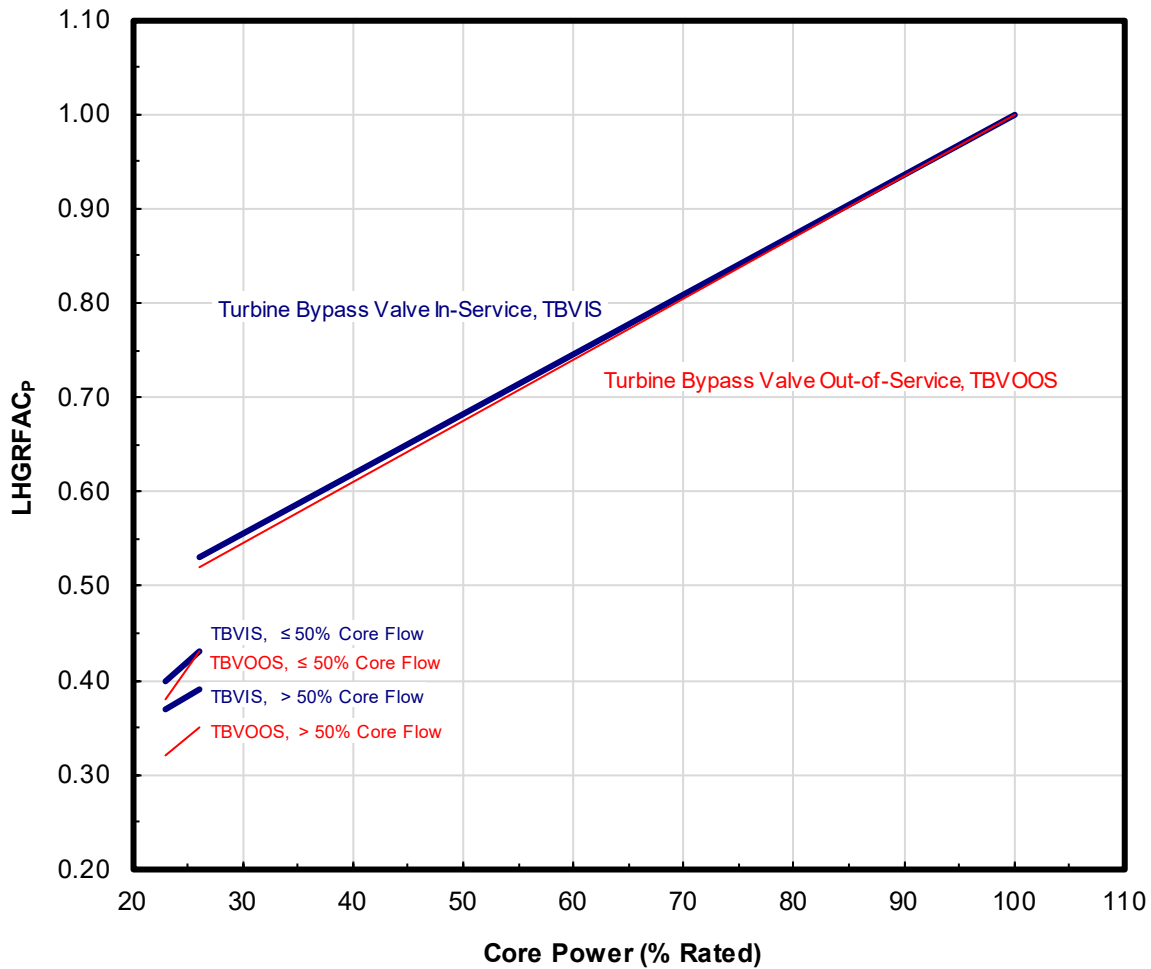
Figure 3.7 Startup Operation LHGRFAC<sub>p</sub> for ATRIUM-10 Fuel:  
Table 3.1 Temperature Range 1  
(no Feedwater heating during startup)  
(Limits valid at and below 50% power)



<i>Turbine Bypass In-Service</i>	
Core Power (% Rated)	LHGRFAC <sub>p</sub>
100.0	1.00
77.6	0.77
26.0	0.54
Core Flow > 50% Rated	
26.0	0.49
23.0	0.46
Core Flow $\leq 50\%$ Rated	
26.0	0.52
23.0	0.49

<i>Turbine Bypass Out-of-Service</i>	
Core Power (% Rated)	LHGRFAC <sub>p</sub>
100.0	0.95
77.6	0.75
26.0	0.54
Core Flow > 50% Rated	
26.0	0.42
23.0	0.39
Core Flow $\leq 50\%$ Rated	
26.0	0.48
23.0	0.40

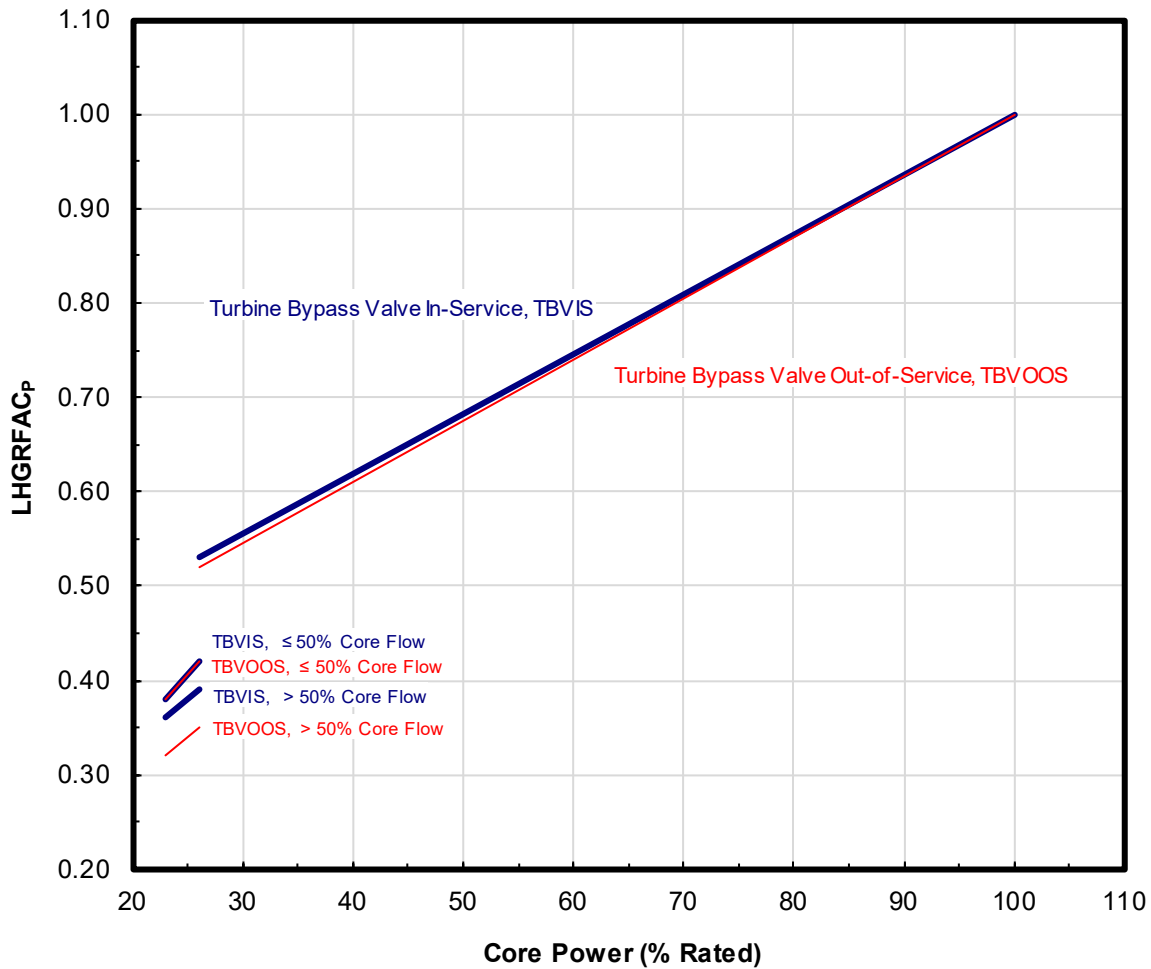
Figure 3.8 Startup Operation LHGRFAC<sub>p</sub> for ATRIUM-10 Fuel:  
 Table 3.1 Temperature Range 2  
 (no Feedwater heating during startup)  
 (Limits valid at and below 50% power)



Turbine Bypass In-Service	
Core Power	LHGRFAC <sub>p</sub>
(% Rated)	
100.0	1.00
26.0	0.53
Core Flow > 50% Rated	
26.0	0.39
23.0	0.37
Core Flow ≤ 50% Rated	
26.0	0.43
23.0	0.40

Turbine Bypass Out-of-Service	
Core Power	LHGRFAC <sub>p</sub>
(% Rated)	
100.0	1.00
26.0	0.52
Core Flow > 50% Rated	
26.0	0.35
23.0	0.32
Core Flow ≤ 50% Rated	
26.0	0.43
23.0	0.38

Figure 3.9 Startup Operation LHGRFAC<sub>p</sub> for ATRIUM-10XM Fuel:  
Table 3.1 Temperature Range 1  
(no Feedwater heating during startup)  
(Limits valid at and below 50% power)



Turbine Bypass In-Service	
Core Power	LHGRFAC <sub>p</sub>
(% Rated)	
100.0	1.00
26.0	0.53
Core Flow > 50% Rated	
26.0	0.39
23.0	0.36
Core Flow ≤ 50% Rated	
26.0	0.42
23.0	0.38

Turbine Bypass Out-of-Service	
Core Power	LHGRFAC <sub>p</sub>
(% Rated)	
100.0	1.00
26.0	0.52
Core Flow > 50% Rated	
26.0	0.35
23.0	0.32
Core Flow ≤ 50% Rated	
26.0	0.42
23.0	0.38

Figure 3.10 Startup Operation LHGRFAC<sub>p</sub> for ATRIUM-10XM  
Fuel: Table 3.1 Temperature Range 2  
(no Feedwater heating during startup)  
(Limits valid at and below 50% power)



## 4 OLMCPR Limits

(Technical Specification 3.2.2, 3.3.4.1, & 3.7.5)

OLMCPR is calculated to be the most limiting of the flow or power dependent values

$$\text{OLMCPR limit} = \text{MAX} ( \text{MCPR}_F , \text{MCPR}_P )$$

where:

$\text{MCPR}_F$	core flow-dependent MCPR limit
$\text{MCPR}_P$	power-dependent MCPR limit

### 4.1 Flow Dependent MCPR Limit: $\text{MCPR}_F$

$\text{MCPR}_F$  limits are dependent upon core flow (% of Rated), and the max core flow limit, (Rated or Increased Core Flow, ICF).  $\text{MCPR}_F$  limits are shown in Figure 4.1, per Reference 1. Limits are valid for all EOOS combinations. No adjustment is required for SLO conditions.

### 4.2 Power Dependent MCPR Limit: $\text{MCPR}_P$

$\text{MCPR}_P$  limits are dependent upon:

- Core Power Level (% of Rated)
- Technical Specification Scram Speed (TSSS), Nominal Scram Speed (NSS), or Optimum Scram Speed (OSS)
- Cycle Operating Exposure (NEOC, EOC, and CD - as defined in this section)
- Equipment Out-Of-Service Options
- Two or Single recirculation Loop Operation (TLO vs. SLO)

The  $\text{MCPR}_P$  limits are provided in Table 4.2 through Table 4.9, where each table contains the limits for all fuel types and EOOS options (for a specified scram speed and exposure range). The CMSS determines  $\text{MCPR}_P$  limits, from these tables, based on linear interpolation between the specified powers.

#### 4.2.1 Startup without Feedwater Heaters

There is a range of operation during startup when the feedwater heaters are not placed into service until after the unit has reached a significant operating power level. Additional power dependent limits are shown in Table 4.5 through Table 4.8 based on temperature conditions identified in Table 3.1.



#### 4.2.2 Scram Speed Dependent Limits (TSSS vs. NSS vs. OSS)

MCPR<sub>P</sub> limits are provided for three different sets of assumed scram speeds. The Technical Specification Scram Speed (TSSS) MCPR<sub>P</sub> limits are applicable at all times, as long as the scram time surveillance demonstrates the times in Technical Specification Table 3.1.4-1 are met. Both Nominal Scram Speeds (NSS) and/or Optimum Scram Speeds (OSS) may be used, as long as the scram time surveillance demonstrates Table 4.1 times are applicable.\*†

Table 4.1 Nominal Scram Time Basis

Notch Position	Nominal Scram Timing	Optimum Scram Timing
(index)	(seconds)	(seconds)
46	0.421	0.392
36	0.991	0.887
26	1.620	1.487
6	3.040	3.040

In demonstrating compliance with the NSS and/or OSS scram time basis, surveillance requirements from Technical Specification 3.1.4 apply; accepting the definition of SLOW rods should conform to scram speeds shown in Table 4.1. If conformance is not demonstrated, TSSS based MCPR<sub>P</sub> limits are applied.

On initial cycle startup, TSSS limits are used until the successful completion of scram timing confirms NSS and/or OSS based limits are applicable.

#### 4.2.3 Exposure Dependent Limits

Exposures are tracked on a Core Average Exposure basis (CAVEX, not Cycle Exposure). Higher exposure MCPR<sub>P</sub> limits are always more limiting and may be used for any Core Average Exposure up to the ending exposure. Per Reference 1, MCPR<sub>P</sub> limits are provided for the following exposure ranges:

BOC to NEOC	NEOC corresponds to	<b>29,058.4 MWd / MTU</b>
BOC to EOCLB	EOCLB corresponds to	<b>33,485.8 MWd / MTU</b>
BOC to End of Coast	End of Coast	<b>35,008.8 MWd / MTU</b>

NEOC refers to a Near EOC exposure point.

\* Reference 1 analysis results are based on information identified in Reference 4.

† Drop out times consistent with method used to perform actual timing measurements (i.e., including pickup/dropout effects).





The EOCLB exposure point is not the true End-Of-Cycle exposure. Instead it corresponds to a licensing exposure window exceeding expected end-of-full-power-life.

The End of Coast exposure point represents a licensing exposure point exceeding the expected end-of-cycle exposure including cycle extension options.

#### 4.2.4 Equipment Out-Of-Service (EOOS) Options

EOOS options \* covered by MCPR<sub>P</sub> limits are given by the following:

In-Service	All equipment In-Service
RPTOOS	EOC-Recirculation Pump Trip Out-Of-Service
TBVOOS	Turbine Bypass Valve(s) Out-Of-Service
RPTOOS+TBVOOS	Combined RPTOOS and TBVOOS
PLUOOS	Power Load Unbalance Out-Of-Service
PLUOOS+RPTOOS	Combined PLUOOS and RPTOOS
PLUOOS+TBVOOS	Combined PLUOOS and TBVOOS
PLUOOS+TBVOOS+RPTOOS	Combined PLUOOS, RPTOOS, and TBVOOS
FHOOS (or FFWTR)	Feedwater Heaters Out-Of-Service (or Final Feedwater Temperature Reduction)
RCPOOS	One Recirculation Pump Out-Of-Service

For exposure ranges up to NEOC and EOCLB, additional combinations of MCPR<sub>P</sub> limits are also provided including FHOOS. The coast down exposure range assumes application of FFWTR. FHOOS based MCPR<sub>P</sub> limits for the coast down exposure are redundant because the temperature setdown assumption is identical with FFWTR.

#### 4.2.5 Single-Loop-Operation (SLO) Limits

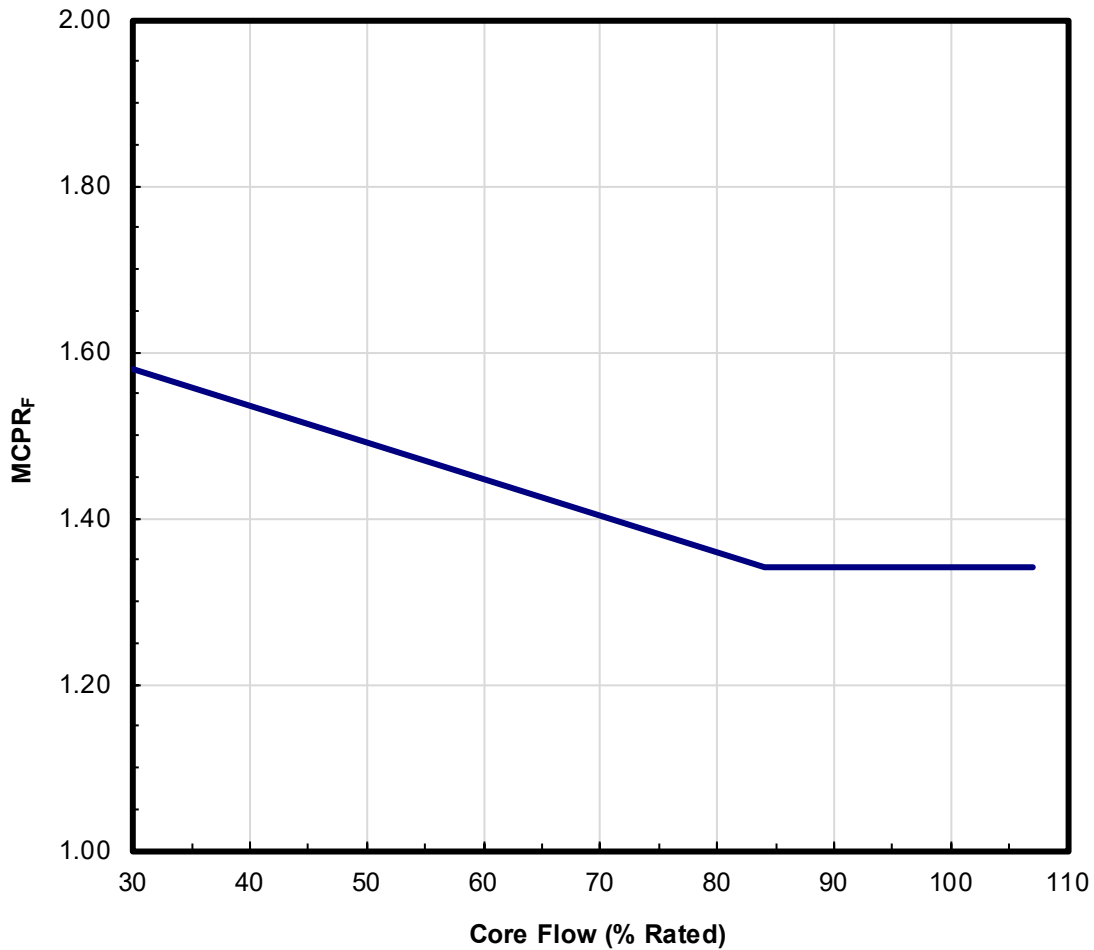
When operating in RCPOOS conditions, MCPR<sub>P</sub> limits are constructed differently from the normal operating RCP conditions. The limiting event for RCPOOS is a pump seizure scenario, which sets the upper bound for allowed core power and flow<sup>†</sup>. This event is not impacted by scram time assumptions. Specific MCPR<sub>P</sub> limits are shown in Table 4.9.

#### 4.2.6 Below Pbypass Limits

Below Pbypass (26% rated power), MCPR<sub>P</sub> limits depend upon core flow. One set of MCPR<sub>P</sub> limits applies for core flow above 50% of rated; a second set applies if the core flow is less than or equal to 50% rated.

\* All equipment service conditions assume 1 SRVOOS.

† RCPOOS limits are only valid up to 43.75% rated core power, 50% rated core flow, and an active recirculation drive flow of 17.73 Mlb<sub>m</sub>/hr.



Core Flow (% Rated)	MCPR <sub>F</sub>
30.0	1.58
84.0	1.34
107.0	1.34

Figure 4.1 MCPR<sub>F</sub> for All Fuel Types  
 (Values bound all EOOS conditions)

(107.0% maximum core flow line is used to support 105% rated flow operation, ICF)

Table 4.2 MCPR<sub>P</sub> Limits for All Fuel Types: Optimum Scram Time Basis \*

Operating Condition	Power (% of rated)	ATRIUM-10			ATRIUM-10XM		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast	BOC to NEOC	BOC to EOCLB	BOC to End of Coast
Base Case	100	1.47	1.50	1.54	1.39	1.40	1.44
	90	1.53	1.56	1.59	1.44	1.45	1.49
	65	1.71	1.72	1.76	1.59	1.60	1.64
	50	1.79	1.79	1.85	1.70	1.70	1.76
	50	2.03	2.03	2.03	1.79	1.80	1.80
	40	2.10	2.10	2.10	1.87	1.87	1.93
	26	2.34	2.34	2.46	2.29	2.29	2.41
	26 at > 50°F	2.65	2.65	2.75	2.60	2.60	2.70
	23 at > 50°F	2.81	2.81	2.92	2.76	2.76	2.87
	26 at ≤ 50°F	2.57	2.57	2.67	2.52	2.52	2.62
	23 at ≤ 50°F	2.73	2.73	2.85	2.68	2.68	2.80
FHOOS	100	1.51	1.54	---	1.43	1.44	---
	90	1.57	1.59	---	1.48	1.49	---
	65	1.74	1.76	---	1.64	1.64	---
	50	1.85	1.85	---	1.76	1.76	---
	50	2.03	2.03	---	1.80	1.80	---
	40	2.10	2.10	---	1.93	1.93	---
	26	2.46	2.46	---	2.41	2.41	---
	26 at > 50°F	2.75	2.75	---	2.70	2.70	---
	23 at > 50°F	2.92	2.92	---	2.87	2.87	---
	26 at ≤ 50°F	2.67	2.67	---	2.62	2.62	---
	23 at ≤ 50°F	2.85	2.85	---	2.80	2.80	---

\* All limits, including "Base Case," support RPTOOS operation; operation is supported for any combination of 1 MSRVOOS, up to 2 TIPOOS (or the equivalent number of TIP channels), and up to 50% of the LPRMs out-of-service.

FFWTR/FHOOS is supported for the BOC to End of Coast limits.

Table 4.3 MCPR<sub>p</sub> Limits for All Fuel Types: Nominal Scram Time Basis \*

Operating Condition	Power (% of rated)	ATRIUM-10			ATRIUM-10XM		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast	BOC to NEOC	BOC to EOCLB	BOC to End of Coast
Base Case	100	1.50	1.53	1.56	1.42	1.43	1.46
	90	1.57	1.59	1.62	1.47	1.48	1.51
	65	1.73	1.74	1.79	1.62	1.62	1.67
	50	1.82	1.82	1.88	1.72	1.72	1.79
	50	2.04	2.04	2.04	1.80	1.82	1.82
	40	2.11	2.11	2.11	1.87	1.88	1.96
	26	2.37	2.37	2.49	2.32	2.32	2.44
	26 at > 50°F	2.65	2.65	2.75	2.60	2.60	2.70
	23 at > 50°F	2.81	2.81	2.92	2.76	2.76	2.87
	26 at ≤ 50°F	2.57	2.57	2.67	2.52	2.52	2.62
TBVOOS	23 at ≤ 50°F	2.73	2.73	2.85	2.68	2.68	2.80
	100	1.56	1.59	1.62	1.45	1.46	1.49
	90	1.62	1.65	1.67	1.50	1.51	1.54
	65	1.79	1.81	1.84	1.65	1.65	1.69
	50	1.86	1.86	1.92	1.74	1.74	1.80
	50	2.04	2.04	2.04	1.80	1.82	1.82
	40	2.11	2.11	2.12	1.88	1.88	1.96
	26	2.37	2.37	2.49	2.32	2.32	2.44
	26 at > 50°F	3.17	3.17	3.29	3.12	3.12	3.24
	23 at > 50°F	3.44	3.44	3.56	3.39	3.39	3.51
FHOOS	26 at ≤ 50°F	2.91	2.91	3.05	2.86	2.86	3.00
	23 at ≤ 50°F	3.20	3.20	3.35	3.15	3.15	3.30
	100	1.54	1.56	---	1.46	1.46	---
	90	1.60	1.62	---	1.51	1.51	---
	65	1.79	1.79	---	1.67	1.67	---
	50	1.88	1.88	---	1.79	1.79	---
	50	2.04	2.04	---	1.80	1.82	---
	40	2.11	2.11	---	1.96	1.96	---
	26	2.49	2.49	---	2.44	2.44	---
	26 at > 50°F	2.75	2.75	---	2.70	2.70	---
PLUOOS	23 at > 50°F	2.92	2.92	---	2.87	2.87	---
	26 at ≤ 50°F	2.67	2.67	---	2.62	2.62	---
	23 at ≤ 50°F	2.85	2.85	---	2.80	2.80	---
	100	1.51	1.53	1.56	1.42	1.43	1.46
	90	1.57	1.59	1.62	1.47	1.48	1.51
	65	1.96	1.96	1.96	1.73	1.75	1.75
	50	---	---	---	---	---	---
	50	2.04	2.04	2.04	1.81	1.82	1.82
	40	2.11	2.11	2.11	1.87	1.88	1.96
	26	2.37	2.37	2.49	2.32	2.32	2.44
	26 at > 50°F	2.65	2.65	2.75	2.60	2.60	2.70
	23 at > 50°F	2.81	2.81	2.92	2.76	2.76	2.87
	26 at ≤ 50°F	2.57	2.57	2.67	2.52	2.52	2.62
	23 at ≤ 50°F	2.73	2.73	2.85	2.68	2.68	2.80

\* All limits, including "Base Case," support RPTOOS operation; operation is supported for any combination of 1 MSRVOOS, up to 2 TIPOOS (or the equivalent number of TIP channels), and up to 50% of the LPRMs out-of-service.

FFWTR and FHOOS assume the same value of temperature drop. Consequently, FHOOS limits are not provided for BOC to End of COAST due to redundancy. Thermal limits for the "BOC to End of COAST" exposure applicability window are developed to conservatively bound FHOOS limits for earlier exposure applicability windows.

Table 4.3 MCPR<sub>P</sub> Limits for All Fuel Types: Nominal Scram Time Basis (*continued*)<sup>\*</sup>

Operating Condition	Power (% of rated)	ATRIUM-10			ATRIUM-10XM		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast	BOC to NEOC	BOC to EOCLB	BOC to End of Coast
TBVOOS FHOOS	100	1.59	1.62	---	1.48	1.49	---
	90	1.65	1.67	---	1.53	1.54	---
	65	1.84	1.84	---	1.68	1.69	---
	50	1.92	1.92	---	---	1.80	---
	50	2.04	2.04	---	1.80	1.82	---
	40	2.12	2.12	---	1.96	1.96	---
	26	2.49	2.49	---	2.44	2.44	---
	26 at > 50°F	3.29	3.29	---	3.24	3.24	---
	23 at > 50°F	3.56	3.56	---	3.51	3.51	---
	26 at ≤ 50°F	3.05	3.05	---	3.00	3.00	---
	23 at ≤ 50°F	3.35	3.35	---	3.30	3.30	---
TBVOOS PLUOOS	100	1.56	1.59	1.62	1.45	1.46	1.49
	90	1.62	1.65	1.67	1.50	1.51	1.54
	65	1.96	1.96	1.96	1.73	1.75	1.75
	50	---	---	---	---	---	---
	50	2.04	2.04	2.04	1.81	1.82	1.82
	40	2.11	2.11	2.12	1.88	1.88	1.96
	26	2.37	2.37	2.49	2.32	2.32	2.44
	26 at > 50°F	3.17	3.17	3.29	3.12	3.12	3.24
	23 at > 50°F	3.44	3.44	3.56	3.39	3.39	3.51
	26 at ≤ 50°F	2.91	2.91	3.05	2.86	2.86	3.00
	23 at ≤ 50°F	3.20	3.20	3.35	3.15	3.15	3.30
FHOOS PLUOOS	100	1.54	1.56	---	1.46	1.46	---
	90	1.60	1.62	---	1.51	1.51	---
	65	1.96	1.96	---	1.73	1.75	---
	50	---	---	---	---	---	---
	50	2.04	2.04	---	1.81	1.82	---
	40	2.11	2.11	---	1.96	1.96	---
	26	2.49	2.49	---	2.44	2.44	---
	26 at > 50°F	2.75	2.75	---	2.70	2.70	---
	23 at > 50°F	2.92	2.92	---	2.87	2.87	---
	26 at ≤ 50°F	2.67	2.67	---	2.62	2.62	---
	23 at ≤ 50°F	2.85	2.85	---	2.80	2.80	---
TBVOOS FHOOS PLUOOS	100	1.59	1.62	---	1.48	1.49	---
	90	1.65	1.67	---	1.53	1.54	---
	65	1.96	1.96	---	1.73	1.75	---
	50	---	---	---	---	---	---
	50	2.04	2.04	---	1.81	1.82	---
	40	2.12	2.12	---	1.96	1.96	---
	26	2.49	2.49	---	2.44	2.44	---
	26 at > 50°F	3.29	3.29	---	3.24	3.24	---
	23 at > 50°F	3.56	3.56	---	3.51	3.51	---
	26 at ≤ 50°F	3.05	3.05	---	3.00	3.00	---
	23 at ≤ 50°F	3.35	3.35	---	3.30	3.30	---

<sup>\*</sup> All limits, including "Base Case," support RPTOOS operation; operation is supported for any combination of 1 MSRVOOS, up to 2 TIPOOS (or the equivalent number of TIP channels), and up to 50% of the LPRMs out-of-service.

FFWTR and FHOOS assume the same value of temperature drop. Consequently, FHOOS limits are not provided for BOC to End of COAST due to redundancy. Thermal limits for the "BOC to End of COAST" exposure applicability window are developed to conservatively bound FHOOS limits for earlier exposure applicability windows.

Table 4.4 MCPR<sub>p</sub> Limits for All Fuel Types: Technical Specification Scram Time Basis \*

Operating Condition	Power (% of rated)	ATRIUM-10			ATRIUM-10XM		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast	BOC to NEOC	BOC to EOCLB	BOC to End of Coast
Base Case	100	1.55	1.55	1.59	1.45	1.45	1.49
	90	1.62	1.62	1.64	1.50	1.50	1.53
	65	1.77	1.77	1.83	1.64	1.64	1.70
	50	1.85	1.85	1.91	1.75	1.75	1.82
	50	2.05	2.05	2.05	1.81	1.83	1.83
	40	2.11	2.11	2.12	1.89	1.89	1.98
	26	2.39	2.39	2.52	2.34	2.34	2.47
	26 at > 50°F	2.65	2.65	2.75	2.60	2.60	2.70
	23 at > 50°F	2.81	2.81	2.92	2.76	2.76	2.87
	26 at ≤ 50°F	2.57	2.57	2.67	2.52	2.52	2.62
	23 at ≤ 50°F	2.73	2.73	2.85	2.68	2.68	2.80
TBVOOS	100	1.60	1.67	1.69	1.48	1.49	1.52
	90	1.67	1.67	1.69	1.53	1.54	1.56
	65	1.83	1.83	1.88	1.67	1.67	1.71
	50	1.90	1.90	1.96	1.76	1.76	---
	50	2.05	2.05	2.05	1.81	1.83	1.83
	40	2.11	2.11	2.15	1.90	1.90	1.99
	26	2.39	2.39	2.52	2.34	2.34	2.47
	26 at > 50°F	3.17	3.17	3.29	3.12	3.12	3.24
	23 at > 50°F	3.44	3.44	3.56	3.39	3.39	3.51
	26 at ≤ 50°F	2.91	2.91	3.05	2.86	2.86	3.00
	23 at ≤ 50°F	3.20	3.20	3.35	3.15	3.15	3.30
FHOOS	100	1.57	1.59	---	1.48	1.49	---
	90	1.64	1.64	---	1.53	1.53	---
	65	1.83	1.83	---	1.70	1.70	---
	50	1.91	1.91	---	---	1.82	---
	50	2.05	2.05	---	1.82	1.83	---
	40	2.12	2.12	---	1.98	1.98	---
	26	2.52	2.52	---	2.47	2.47	---
	26 at > 50°F	2.75	2.75	---	2.70	2.70	---
	23 at > 50°F	2.92	2.92	---	2.87	2.87	---
	26 at ≤ 50°F	2.67	2.67	---	2.62	2.62	---
	23 at ≤ 50°F	2.85	2.85	---	2.80	2.80	---
PLUOOS	100	1.55	1.63	1.68	1.45	1.45	1.49
	90	1.62	1.63	1.68	1.50	1.50	1.53
	65	1.97	1.97	1.97	1.74	1.76	1.76
	50	---	---	---	---	---	---
	50	2.05	2.05	2.05	1.82	1.84	1.84
	40	2.11	2.11	2.12	1.89	1.89	1.98
	26	2.39	2.39	2.52	2.34	2.34	2.47
	26 at > 50°F	2.65	2.65	2.75	2.60	2.60	2.70
	23 at > 50°F	2.81	2.81	2.92	2.76	2.76	2.87
	26 at ≤ 50°F	2.57	2.57	2.67	2.52	2.52	2.62
	23 at ≤ 50°F	2.73	2.73	2.85	2.68	2.68	2.80

\* All limits, including "Base Case," support RPTOOS operation; operation is supported for any combination of 1 MSRVOOS, up to 2 TIPOOS (or the equivalent number of TIP channels), and up to 50% of the LPRMs out-of-service.

FFWTR and FHOOS assume the same value of temperature drop. Consequently, FHOOS limits are not provided for BOC to End of COAST due to redundancy. Thermal limits for the "BOC to End of COAST" exposure applicability window are developed to conservatively bound FHOOS limits for earlier exposure applicability windows.

Table 4.4 MCPR<sub>P</sub> Limits for All Fuel Types: Technical Specification Scram Time Basis (*continued*)\*

Operating Condition	Power (% of rated)	ATRIUM-10			ATRIUM-10XM		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast	BOC to NEOC	BOC to EOCLB	BOC to End of Coast
TBVOOS FHOOS	100	1.62	1.67	---	1.51	1.52	---
	90	1.69	1.69	---	1.56	1.56	---
	65	1.88	1.88	---	1.71	1.71	---
	50	1.96	1.96	---	---	---	---
	50	2.05	2.05	---	1.83	1.83	---
	40	2.15	2.15	---	1.99	1.99	---
	26	2.52	2.52	---	2.47	2.47	---
	26 at > 50°F	3.29	3.29	---	3.24	3.24	---
	23 at > 50°F	3.56	3.56	---	3.51	3.51	---
	26 at ≤ 50°F	3.05	3.05	---	3.00	3.00	---
	23 at ≤ 50°F	3.35	3.35	---	3.30	3.30	---
TBVOOS PLUOOS	100	1.60	1.67	1.69	1.48	1.49	1.52
	90	1.67	1.67	1.69	1.53	1.54	1.56
	65	1.97	1.97	1.97	1.74	1.76	1.76
	50	---	---	---	---	---	---
	50	2.05	2.05	2.05	1.82	1.84	1.84
	40	2.11	2.11	2.15	1.90	1.90	1.99
	26	2.39	2.39	2.52	2.34	2.34	2.47
	26 at > 50°F	3.17	3.17	3.29	3.12	3.12	3.24
	23 at > 50°F	3.44	3.44	3.56	3.39	3.39	3.51
	26 at ≤ 50°F	2.91	2.91	3.05	2.86	2.86	3.00
	23 at ≤ 50°F	3.20	3.20	3.35	3.15	3.15	3.30
FHOOS PLUOOS	100	1.57	1.63	---	1.48	1.49	---
	90	1.64	1.64	---	1.53	1.53	---
	65	1.97	1.97	---	1.74	1.76	---
	50	---	---	---	---	---	---
	50	2.05	2.05	---	1.82	1.84	---
	40	2.12	2.12	---	1.98	1.98	---
	26	2.52	2.52	---	2.47	2.47	---
	26 at > 50°F	2.75	2.75	---	2.70	2.70	---
	23 at > 50°F	2.92	2.92	---	2.87	2.87	---
	26 at ≤ 50°F	2.67	2.67	---	2.62	2.62	---
	23 at ≤ 50°F	2.85	2.85	---	2.80	2.80	---
TBVOOS FHOOS PLUOOS	100	1.62	1.67	---	1.51	1.52	---
	90	1.69	1.69	---	1.56	1.56	---
	65	1.97	1.97	---	1.74	1.76	---
	50	---	---	---	---	---	---
	50	2.05	2.05	---	1.83	1.84	---
	40	2.15	2.15	---	1.99	1.99	---
	26	2.52	2.52	---	2.47	2.47	---
	26 at > 50°F	3.29	3.29	---	3.24	3.24	---
	23 at > 50°F	3.56	3.56	---	3.51	3.51	---
	26 at ≤ 50°F	3.05	3.05	---	3.00	3.00	---
	23 at ≤ 50°F	3.35	3.35	---	3.30	3.30	---

\* All limits, including "Base Case," support RPTOOS operation; operation is supported for any combination of 1 MSRVOOS, up to 2 TIPOOS (or the equivalent number of TIP channels), and up to 50% of the LPRMs out-of-service.

FFWTR and FHOOS assume the same value of temperature drop. Consequently, FHOOS limits are not provided for BOC to End of COAST due to redundancy. Thermal limits for the "BOC to End of COAST" exposure applicability window are developed to conservatively bound FHOOS limits for earlier exposure applicability windows.



Table 4.5 Startup Operation MCPRP Limits for Table 3.1 Temperature Range 1 for All Fuel Types: Nominal Scram Time Basis \*

Operating Condition	Power (% of rated)	ATRIUM-10			ATRIUM-10XM		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast	BOC to NEOC	BOC to EOCLB	BOC to End of Coast
TBVIS	100	1.54	1.56	1.56	1.46	1.46	1.46
	90	1.60	1.62	1.62	1.51	1.51	1.51
	65	1.96	1.96	1.96	1.73	1.75	1.75
	50	---	---	---	---	---	---
	50	2.07	2.07	2.07	1.95	1.95	1.95
	40	2.32	2.32	2.32	2.16	2.16	2.16
	26	2.82	2.82	2.82	2.77	2.77	2.77
	26 at > 50°F	3.03	3.03	3.03	2.98	2.98	2.98
	23 at > 50°F	3.28	3.28	3.28	3.23	3.23	3.23
	26 at ≤ 50°F	2.96	2.96	2.96	2.91	2.91	2.91
	23 at ≤ 50°F	3.19	3.19	3.19	3.14	3.14	3.14
TBVOOS	100	1.59	1.62	1.62	1.48	1.49	1.49
	90	1.65	1.67	1.67	1.53	1.54	1.54
	65	1.96	1.96	1.96	1.73	1.75	1.75
	50	---	---	---	---	---	---
	50	2.09	2.09	2.09	1.95	1.95	1.95
	40	2.33	2.33	2.33	2.16	2.16	2.16
	26	2.82	2.82	2.82	2.77	2.77	2.77
	26 at > 50°F	3.53	3.53	3.53	3.48	3.48	3.48
	23 at > 50°F	3.83	3.83	3.83	3.78	3.78	3.78
	26 at ≤ 50°F	3.29	3.29	3.29	3.24	3.24	3.24
	23 at ≤ 50°F	3.62	3.62	3.62	3.57	3.57	3.57

\* Limits support RPTOOS operation; operation is supported for any combination of 1 MSRVOOS, up to 2 TIPOOS (or the equivalent number of TIP channels), and up to 50% of the LPRMs out-of-service.

Limits are applicable for all other EOOS scenarios, apart from TBV.

Limits are only valid up to 50% rated core power.





Table 4.6 Startup Operation MCPR<sub>P</sub> Limits for Table 3.1 Temperature Range 2 for All Fuel Types: Nominal Scram Time Basis\*

Operating Condition	Power (% of rated)	ATRIUM-10			ATRIUM-10XM		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast	BOC to NEOC	BOC to EOCLB	BOC to End of Coast
TBVIS	100	1.54	1.56	1.56	1.46	1.46	1.46
	90	1.60	1.62	1.62	1.51	1.51	1.51
	65	1.96	1.96	1.96	1.73	1.75	1.75
	50	---	---	---	---	---	---
	50	2.07	2.07	2.07	1.96	1.96	1.96
	40	2.33	2.33	2.33	2.17	2.17	2.17
	26	2.83	2.83	2.83	2.78	2.78	2.78
	26 at > 50°F	3.05	3.05	3.05	3.00	3.00	3.00
	23 at > 50°F	3.30	3.30	3.30	3.25	3.25	3.25
	26 at ≤ 50°F	2.98	2.98	2.98	2.93	2.93	2.93
	23 at ≤ 50°F	3.27	3.27	3.27	3.22	3.22	3.22
TBVOOS	100	1.59	1.62	1.62	1.48	1.49	1.49
	90	1.65	1.67	1.67	1.53	1.54	1.54
	65	1.96	1.96	1.96	1.73	1.75	1.75
	50	---	---	---	---	---	---
	50	2.10	2.10	2.10	1.96	1.96	1.96
	40	2.34	2.34	2.34	2.17	2.17	2.17
	26	2.83	2.83	2.83	2.78	2.78	2.78
	26 at > 50°F	3.54	3.54	3.54	3.49	3.49	3.49
	23 at > 50°F	3.84	3.84	3.84	3.79	3.79	3.79
	26 at ≤ 50°F	3.30	3.30	3.30	3.25	3.25	3.25
	23 at ≤ 50°F	3.73	3.73	3.73	3.68	3.68	3.68

\* Limits support RPTOOS operation; operation is supported for any combination of 1 MSRVOOS, up to 2 TIPOOS (or the equivalent number of TIP channels), and up to 50% of the LPRMs out-of-service.

Limits are applicable for all other EOOS scenarios, apart from TBV.

Limits are only valid up to 50% rated core power.



Table 4.7 Startup Operation MCPR<sub>P</sub> Limits for Table 3.1 Temperature Range 1 for All Fuel Types: Technical Specification Scram Time Basis\*

Operating Condition	Power (% of rated)	ATRIUM-10			ATRIUM-10XM		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast	BOC to NEOC	BOC to EOCLB	BOC to End of Coast
TBVIS	100	1.57	1.63	1.68	1.48	1.49	1.49
	90	1.64	1.64	1.68	1.53	1.53	1.53
	65	1.97	1.97	1.97	1.74	1.76	1.76
	50	---	---	---	---	---	---
	50	2.09	2.09	2.09	1.97	1.97	1.97
	40	2.35	2.35	2.35	2.19	2.19	2.19
	26	2.84	2.84	2.84	2.79	2.79	2.79
	26 at > 50°F	3.03	3.03	3.03	2.98	2.98	2.98
	23 at > 50°F	3.28	3.28	3.28	3.23	3.23	3.23
	26 at ≤ 50°F	2.96	2.96	2.96	2.91	2.91	2.91
	23 at ≤ 50°F	3.19	3.19	3.19	3.14	3.14	3.14
TBVOOS	100	1.62	1.67	1.69	1.51	1.52	1.52
	90	1.69	1.69	1.69	1.56	1.56	1.56
	65	1.97	1.97	1.97	1.74	1.76	1.76
	50	---	---	---	---	---	---
	50	2.13	2.13	2.13	1.97	1.97	1.97
	40	2.37	2.37	2.37	2.19	2.19	2.19
	26	2.84	2.84	2.84	2.79	2.79	2.79
	26 at > 50°F	3.53	3.53	3.53	3.48	3.48	3.48
	23 at > 50°F	3.83	3.83	3.83	3.78	3.78	3.78
	26 at ≤ 50°F	3.29	3.29	3.29	3.24	3.24	3.24
	23 at ≤ 50°F	3.62	3.62	3.62	3.57	3.57	3.57

\* Limits support RPTOOS operation; operation is supported for any combination of 1 MSRVOOS, up to 2 TIPOOS (or the equivalent number of TIP channels), and up to 50% of the LPRMs out-of-service.

Limits are applicable for all other EOOS scenarios, apart from TBV.

Limits are only valid up to 50% rated core power.



Table 4.8 Startup Operation MCPR<sub>P</sub> Limits for Table 3.1 Temperature Range 2 for All Fuel Types: Technical Specification Scram Time Basis\*

Operating Condition	Power (% of rated)	ATRIUM-10			ATRIUM-10XM		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast	BOC to NEOC	BOC to EOCLB	BOC to End of Coast
TBVIS	100	1.57	1.63	1.68	1.48	1.49	1.49
	90	1.64	1.64	1.68	1.53	1.53	1.53
	65	1.97	1.97	1.97	1.74	1.76	1.76
	50	---	---	---	---	---	---
	50	2.10	2.10	2.10	1.98	1.98	1.98
	40	2.36	2.36	2.36	2.19	2.19	2.19
	26	2.86	2.86	2.86	2.81	2.81	2.81
	26 at > 50°F	3.05	3.05	3.05	3.00	3.00	3.00
	23 at > 50°F	3.30	3.30	3.30	3.25	3.25	3.25
	26 at ≤ 50°F	2.98	2.98	2.98	2.93	2.93	2.93
	23 at ≤ 50°F	3.27	3.27	3.27	3.22	3.22	3.22
TBVOOS	100	1.62	1.67	1.69	1.51	1.52	1.52
	90	1.69	1.69	1.69	1.56	1.56	1.56
	65	1.97	1.97	1.97	1.74	1.76	1.76
	50	---	---	---	---	---	---
	50	2.14	2.14	2.14	1.98	1.98	1.98
	40	2.38	2.38	2.38	2.19	2.19	2.19
	26	2.86	2.86	2.86	2.81	2.81	2.81
	26 at > 50°F	3.54	3.54	3.54	3.49	3.49	3.49
	23 at > 50°F	3.84	3.84	3.84	3.79	3.79	3.79
	26 at ≤ 50°F	3.30	3.30	3.30	3.25	3.25	3.25
	23 at ≤ 50°F	3.73	3.73	3.73	3.68	3.68	3.68

\* Limits support RPTOOS operation; operation is supported for any combination of 1 MSRVOOS, up to 2 TIPOOS (or the equivalent number of TIP channels), and up to 50% of the LPRMs out-of-service.

Limits are applicable for all other EOOS scenarios, apart from TBV.

Limits are only valid up to 50% rated core power.

Table 4.9 MCPR<sub>P</sub> Limits for All Fuel Types: Single Loop Operation for All Scram Times \*

Operating Condition	Power (% of rated)	BOC to End of COAST	
		ATRIUM-10	ATRIUM-10XM
RCPOOS FHOOS	100	2.12	2.05
	43.75	2.12	2.05
	40	2.14	2.05
	26	2.54	2.49
	26 at > 50°F	2.77	2.72
	23 at > 50°F	2.94	2.89
	26 at ≤ 50°F	2.69	2.64
	23 at ≤ 50°F	2.87	2.82
RCPOOS TBVOOS PLUOOS FHOOS	100	2.14	2.05
	43.75	2.14	2.05
	40	2.17	2.05
	26	2.54	2.49
	26 at > 50°F	3.31	3.26
	23 at > 50°F	3.58	3.53
	26 at ≤ 50°F	3.07	3.02
	23 at ≤ 50°F	3.37	3.32
RCPOOS TBVOOS FHOOS1	100	2.30	2.13
	43.75	2.30	2.13
	40	2.39	2.21
	26	2.86	2.81
	26 at > 50°F	3.55	3.50
	23 at > 50°F	3.85	3.80
	26 at ≤ 50°F	3.31	3.26
	23 at ≤ 50°F	3.64	3.59
RCPOOS TBVOOS FHOOS2	100	2.31	2.14
	43.75	2.31	2.14
	40	2.40	2.21
	26	2.88	2.83
	26 at > 50°F	3.56	3.51
	23 at > 50°F	3.86	3.81
	26 at ≤ 50°F	3.32	3.27
	23 at ≤ 50°F	3.75	3.70

\* All limits, including "Base Case," support RPTOOS operation; operation is supported for any combination of 1 MSRVOOS, up to 2 TIPOOS (or the equivalent number of TIP channels), and up to 50% of the LPRMs out-of-service.

FFWTR and FHOOS assume the same value of temperature drop.

RCPOOS limits are only valid up to 50% rated core power, 50% rated core flow, and an active recirculation drive flow of 17.73 Mlbm/hr.



## 5 Thermal-Hydraulic Stability Protection

### (Technical Specification 3.3.1.1)

Technical Specification Table 3.3.1.1-1, Function 2f, identifies the function.

Instrument setpoints are established, such that the reactor will be tripped before an oscillation can grow to the point where the SLMCPR is exceeded. With application of Reference 30, the DSS-CD stability solution will be used per Reference 26. The DSS-CD  $S_{AD}$  setpoint is 1.10 for TLO and SLO.

New analyses have been developed based on Reference 26. With the implementation of the MELLLA+ operating domain expansion, an ABSP trip is required when the OPRM is out-of-service. The ABSP trip settings define a region of the power to flow map within which an automatic reactor scram occurs. The ABSP trip settings are provided in Table 5.1. If both the OPRM and ABSP are out-of-service, operation within the MELLLA+ domain is not allowed and the MBSP Regions provide stability protection. Table 5.2 and Table 5.3 provide the endpoints for the MBSP regions for nominal and reduced feedwater temperature conditions.

Table 5.1 ABSP Setpoints for the Scram Region

Parameter	Symbol	Setting Value (unit)	Comments
Slope for Trip	$m_{TRIP}$	2.00 (% RTP/% RDF)	Slope of ABSP APRM low Flow Biased Trip Linear Segment
Constant Power Line for Trip	$P_{BSP-TRIP}$	35.0 (% RTP)	ABSP APRM Flow Biased Trip Setpoint Power Intercept. Constant Power Line for Trip from Zero Drive Flow to Flow Breakpoint Value
Constant Flow Line for Trip	$W_{BSP-TRIP}$	49 (% RDF)	ABSP APRM Flow Biased Trip Setpoint Drive Flow Intercept. Constant Flow Line for Trip (see Note 1 below)
Flow Breakpoint	$W_{BSP-BREAK}$	30.0 (% RDF)	Flow Breakpoint Value

Note 1:  $W_{BSP-TRIP}$  can be set to 49.0 % RDF or any higher value up to the intersection of the ABSP sloped line with the APRM Flow Biased STP scram line.



Table 5.2 Analyzed MBSP Endpoints: Nominal Feedwater Temperature

Endpoint	Power (% Rated)	Core Flow (% Rated)	Definition
A1	75.9	52.7	Scram Region (Region I) Boundary Intercept on MELLLA+ Line
B1	35.5	29	Scram Region (Region I) Boundary Intercept on Natural Circulation Line (NCL)
A2	66.1	52	Controlled Entry Region (Region II) Boundary Intercept on MELLLA Line
B2	25.5	29	Controlled Entry Region (Region II) Boundary Intercept on Natural Circulation Line (NCL)

Table 5.3 Analyzed MBSP Endpoints: Reduced Feedwater Temperature

Endpoint	Power (% Rated)	Core Flow (% Rated)	Definition
A1	64.9	50.5	Scram Region (Region I) Boundary Intercept on MELLLA Line
B1	29.4	29	Scram Region (Region I) Boundary Intercept on Natural Circulation Line (NCL)
A2	68.3	54.9	Controlled Entry Region (Region II) Boundary Intercept on MELLLA Line
B2	24.5	29	Controlled Entry Region (Region II) Boundary Intercept on Natural Circulation Line (NCL)



## 6 APRM Flow Biased Rod Block Trip Settings

(Technical Requirements Manual Section 5.3.1 and Table 3.3.4-1)

The APRM rod block trip setting is based upon References 27 & 29, and is defined by the following:

for two loop operation:

$$\begin{aligned} \text{SRB} &\leq (0.61W_d + 63.3) && \text{Allowable Value} \\ \text{SRB} &\leq (0.61W_d + 62.0) && \text{Nominal Trip Setpoint (NTSP)} \end{aligned}$$

where:

$$\begin{aligned} \text{SRB} &= \text{Rod Block setting in percent of rated thermal power (3952 MW}_t\text{)} \\ W_d &= \text{Recirculation drive flow rate in percent of rated} \\ &\quad \text{(100\% drive flow required to achieve 100\% core power and flow)} \end{aligned}$$

and for single loop operation:

$$\begin{aligned} \text{SRB} &\leq (0.55(W_d - \Delta W) + 60.5) && \text{Allowable Value} \\ \text{SRB} &\leq (0.55(W_d - \Delta W) + 58.5) && \text{Nominal Trip Setpoint (NTSP)} \end{aligned}$$

where:

$$\begin{aligned} \text{SRB} &= \text{Rod Block setting in percent of rated thermal power (3952 MW}_t\text{)} \\ W_d &= \text{Recirculation drive flow rate in percent of rated} \\ &\quad \text{(100\% drive flow required to achieve 100\% core power and flow)} \\ \Delta W &= \text{Difference between two-loop and single-loop effective recirculation flow} \\ &\quad \text{at the same core flow } (\Delta W = 0.0 \text{ for two-loop operation)} \end{aligned}$$

The APRM rod block trip setting is clamped at a maximum allowable value of 115% (corresponding to a NTSP of 113%).



## 7 Rod Block Monitor (RBM) Trip Setpoints and Operability

### (Technical Specification Table 3.3.2.1-1)

The RBM trip setpoints and applicable power ranges, based on References 27 & 28, are shown in Table 7.1. Setpoints are based on an HTSP, unfiltered analytical limit of 114%. Unfiltered setpoints are consistent with a nominal RBM filter setting of 0.0 seconds; filtered setpoints are consistent with a nominal RBM filter setting less than 0.5 seconds. Cycle specific CRWE analyses of OLMCPR are documented in Reference 1, superseding values reported in References 27, 28, and 29.

Table 7.1 Analytical RBM Trip Setpoints \*

RBM Trip Setpoint	Allowable Value (AV)	Nominal Trip Setpoint (NTSP)
LPSP	27%	25%
IPSP	62%	60%
HPSP	82%	80%
LTSP - unfiltered	121.7%	120.0%
- filtered	120.7%	119.0%
ITSP - unfiltered	116.7%	115.0%
- filtered	115.7%	114.0%
HTSP - unfiltered	111.7%	110.0%
- filtered	110.9%	109.2%
DTSP	90%	92%

As a result of cycle specific CRWE analyses, RBM setpoints in Technical Specification Table 3.3.2.1-1 are applicable as shown in Table 7.2. Cycle specific setpoint analysis results are shown in Table 7.3, per Reference 1.

Table 7.2 RBM Setpoint Applicability

Thermal Power (% Rated)	Applicable MCPR <sup>†</sup>	Notes from Table 3.3.2.1-1	Comment
> 27% and < 90%	< 1.71	(a), (b), (f), (h)	two loop operation
	< 1.75	(a), (b), (f), (h)	single loop operation
≥ 90%	< 1.40	(g)	two loop operation <sup>‡</sup>

\* Values are considered maximums. Using lower values, due to RBM system hardware/software limitations, is conservative, and acceptable.

<sup>†</sup> MCPR values shown correspond with, (support), SLMPCR values identified in Reference 1.

<sup>‡</sup> Greater than 90% rated power is not attainable in single loop operation.





Table 7.3 Control Rod Withdrawal Error Results

<b>RBM HTSP Analytical Limit</b>	<b>CRWE OLMCPR</b>
<b>Unfiltered</b>	
107	1.26
111	1.29
114	1.33
117	1.37

Results, compared against the base case OLMCPR results of Table 4.2, indicate SLMCPR remains protected for RBM inoperable conditions (i.e., 114% unblocked).



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## 8 Shutdown Margin Limit

### (Technical Specification 3.1.1)

Assuming the strongest OPERABLE control blade is fully withdrawn, and all other OPERABLE control blades are fully inserted, the core shall be sub-critical and meet the following minimum shutdown margin:

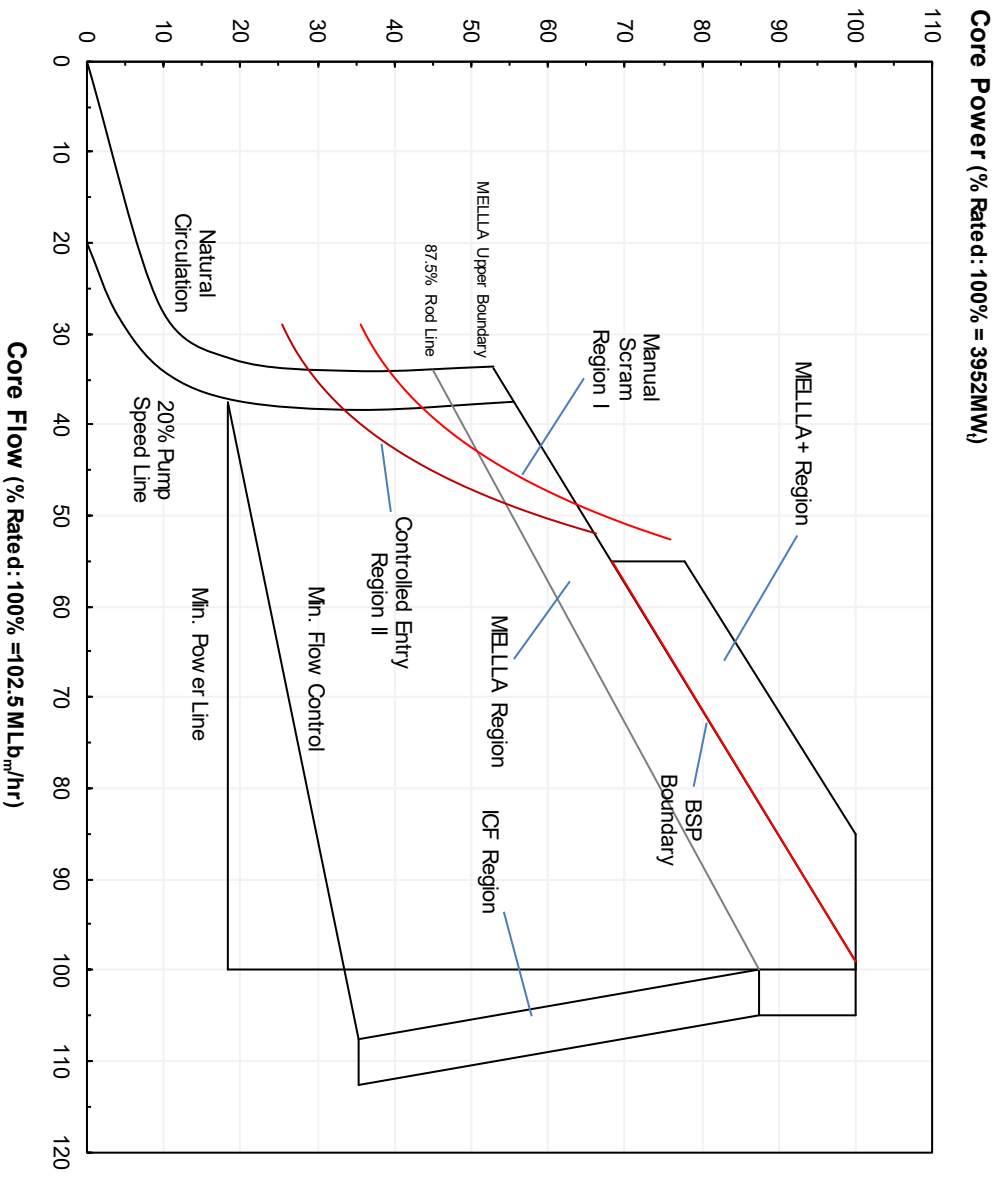
$$\text{SDM} > 0.38\% \text{ dk/k}$$

**Note:** The basis for the SDM value is tied to manufacturing tolerance and uncertainty stack-up. This tie only has the potential to change with new fuel type introduction. Since no new fuel type is being introduced, the value is good for all Mode 3, 4, and 5 operation prior to initial cycle startup, during cycle operation, and after final cycle shutdown.



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## Appendix A: MBSP Maps



**Figure A.1 MBSP Boundaries For Nominal Feedwater Temperature**  
*(Operation in the MELLA+ Region Prohibited for Feedwater Temperature greater than 10 degrees F below the Nominal Feedwater Temperature)*



Core Power (% Rated: 100% = 3952MW<sub>t</sub>)

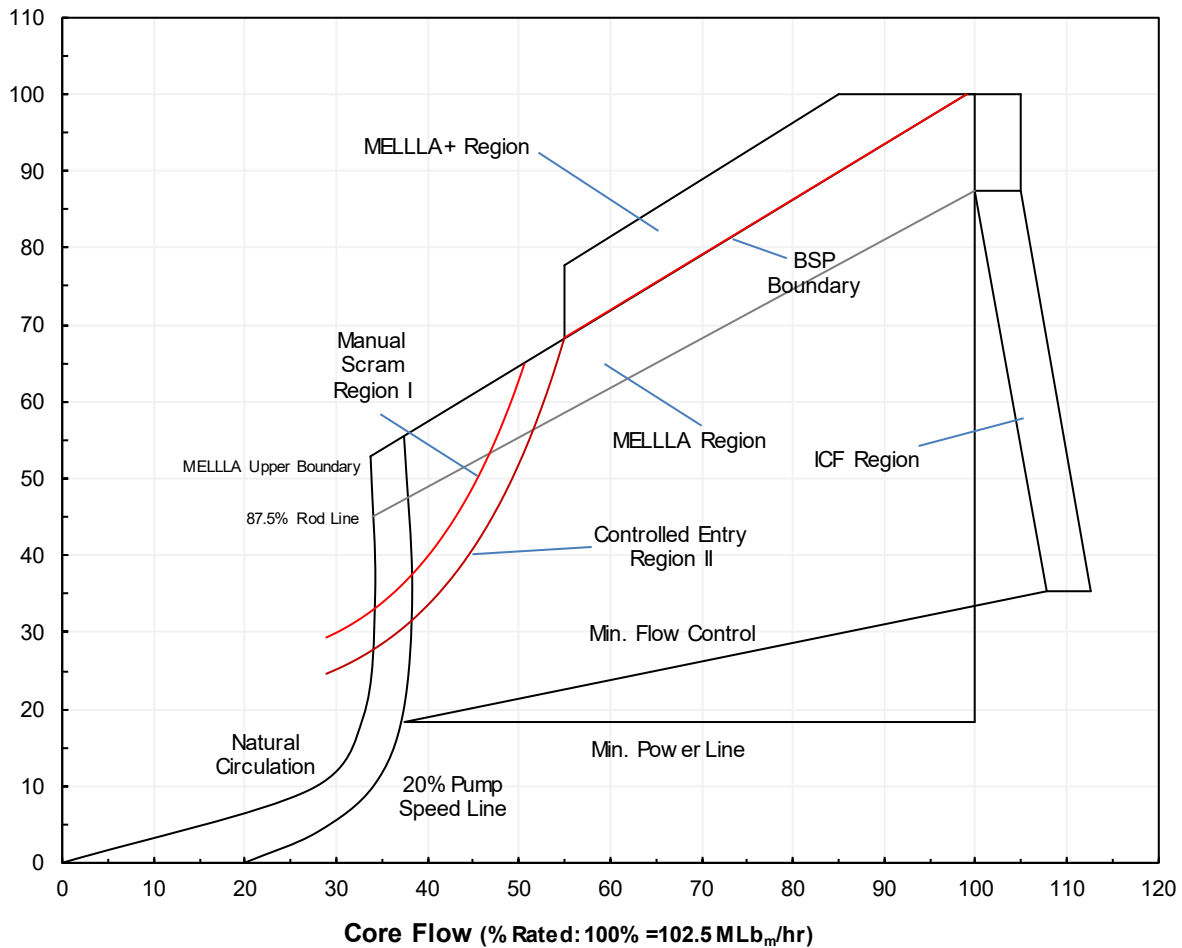


Figure A.2 MBSP Boundaries For Reduced Feedwater Temperature

*(Operation in the MELLLA+ Region Prohibited for a Reduced Feedwater Temperature greater than 10 degrees F below the Nominal Feedwater Temperature)*