TENNESSEE VALLEY AUTHORITY

Post Office Box 2000, Decatur, Alabama 35609-2000

February 4, 2022

10 CFR 50.4

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

Browns Ferry Nuclear Plant, Units 1, 2, and 3
Renewed Facility Operating License Nos. DPR-33, DPR-52, and DPR-68
NRC Docket Nos. 50-259, 50-260, and 50-296

Subject: **Browns Ferry Nuclear Plant, Core Operating Limits Report for Unit 1 Cycle 14 Operation, Revision 1; Unit 2 Cycle 22 Operation, Revision 1; and Unit 3 Cycle 20 Operation, Revision 2.**

References:
1. Browns Ferry Nuclear Plant, Unit 1 Core Operating Limits Report for Cycle 14 Operation, Revision 0
2. Browns Ferry Nuclear Plant, Unit 2 Core Operating Limits Report for Cycle 22 Operation, Revision 0
3. Browns Ferry Nuclear Plant, Unit 3 Core Operating Limits Report for Cycle 20 Operation, Revision 0
4. Browns Ferry Nuclear Plant, Unit 3 Core Operating Limits Report for Cycle 20 Operation, Revision 1

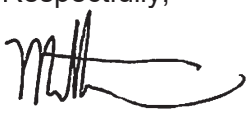
In accordance with the requirements of Technical Specification (TS) 5.6.5.d, the Tennessee Valley Authority (TVA) is submitting an update to the Browns Ferry Nuclear Plant (BFN), Unit 1, Cycle 14 Core Operating Limits Report (COLR). Revision 0 (Reference 1) of the Unit 1 COLR included all Modes of operation (Modes 1 through 5). Revision 1 corrects the footnote in Table 4.9 to state that the limits are valid up to the Extended Power Uprate (EPU) Single Loop Operation (SLO) limit of 43.75% as stated in the footnote of COLR Section 4.2.5 and in the Reload Analyses (RAs) for all three units.

Additionally, TVA is submitting an update to the BFN, Unit 2, Cycle 22 COLR. Revision 0 (Reference 2) of the Unit 2 COLR included all Modes of operation (Modes 1 through 5). Revision 1 corrects the footnote in Table 4.9 to state that the limits are valid up to the EPU SLO limit of 43.75% as stated in the footnote of COLR Section 4.2.5 and in the RAs for all three units.

Finally, TVA is submitting an update to the BFN, Unit 3, Cycle 20 COLR. Revision 0 (Reference 3) of the Unit 3 COLR included all Modes of operation (Modes 1 through 5). Revision 1 (Reference 4) corrected values given for the Nominal Scram Time Basis and corrected a typographical error. Revision 2 corrects the footnote in Table 4.9 to state that the limits are valid up to the EPU SLO limit of 43.75% as stated in the footnote of COLR Section 4.2.5 and in the RAs for all three units.

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

Respectfully,



Matthew Rasmussen
Site Vice President

Enclosures:
1. Core Operating Limits Report, (120% OLTP, MELLLA+), for Unit 1 Cycle 14 Operation, TVA-COLR-BF1C14, Revision 1
2. Core Operating Limits Report, (120% OLTP, MELLLA+), for Unit 2 Cycle 22 Operation, TVA-COLR-BF2C22, Revision 1
3. Core Operating Limits Report, (120% OLTP, MELLLA+), for Unit 3 Cycle 20 Operation, TVA-COLR-BF3C20, Revision 2

cc: (w/ Enclosures)

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 Unit 1 Cycle 14 Operation, TVA-COLR-BF1C14, Revision 1

(See Attached)

ECM L32 210902 800
QA Record
BFE-4537, Revision 1

Reactor Engineering and Fuels - BWRFE
1101 Market Street, Chattanooga, TN 37402

Browns Ferry Unit 1 Cycle 14

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

TVA-COLR-BF1C14 Revision 1 (Final)
(Revision Log, Page v)

September 2021

Prepared: Mitchell, Brye C. Digitally signed by Mitchell, Brye C. Date: 2021.11.18 11:32:10 -05'00' Date: _____
B. C. Mitchell, Engineer

Verified: _____ Date: 11/18/2021
T. W. Eichenberg, Engineer

Approved: _____ Digitally signed by Seifert, Christine A DN: dc=gov, dc=tva, dc=main, ou=Main, ou=Corporate, ou=Users, cn=Seifert, Christine A, email=caseifert@tva.gov Reason: I am approving this document Date: 2021.11.19 05:13:38 -05'00' Date: _____
C. A. Setter, Manager, BWRFE

Reviewed: _____ Date: 11/19/2021
B. T. Williamson, Manager, Reactor Engineering

Approved: _____ Date: 12/17/21
Chairman, PORC

Approved: _____ Date: 12-21-21
Plant Manager

Table of Contents

Total Number of Pages = 44 (*including review cover sheet*)

List of Tables

List of Figures

Revision Log

Number	Page	Description
1-R1	26	Updated Table 4.9 footnote per CR 1718921
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
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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Methodology References

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7. XN-NF-85-67(P)(A) Revision 1, **Generic Mechanical Design for Exxon Nuclear Jet Pump BWR Reload Fuel**, Exxon Nuclear Company, September 1986.

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Setpoint References

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Reactor Engineering and Fuels - BWRFE
1101 Market Street, Chattanooga TN 37402

Date: September 8, 2021

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, ≥ 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, ≥ 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, ≥ 23% RTP (Technical Specifications definition of RTP)
- Thermal-Hydraulic Stability Protection
  (Technical Specification Table 3.3.1.1)
  Applicability: Mode 1, ≥ (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, ≥ (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, ≥ % 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 fresh, and previously 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 10XM XMLC-4102B-11GV70-FAC-B	12	35	26	FAC701-FAC740
ATRIUM 10XM XMLC-3969B-13GV80-FAC-C	12	33	27	FAC754-FAC868
ATRIUM 10XM XMLC-3948B-13GV70-FAC-B	12	48	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
ATRIUM 10XM XMLC-3943B-15GV80-FAE	14	96	33	FAE333-FAE428
ATRIUM 10XM XMLC-3944B-14GV80-FAE	14	140	34	FAE429-FAE568
ATRIUM 10XM XMLC-4001B-12GV80-FAE	14	80	35	FAE569-FAE648

1.4 Acceptability

Limits discussed in this document were generated based on NRC approved methodologies per References 6 through 26.

* 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:

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

where:

APLHGR_P	off-rated power APLHGR limit	$[\text{APLHGR}_{RATED} * \text{MAPFAC}_P]$
APLHGR_F	off-rated flow APLHGR limit	$[\text{APLHGR}_{RATED} * \text{MAPFAC}_F]$
APLHGR_{SLO}	SLO APLHGR limit	$[\text{APLHGR}_{RATED} * \text{SLO Multiplier}]$

2.1 Rated Power and Flow Limit: APLHGR_{RATED}

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

2.2 Off-Rated Power Dependent Limit: APLHGR_P

Reference 1 does not specify a power dependent APLHGR. Therefore, MAPFAC_P is set to a value of **1.0**.

2.2.1 Startup without Feedwater Heaters

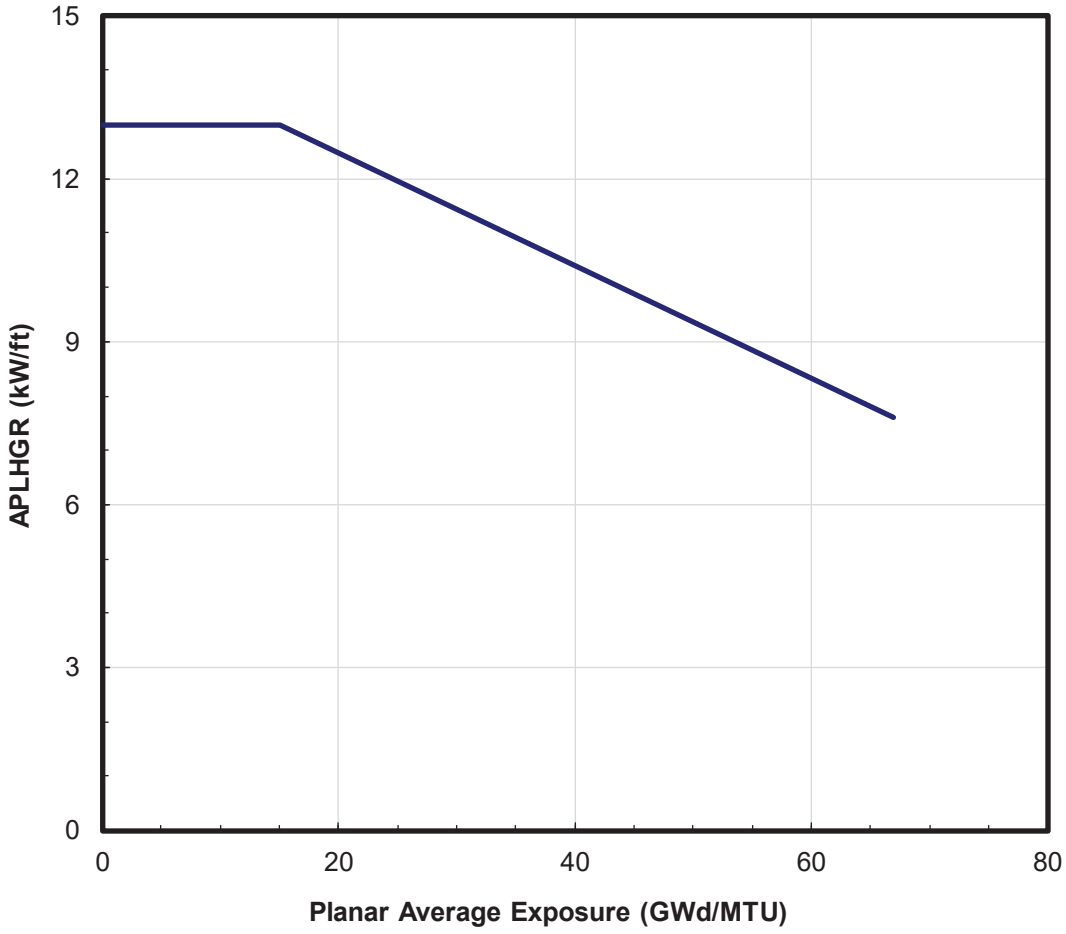
There is a range of operation during startup when the feedwater heaters are not placed into service until after the unit has reached a significant operating power level. No additional power dependent limitation is required.

2.3 Off-Rated Flow Dependent Limit: APLHGR_F

Reference 1 does not specify a flow dependent APLHGR. Therefore, MAPFAC_F is set to a value of **1.0**.

2.4 Single Loop Operation Limit: APLHGR_{SLO}

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



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

Figure 2.1 $APLHGR_{RATED}$ for ATRIUM-10XM Fuel

2.5 Equipment Out-Of-Service Corrections

The limits shown in Figure 2.1 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

* 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:

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

3.1 Rated Power and Flow Limit: LHGR_{RATED}

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

3.2 Off-Rated Power Dependent Limit: LHGR_P

LHGR limits are adjusted for off-rated power conditions using the 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 3.2.

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 3.4 and Figure 3.5, based on temperature conditions identified in Table 3.1.

Table 3.1 Startup Feedwater Temperature Basis

Power	Temperature	
	Range 1	Range 2
(% Rated)	(°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: $LHGR_F$

LHGR limits are adjusted for off-rated flow conditions using the $LHGRFAC_F$ multiplier provided in Reference 1. Multipliers are shown in Figure 3.3.

3.4 Equipment Out-Of-Service Corrections

The limits shown in Figure 3.1 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.*

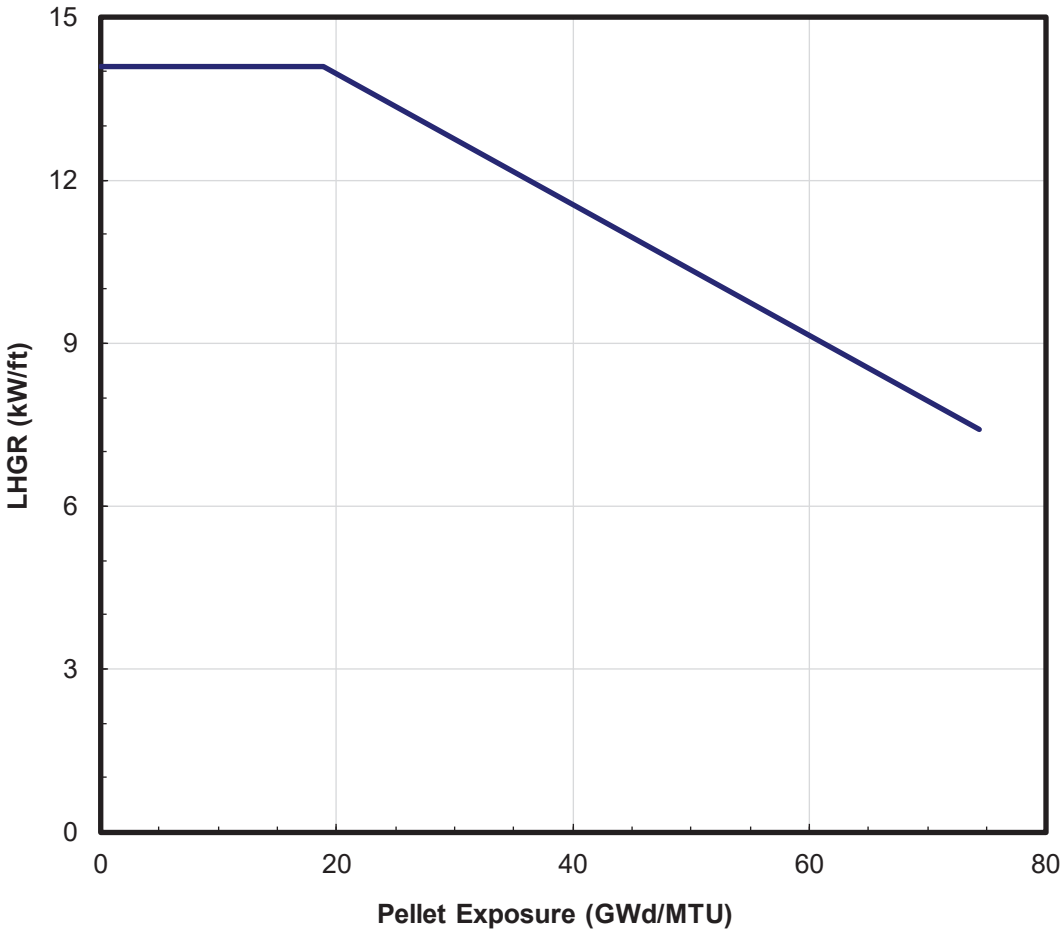
In-Service	All equipment In-Service
RPTOOS	EOC-Recirculation Pump Trip Out-Of-Service
TBVOOS	Turbine Bypass Valve(s) Out-Of-Service
PLUOOS	Power Load Unbalance Out-Of-Service
FHOOS (or FFWTR)	Feedwater Heaters Out-Of-Service or Final Feedwater Temperature Reduction
RCPOOS	One Recirculation Pump Out-Of-Service

Off-rated power corrections shown in Figure 3.2 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 3.3 are bounding for all EOOS conditions.

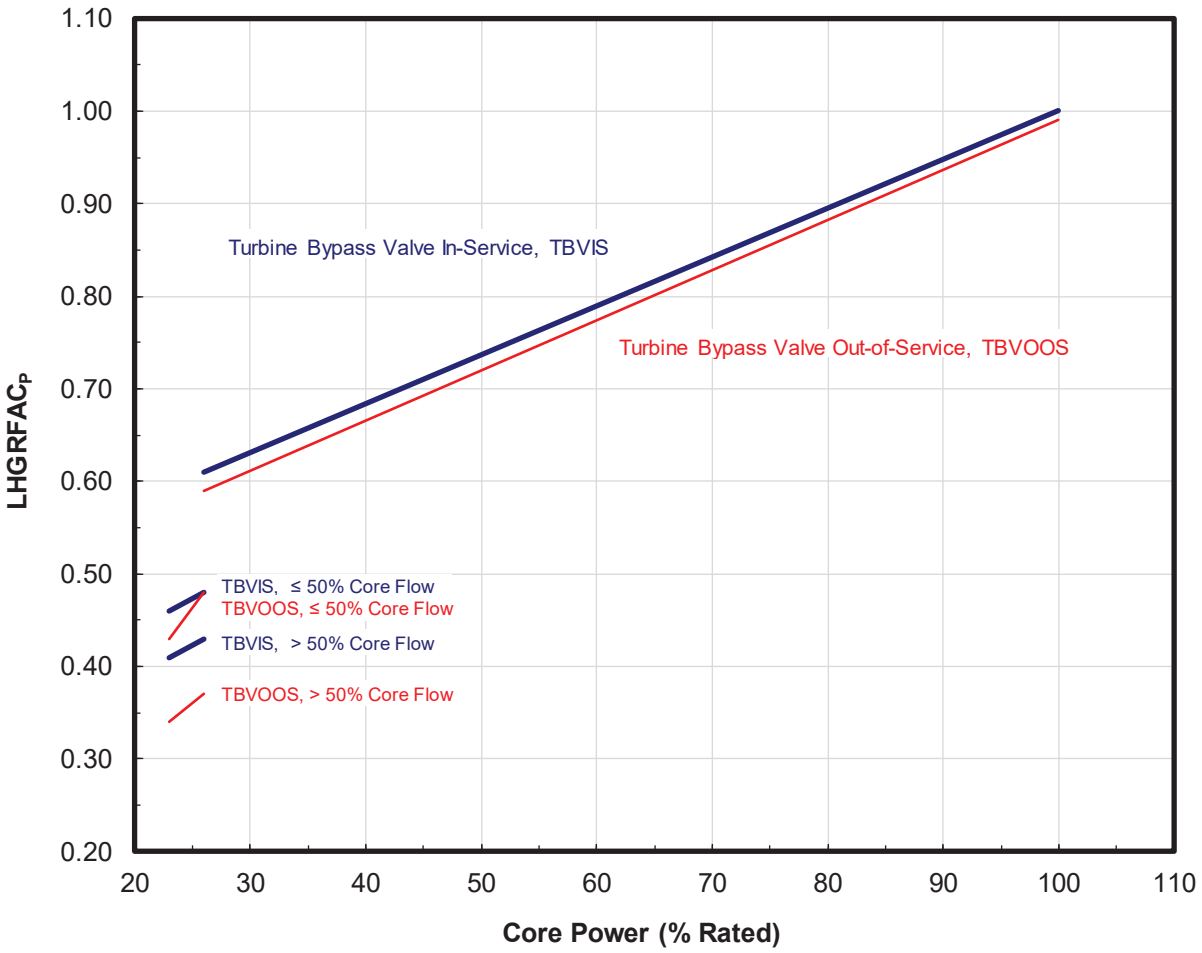
Off-rated power corrections shown in Figure 3.4 and Figure 3.5 are also dependent on operation of the Turbine Bypass Valve system. In this case, limits support FHOOS operation during startup. These limits have no dependency on RPTOOS, PLUOOS, or SLO.

* All equipment service conditions assume 1 SRVOOS.



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

Figure 3.1 $LHGR_{RATED}$ for ATRIUM-10XM Fuel

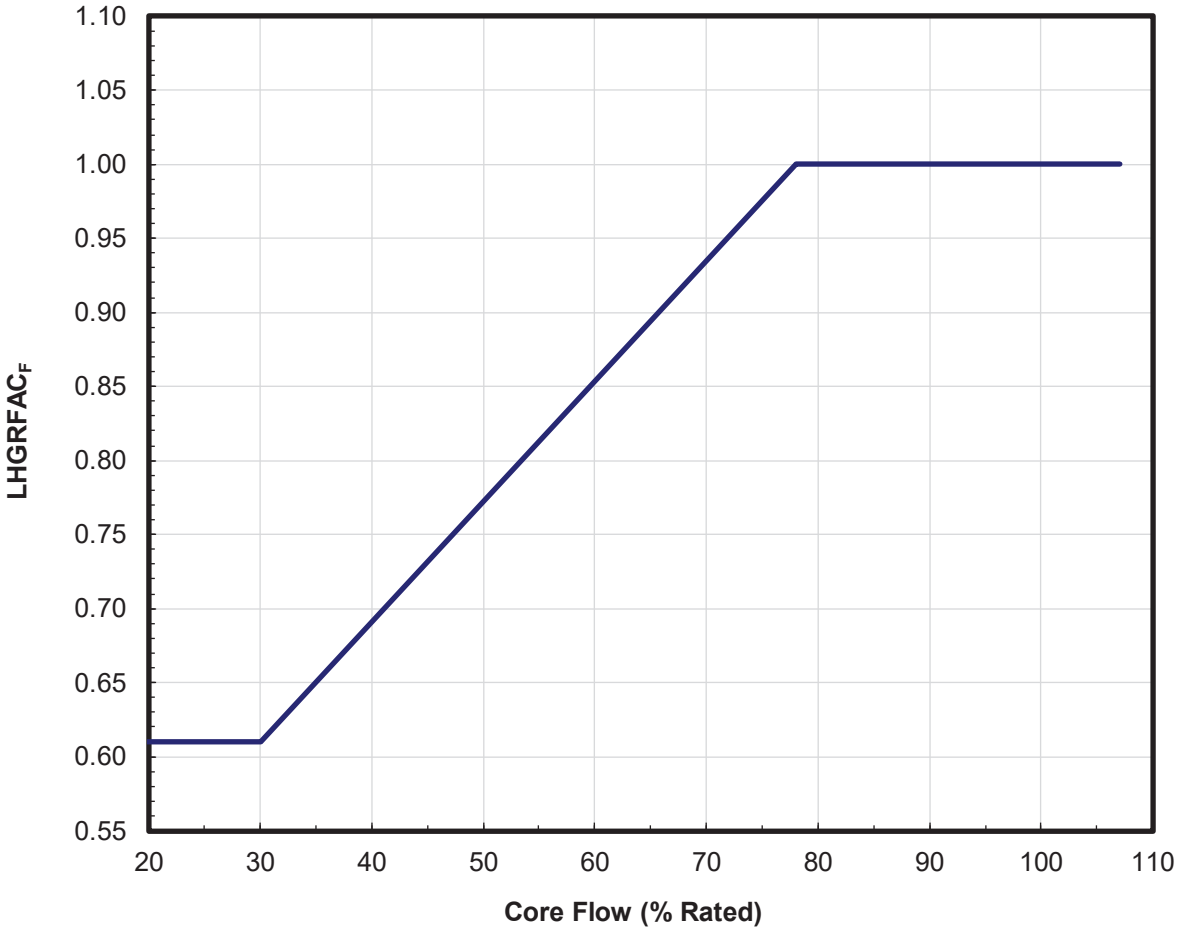


Turbine Bypass In-Service	
Core Power (% Rated)	**LHGRFAC$_P$**
100.0	1.00
26.0	0.61
Core Flow > 50% Rated	
26.0	0.43
23.0	0.41
Core Flow ≤ 50% Rated	
26.0	0.48
23.0	0.46

Turbine Bypass Out-of-Service	
Core Power (% Rated)	**LHGRFAC$_P$**
100.0	0.99
26.0	0.59
Core Flow > 50% Rated	
26.0	0.37
23.0	0.34
Core Flow ≤ 50% Rated	
26.0	0.48
23.0	0.43

Figure 3.2 Base Operation LHGRFAC$_P$ for ATRIUM-10XM Fuel

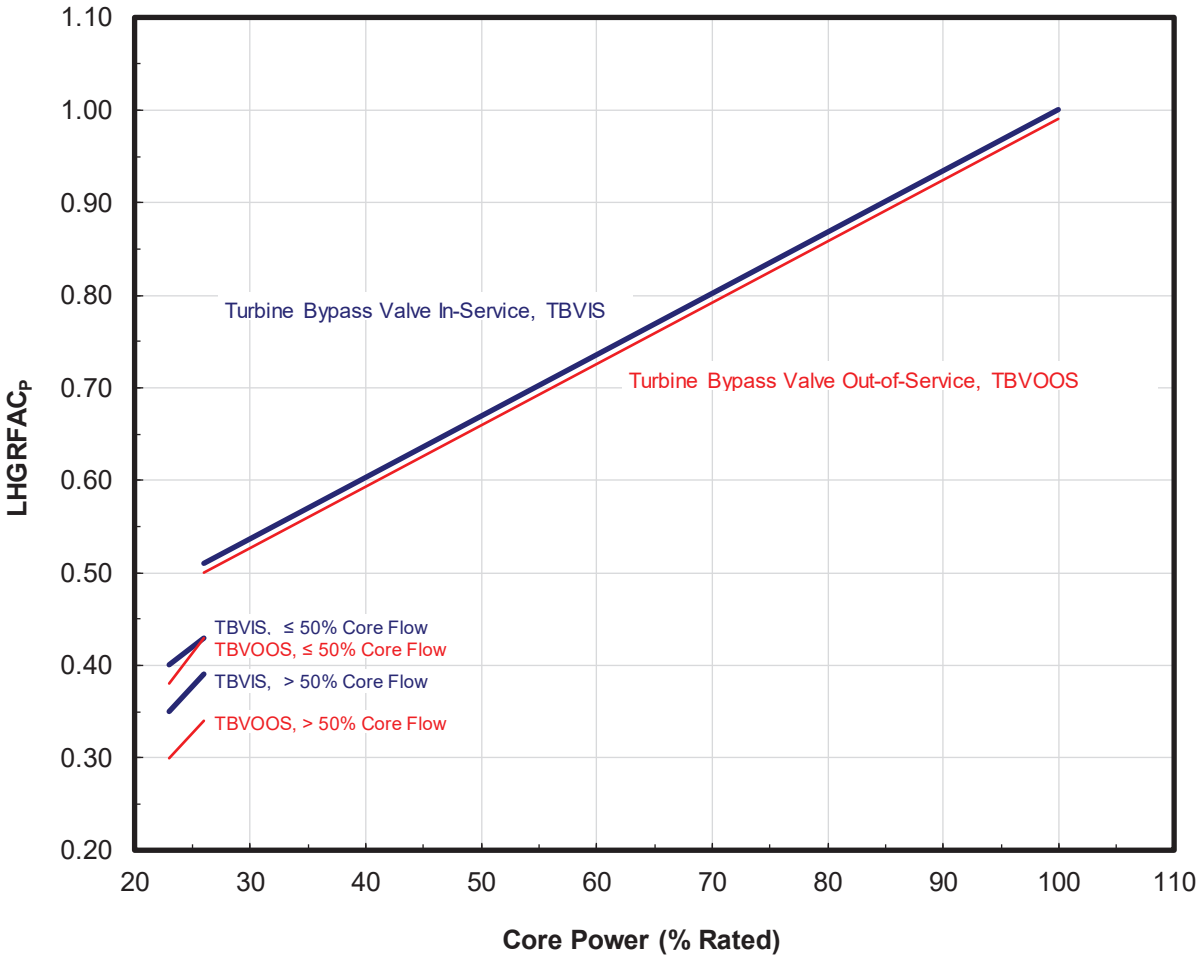
(*Independent of other EOOS conditions*)



Core Flow (% Rated)	LHGRFAC$_F$
0.0	0.61
30.0	0.61
78.1	1.00
107.0	1.00

Figure 3.3 LHGRFAC$_F$ for ATRIUM-10XM Fuel
(*Values bound all EOOS conditions*)

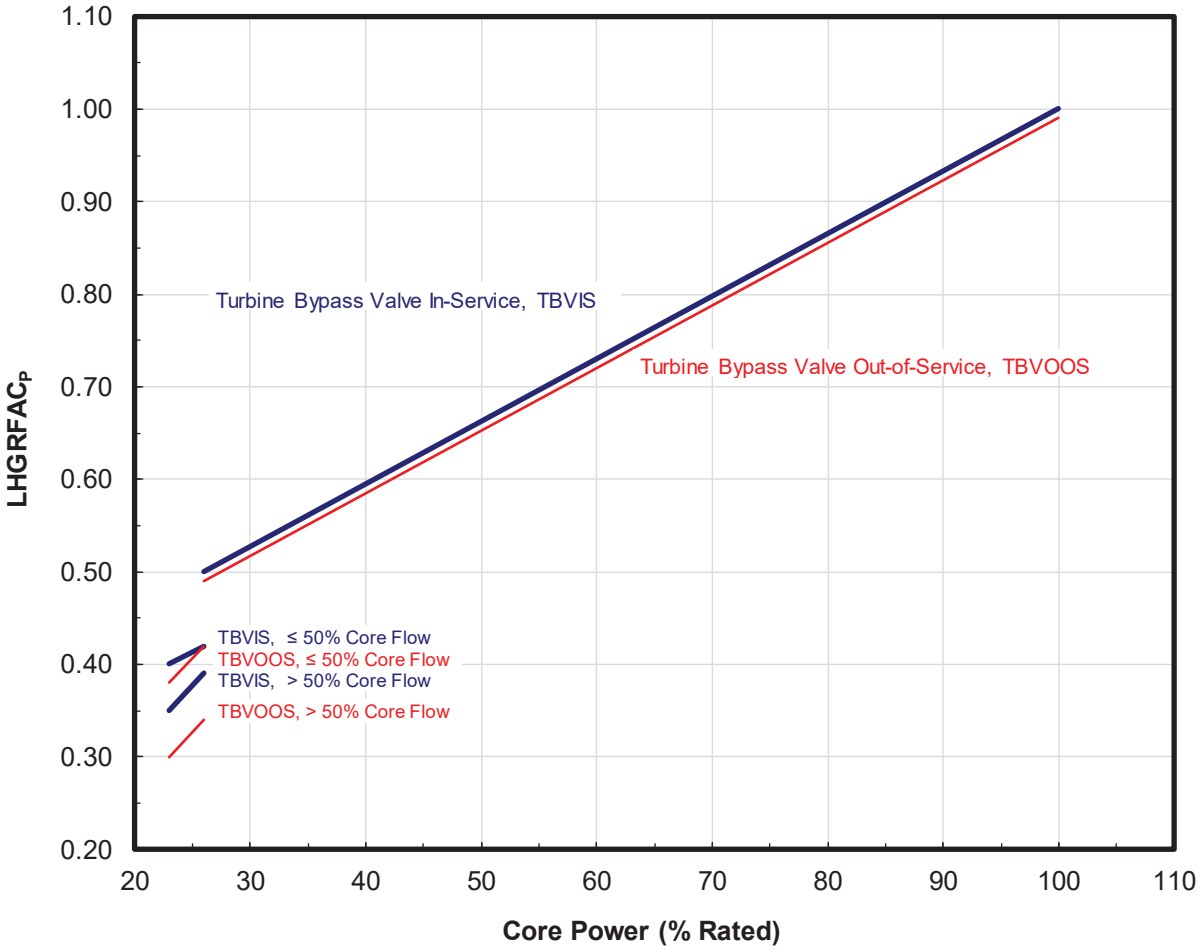
(*107.0% maximum core flow line is used to support 105% rated flow operation, ICF*)



Turbine Bypass In-Service	
Core Power (% Rated)	**LHGRFAC$_P$**
100.0	1.00
26.0	0.51
Core Flow > 50% Rated	
26.0	0.39
23.0	0.35
Core Flow ≤ 50% Rated	
26.0	0.43
23.0	0.40

Turbine Bypass Out-of-Service	
Core Power (% Rated)	**LHGRFAC$_P$**
100.0	0.99
26.0	0.50
Core Flow > 50% Rated	
26.0	0.34
23.0	0.30
Core Flow ≤ 50% Rated	
26.0	0.43
23.0	0.38

Figure 3.4 Startup Operation LHGRFAC$_P$ 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 (% Rated)	**$LHGRFAC_P$**
100.0	1.00
26.0	0.50
Core Flow > 50% Rated	
26.0	0.39
23.0	0.35
Core Flow ≤ 50% Rated	
26.0	0.42
23.0	0.40

Turbine Bypass Out-of-Service	
Core Power (% Rated)	**$LHGRFAC_P$**
100.0	0.99
26.0	0.49
Core Flow > 50% Rated	
26.0	0.34
23.0	0.30
Core Flow ≤ 50% Rated	
26.0	0.42
23.0	0.38

Figure 3.5 Startup Operation $LHGRFAC_P$ 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

$$\text{OLMCPR limit} = \text{MAX} (MCPR_F , MCPR_P)$$

where:

$MCPR_F$	core flow-dependent MCPR limit
$MCPR_P$	power-dependent MCPR limit

4.1 Flow Dependent MCPR Limit: $MCPR_F$

$MCPR_F$ limits are dependent upon core flow (% of Rated), and the max core flow limit, (Rated or Increased Core Flow, ICF). $MCPR_F$ 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: $MCPR_P$

$MCPR_P$ 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 $MCPR_P$ 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 $MCPR_P$ 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)*

$MCPR_P$ limits are provided for three different sets of assumed scram speeds. The Technical Specification Scram Speed (TSSS) $MCPR_P$ 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	0.420	0.380
36	0.980	0.875
26	1.600	1.465
6	2.900	2.900

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 $MCPR_P$ 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 $MCPR_P$ limits are always more limiting and may be used for any Core Average Exposure up to the ending exposure. Per Reference 1, $MCPR_P$ limits are provided for the following exposure ranges:

BOC to NEOC	NEOC corresponds to	**30,758.8 MWd / MTU**
BOC to EOCLB	EOCLB corresponds to	**34,078.5 MWd / MTU**
BOC to End of Coast	End of Coast	**35,767.8 MWd / MTU**

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 $MCPR_P$ 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 $MCPR_P$ limits are also provided including FHOOS. The coast down exposure range assumes application of FFWTR. FHOOS based $MCPR_P$ 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

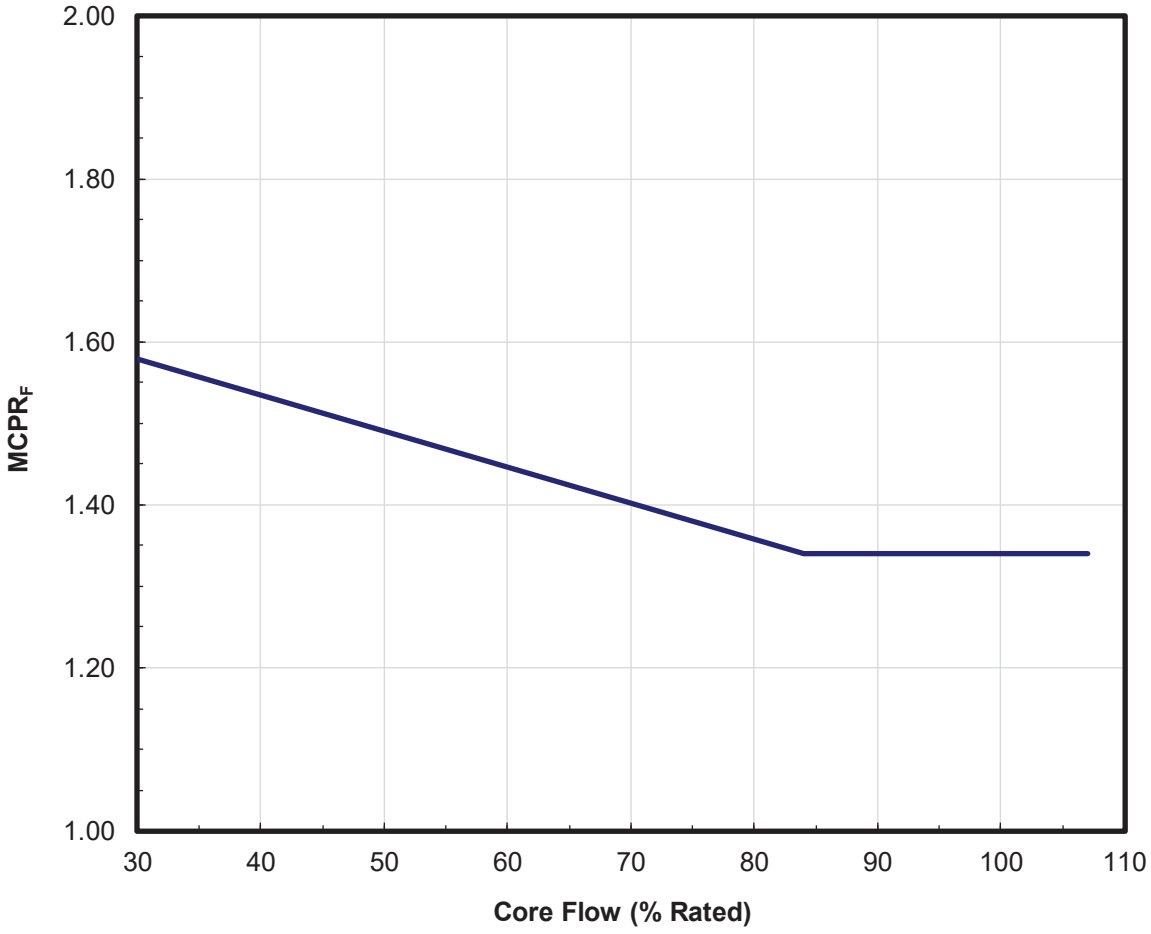
When operating in RCPOOS conditions, MCPRp limits are constructed differently from the normal operating RCP conditions. The limiting event for RCPOOS is a pump seizure scenario, which sets the upper bound for allowed core power and flow†. This event is not impacted by scram time assumptions. Specific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

4.2.6 Below Pbypass Limits

Below Pbypass (26% rated power), $MCPR_P$ limits depend upon core flow. One set of $MCPR_P$ 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_m/hr.



Core Flow (% Rated)	MCPR$_F$
30.0	1.58
84.0	1.34
107.0	1.34

Figure 4.1 MCPR$_F$ 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 $MCPR_P$ Limits for All Fuel Types: Optimum Scram Time Basis*

Operating Condition	Power (% of rated)	ATRIUM-10XM		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast
Base Case	100	1.40	1.41	1.42
	90	1.44	1.44	1.47
	77.6	1.49	1.50	1.52
	65	1.55	1.55	1.59
	>50	1.65	1.65	1.72
	≤50	1.81	1.81	1.81
	40	1.89	1.89	1.92
	26	2.36	2.36	2.49
	26 at > 50%F	2.66	2.66	2.78
	23 at > 50%F	2.84	2.84	2.97
	26 at ≤ 50%F	2.53	2.53	2.64
	23 at ≤ 50%F	2.70	2.70	2.83
FHOOS	100	1.42	1.42	---
	90	1.46	1.47	---
	77.6	1.52	1.52	---
	65	1.58	1.59	---
	>50	1.72	1.72	---
	≤50	1.81	1.81	---
	40	1.92	1.92	---
	26	2.49	2.49	---
	26 at > 50%F	2.78	2.78	---
	23 at > 50%F	2.97	2.97	---
	26 at ≤ 50%F	2.64	2.64	---
	23 at ≤ 50%F	2.83	2.83	---

* 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 $MCPR_P$ Limits for All Fuel Types: Nominal Scram Time Basis*

Operating Condition	Power (% of rated)	ATRIUM-10XM BOC to NEOC	ATRIUM-10XM BOC to EOCLB	ATRIUM-10XM BOC to End of Coast
Base Case	100	1.41	1.42	1.44
	90	1.45	1.45	1.48
	77.6	1.50	1.50	1.53
	65	1.56	1.56	1.61
	>50	1.68	1.68	1.74
	≤50	1.81	1.81	1.81
	40	1.89	1.89	1.95
	26	2.39	2.39	2.52
	26 at > 50%F	2.66	2.66	2.78
	23 at > 50%F	2.84	2.84	2.97
	26 at ≤ 50%F	2.53	2.53	2.64
	23 at ≤ 50%F	2.70	2.70	2.83
TBVOOS	100	1.45	1.46	1.48
	90	1.48	1.49	1.52
	77.6	1.53	1.54	1.57
	65	1.59	1.60	1.64
	>50	1.68	1.68	1.76
	≤50	1.81	1.81	1.82
	40	1.89	1.89	1.96
	26	2.39	2.39	2.53
	26 at > 50%F	3.21	3.21	3.33
	23 at > 50%F	3.46	3.46	3.62
	26 at ≤ 50%F	2.88	2.88	3.04
	23 at ≤ 50%F	3.18	3.18	3.35
FHOOS	100	1.43	1.44	---
	90	1.47	1.48	---
	77.6	1.52	1.53	---
	65	1.61	1.61	---
	>50	1.74	1.74	---
	≤50	1.81	1.81	---
	40	1.95	1.95	---
	26	2.52	2.52	---
	26 at > 50%F	2.78	2.78	---
	23 at > 50%F	2.97	2.97	---
	26 at ≤ 50%F	2.64	2.64	---
	23 at ≤ 50%F	2.83	2.83	---
PLUOOS	100	1.41	1.42	1.44
	90	1.45	1.45	1.48
	77.6	1.50	1.50	1.53
	65	1.74	1.74	1.74
	>50	---	---	---
	≤50	1.82	1.82	1.82
	40	1.89	1.89	1.95
	26	2.39	2.39	2.52
	26 at > 50%F	2.66	2.66	2.78
	23 at > 50%F	2.84	2.84	2.97
	26 at ≤ 50%F	2.53	2.53	2.64
	23 at ≤ 50%F	2.70	2.70	2.83

* 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 $MCPR_P$ Limits for All Fuel Types: Nominal Scram Time Basis (*continued*)*

Operating Condition	Power (% of rated)	ATRIUM-10XM BOC to NEOC	ATRIUM-10XM BOC to EOCLB	ATRIUM-10XM BOC to End of Coast
TBVOOS FHOOS	100	1.47	1.48	---
	90	1.51	1.52	---
	77.6	1.57	1.57	---
	65	1.64	1.64	---
	>50	1.76	1.76	---
	≤50	1.82	1.82	---
	40	1.96	1.96	---
	26	2.53	2.53	---
	26 at > 50%F	3.33	3.33	---
	23 at > 50%F	3.62	3.62	---
	26 at ≤ 50%F	3.04	3.04	---
	23 at ≤ 50%F	3.35	3.35	---
TBVOOS PLUOOS	100	1.45	1.46	1.48
	90	1.48	1.49	1.52
	77.6	1.53	1.54	1.57
	65	1.74	1.74	1.75
	>50	---	---	---
	≤50	1.82	1.82	1.82
	40	1.89	1.89	1.96
	26	2.39	2.39	2.53
	26 at > 50%F	3.21	3.21	3.33
	23 at > 50%F	3.46	3.46	3.62
	26 at ≤ 50%F	2.88	2.88	3.04
	23 at ≤ 50%F	3.18	3.18	3.35
FHOOS PLUOOS	100	1.43	1.44	---
	90	1.47	1.48	---
	77.6	1.52	1.53	---
	65	1.74	1.74	---
	>50	---	---	---
	≤50	1.82	1.82	---
	40	1.95	1.95	---
	26	2.52	2.52	---
	26 at > 50%F	2.78	2.78	---
	23 at > 50%F	2.97	2.97	---
	26 at ≤ 50%F	2.64	2.64	---
	23 at ≤ 50%F	2.83	2.83	---
TBVOOS FHOOS PLUOOS	100	1.47	1.48	---
	90	1.51	1.52	---
	77.6	1.57	1.57	---
	65	1.75	1.75	---
	>50	---	---	---
	≤50	1.82	1.82	---
	40	1.96	1.96	---
	26	2.53	2.53	---
	26 at > 50%F	3.33	3.33	---
	23 at > 50%F	3.62	3.62	---
	26 at ≤ 50%F	3.04	3.04	---
	23 at ≤ 50%F	3.35	3.35	---

* 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 $MCPR_P$ Limits for All Fuel Types: Technical Specification Scram Time Basis*

Operating Condition	Power (% of rated)	ATRIUM-10XM		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast
Base Case	100	1.42	1.43	1.46
	90	1.46	1.47	1.50
	77.6	1.51	1.51	1.57
	65	1.59	1.59	1.65
	>50	1.70	1.70	1.78
	≤50	1.82	1.82	1.83
	40	1.90	1.90	1.98
	26	2.41	2.41	2.55
	26 at > 50%F	2.66	2.66	2.79
	23 at > 50%F	2.84	2.84	2.98
	26 at ≤ 50%F	2.53	2.53	2.65
	23 at ≤ 50%F	2.70	2.70	2.84
TBVOOS	100	1.46	1.47	1.50
	90	1.49	1.50	1.54
	77.6	1.54	1.55	1.60
	65	1.61	1.61	1.68
	>50	1.71	1.71	1.80
	≤50	1.82	1.82	1.84
	40	1.90	1.90	2.00
	26	2.41	2.41	2.56
	26 at > 50%F	3.21	3.21	3.34
	23 at > 50%F	3.46	3.46	3.63
	26 at ≤ 50%F	2.88	2.88	3.05
	23 at ≤ 50%F	3.18	3.18	3.36
FHOOS	100	1.46	1.46	---
	90	1.50	1.50	---
	77.6	1.57	1.57	---
	65	1.65	1.65	---
	>50	1.78	1.78	---
	≤50	1.83	1.83	---
	40	1.98	1.98	---
	26	2.55	2.55	---
	26 at > 50%F	2.79	2.79	---
	23 at > 50%F	2.98	2.98	---
	26 at ≤ 50%F	2.65	2.65	---
	23 at ≤ 50%F	2.84	2.84	---
PLUOOS	100	1.42	1.43	1.46
	90	1.46	1.47	1.50
	77.6	1.51	1.51	1.57
	65	1.74	1.74	1.75
	>50	---	---	---
	≤50	1.83	1.83	1.83
	40	1.90	1.90	1.90
	26	2.41	2.41	2.55
	26 at > 50%F	2.66	2.66	2.79
	23 at > 50%F	2.84	2.84	2.98
	26 at ≤ 50%F	2.53	2.53	2.65
	23 at ≤ 50%F	2.70	2.70	2.84

* 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 $MCPR_P$ Limits for All Fuel Types: Technical Specification Scram Time Basis (*continued*)*

Operating Condition	Power (% of rated)	ATRIUM-10XM BOC to NEOC	ATRIUM-10XM BOC to EOCLB	ATRIUM-10XM BOC to End of Coast
TBVOOS FHOOS	100	1.50	1.50	---
	90	1.53	1.54	---
	77.6	1.60	1.60	---
	65	1.68	1.68	---
	>50	1.80	1.80	---
	≤50	1.84	1.84	---
	40	2.00	2.00	---
	26	2.56	2.56	---
	26 at > 50%F	3.34	3.34	---
	23 at > 50%F	3.63	3.63	---
	26 at ≤ 50%F	3.05	3.05	---
	23 at ≤ 50%F	3.36	3.36	---
TBVOOS PLUOOS	100	1.46	1.47	1.50
	90	1.49	1.50	1.54
	77.6	1.54	1.55	1.60
	65	1.74	1.74	1.76
	>50	---	---	---
	≤50	1.83	1.83	1.84
	40	1.90	1.90	2.00
	26	2.41	2.41	2.56
	26 at > 50%F	3.21	3.21	3.34
	23 at > 50%F	3.46	3.46	3.63
	26 at ≤ 50%F	2.88	2.88	3.05
	23 at ≤ 50%F	3.18	3.18	3.36
FHOOS PLUOOS	100	1.46	1.46	---
	90	1.50	1.50	---
	77.6	1.57	1.57	---
	65	1.75	1.75	---
	>50	---	---	---
	≤50	1.83	1.83	---
	40	1.98	1.98	---
	26	2.55	2.55	---
	26 at > 50%F	2.79	2.79	---
	23 at > 50%F	2.98	2.98	---
	26 at ≤ 50%F	2.65	2.65	---
	23 at ≤ 50%F	2.84	2.84	---
TBVOOS FHOOS PLUOOS	100	1.50	1.50	---
	90	1.53	1.54	---
	77.6	1.60	1.60	---
	65	1.76	1.76	---
	>50	---	---	---
	≤50	1.84	1.84	---
	40	2.00	2.00	---
	26	2.56	2.56	---
	26 at > 50%F	3.34	3.34	---
	23 at > 50%F	3.63	3.63	---
	26 at ≤ 50%F	3.05	3.05	---
	23 at ≤ 50%F	3.36	3.36	---

* 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 $MCPR_P$ Limits for Table 3.1 Temperature Range 1 for All Fuel Types: Nominal Scram Time Basis *

Operating Condition	Power (% of rated)	ATRIUM-10XM		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast
TBVIS	100	1.43	1.44	1.44
	90	1.47	1.48	1.48
	77.6	1.52	1.53	1.53
	65	1.74	1.74	1.74
	>50	---	---	---
	≤50	1.89	1.89	1.89
	40	2.14	2.14	2.14
	26	2.82	2.82	2.82
	26 at > 50%F	3.06	3.06	3.06
	23 at > 50%F	3.31	3.31	3.31
	26 at ≤ 50%F	2.91	2.91	2.91
	23 at ≤ 50%F	3.14	3.14	3.14
TBVOOS	100	1.47	1.48	1.48
	90	1.51	1.52	1.52
	77.6	1.57	1.57	1.57
	65	1.75	1.75	1.75
	>50	---	---	---
	≤50	1.90	1.90	1.90
	40	2.15	2.15	2.15
	26	2.83	2.83	2.83
	26 at > 50%F	3.57	3.57	3.57
	23 at > 50%F	3.87	3.87	3.87
	26 at ≤ 50%F	3.27	3.27	3.27
	23 at ≤ 50%F	3.61	3.61	3.61

* 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 $MCPR_P$ Limits for Table 3.1 Temperature Range 2 for All Fuel Types: Nominal Scram Time Basis*

Operating Condition	Power (% of rated)	ATRIUM-10XM		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast
TBVIS	100	1.43	1.44	1.44
	90	1.47	1.48	1.48
	77.6	1.52	1.53	1.53
	65	1.74	1.74	1.74
	>50	---	---	---
	≤50	1.90	1.90	1.90
	40	2.16	2.16	2.16
	26	2.85	2.85	2.85
	26 at > 50%F	3.08	3.08	3.08
	23 at > 50%F	3.32	3.32	3.32
	26 at ≤ 50%F	2.92	2.92	2.92
	23 at ≤ 50%F	3.17	3.17	3.17
TBVOOS	100	1.47	1.48	1.48
	90	1.51	1.52	1.52
	77.6	1.57	1.57	1.57
	65	1.75	1.75	1.75
	>50	---	---	---
	≤50	1.91	1.91	1.91
	40	2.17	2.17	2.17
	26	2.86	2.86	2.86
	26 at > 50%F	3.58	3.58	3.58
	23 at > 50%F	3.89	3.89	3.89
	26 at ≤ 50%F	3.28	3.28	3.28
	23 at ≤ 50%F	3.63	3.63	3.63

* 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 $MCPR_P$ Limits for Table 3.1 Temperature Range 1 for All Fuel Types: Technical Specification Scram Time Basis *

Operating Condition	Power (% of rated)	ATRIUM-10XM		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast
TBVIS	100	1.46	1.46	1.46
	90	1.50	1.50	1.50
	77.6	1.57	1.57	1.57
	65	1.75	1.75	1.75
	>50	---	---	---
	≤50	1.93	1.93	1.93
	40	2.18	2.18	2.18
	26	2.86	2.86	2.86
	26 at > 50%F	3.07	3.07	3.07
	23 at > 50%F	3.32	3.32	3.32
	26 at ≤ 50%F	2.92	2.92	2.92
	23 at ≤ 50%F	3.15	3.15	3.15
TBVOOS	100	1.50	1.50	1.50
	90	1.53	1.54	1.54
	77.6	1.60	1.60	1.60
	65	1.76	1.76	1.76
	>50	---	---	---
	≤50	1.94	1.94	1.94
	40	2.19	2.19	2.19
	26	2.87	2.87	2.87
	26 at > 50%F	3.58	3.58	3.58
	23 at > 50%F	3.88	3.88	3.88
	26 at ≤ 50%F	3.28	3.28	3.28
	23 at ≤ 50%F	3.62	3.62	3.62

* 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 $MCPR_P$ Limits for Table 3.1 Temperature Range 2 for All Fuel Types: Technical Specification Scram Time Basis *

Operating Condition	Power (% of rated)	ATRIUM-10XM		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast
TBVIS	100	1.46	1.46	1.46
	90	1.50	1.50	1.50
	77.6	1.57	1.57	1.57
	65	1.75	1.75	1.75
	>50	---	---	---
	≤50	1.94	1.94	1.94
	40	2.20	2.20	2.20
	26	2.89	2.89	2.89
	26 at > 50%F	3.09	3.09	3.09
	23 at > 50%F	3.33	3.33	3.33
	26 at ≤ 50%F	2.93	2.93	2.93
	23 at ≤ 50%F	3.18	3.18	3.18
TBVOOS	100	1.50	1.50	1.50
	90	1.53	1.54	1.54
	77.6	1.60	1.60	1.60
	65	1.76	1.76	1.76
	>50	---	---	---
	≤50	1.95	1.95	1.95
	40	2.21	2.21	2.21
	26	2.90	2.90	2.90
	26 at > 50%F	3.59	3.59	3.59
	23 at > 50%F	3.90	3.90	3.90
	26 at ≤ 50%F	3.29	3.29	3.29
	23 at ≤ 50%F	3.64	3.64	3.64

* 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 $MCPR_P$ Limits for All Fuel Types: Single Loop Operation for All Scram Times *

Operating Condition	Power (% of rated)	BOC to End of COAST ATRIUM-10XM
RCPOOS FHOOS	100	2.09
	43.75	2.09
	40	2.09
	26	2.57
	26 at > 50%F	2.81
	23 at > 50%F	3.00
	26 at ≤ 50%F	2.67
	23 at ≤ 50%F	2.86
RCPOOS TBVOOS PLUOOS FHOOS	100	2.09
	43.75	2.09
	40	2.09
	26	2.58
	26 at > 50%F	3.36
	23 at > 50%F	3.65
	26 at ≤ 50%F	3.07
	23 at ≤ 50%F	3.38
RCPOOS TBVOOS FHOOS1	100	2.12
	43.75	2.12
	40	2.21
	26	2.89
	26 at > 50%F	3.60
	23 at > 50%F	3.90
	26 at ≤ 50%F	3.30
	23 at ≤ 50%F	3.64
RCPOOS TBVOOS FHOOS2	100	2.14
	43.75	2.14
	40	2.23
	26	2.92
	26 at > 50%F	3.61
	23 at > 50%F	3.92
	26 at ≤ 50%F	3.31
	23 at ≤ 50%F	3.66

* 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 43.75% 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	29.0	Scram Region (Region I) Boundary Intercept on Natural Circulation Line (NCL)
A2	66.1	52.0	Controlled Entry Region (Region II) Boundary Intercept on MELLLA Line
B2	25.5	29.0	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	29.0	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	29.0	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:

$SRB \leq (0.61W_d + 63.3)$ Allowable Value

$SRB \leq (0.61W_d + 62.0)$ Nominal Trip Setpoint (NTSP)

where:

SRB = Rod Block setting in percent of rated thermal power (3952 MW_t)

W_d = Recirculation drive flow rate in percent of rated
(100% drive flow required to achieve 100% core power and flow)

and for single loop operation:

$SRB \leq (0.55(W_d-\Delta W) + 60.5)$ Allowable Value

$SRB \leq (0.55(W_d-\Delta W) + 58.5)$ Nominal Trip Setpoint (NTSP)

where:

SRB = Rod Block setting in percent of rated thermal power (3952 MW_t)

W_d = Recirculation drive flow rate in percent of rated
(100% drive flow required to achieve 100% core power and flow)

ΔW = Difference between two-loop and single-loop effective recirculation flow at the same core flow (ΔW=0.0 for two-loop operation)

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†	Notes from Table 3.3.2.1-1	Comment
≥ 27% and < 90%	< 1.65	(a), (b), (f), (h)	two loop operation
	< 1.68	(a), (b), (f), (h)	single loop operation
≥ 90%	< 1.36	(g)	two loop operation‡

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

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

‡ Greater than 90% rated power is not attainable in single loop operation.

Table 7.3 Control Rod Withdrawal Error Results

RBM HTSP Analytical Limit	CRWE OLMCPR
Unfiltered	
107	1.26
111	1.30
114	1.31
117	1.33

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

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:

SDM ≥ 0.38% dk/k

Appendix A: MBSP Maps

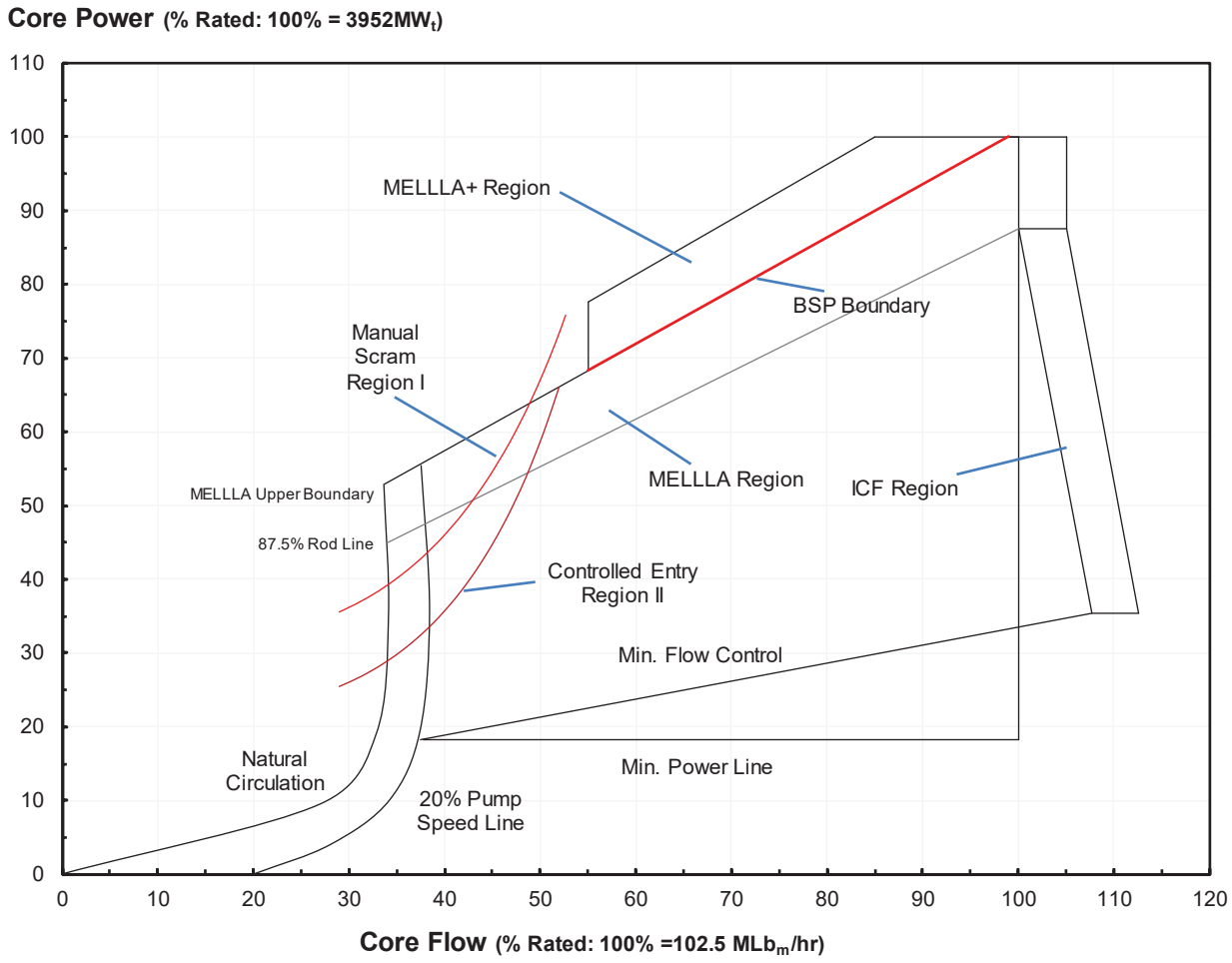


Figure A.1 MBSP Boundaries For Nominal Feedwater Temperature
(Operation in the MELLLA+ Region Prohibited for Feedwater Temperature greater than 10 degrees F below the Nominal Feedwater Temperature)

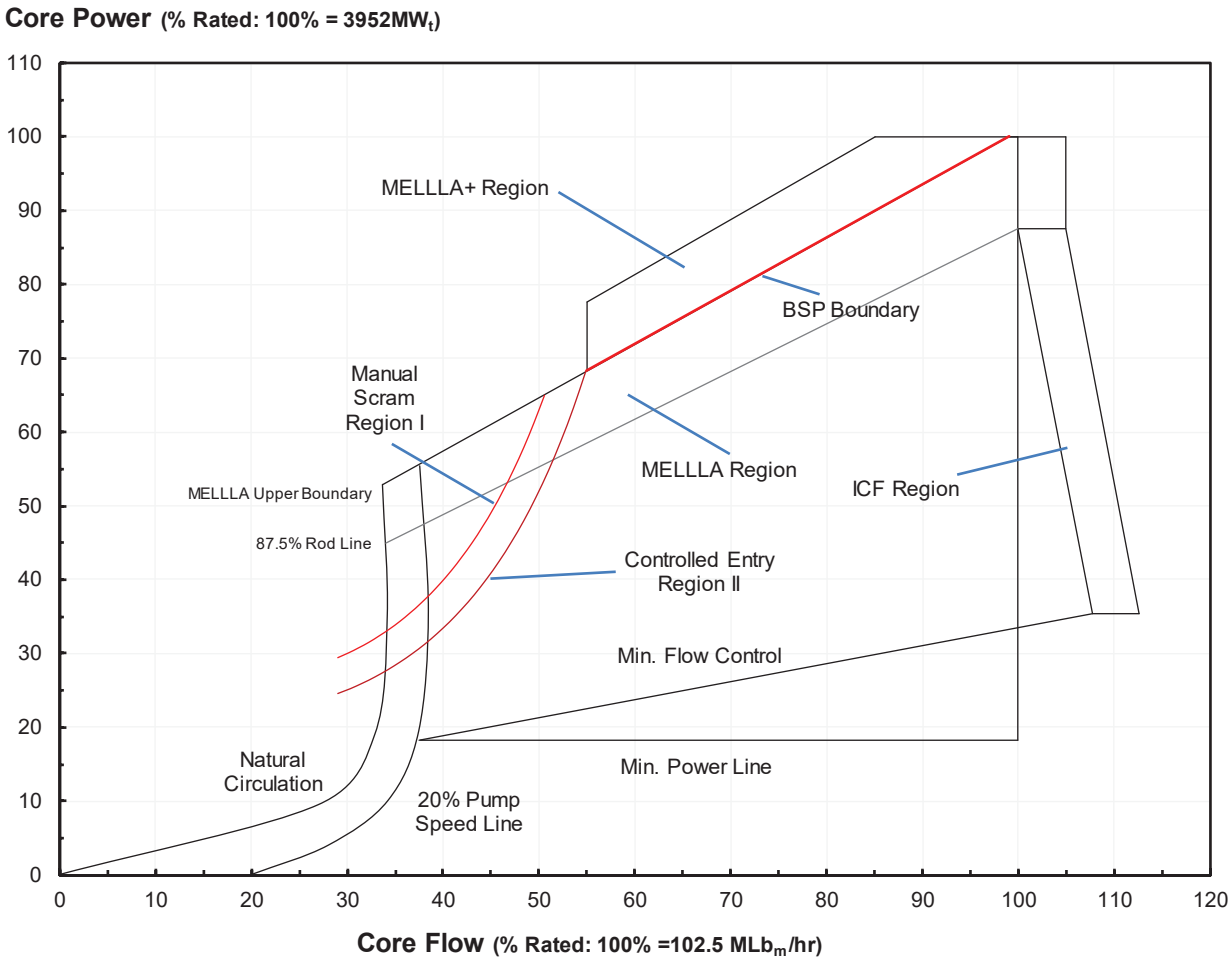


Figure A.2 MBSP Boundaries For Reduced Feedwater Temperature

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

Enclosure
Tennessee Valley Authority
Browns Ferry Nuclear Plant
Unit 2

Core Operating Limits Report, (120% OLTP, MELLLA+), for Unit 2 Cycle 22 Operation, TVA-COLR-BF2C22, Revision 1

(See Attached)

ECM L32 210902 801
QA Record
BFE-4581, Revision 1

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Browns Ferry Unit 2 Cycle 22

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

TVA-COLR-BF2C22 Revision 1 (Final)
(Revision Log, Page v)

September 2021

Prepared: Mitchell, Brye C. Digitally signed by Mitchell, Brye C. Date: 2021.11.18 11:31:21 -05'00' Date: _____
B. C. Mitchell, Engineer

Verified: _____ Date: 11/18/2021
T. W. Eichenberg, Engineer

A. Digitally signed by Seifert, Christine A DN: dc=gov, dc=tva, dc=main, ou=Main, ou=Corporate, ou=Users, cn=Seifert, Christine A, email=caseifert@tva.gov Reason: I am approving this document Date: 2021.11.19 05:58:42 -05'00'

Approved: _____ Date: _____
C. A. Setter, Manager, BWRFE

Reviewed: _____ Date: 11/19/2021
B. T. Williamson, Manager, Reactor Engineering

Approved: _____ Date: 12/17/21
Chairman, PORC

Approved: _____ Date: 12-21-21
~~Plant~~ Manager

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Total Number of Pages = 50 (*including review cover sheet*)

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1101 Market Street, Chattanooga TN 37402

Date: September 8, 2021

Revision Log

Number	Page	Description
1-R1	32	Updated Table 4.9 footnote per CR 1718921
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
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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Date: September 8, 2021

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, ≥ 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, ≥ 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, ≥ 23% RTP (Technical Specifications definition of RTP)
- Thermal-Hydraulic Stability Protection
  (Technical Specification Table 3.3.1.1)
  Applicability: Mode 1, ≥ (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, ≥ (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, ≥ % 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 fresh and exposed ATRIUM-10XM, as well as a limited number of ATRIUM-11 lead fuel assemblies. 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 11 A11-3693B-13GV80-FBF	19	4	17	FBF653-FBF660
ATRIUM 10XM XMLC-4102B-11GV70-FBG-B	20	47	18	FBG701-FBG748
ATRIUM 10XM XMLC-4062B-13GV80-FBG-C	20	77	19	FBG749-FBG900
ATRIUM 10XM XMLC-3948B-13GV70-FBG-B	20	8	20	FBG901-FBG988
ATRIUM-10XM XMLC-4087B-15GV80-FBH	21	176	21	FBH001-FBH176
ATRIUM-10XM XMLC-4036B-15GV80-FBH	21	88	22	FBH177-FBH264
ATRIUM-10XM XMLC-4093B-10GV80-FBH	21	56	23	FBH265-FBH320
ATRIUM-10XM XMLC-4058B-15GV80-FBJ	22	216	24	FBJ331-FBJ546
ATRIUM-10XM XMLC-4015B-15GV80-FBJ	22	92	25	FBJ547-FBJ638

1.4 Acceptability

Limits discussed in this document were generated based on NRC approved methodologies per References 6 through 26.

* 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:

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

where:

APLHGR_P	off-rated power APLHGR limit	[APLHGR_{RATED} * MAPFAC_P]
APLHGR_F	off-rated flow APLHGR limit	[APLHGR_{RATED} * MAPFAC_F]
APLHGR_{SLO}	SLO APLHGR limit	[APLHGR_{RATED} * SLO Multiplier]

2.1 Rated Power and Flow Limit: APLHGR_{RATED}

The rated conditions APLHGR for all fuel are identified per Reference 1. The rated conditions APLHGR for ATRIUM-10XM fuel are shown in Figure 2.1. The rated conditions APLHGR for ATRIUM-11 are shown in Figure 2.2.

2.2 Off-Rated Power Dependent Limit: APLHGR_P

Reference 1 does not specify a power dependent APLHGR. Therefore, MAPFAC_P is set to a value of **1.0**.

2.2.1 Startup without Feedwater Heaters

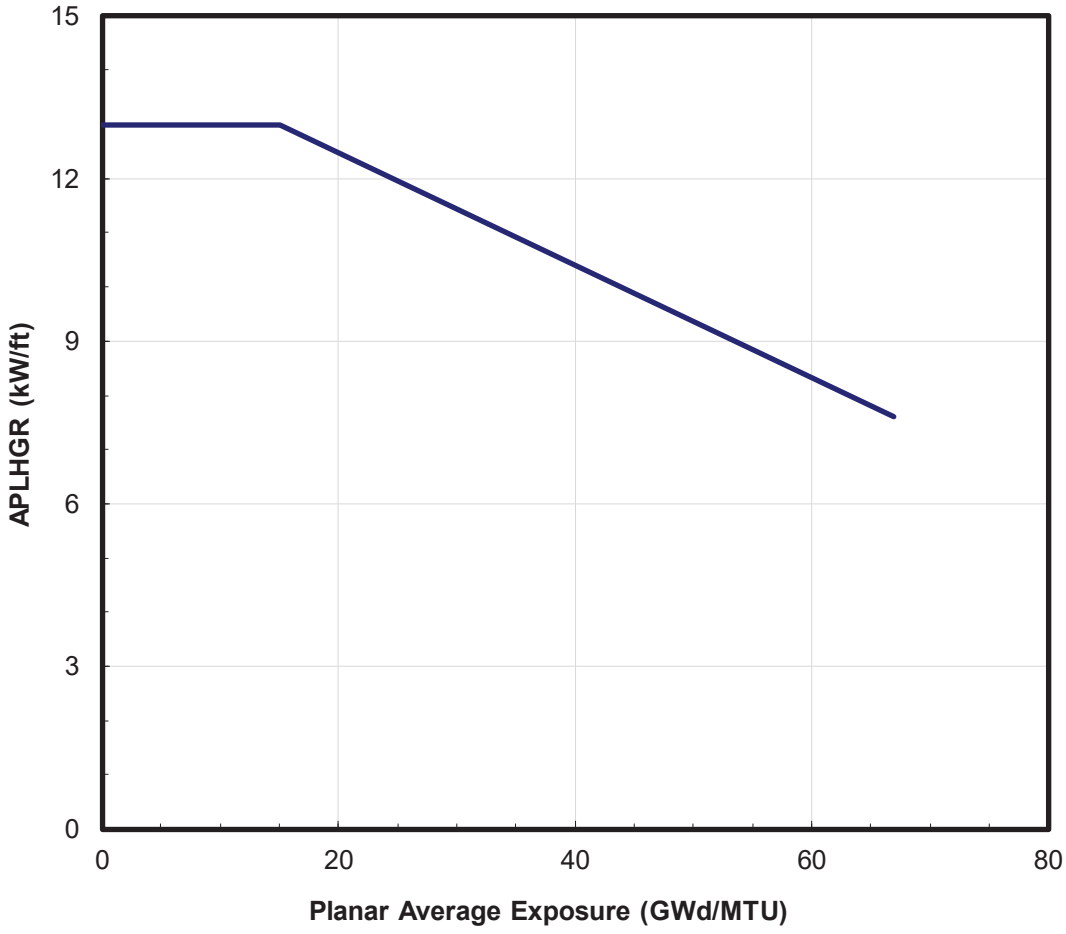
There is a range of operation during startup when the feedwater heaters are not placed into service until after the unit has reached a significant operating power level. No additional power dependent limitation is required.

2.3 Off-Rated Flow Dependent Limit: APLHGR_F

Reference 1 does not specify a flow dependent APLHGR. Therefore, MAPFAC_F is set to a value of **1.0**.

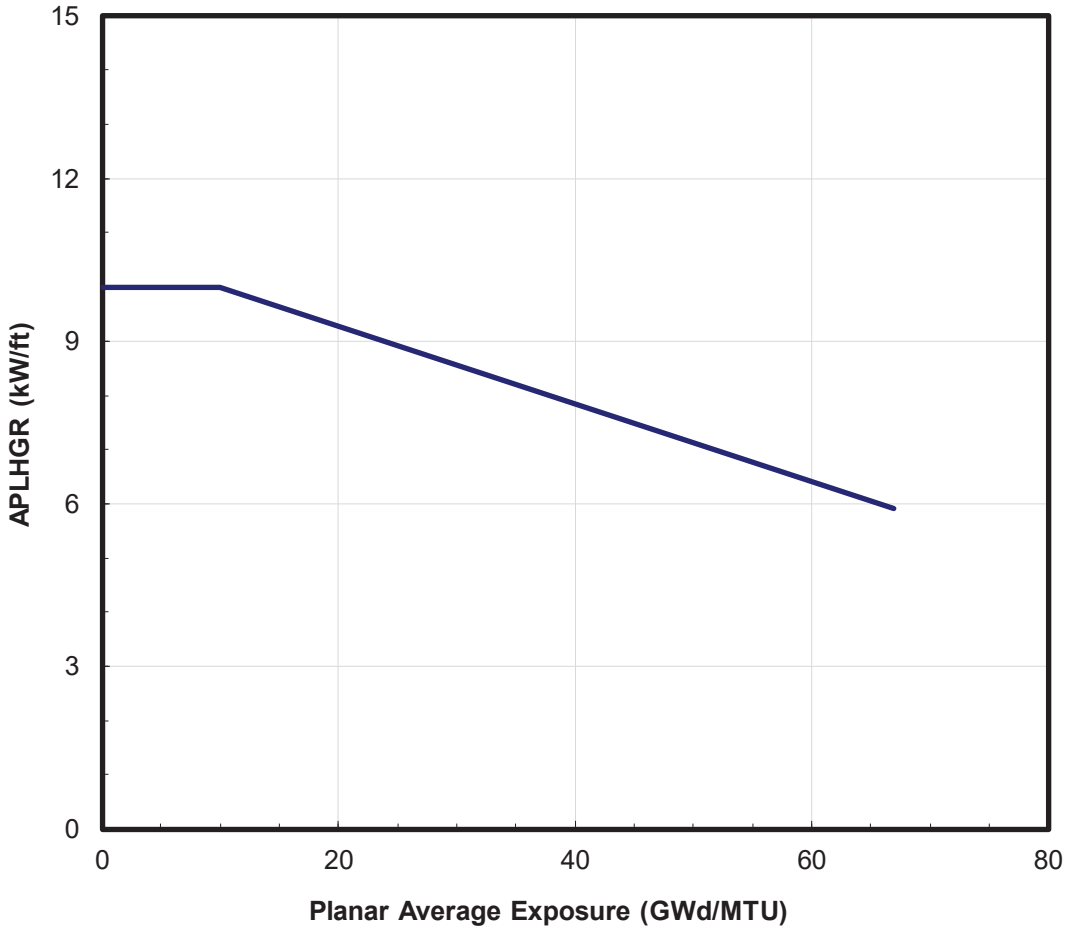
2.4 Single Loop Operation Limit: APLHGR_{SLO}

The single loop operation multiplier for ATRIUM-10XM and ATRIUM-11 fuel is **0.85**, per Reference 1.



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

Figure 2.1 $APLHGR_{RATED}$ for ATRIUM-10XM Fuel



Planar Avg. Exposure (GWd/MTU)	APLHGR Limit (kW/ft)
0.0	10
10.0	10
67.0	5.9

Figure 2.2 $APLHGR_{RATED}$ for ATRIUM-11 Fuel

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

* 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:

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

3.1 Rated Power and Flow Limit: LHGR_{RATED}

The rated conditions LHGR for all fuel are identified per Reference 1. The rated conditions LHGR for ATRIUM-10XM are shown in Figure 3.1. The rated conditions LHGR for ATRIUM-11 fuel is shown in Figure 3.2. The LHGR limit is consistent with Reference 3.

3.2 Off-Rated Power Dependent Limit: LHGR_P

LHGR limits are adjusted for off-rated power conditions using the 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	Temperature	
	Range 1	Range 2
(% Rated)	(°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: $LHGR_F$

LHGR limits are adjusted for off-rated flow conditions using the $LHGRFAC_F$ 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.*

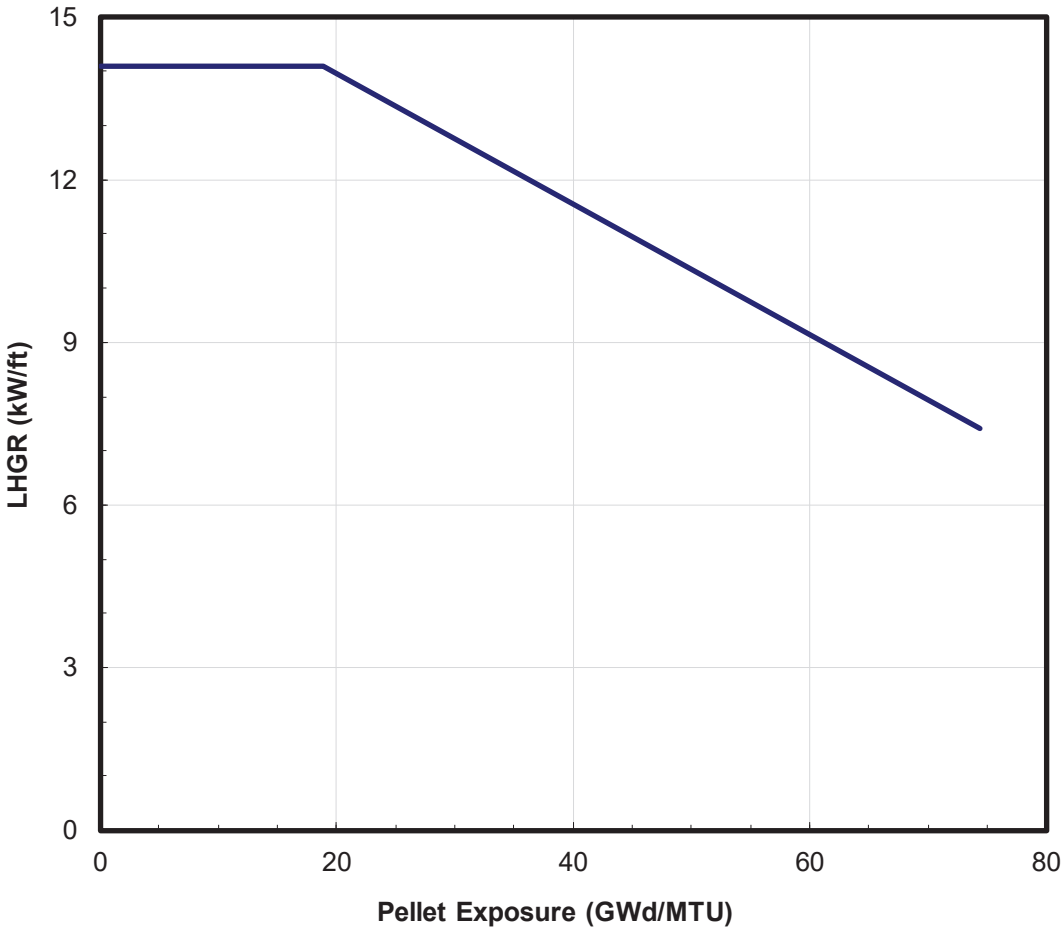
In-Service	All equipment In-Service
RPTOOS	EOC-Recirculation Pump Trip Out-Of-Service
TBVOOS	Turbine Bypass Valve(s) Out-Of-Service
PLUOOS	Power Load Unbalance Out-Of-Service
FHOOS (or FFWTR)	Feedwater Heaters Out-Of-Service or Final Feedwater Temperature Reduction
RCPOOS	One Recirculation Pump Out-Of-Service

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.

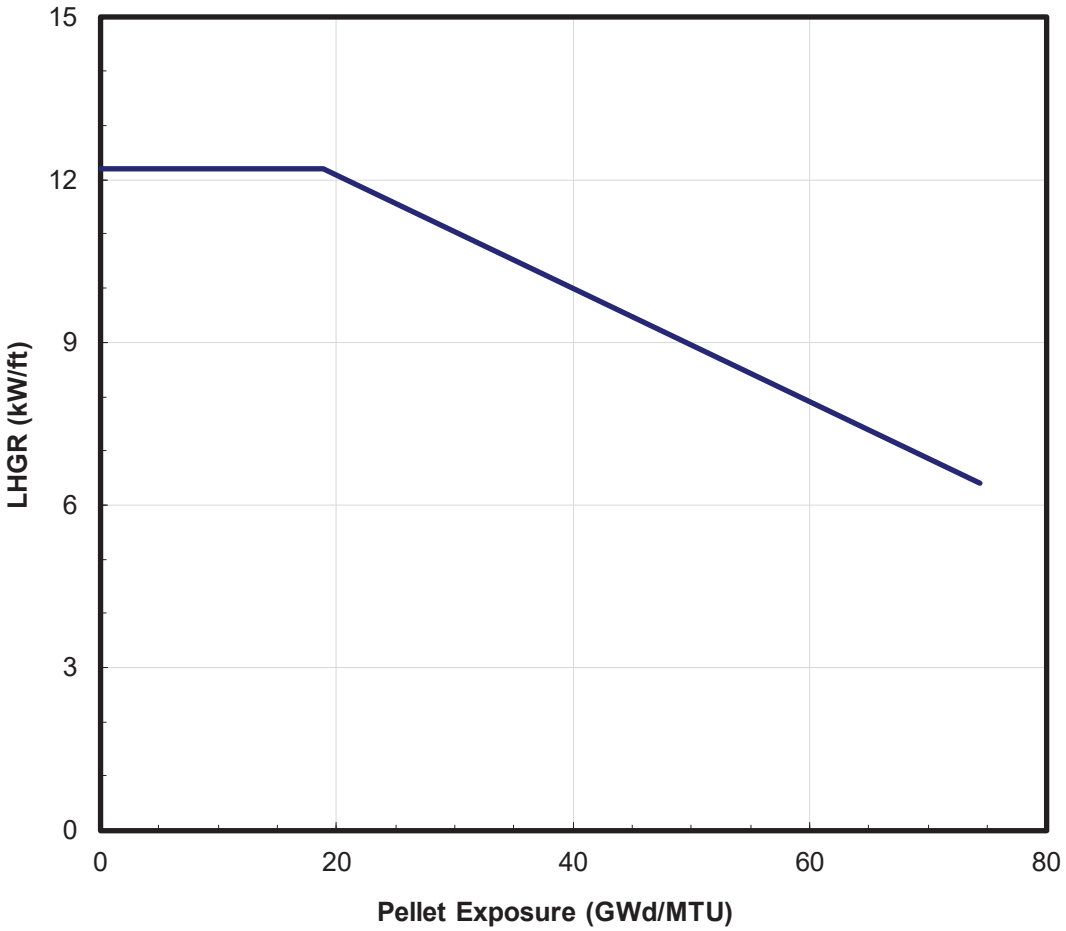
Off-rated power corrections shown in Figure 3.7 through Figure 3.10 are also dependent on operation of the Turbine Bypass Valve system. In this case, limits support FHOOS operation during startup. These limits have no dependency on RPTOOS, PLUOOS, or SLO.

* All equipment service conditions assume 1 SRVOOS.



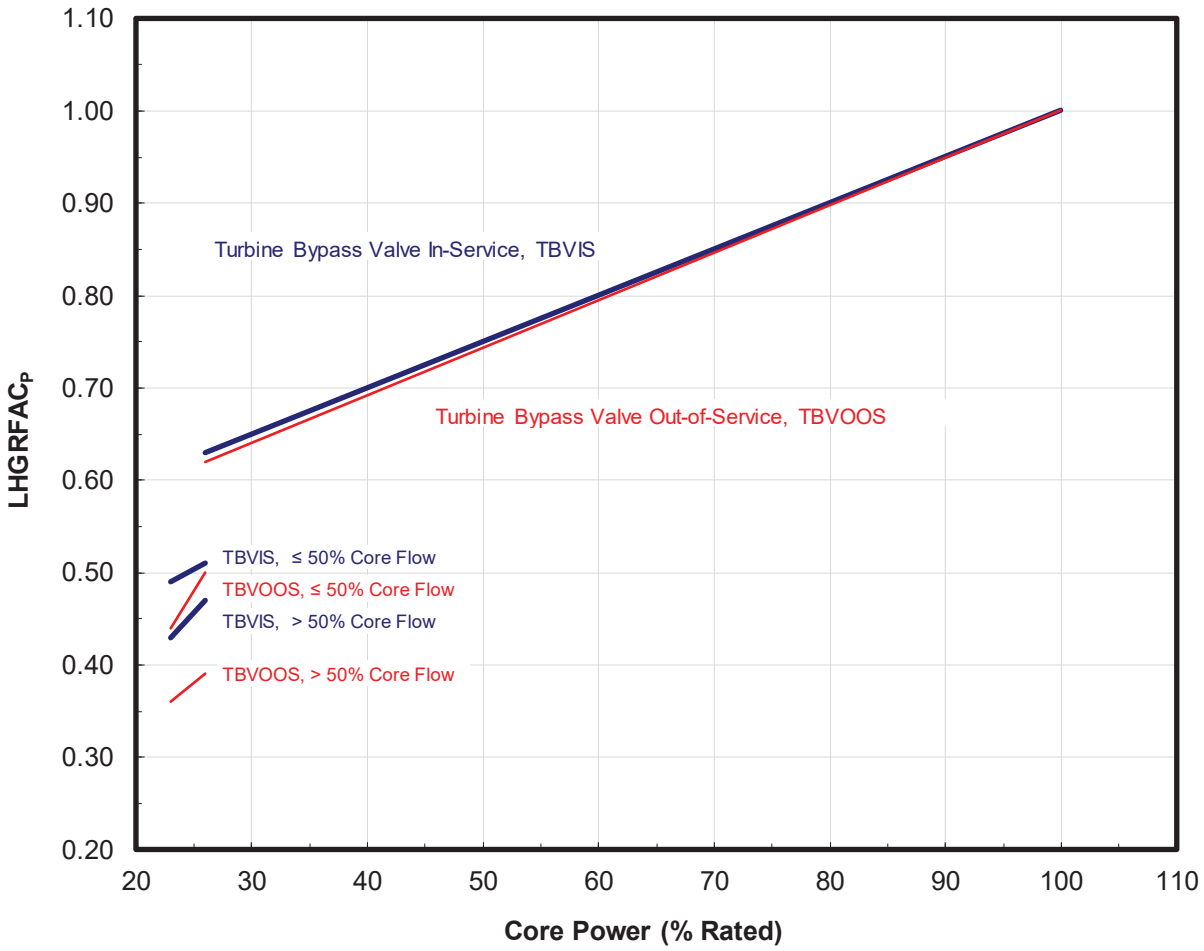
Pellet Exposure (GWd/MTU)	LHGR Limit (kW/ft)
0.0	14.1
18.9	14.1
74.4	7.4

Figure 3.1 $LHGR_{RATED}$ for ATRIUM-10XM Fuel



Pellet Exposure (GWd/MTU)	LHGR Limit (kW/ft)
0.0	12.2
18.9	12.2
74.4	6.4

Figure 3.2 $LHGR_{RATED}$ for ATRIUM-11 Fuel

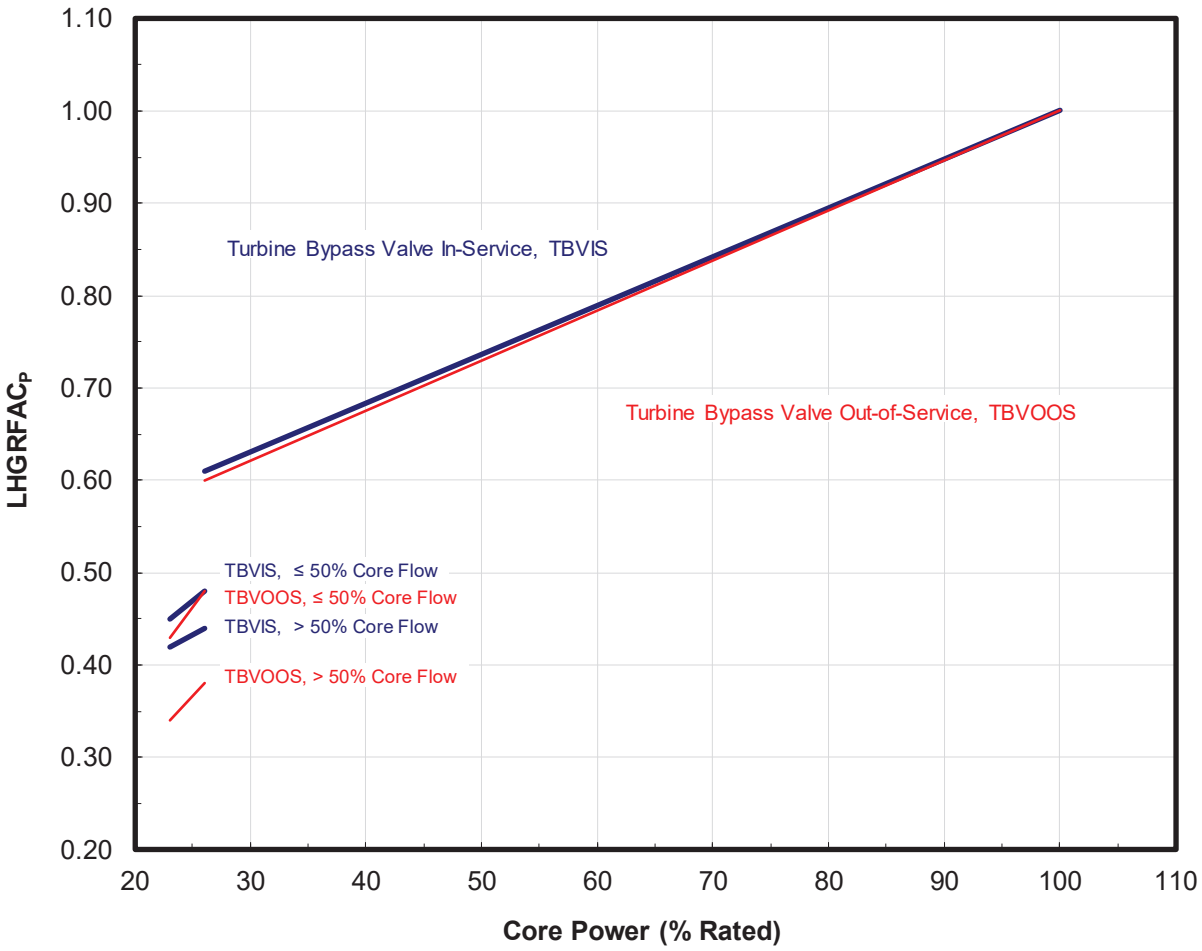


Turbine Bypass In-Service	
Core Power (% Rated)	**$LHGRFAC_P$**
100.0	1.00
26.0	0.63
Core Flow > 50% Rated	
26.0	0.47
23.0	0.43
Core Flow ≤ 50% Rated	
26.0	0.51
23.0	0.49

Turbine Bypass Out-of-Service	
Core Power (% Rated)	**$LHGRFAC_P$**
100.0	1.00
26.0	0.62
Core Flow > 50% Rated	
26.0	0.39
23.0	0.36
Core Flow ≤ 50% Rated	
26.0	0.50
23.0	0.44

Figure 3.3 Base Operation $LHGRFAC_P$ for ATRIUM-10XM Fuel

(*Independent of other EOOS conditions*)

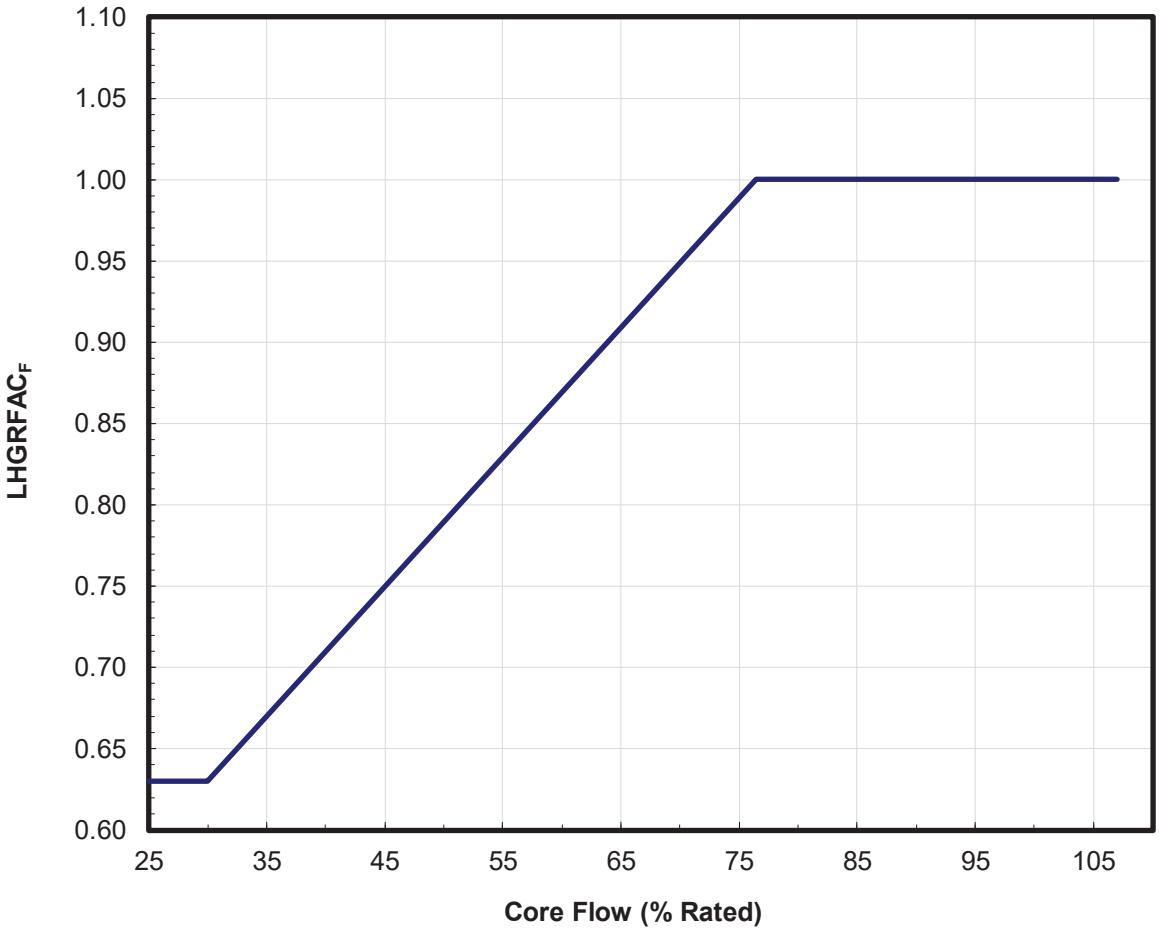


Turbine Bypass In-Service	
Core Power (% Rated)	**LHGRFAC$_P$**
100.0	1.00
26.0	0.61
Core Flow > 50% Rated	
26.0	0.44
23.0	0.42
Core Flow ≤ 50% Rated	
26.0	0.48
23.0	0.45

Turbine Bypass Out-of-Service	
Core Power (% Rated)	**LHGRFAC$_P$**
100.0	1.00
26.0	0.60
Core Flow > 50% Rated	
26.0	0.38
23.0	0.34
Core Flow ≤ 50% Rated	
26.0	0.48
23.0	0.43

Figure 3.4 Base Operation LHGRFAC$_P$ for ATRIUM-11 Fuel

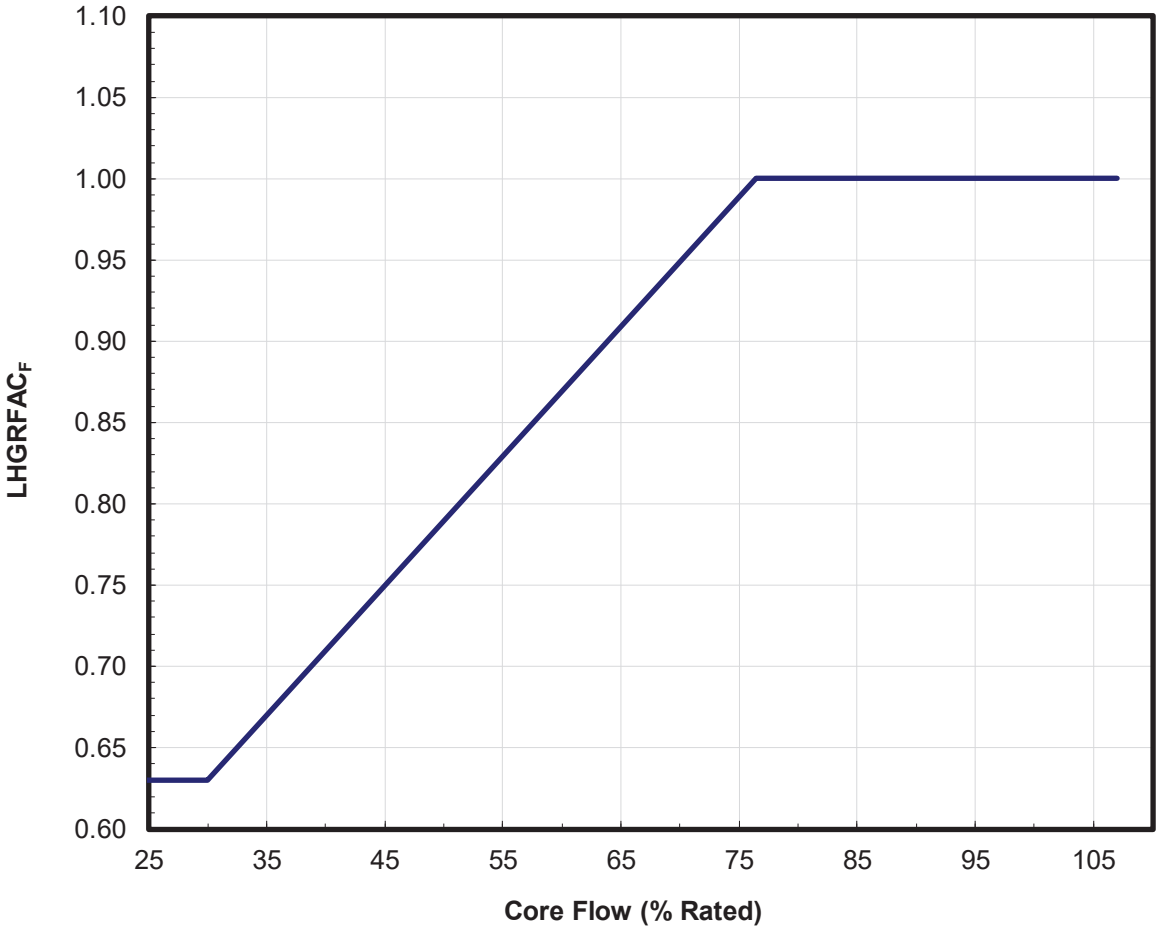
(*Independent of other EOOS conditions*)



Core Flow (% Rated)	LHGRFAC$_F$
0.0	0.63
30.0	0.63
76.4	1.00
107.0	1.00

Figure 3.5 LHGRFAC$_F$ for ATRIUM-10XM Fuel
(*Values bound all EOOS conditions*)

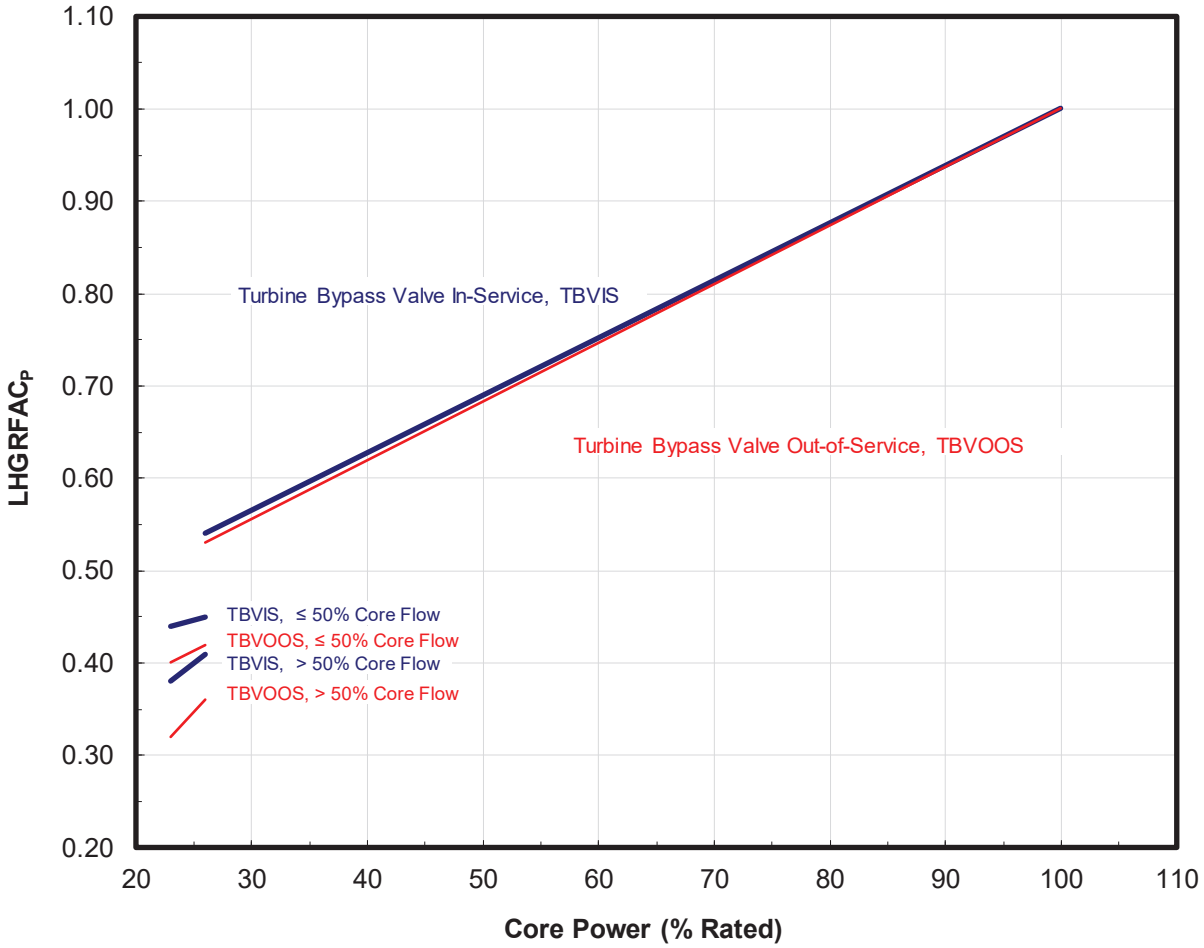
(*107.0% maximum core flow line is used to support 105% rated flow operation, ICF*)



Core Flow (% Rated)	LHGRFAC$_F$
0.0	0.63
30.0	0.63
76.4	1.00
107.0	1.00

Figure 3.6 LHGRFAC$_F$ for ATRIUM-11 Fuel
(*Values bound all EOOS conditions*)

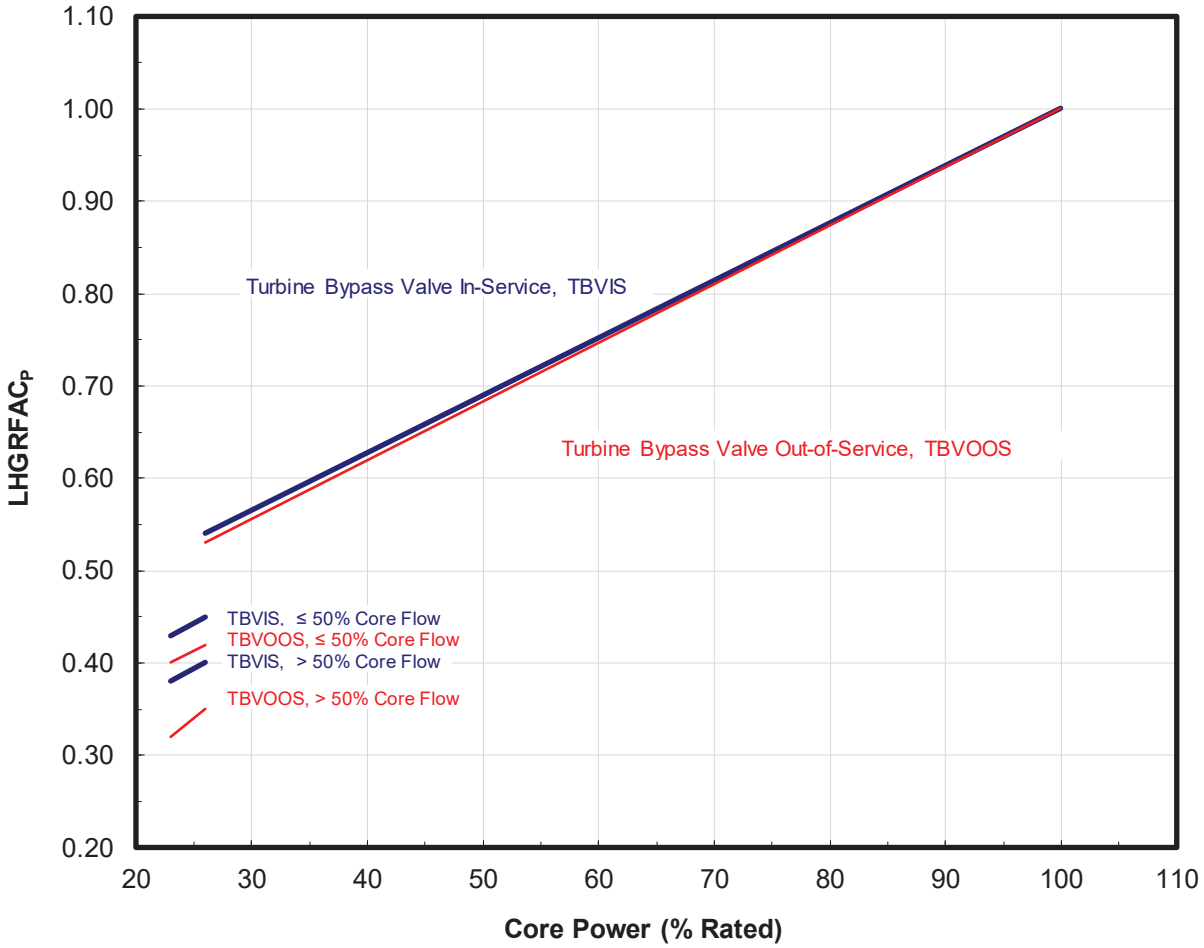
(*107.0% maximum core flow line is used to support 105% rated flow operation, ICF*)



Turbine Bypass In-Service	
Core Power (% Rated)	**$LHGRFAC_P$**
100.0	1.00
26.0	0.54
Core Flow > 50% Rated	
26.0	0.41
23.0	0.38
Core Flow ≤ 50% Rated	
26.0	0.45
23.0	0.44

Turbine Bypass Out-of-Service	
Core Power (% Rated)	**$LHGRFAC_P$**
100.0	1.00
26.0	0.53
Core Flow > 50% Rated	
26.0	0.36
23.0	0.32
Core Flow ≤ 50% Rated	
26.0	0.42
23.0	0.40

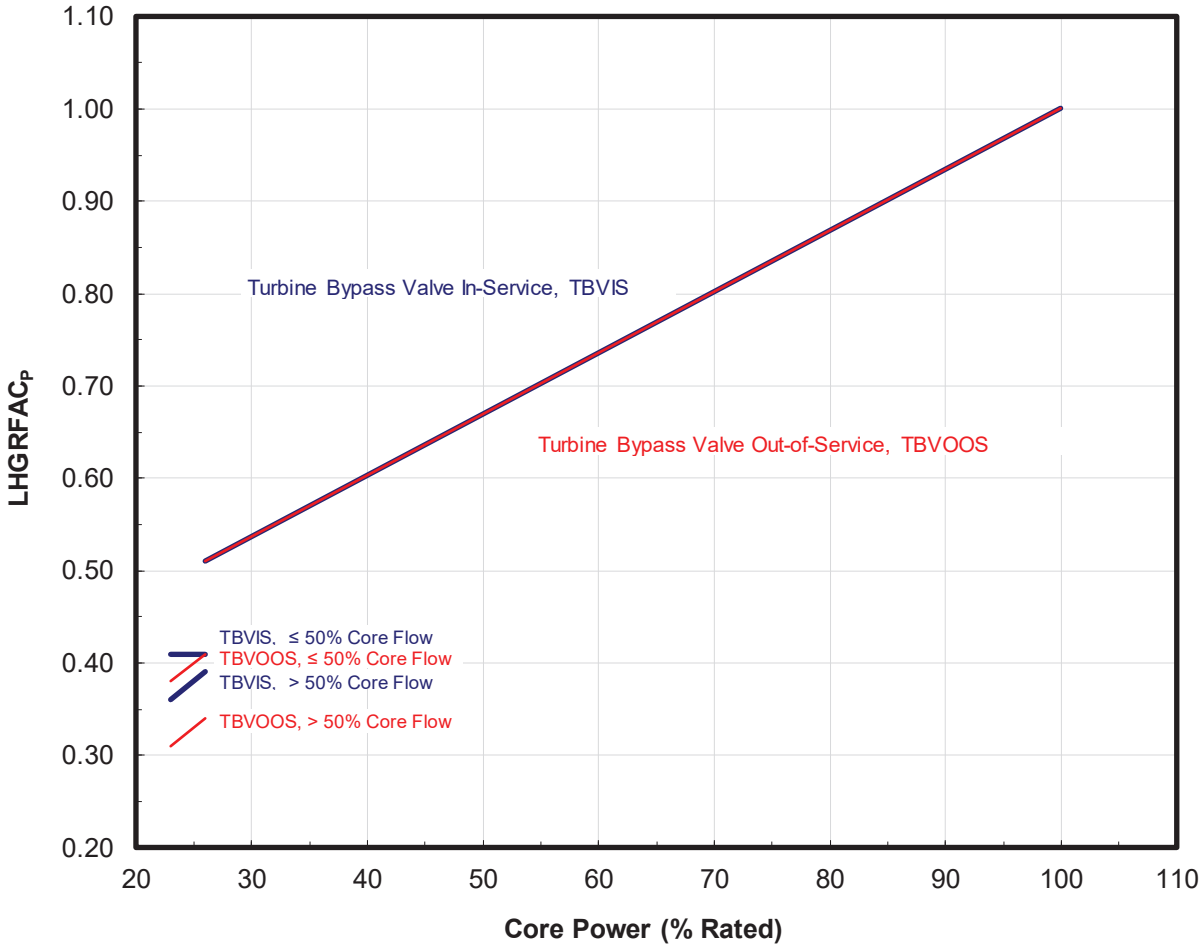
Figure 3.7 Startup Operation $LHGRFAC_P$ for ATRIUM-10XM Fuel:
Table 3.1 Temperature Range 1
(no Feedwater heating during startup)
(Limits valid at and below 50% power)



Turbine Bypass In-Service	
Core Power (% Rated)	**$LHGRFAC_P$**
100.0	1.00
26.0	0.54
Core Flow > 50% Rated	
26.0	0.40
23.0	0.38
Core Flow ≤ 50% Rated	
26.0	0.45
23.0	0.43

Turbine Bypass Out-of-Service	
Core Power (% Rated)	**$LHGRFAC_P$**
100.0	1.00
26.0	0.53
Core Flow > 50% Rated	
26.0	0.35
23.0	0.32
Core Flow ≤ 50% Rated	
26.0	0.42
23.0	0.40

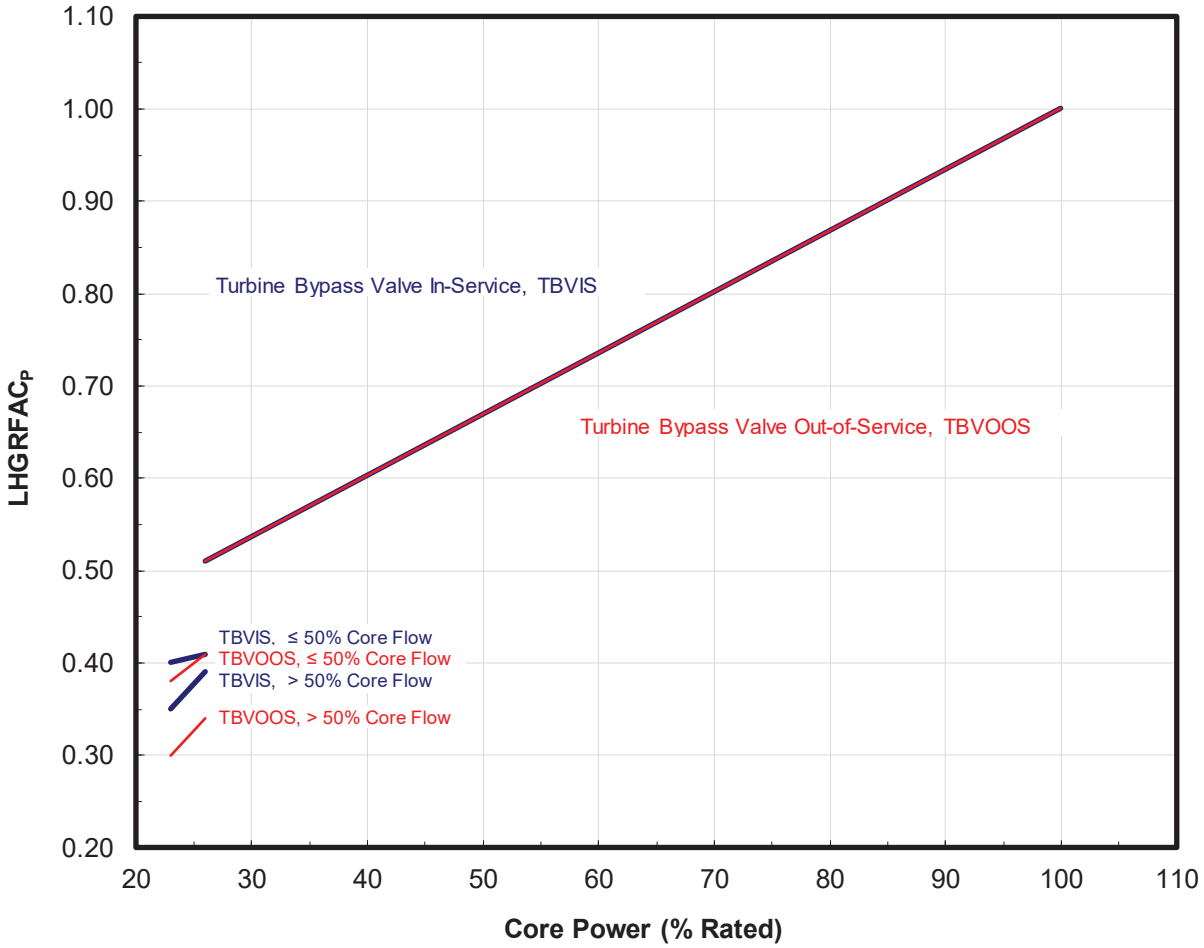
Figure 3.8 Startup Operation $LHGRFAC_P$ for ATRIUM-10XM Fuel:
Table 3.1 Temperature Range 2
(no Feedwater heating during startup)
(Limits valid at and below 50% power)



Turbine Bypass In-Service	
Core Power (% Rated)	**LHGRFACP**
100.0	1.00
26.0	0.51
Core Flow > 50% Rated	
26.0	0.39
23.0	0.36
Core Flow ≤ 50% Rated	
26.0	0.41
23.0	0.41

Turbine Bypass Out-of-Service	
Core Power (% Rated)	**LHGRFACP**
100.0	1.00
26.0	0.51
Core Flow > 50% Rated	
26.0	0.34
23.0	0.31
Core Flow ≤ 50% Rated	
26.0	0.41
23.0	0.38

Figure 3.9 Startup Operation $LHGRFAC_P$ for ATRIUM-11 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 (% Rated)	**$LHGRFAC_P$**
100.0	1.00
26.0	0.51
Core Flow > 50% Rated	
26.0	0.39
23.0	0.35
Core Flow ≤ 50% Rated	
26.0	0.41
23.0	0.40

Turbine Bypass Out-of-Service	
Core Power (% Rated)	**$LHGRFAC_P$**
100.0	1.00
26.0	0.51
Core Flow > 50% Rated	
26.0	0.34
23.0	0.30
Core Flow ≤ 50% Rated	
26.0	0.41
23.0	0.38

Figure 3.10 Startup Operation $LHGRFAC_P$ for ATRIUM-11 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

$$\text{OLMCPR limit} = \text{MAX} (MCPR_F , MCPR_P)$$

where:

$MCPR_F$	core flow-dependent MCPR limit
$MCPR_P$	power-dependent MCPR limit

4.1 Flow Dependent MCPR Limit: $MCPR_F$

$MCPR_F$ limits are dependent upon core flow (% of Rated), and the max core flow limit, (Rated or Increased Core Flow, ICF). $MCPR_F$ 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: $MCPR_P$

$MCPR_P$ 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 $MCPR_P$ 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 $MCPR_P$ 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)

$MCPR_P$ limits are provided for three different sets of assumed scram speeds. The Technical Specification Scram Speed (TSSS) $MCPR_P$ 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	0.420	0.380
36	0.980	0.875
26	1.600	1.465
6	2.900	2.900

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 $MCPR_P$ 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 $MCPR_P$ limits are always more limiting and may be used for any Core Average Exposure up to the ending exposure. Per Reference 1, $MCPR_P$ limits are provided for the following exposure ranges:

BOC to NEOC	NEOC corresponds to	**31,055.6 MWd / MTU**
BOC to EOCLB	EOCLB corresponds to	**34,233.1 MWd / MTU**
BOC to End of Coast	End of Coast	**35,926.7 MWd / MTU**

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 $MCPR_P$ 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 $MCPR_P$ limits are also provided including FHOOS. The coast down exposure range assumes application of FFWTR. FHOOS based $MCPR_P$ 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

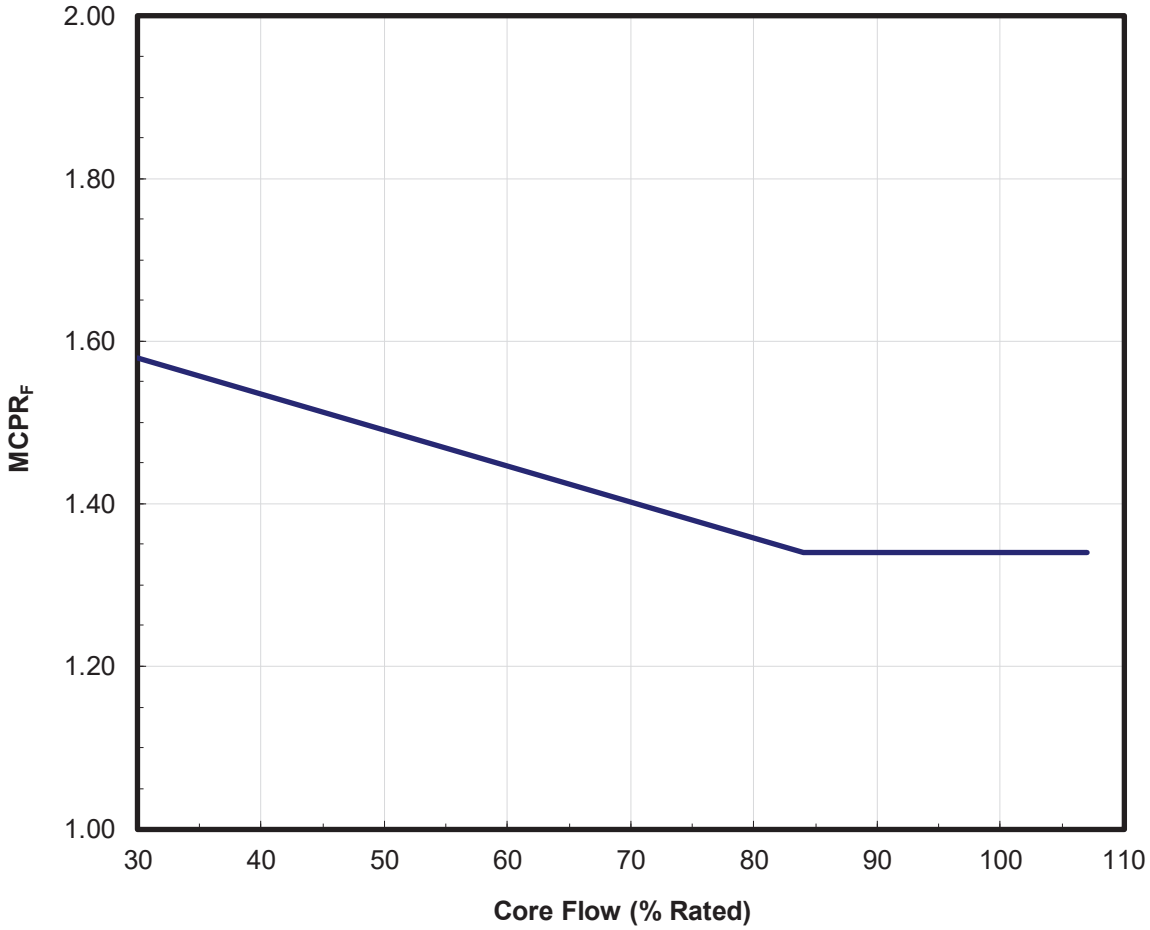
When operating in RCPOOS conditions, MCPRp limits are constructed differently from the normal operating RCP conditions. The limiting event for RCPOOS is a pump seizure scenario, which sets the upper bound for allowed core power and flow†. This event is not impacted by scram time assumptions. Specific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

4.2.6 Below Pbypass Limits

Below Pbypass (26% rated power), $MCPR_P$ limits depend upon core flow. One set of $MCPR_P$ 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_m/hr.



Core Flow (% Rated)	MCPR$_F$
30.0	1.58
84.0	1.34
107.0	1.34

Figure 4.1 MCPR$_F$ 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$_P$ Limits for All Fuel Types: Optimum Scram Time Basis*

Operating Condition	Power (% of rated)	ATRIUM-10XM			ATRIUM-11		
		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	1.38	1.42	1.46	1.38	1.43	1.46
	90	1.44	1.45	1.51	1.44	1.46	1.51
	77.6	1.52	1.53	1.58	1.52	1.53	1.59
	65	1.58	1.60	1.66	1.59	1.60	1.66
	> 50	1.67	1.68	1.76	1.73	1.73	1.81
	≤ 50	1.82	1.82	1.84	1.91	1.91	1.91
	40	1.92	1.92	1.94	1.99	1.99	2.03
	26	2.26	2.26	2.39	2.51	2.51	2.66
	26 at > 50%F	2.47	2.47	2.59	2.68	2.68	2.81
	23 at > 50%F	2.62	2.62	2.76	2.93	2.93	3.05
	26 at ≤ 50%F	2.38	2.38	2.49	2.63	2.63	2.72
	23 at ≤ 50%F	2.52	2.52	2.65	2.93	2.93	3.05
FHOOS	100	1.43	1.46	---	1.43	1.46	---
	90	1.49	1.51	---	1.49	1.51	---
	77.6	1.55	1.58	---	1.57	1.59	---
	65	1.64	1.66	---	1.64	1.66	---
	> 50	1.74	1.76	---	1.81	1.81	---
	≤ 50	1.83	1.84	---	1.91	1.91	---
	40	1.93	1.94	---	2.03	2.03	---
	26	2.38	2.39	---	2.66	2.66	---
	26 at > 50%F	2.58	2.59	---	2.81	2.81	---
	23 at > 50%F	2.75	2.76	---	3.05	3.05	---
	26 at ≤ 50%F	2.48	2.49	---	2.72	2.72	---
	23 at ≤ 50%F	2.64	2.65	---	3.05	3.05	---

* 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 $MCPR_P$ Limits for All Fuel Types: Nominal Scram Time Basis*

Operating Condition	Power (% of rated)	ATRIUM-10XM			ATRIUM-11		
		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	1.43	1.45	1.51	1.43	1.45	1.51
	90	1.48	1.49	1.56	1.48	1.49	1.56
	77.6	1.56	1.56	1.62	1.56	1.56	1.64
	65	1.62	1.63	1.69	1.62	1.63	1.72
	> 50	1.70	1.71	1.79	1.76	1.76	1.84
	≤ 50	1.83	1.83	1.86	1.92	1.92	1.92
	40	1.93	1.93	1.96	2.00	2.00	2.06
	26	2.29	2.29	2.43	2.55	2.55	2.69
	26 at > 50%F	2.48	2.48	2.61	2.68	2.68	2.81
	23 at > 50%F	2.63	2.63	2.78	2.93	2.93	3.05
	26 at ≤ 50%F	2.39	2.39	2.51	2.63	2.63	2.72
	23 at ≤ 50%F	2.53	2.53	2.67	2.93	2.93	3.05
TBVOOS	100	1.48	1.52	1.56	1.48	1.52	1.56
	90	1.53	1.55	1.61	1.53	1.55	1.61
	77.6	1.60	1.62	1.68	1.60	1.62	1.68
	65	1.67	1.69	1.75	1.67	1.69	1.75
	> 50	1.75	1.77	1.85	1.78	1.78	1.87
	≤ 50	1.85	1.86	1.89	1.92	1.92	1.92
	40	1.95	1.96	1.99	2.00	2.00	2.06
	26	2.32	2.33	2.47	2.55	2.55	2.69
	26 at > 50%F	3.04	3.05	3.19	3.28	3.28	3.38
	23 at > 50%F	3.28	3.29	3.42	3.57	3.57	3.69
	26 at ≤ 50%F	2.79	2.80	2.94	3.04	3.04	3.16
	23 at ≤ 50%F	3.04	3.05	3.22	3.32	3.32	3.56
FHOOS	100	1.48	1.51	---	1.50	1.51	---
	90	1.54	1.56	---	1.55	1.56	---
	77.6	1.60	1.62	---	1.64	1.64	---
	65	1.68	1.69	---	1.72	1.72	---
	> 50	1.78	1.79	---	1.84	1.84	---
	≤ 50	1.85	1.86	---	1.92	1.92	---
	40	1.95	1.96	---	2.06	2.06	---
	26	2.42	2.43	---	2.69	2.69	---
	26 at > 50%F	2.60	2.61	---	2.81	2.81	---
	23 at > 50%F	2.77	2.78	---	3.05	3.05	---
	26 at ≤ 50%F	2.50	2.51	---	2.72	2.72	---
	23 at ≤ 50%F	2.66	2.67	---	3.05	3.05	---
PLUOOS	100	1.43	1.45	1.51	1.43	1.45	1.51
	90	1.48	1.49	1.56	1.48	1.49	1.56
	77.6	1.56	1.56	1.62	1.66	1.66	1.70
	65	1.75	1.75	1.78	1.83	1.83	1.83
	> 50	---	---	---	---	---	---
	≤ 50	1.83	1.83	1.86	1.92	1.92	1.92
	40	1.93	1.93	1.96	2.00	2.00	2.06
	26	2.29	2.29	2.43	2.55	2.55	2.69
	26 at > 50%F	2.48	2.48	2.61	2.68	2.68	2.81
	23 at > 50%F	2.63	2.63	2.78	2.93	2.93	3.05
	26 at ≤ 50%F	2.39	2.39	2.51	2.63	2.63	2.72
	23 at ≤ 50%F	2.53	2.53	2.67	2.93	2.93	3.05

* 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 $MCPR_P$ Limits for All Fuel Types: Nominal Scram Time Basis (*continued*)*

Operating Condition	Power (% of rated)	ATRIUM-10XM BOC to NEOC	ATRIUM-10XM BOC to EOCLB	ATRIUM-10XM BOC to End of Coast	ATRIUM-11 BOC to NEOC	ATRIUM-11 BOC to EOCLB	ATRIUM-11 BOC to End of Coast
TBVOOS FHOOS	100	1.54	1.56	---	1.54	1.56	---
	90	1.59	1.61	---	1.59	1.61	---
	77.6	1.66	1.68	---	1.67	1.68	---
	65	1.74	1.75	---	1.75	1.75	---
	> 50	1.83	1.85	---	1.87	1.87	---
	≤ 50	1.88	1.89	---	1.92	1.92	---
	40	1.98	1.99	---	2.06	2.06	---
	26	2.46	2.47	---	2.69	2.69	---
	26 at > 50%F	3.18	3.19	---	3.38	3.38	---
	23 at > 50%F	3.41	3.42	---	3.69	3.69	---
	26 at ≤ 50%F	2.93	2.94	---	3.16	3.16	---
	23 at ≤ 50%F	3.21	3.22	---	3.56	3.56	---
TBVOOS PLUOOS	100	1.48	1.52	1.56	1.48	1.52	1.56
	90	1.53	1.55	1.61	1.53	1.55	1.61
	77.6	1.60	1.62	1.68	1.68	1.69	1.72
	65	1.77	1.78	1.81	1.83	1.83	1.83
	> 50	---	---	---	---	---	---
	≤ 50	1.85	1.86	1.89	1.92	1.92	1.92
	40	1.95	1.96	1.99	2.00	2.00	2.06
	26	2.32	2.33	2.47	2.55	2.55	2.69
	26 at > 50%F	3.04	3.05	3.19	3.28	3.28	3.38
	23 at > 50%F	3.28	3.29	3.42	3.57	3.57	3.69
	26 at ≤ 50%F	2.79	2.80	2.94	3.04	3.04	3.16
	23 at ≤ 50%F	3.04	3.05	3.22	3.32	3.32	3.56
FHOOS PLUOOS	100	1.48	1.51	---	1.50	1.51	---
	90	1.54	1.56	---	1.55	1.56	---
	77.6	1.60	1.62	---	1.69	1.70	---
	65	1.77	1.78	---	1.83	1.83	---
	> 50	---	---	---	---	---	---
	≤ 50	1.85	1.86	---	1.92	1.92	---
	40	1.95	1.96	---	2.06	2.06	---
	26	2.42	2.43	---	2.69	2.69	---
	26 at > 50%F	2.60	2.61	---	2.81	2.81	---
	23 at > 50%F	2.77	2.78	---	3.05	3.05	---
	26 at ≤ 50%F	2.50	2.51	---	2.72	2.72	---
	23 at ≤ 50%F	2.66	2.67	---	3.05	3.05	---
TBVOOS FHOOS PLUOOS	100	1.54	1.56	---	1.54	1.56	---
	90	1.59	1.61	---	1.59	1.61	---
	77.6	1.66	1.68	---	1.71	1.72	---
	65	1.80	1.81	---	1.83	1.83	---
	> 50	---	---	---	---	---	---
	≤ 50	1.88	1.89	---	1.92	1.92	---
	40	1.98	1.99	---	2.06	2.06	---
	26	2.46	2.47	---	2.69	2.69	---
	26 at > 50%F	3.18	3.19	---	3.38	3.38	---
	23 at > 50%F	3.41	3.42	---	3.69	3.69	---
	26 at ≤ 50%F	2.93	2.94	---	3.16	3.16	---
	23 at ≤ 50%F	3.21	3.22	---	3.56	3.56	---

* 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 $MCPR_P$ Limits for All Fuel Types: Technical Specification Scram Time Basis*

Operating Condition	Power (% of rated)	ATRIUM-10XM			ATRIUM-11		
		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	1.48	1.50	1.55	1.48	1.50	1.56
	90	1.53	1.53	1.60	1.53	1.53	1.61
	77.6	1.60	1.60	1.66	1.60	1.60	1.70
	65	1.66	1.66	1.73	1.67	1.67	1.78
	> 50	1.74	1.74	1.83	1.79	1.79	1.90
	≤ 50	1.86	1.86	1.89	1.93	1.93	1.93
	40	1.96	1.96	1.99	2.01	2.01	2.08
	26	2.33	2.33	2.48	2.57	2.57	2.72
	26 at > 50%F	2.50	2.50	2.63	2.68	2.68	2.81
	23 at > 50%F	2.65	2.65	2.80	2.93	2.93	3.05
	26 at ≤ 50%F	2.41	2.41	2.53	2.63	2.63	2.72
	23 at ≤ 50%F	2.55	2.55	2.69	2.93	2.93	3.05
TBVOOS	100	1.54	1.57	1.61	1.54	1.57	1.61
	90	1.59	1.60	1.65	1.59	1.60	1.65
	77.6	1.66	1.66	1.72	1.67	1.67	1.74
	65	1.72	1.72	1.79	1.74	1.74	1.82
	> 50	1.79	1.80	1.88	1.83	1.83	---
	≤ 50	1.89	1.89	1.92	1.93	1.93	1.93
	40	1.99	1.99	2.03	2.01	2.01	2.09
	26	2.38	2.38	2.51	2.57	2.57	2.72
	26 at > 50%F	3.07	3.07	3.21	3.28	3.28	3.38
	23 at > 50%F	3.31	3.31	3.44	3.57	3.57	3.69
	26 at ≤ 50%F	2.82	2.82	2.96	3.04	3.04	3.16
	23 at ≤ 50%F	3.07	3.07	3.24	3.32	3.32	3.56
FHOOS	100	1.53	1.55	---	1.56	1.56	---
	90	1.59	1.60	---	1.61	1.61	---
	77.6	1.64	1.66	---	1.70	1.70	---
	65	1.72	1.73	---	1.78	1.78	---
	> 50	1.82	1.83	---	1.90	1.90	---
	≤ 50	1.88	1.89	---	1.93	1.93	---
	40	1.98	1.99	---	2.08	2.08	---
	26	2.47	2.48	---	2.72	2.72	---
	26 at > 50%F	2.62	2.63	---	2.81	2.81	---
	23 at > 50%F	2.79	2.80	---	3.05	3.05	---
	26 at ≤ 50%F	2.52	2.53	---	2.72	2.72	---
	23 at ≤ 50%F	2.68	2.69	---	3.05	3.05	---
PLUOOS	100	1.48	1.50	1.55	1.48	1.50	1.56
	90	1.53	1.53	1.60	1.53	1.53	1.61
	77.6	1.60	1.60	1.66	1.69	1.69	1.73
	65	1.78	1.78	1.81	1.84	1.84	1.84
	> 50	---	---	---	---	---	---
	≤ 50	1.86	1.86	1.89	1.93	1.93	1.93
	40	1.96	1.96	1.99	2.01	2.01	2.08
	26	2.33	2.33	2.48	2.57	2.57	2.72
	26 at > 50%F	2.50	2.50	2.63	2.68	2.68	2.81
	23 at > 50%F	2.65	2.65	2.80	2.93	2.93	3.05
	26 at ≤ 50%F	2.41	2.41	2.53	2.63	2.63	2.72
	23 at ≤ 50%F	2.55	2.55	2.69	2.93	2.93	3.05

* 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 $MCPR_P$ Limits for All Fuel Types: Technical Specification Scram Time Basis (*continued*)*

Operating Condition	Power (% of rated)	ATRIUM-10XM			ATRIUM-11		
		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	1.61	---	1.60	1.61	---
	90	1.64	1.65	---	1.65	1.65	---
	77.6	1.70	1.72	---	1.74	1.74	---
	65	1.78	1.79	---	1.82	1.82	---
	> 50	1.87	1.88	---	---	---	---
	≤ 50	1.91	1.92	---	1.93	1.93	---
	40	2.02	2.03	---	2.09	2.09	---
	26	2.50	2.51	---	2.72	2.72	---
	26 at > 50%F	3.20	3.21	---	3.38	3.38	---
	23 at > 50%F	3.43	3.44	---	3.69	3.69	---
	26 at ≤ 50%F	2.95	2.96	---	3.16	3.16	---
	23 at ≤ 50%F	3.23	3.24	---	3.56	3.56	---
TBVOOS PLUOOS	100	1.54	1.57	1.61	1.54	1.57	1.61
	90	1.59	1.60	1.65	1.59	1.60	1.65
	77.6	1.66	1.66	1.72	1.72	1.72	1.75
	65	1.81	1.81	1.84	1.84	1.84	1.84
	> 50	---	---	---	---	---	---
	≤ 50	1.89	1.89	1.92	1.93	1.93	1.93
	40	1.99	1.99	2.03	2.01	2.01	2.09
	26	2.38	2.38	2.51	2.57	2.57	2.72
	26 at > 50%F	3.07	3.07	3.21	3.28	3.28	3.38
	23 at > 50%F	3.31	3.31	3.44	3.57	3.57	3.69
	26 at ≤ 50%F	2.82	2.82	2.96	3.04	3.04	3.16
	23 at ≤ 50%F	3.07	3.07	3.24	3.32	3.32	3.56
FHOOS PLUOOS	100	1.53	1.55	---	1.56	1.56	---
	90	1.59	1.60	---	1.61	1.61	---
	77.6	1.64	1.66	---	1.73	1.73	---
	65	1.80	1.81	---	1.84	1.84	---
	> 50	---	---	---	---	---	---
	≤ 50	1.88	1.89	---	1.93	1.93	---
	40	1.98	1.99	---	2.08	2.08	---
	26	2.47	2.48	---	2.72	2.72	---
	26 at > 50%F	2.62	2.63	---	2.81	2.81	---
	23 at > 50%F	2.79	2.80	---	3.05	3.05	---
	26 at ≤ 50%F	2.52	2.53	---	2.72	2.72	---
	23 at ≤ 50%F	2.68	2.69	---	3.05	3.05	---
TBVOOS FHOOS PLUOOS	100	1.59	1.61	---	1.60	1.61	---
	90	1.64	1.65	---	1.65	1.65	---
	77.6	1.70	1.72	---	1.75	1.75	---
	65	1.83	1.84	---	1.84	1.84	---
	> 50	---	---	---	---	---	---
	≤ 50	1.91	1.92	---	1.93	1.93	---
	40	2.02	2.03	---	2.09	2.09	---
	26	2.50	2.51	---	2.72	2.72	---
	26 at > 50%F	3.20	3.21	---	3.38	3.38	---
	23 at > 50%F	3.43	3.44	---	3.69	3.69	---
	26 at ≤ 50%F	2.95	2.96	---	3.16	3.16	---
	23 at ≤ 50%F	3.23	3.24	---	3.56	3.56	---

* 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 $MCPR_P$ Limits for Table 3.1 Temperature Range 1 for All Fuel Types: Nominal Scram Time Basis*

Operating Condition	Power (% of rated)	ATRIUM-10XM			ATRIUM-11		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast	BOC to NEOC	BOC to EOCLB	BOC to End of Coast
TBVIS	100	1.48	1.51	1.51	1.50	1.51	1.51
	90	1.54	1.56	1.56	1.55	1.56	1.56
	77.6	1.60	1.62	1.62	1.69	1.70	1.70
	65	1.77	1.78	1.78	1.83	1.83	1.83
	> 50	---	---	---	---	---	---
	≤ 50	1.94	1.95	1.95	2.02	2.02	2.02
	40	2.11	2.12	2.12	2.29	2.29	2.29
	26	2.68	2.69	2.69	3.07	3.07	3.07
	26 at > 50%F	2.85	2.86	2.86	3.12	3.12	3.12
	23 at > 50%F	3.06	3.07	3.07	3.42	3.42	3.42
	26 at ≤ 50%F	2.74	2.75	2.75	3.07	3.07	3.07
	23 at ≤ 50%F	2.93	2.94	2.94	3.37	3.37	3.37
TBVOOS	100	1.54	1.56	1.56	1.54	1.56	1.56
	90	1.59	1.61	1.61	1.59	1.61	1.61
	77.6	1.66	1.68	1.68	1.71	1.72	1.72
	65	1.80	1.81	1.81	1.83	1.83	1.83
	> 50	---	---	---	---	---	---
	≤ 50	1.97	1.98	1.98	2.02	2.02	2.02
	40	2.14	2.15	2.15	2.29	2.29	2.29
	26	2.71	2.72	2.72	3.07	3.07	3.07
	26 at > 50%F	3.36	3.37	3.37	3.60	3.60	3.60
	23 at > 50%F	3.62	3.63	3.63	4.00	4.00	4.00
	26 at ≤ 50%F	3.12	3.13	3.13	3.39	3.39	3.39
	23 at ≤ 50%F	3.42	3.43	3.43	3.89	3.89	3.89

* 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 $MCPR_P$ Limits for Table 3.1 Temperature Range 2 for All Fuel Types: Nominal Scram Time Basis*

Operating Condition	Power (% of rated)	ATRIUM-10XM			ATRIUM-11		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast	BOC to NEOC	BOC to EOCLB	BOC to End of Coast
TBVIS	100	1.48	1.51	1.51	1.50	1.51	1.51
	90	1.54	1.56	1.56	1.55	1.56	1.56
	77.6	1.60	1.62	1.62	1.69	1.70	1.70
	65	1.77	1.78	1.78	1.83	1.83	1.83
	> 50	---	---	---	---	---	---
	≤ 50	1.95	1.96	1.96	2.02	2.02	2.02
	40	2.12	2.13	2.13	2.30	2.30	2.30
	26	2.70	2.71	2.71	3.09	3.09	3.09
	26 at > 50%F	2.86	2.87	2.87	3.14	3.14	3.14
	23 at > 50%F	3.08	3.09	3.09	3.44	3.44	3.44
	26 at ≤ 50%F	2.75	2.76	2.76	3.09	3.09	3.09
	23 at ≤ 50%F	2.95	2.96	2.96	3.39	3.39	3.39
TBVOOS	100	1.54	1.56	1.56	1.54	1.56	1.56
	90	1.59	1.61	1.61	1.59	1.61	1.61
	77.6	1.66	1.68	1.68	1.71	1.72	1.72
	65	1.80	1.81	1.81	1.83	1.83	1.83
	> 50	---	---	---	---	---	---
	≤ 50	1.98	1.99	1.99	2.02	2.02	2.02
	40	2.15	2.16	2.16	2.30	2.30	2.30
	26	2.73	2.74	2.74	3.09	3.09	3.09
	26 at > 50%F	3.38	3.39	3.39	3.62	3.62	3.62
	23 at > 50%F	3.63	3.64	3.64	4.02	4.02	4.02
	26 at ≤ 50%F	3.13	3.14	3.14	3.40	3.40	3.40
	23 at ≤ 50%F	3.43	3.44	3.44	3.90	3.90	3.90

* 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 $MCPR_P$ Limits for Table 3.1 Temperature Range 1 for All Fuel Types: Technical Specification Scram Time Basis*

Operating Condition	Power (% of rated)	ATRIUM-10XM			ATRIUM-11		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast	BOC to NEOC	BOC to EOCLB	BOC to End of Coast
TBVIS	100	1.53	1.55	1.55	1.56	1.56	1.56
	90	1.59	1.60	1.60	1.61	1.61	1.61
	77.6	1.64	1.66	1.66	1.73	1.73	1.73
	65	1.80	1.81	1.81	1.84	1.84	1.84
	> 50	---	---	---	---	---	---
	≤ 50	1.98	1.99	1.99	2.04	2.04	2.04
	40	2.15	2.16	2.16	2.32	2.32	2.32
	26	2.73	2.74	2.74	3.10	3.10	3.10
	26 at > 50%F	2.87	2.88	2.88	3.12	3.12	3.12
	23 at > 50%F	3.08	3.09	3.09	3.42	3.42	3.42
	26 at ≤ 50%F	2.76	2.77	2.77	3.10	3.10	3.10
	23 at ≤ 50%F	2.95	2.96	2.96	3.40	3.40	3.40
TBVOOS	100	1.59	1.61	1.61	1.60	1.61	1.61
	90	1.64	1.65	1.65	1.65	1.65	1.65
	77.6	1.70	1.72	1.72	1.75	1.75	1.75
	65	1.83	1.84	1.84	1.84	1.84	1.84
	> 50	---	---	---	---	---	---
	≤ 50	2.01	2.02	2.02	2.05	2.05	2.05
	40	2.19	2.20	2.20	2.32	2.32	2.32
	26	2.76	2.77	2.77	3.10	3.10	3.10
	26 at > 50%F	3.38	3.39	3.39	3.60	3.60	3.60
	23 at > 50%F	3.64	3.65	3.65	4.00	4.00	4.00
	26 at ≤ 50%F	3.14	3.15	3.15	3.39	3.39	3.39
	23 at ≤ 50%F	3.44	3.45	3.45	3.89	3.89	3.89

* 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 $MCPR_P$ Limits for Table 3.1 Temperature Range 2 for All Fuel Types: Technical Specification Scram Time Basis*

Operating Condition	Power (% of rated)	ATRIUM-10XM			ATRIUM-11		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast	BOC to NEOC	BOC to EOCLB	BOC to End of Coast
TBVIS	100	1.53	1.55	1.55	1.56	1.56	1.56
	90	1.59	1.60	1.60	1.61	1.61	1.61
	77.6	1.64	1.66	1.66	1.73	1.73	1.73
	65	1.80	1.81	1.81	1.84	1.84	1.84
	> 50	---	---	---	---	---	---
	≤ 50	1.99	2.00	2.00	2.05	2.05	2.05
	40	2.16	2.17	2.17	2.33	2.33	2.33
	26	2.75	2.76	2.76	3.12	3.12	3.12
	26 at > 50%F	2.88	2.89	2.89	3.14	3.14	3.14
	23 at > 50%F	3.10	3.11	3.11	3.44	3.44	3.44
	26 at ≤ 50%F	2.77	2.78	2.78	3.12	3.12	3.12
	23 at ≤ 50%F	2.97	2.98	2.98	3.42	3.42	3.42
TBVOOS	100	1.59	1.61	1.61	1.60	1.61	1.61
	90	1.64	1.65	1.65	1.65	1.65	1.65
	77.6	1.70	1.72	1.72	1.75	1.75	1.75
	65	1.83	1.84	1.84	1.84	1.84	1.84
	> 50	---	---	---	---	---	---
	≤ 50	2.02	2.03	2.03	2.06	2.06	2.06
	40	2.20	2.21	2.21	2.33	2.33	2.33
	26	2.78	2.79	2.79	3.12	3.12	3.12
	26 at > 50%F	3.40	3.41	3.41	3.62	3.62	3.62
	23 at > 50%F	3.65	3.66	3.66	4.02	4.02	4.02
	26 at ≤ 50%F	3.15	3.16	3.16	3.40	3.40	3.40
	23 at ≤ 50%F	3.45	3.46	3.46	3.90	3.90	3.90

* 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 $MCPR_P$ Limits for All Fuel Types: Single Loop Operation for All Scram Times*

Operating Condition	Power (% of rated)	All Cycle Exposures	
		ATRIUM-10XM	ATRIUM-11
RCPOOS FHOOS	100	2.03	2.05
	43.75	2.03	2.05
	40	2.03	2.10
	26	2.50	2.74
	26 at > 50%F	2.65	2.83
	23 at > 50%F	2.82	3.07
	26 at ≤ 50%F	2.55	2.74
	23 at ≤ 50%F	2.71	3.07
RCPOOS TBVOOS PLUOOS FHOOS	100	2.03	2.05
	43.75	2.03	2.05
	40	2.05	2.11
	26	2.53	2.74
	26 at > 50%F	3.23	3.40
	23 at > 50%F	3.46	3.71
	26 at ≤ 50%F	2.98	3.18
	23 at ≤ 50%F	3.26	3.58
RCPOOS TBVOOS FHOOS1	100	2.16	2.24
	43.75	2.16	2.24
	40	2.22	2.34
	26	2.79	3.12
	26 at > 50%F	3.41	3.62
	23 at > 50%F	3.67	4.02
	26 at ≤ 50%F	3.17	3.41
	23 at ≤ 50%F	3.47	3.91
RCPOOS TBVOOS FHOOS2	100	2.17	2.25
	43.75	2.17	2.25
	40	2.23	2.35
	26	2.81	3.14
	26 at > 50%F	3.43	3.64
	23 at > 50%F	3.68	4.04
	26 at ≤ 50%F	3.18	3.42
	23 at ≤ 50%F	3.48	3.92

* 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 43.75% 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: WBSP-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	29.0	Scram Region (Region I) Boundary Intercept on Natural Circulation Line (NCL)
A2	66.1	52.0	Controlled Entry Region (Region II) Boundary Intercept on MELLLA Line
B2	25.5	29.0	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	29.0	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	29.0	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:

$SRB \leq (0.61W_d + 63.3)$ Allowable Value

$SRB \leq (0.61W_d + 62.0)$ Nominal Trip Setpoint (NTSP)

where:

SRB = Rod Block setting in percent of rated thermal power (3952 MW_t)

W_d = Recirculation drive flow rate in percent of rated
(100% drive flow required to achieve 100% core power and flow)

and for single loop operation:

$SRB \leq (0.55(W_d-\Delta W) + 60.5)$ Allowable Value

$SRB \leq (0.55(W_d-\Delta W) + 58.5)$ Nominal Trip Setpoint (NTSP)

where:

SRB = Rod Block setting in percent of rated thermal power (3952 MW_t)

W_d = Recirculation drive flow rate in percent of rated
(100% drive flow required to achieve 100% core power and flow)

ΔW = Difference between two-loop and single-loop effective recirculation flow at the same core flow (ΔW=0.0 for two-loop operation)

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†	Notes from Table 3.3.2.1-1	Comment
≥ 27% and < 90%	< 1.72	(a), (b), (f), (h)	two loop operation
	< 1.76	(a), (b), (f), (h)	single loop operation
≥ 90%	< 1.41	(g)	two loop operation‡

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

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

‡ Greater than 90% rated power is not attainable in single loop operation.

Table 7.3 Control Rod Withdrawal Error Results

RBM HTSP Analytical Limit	CRWE OLMCPR
Unfiltered	
107	1.28
111	1.34
114	1.37
117	1.39

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

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:

SDM ≥ 0.38% dk/k

Appendix A: MBSP Maps

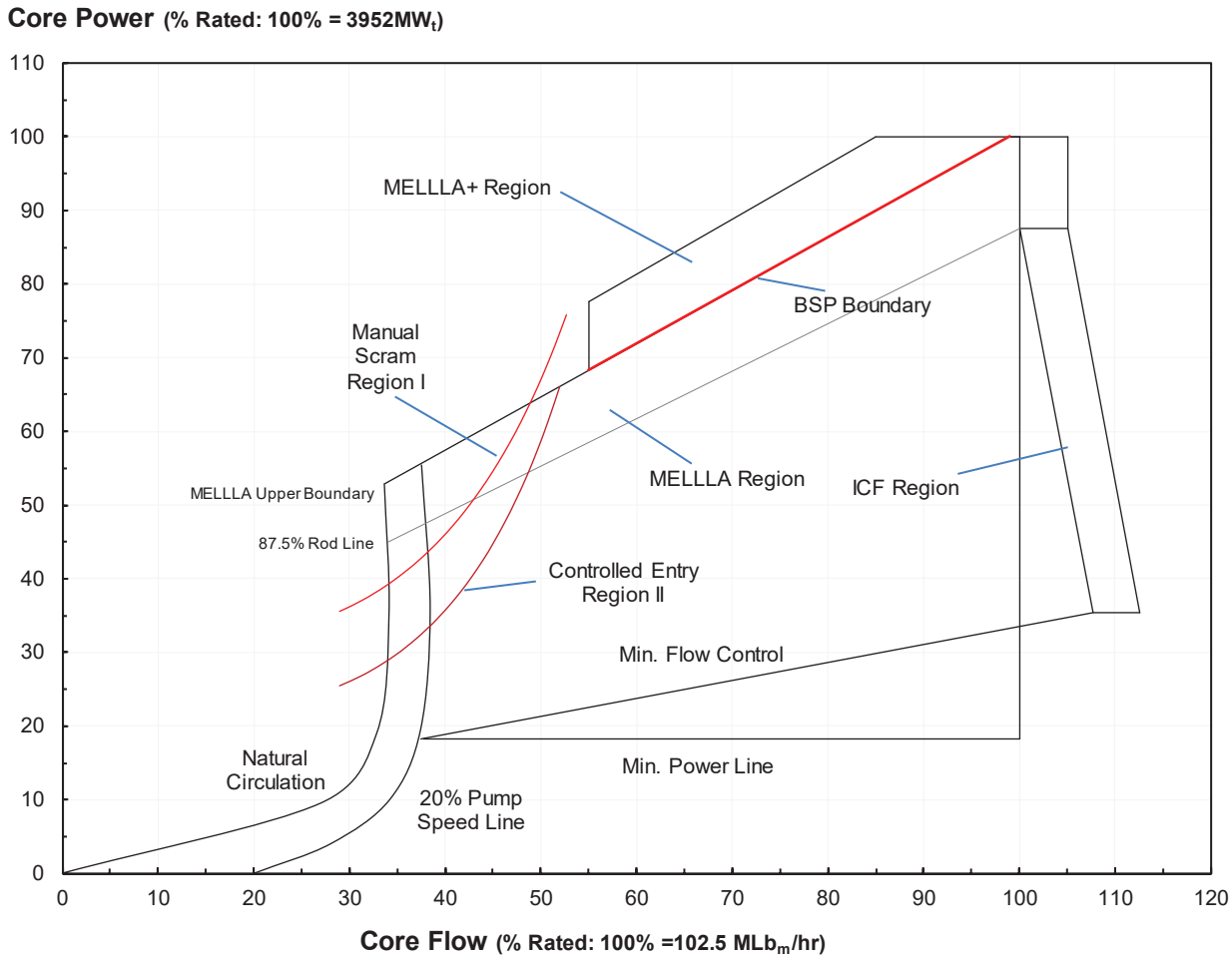


Figure A.1 MBSP Boundaries For Nominal Feedwater Temperature
(Operation in the MELLLA+ Region Prohibited for Feedwater Temperature greater than 10 degrees F below the Nominal Feedwater Temperature)

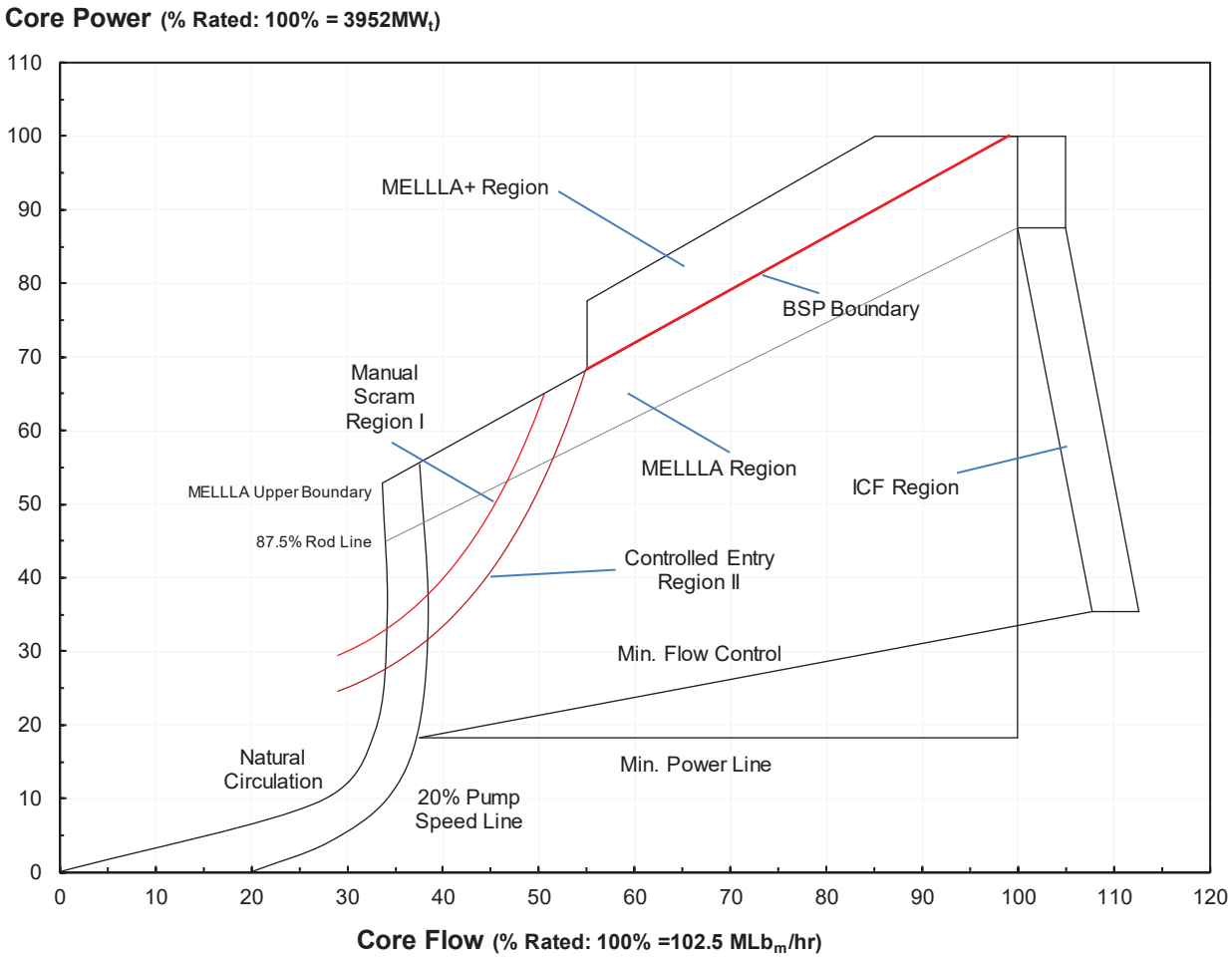


Figure A.2 MBSP Boundaries For Reduced Feedwater Temperature

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

Enclosure
Tennessee Valley Authority
Browns Ferry Nuclear Plant
Unit 3

Core Operating Limits Report, (120% OLTP, MELLLA+), for Unit 3 Cycle 20 Operation, TVA-COLR-BF3C20, Revision 2

(See Attached)

ECM L32 210902 802
QA RECORD
BFE-4485, Revision 2

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Browns Ferry Unit 3 Cycle 20

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

TVA-COLR-BF3C20 Revision 2 (Final)
(Revision Log, Page v)

September 2021

Prepared: Mitchell, Brye C. Digitally signed by Mitchell, Brye C Date: 2021.11.18 11:30:25 -05'00' Date: _____
B. C. Mitchell, Engineer

Verified: _____ Date: 11/18/2021
T. W. Eichenberg, Engineer

Approved: _____ Digitally signed by Seifert, Christine A DN: dc=gov, dc=tva, dc=main, ou=Main, ou=Corporate, ou=Users, cn=Seifert, Christine A, email=caseifert@tva.gov Reason: I am approving this document Date: 2021.11.19 [illegible] -05'00' Date: _____
C. A. Setter, Manager, BWRFE

Reviewed: _____ Date: 11/19/2021
B. T. Williamson, Manager, Reactor Engineering

Approved: _____ Date: 12/21/21
Chairman, PORC

Approved: _____ Date: 12-21-21
Plant Manager

TVA NPG
Reactor Engineering and Fuels - BWRFE
1101 Market Street, Chattanooga TN 37402

Date: September 8, 2021

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Number	Page	Description
1-R2	26	Updated Table 4.9 footnote per CR 1718921
1-R1	14	Updated Table 4.1 Nominal Scram Time Basis per CR 1604385
2-R1	32	Updated ≥ symbol per CR 1596417
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

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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Reactor Engineering and Fuels - BWRFE
1101 Market Street, Chattanooga TN 37402

Date: September 8, 2021

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, ≥ 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, ≥ 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, ≥ 23% RTP (Technical Specifications definition of RTP)
- Thermal-Hydraulic Stability Protection
  (Technical Specification Table 3.3.1.1)
  Applicability: Mode 1, ≥ (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, ≥ (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, ≥ % 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 fresh, and previously 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-10XM XMLC-4105B-11GV70-FCG	18	72	19	FCG601-FCG672
ATRIUM-10XM XMLC-4096B-12GV80-FCG	18	22	20	FCG673-FCG808
ATRIUM-10XM XMLC-4055B-13GV70-FCG	18	17	21	FCG809-FCG904
ATRIUM-10XM XMLC-3911B-13GV80-FCH	19	238	22	FCH001-FCH240
ATRIUM-10XM XMLC-4053B-12GV80-FCH	19	103	23	FCH241-FCH344
ATRIUM-10XM XMLC-3920B-14GV80-FCJ	20	224	24	FCJ345-FCJ568
ATRIUM-10XM XMLC-3957B-12GV80-FCJ	20	88	25	FCJ569-FCJ656

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:

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

where:

APLHGR_P	off-rated power APLHGR limit	[APLHGR_{RATED} * MAPFAC_P]
APLHGR_F	off-rated flow APLHGR limit	[APLHGR_{RATED} * MAPFAC_F]
APLHGR_{SLO}	SLO APLHGR limit	[APLHGR_{RATED} * SLO Multiplier]

2.1 Rated Power and Flow Limit: APLHGR_{RATED}

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

2.2 Off-Rated Power Dependent Limit: APLHGR_P

Reference 1 does not specify a power dependent APLHGR. Therefore, MAPFAC_P is set to a value of **1.0**.

2.2.1 Startup without Feedwater Heaters

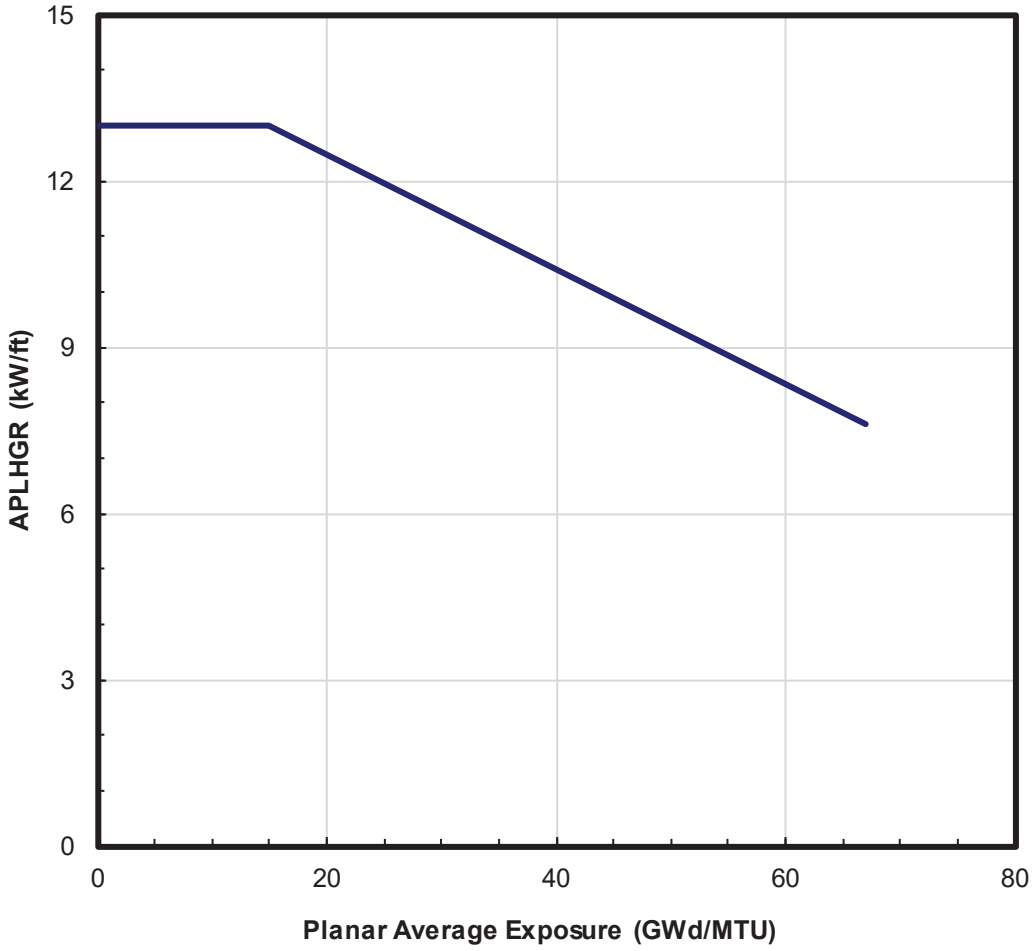
There is a range of operation during startup when the feedwater heaters are not placed into service until after the unit has reached a significant operating power level. No additional power dependent limitation is required.

2.3 Off-Rated Flow Dependent Limit: APLHGR_F

Reference 1 does not specify a flow dependent APLHGR. Therefore, MAPFAC_F is set to a value of **1.0**.

2.4 Single Loop Operation Limit: APLHGR_{SLO}

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



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

Figure 2.1 $APLHGR_{RATED}$ for ATRIUM-10XM Fuel

2.5 Equipment Out-Of-Service Corrections

The limits shown in Figure 2.1 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

* 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:

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

3.1 Rated Power and Flow Limit: LHGR_{RATED}

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

3.2 Off-Rated Power Dependent Limit: LHGR_P

LHGR limits are adjusted for off-rated power conditions using the 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 3.2.

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 3.4 and Figure 3.5, based on temperature conditions identified in Table 3.1.

Table 3.1 Startup Feedwater Temperature Basis

Power	Temperature	
	Range 1	Range 2
(% Rated)	(°F)	(°F)
23	160.0	155.0
30	167.0	162.0
40	177.0	172.0
50	187.0	182.0

3.3 Off-Rated Flow Dependent Limit: $LHGR_F$

LHGR limits are adjusted for off-rated flow conditions using the $LHGRFAC_F$ multiplier provided in Reference 1. Multipliers are shown in Figure 3.3.

3.4 Equipment Out-Of-Service Corrections

The limits shown in Figure 3.1 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.*

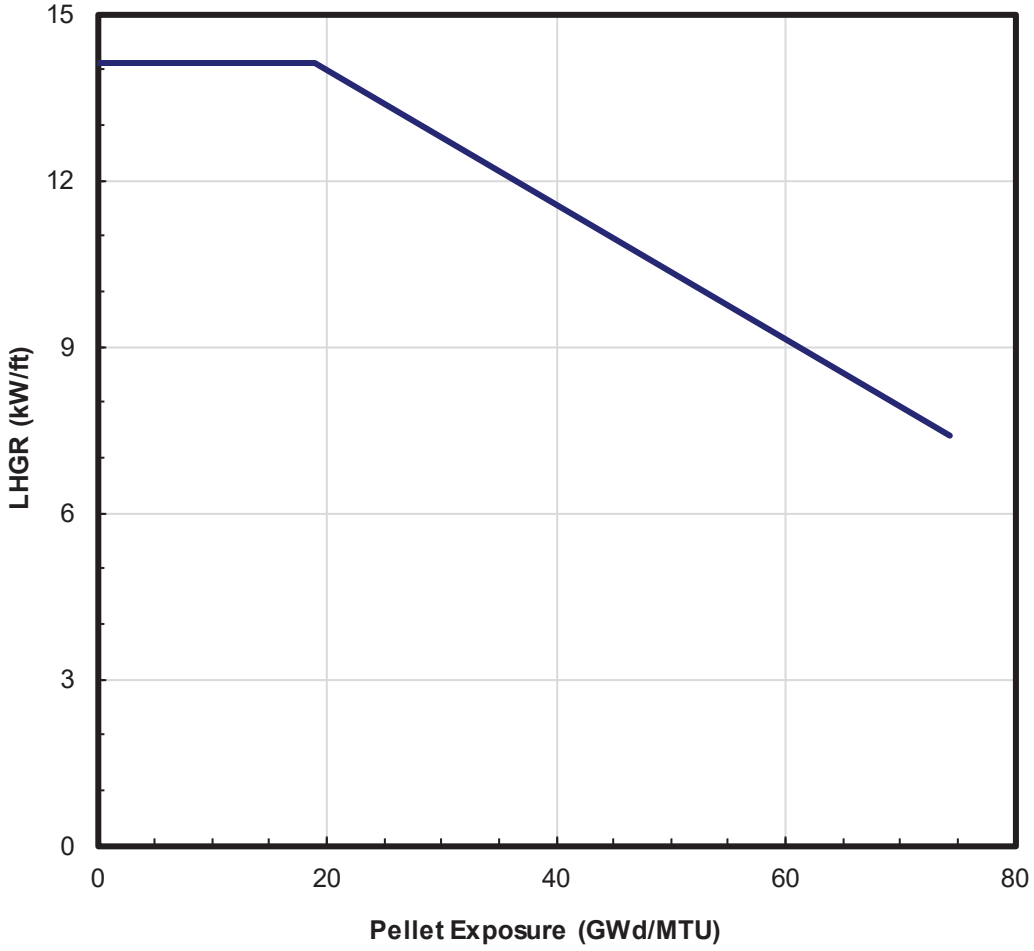
In-Service	All equipment In-Service
RPTOOS	EOC-Recirculation Pump Trip Out-Of-Service
TBVOOS	Turbine Bypass Valve(s) Out-Of-Service
PLUOOS	Power Load Unbalance Out-Of-Service
FHOOS (or FFWTR)	Feedwater Heaters Out-Of-Service or Final Feedwater Temperature Reduction
RCPOOS	One Recirculation Pump Out-Of-Service

Off-rated power corrections shown in Figure 3.2 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 3.3 are bounding for all EOOS conditions.

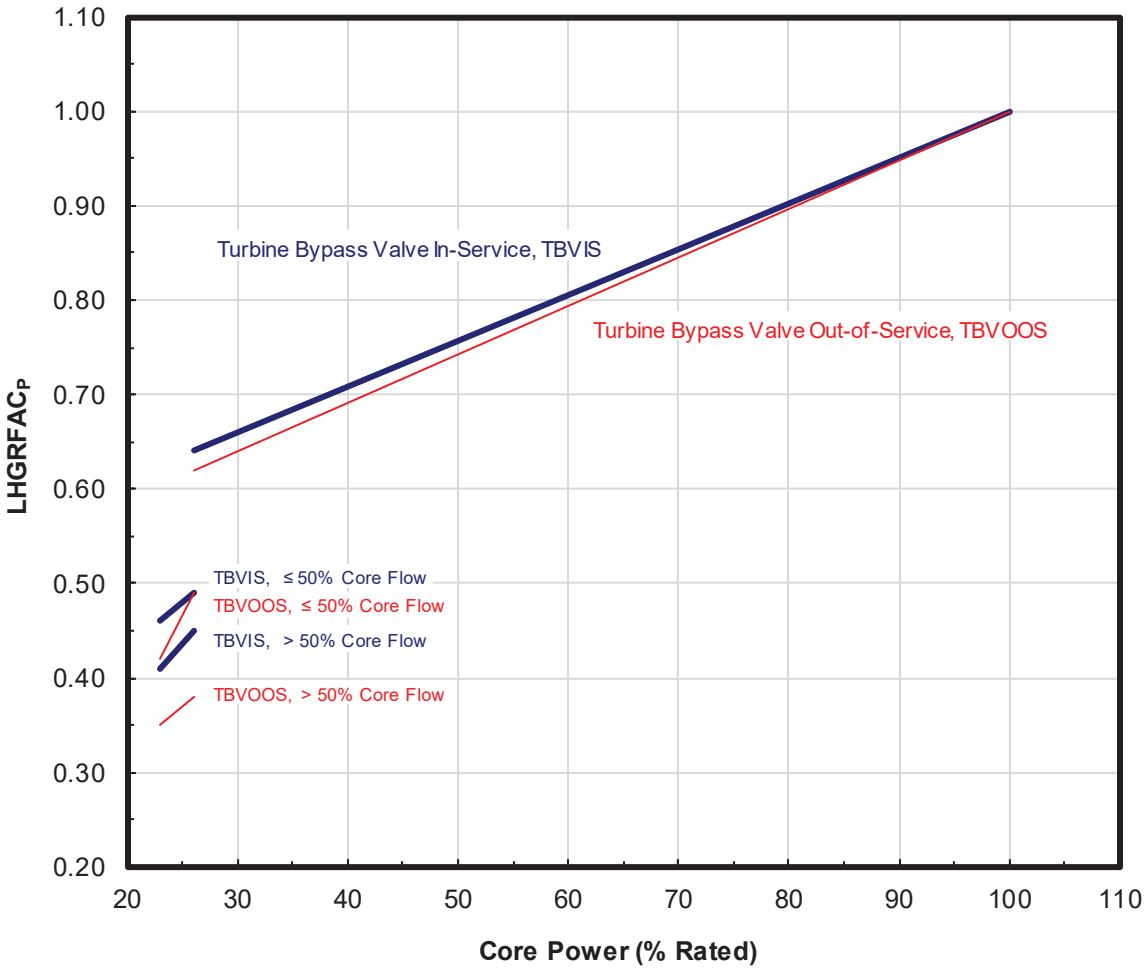
Off-rated power corrections shown in Figure 3.4 and Figure 3.5 are also dependent on operation of the Turbine Bypass Valve system. In this case, limits support FHOOS operation during startup. These limits have no dependency on RPTOOS, PLUOOS, or SLO.

* All equipment service conditions assume 1 SRVOOS.



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

Figure 3.1 $LHGR_{RATED}$ for ATRIUM-10XM Fuel

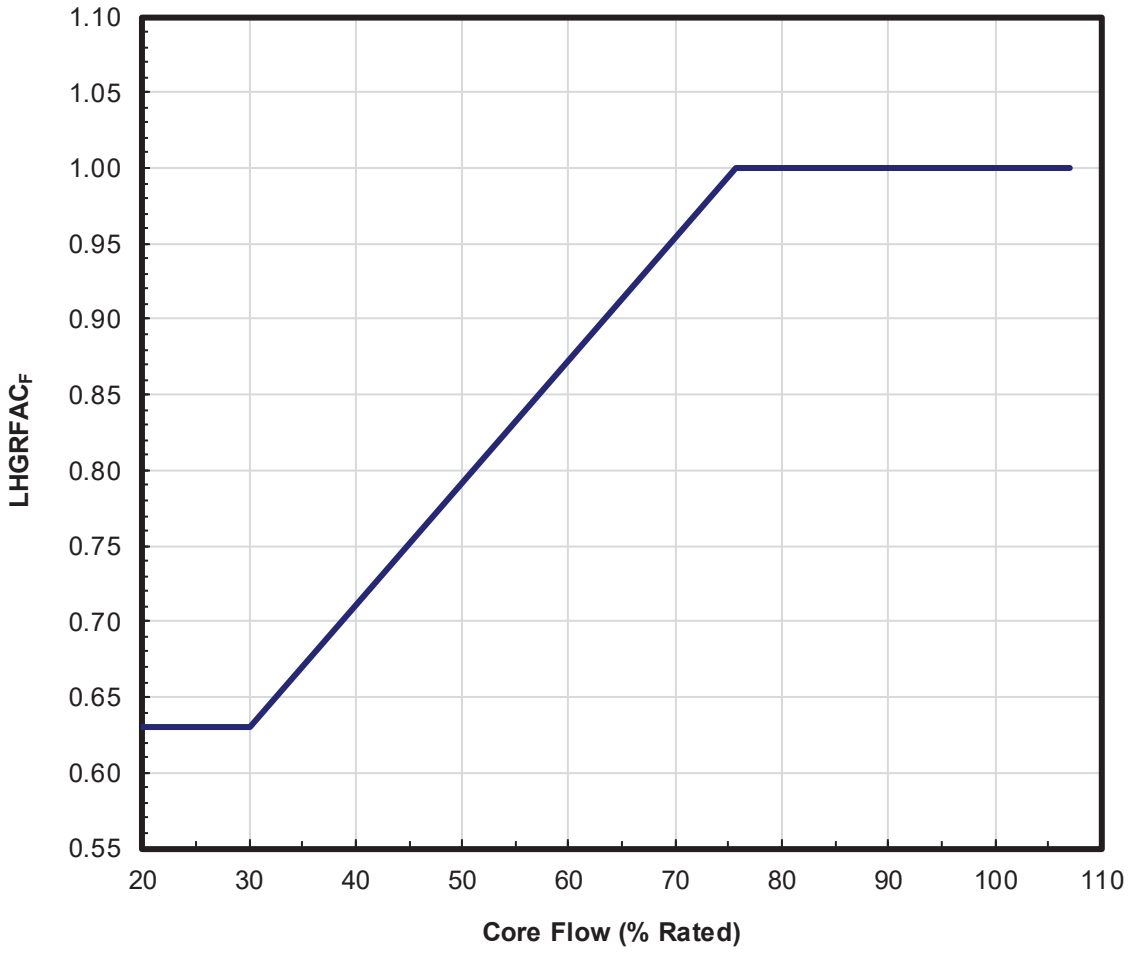


Turbine Bypass In-Service	
Core Power (% Rated)	**LHGRFAC$_P$**
100.0	1.00
26.0	0.64
Core Flow > 50% Rated	
26.0	0.45
23.0	0.41
Core Flow ≤ 50% Rated	
26.0	0.49
23.0	0.46

Turbine Bypass Out-of-Service	
Core Power (% Rated)	**LHGRFAC$_P$**
100.0	1.00
26.0	0.62
Core Flow > 50% Rated	
26.0	0.38
23.0	0.35
Core Flow ≤ 50% Rated	
26.0	0.49
23.0	0.42

Figure 3.2 Base Operation LHGRFAC$_P$ for ATRIUM-10XM Fuel

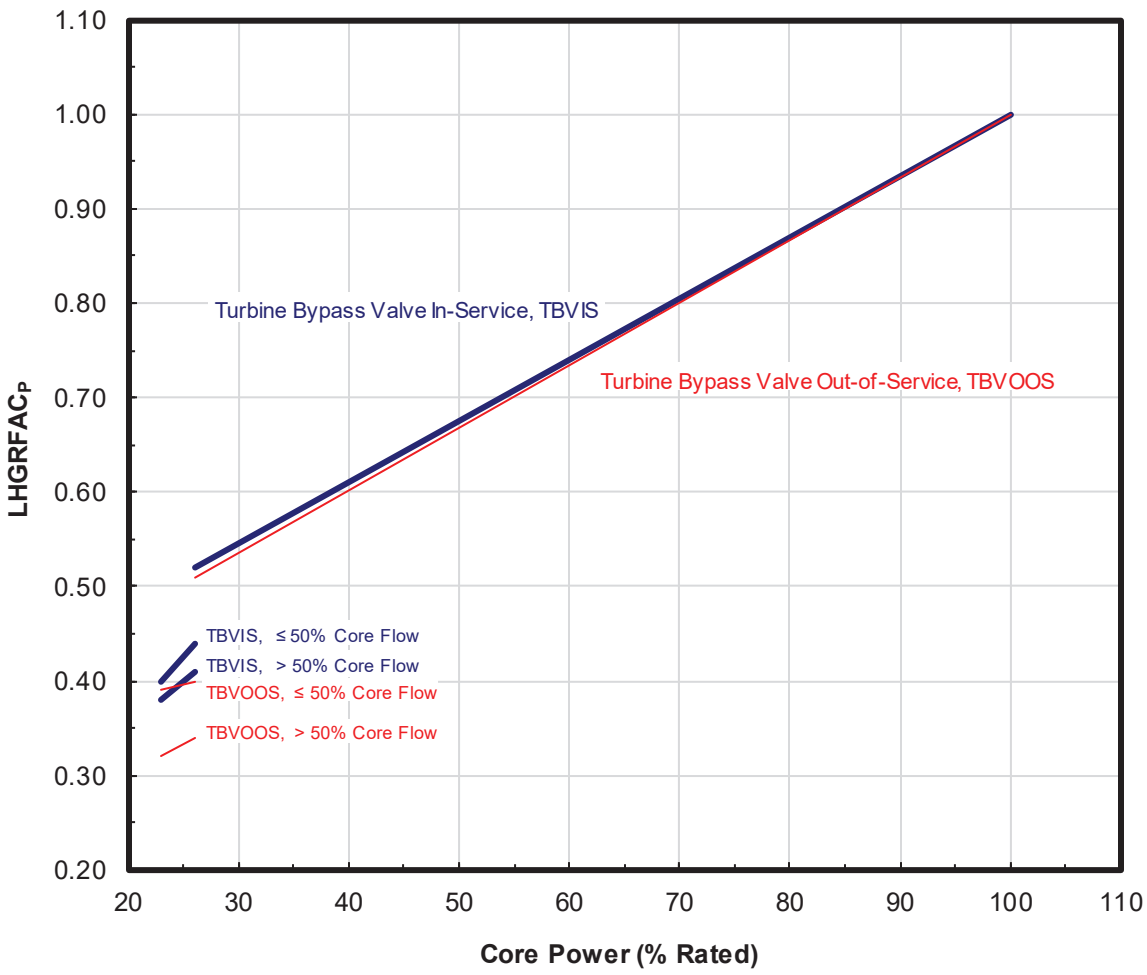
(*Independent of other EOOS conditions*)



Core Flow (% Rated)	LHGRFAC$_F$
0.0	0.63
30.0	0.63
75.6	1.00
107.0	1.00

Figure 3.3 LHGRFAC$_F$ for ATRIUM-10XM Fuel
(*Values bound all EOOS conditions*)

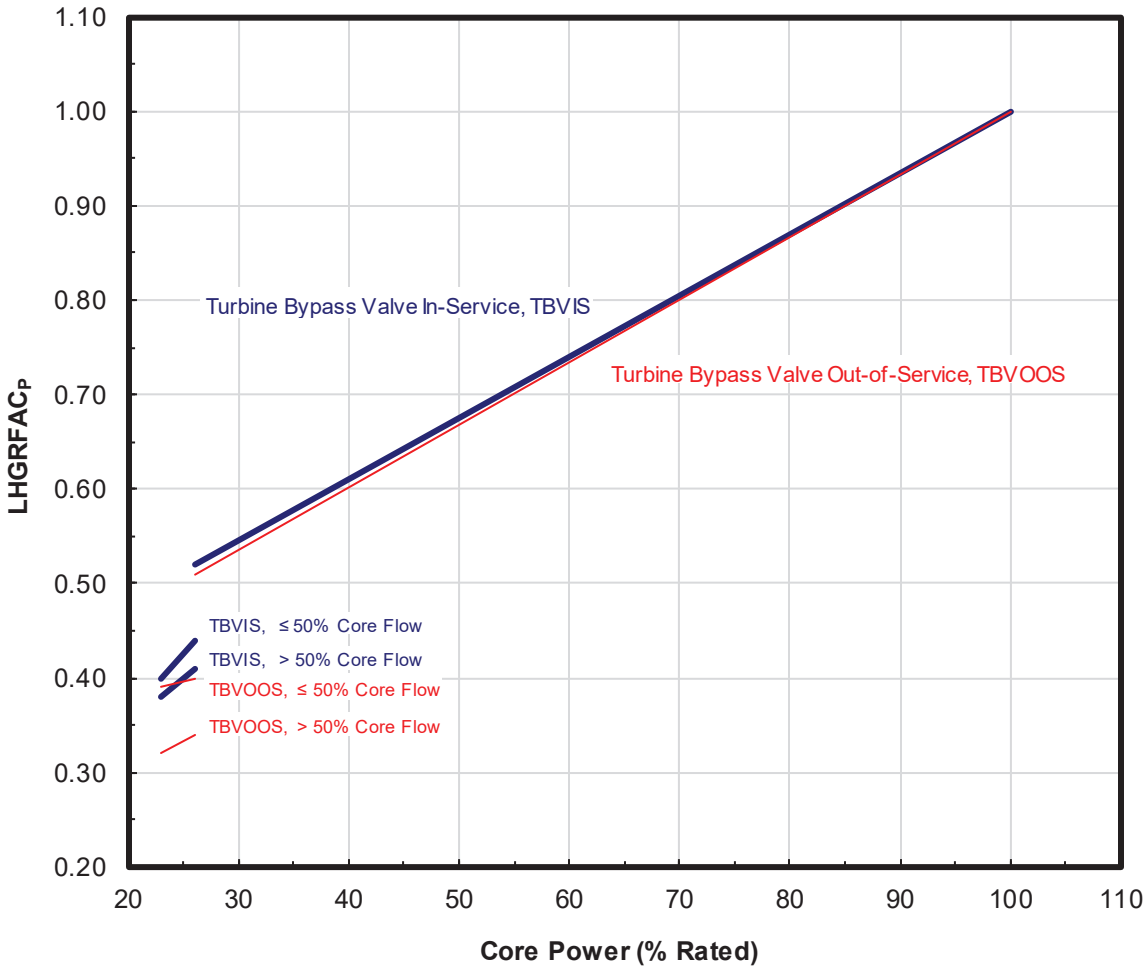
(*107.0% maximum core flow line is used to support 105% rated flow operation, ICF*)



Turbine Bypass In-Service	
Core Power (% Rated)	**LHGRFAC$_P$**
100.0	1.00
26.0	0.52
Core Flow > 50% Rated	
26.0	0.41
23.0	0.38
Core Flow ≤ 50% Rated	
26.0	0.44
23.0	0.40

Turbine Bypass Out-of-Service	
Core Power (% Rated)	**LHGRFAC$_P$**
100.0	1.00
26.0	0.51
Core Flow > 50% Rated	
26.0	0.34
23.0	0.32
Core Flow ≤ 50% Rated	
26.0	0.40
23.0	0.39

Figure 3.4 Startup Operation LHGRFAC$_P$ 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 (% Rated)	**LHGRFAC$_P$**
100.0	1.00
26.0	0.52
Core Flow > 50% Rated	
26.0	0.41
23.0	0.38
Core Flow ≤ 50% Rated	
26.0	0.44
23.0	0.40

Turbine Bypass Out-of-Service	
Core Power (% Rated)	**LHGRFAC$_P$**
100.0	1.00
26.0	0.51
Core Flow > 50% Rated	
26.0	0.34
23.0	0.32
Core Flow ≤ 50% Rated	
26.0	0.40
23.0	0.39

Figure 3.5 Startup Operation LHGRFAC$_P$ 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

$$\text{OLMCPR limit} = \text{MAX} (MCPR_F , MCPR_P)$$

where:

$MCPR_F$	core flow-dependent MCPR limit
$MCPR_P$	power-dependent MCPR limit

4.1 Flow Dependent MCPR Limit: $MCPR_F$

$MCPR_F$ limits are dependent upon core flow (% of Rated), and the max core flow limit, (Rated or Increased Core Flow, ICF). $MCPR_F$ 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: $MCPR_P$

$MCPR_P$ 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 $MCPR_P$ 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 $MCPR_P$ 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)*

$MCPR_P$ limits are provided for three different sets of assumed scram speeds. The Technical Specification Scram Speed (TSSS) $MCPR_P$ 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	0.420	0.380
36	0.980	0.875
26	1.600	1.465
6	2.900	2.900

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 $MCPR_P$ 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 $MCPR_P$ limits are always more limiting and may be used for any Core Average Exposure up to the ending exposure. Per Reference 1, $MCPR_P$ limits are provided for the following exposure ranges:

BOC to NEOC	NEOC corresponds to	**27,972.7 MWd / MTU**
BOC to EOCLB	EOCLB corresponds to	**33,104.7 MWd / MTU**
BOC to End of Coast	End of Coast	**34,799.5 MWd / MTU**

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 $MCPR_P$ 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 $MCPR_P$ limits are also provided including FHOOS. The coast down exposure range assumes application of FFWTR. FHOOS based $MCPR_P$ 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

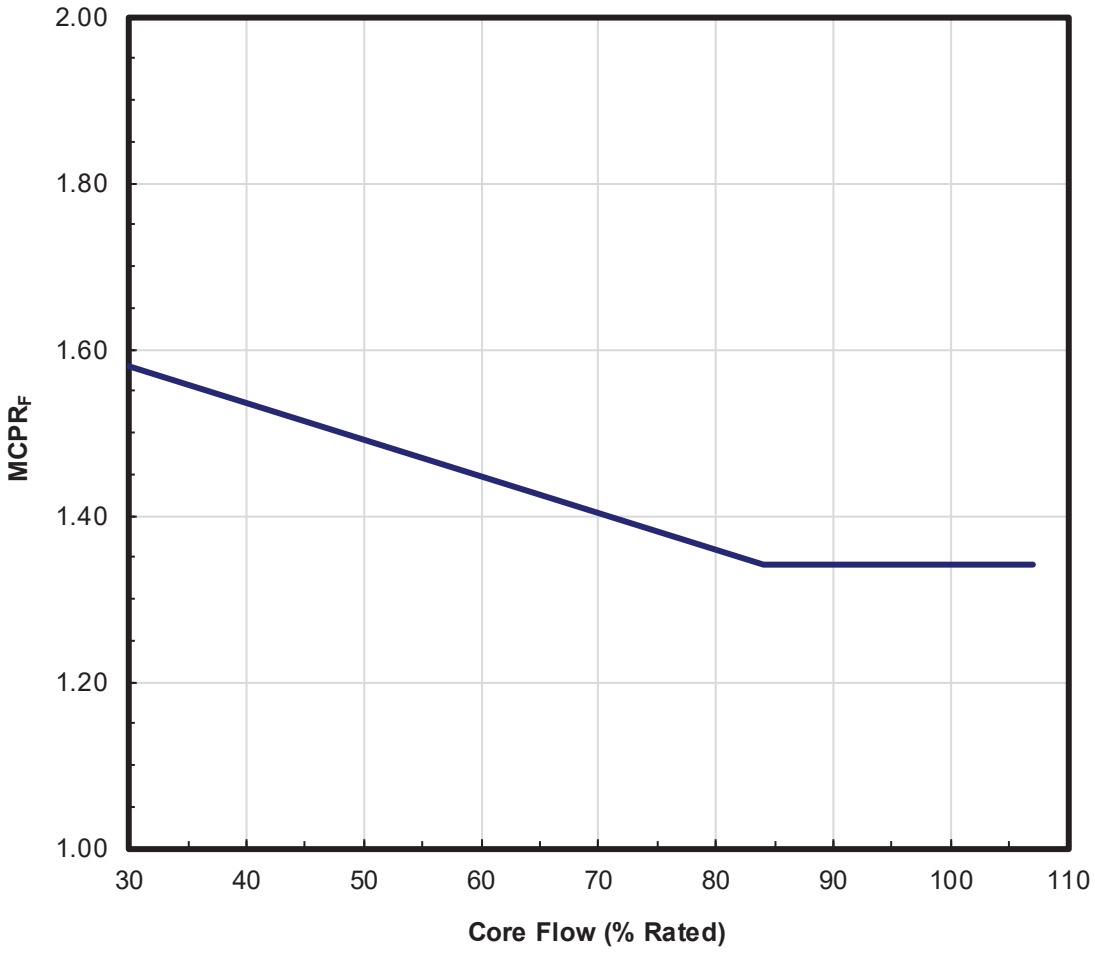
When operating in RCPOOS conditions, MCPRp limits are constructed differently from the normal operating RCP conditions. The limiting event for RCPOOS is a pump seizure scenario, which sets the upper bound for allowed core power and flow†. This event is not impacted by scram time assumptions. Specific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

4.2.6 Below Pbypass Limits

Below Pbypass (26% rated power), $MCPR_P$ limits depend upon core flow. One set of $MCPR_P$ 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_m/hr.



Core Flow (% Rated)	$MCPR_F$
30.0	1.58
84.0	1.34
107.0	1.34

Figure 4.1 $MCPR_F$ 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 $MCPR_P$ Limits for All Fuel Types: Optimum Scram Time Basis*

Operating Condition	Power (% of rated)	ATRIUM-10XM		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast
Base Case	100	1.39	1.41	1.44
	90	1.45	1.46	1.48
	77.6	1.50	1.51	1.54
	65	1.57	1.57	1.61
	>50	1.65	1.65	1.70
	≤50	1.79	1.79	1.79
	40	1.87	1.87	1.88
	26	2.27	2.27	2.38
	26 at > 50%F	2.60	2.60	2.70
	23 at > 50%F	2.76	2.76	2.88
	26 at ≤ 50%F	2.49	2.49	2.60
	23 at ≤ 50%F	2.64	2.64	2.77
FHOOS	100	1.42	1.44	---
	90	1.48	1.48	---
	77.6	1.54	1.54	---
	65	1.61	1.61	---
	>50	1.70	1.70	---
	≤50	1.79	1.79	---
	40	1.88	1.88	---
	26	2.38	2.38	---
	26 at > 50%F	2.70	2.70	---
	23 at > 50%F	2.88	2.88	---
	26 at ≤ 50%F	2.60	2.60	---
	23 at ≤ 50%F	2.77	2.77	---

* 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 $MCPR_P$ Limits for All Fuel Types: Nominal Scram Time Basis*

Operating Condition	Power (% of rated)	ATRIUM-10XM		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast
Base Case	100	1.42	1.44	1.46
	90	1.48	1.48	1.51
	77.6	1.53	1.53	1.56
	65	1.59	1.59	1.63
	>50	1.67	1.67	1.72
	≤50	1.80	1.80	1.80
	40	1.88	1.88	1.90
	26	2.30	2.30	2.41
	26 at > 50%F	2.60	2.60	2.70
	23 at > 50%F	2.76	2.76	2.88
	26 at ≤ 50%F	2.49	2.49	2.60
	23 at ≤ 50%F	2.64	2.64	2.77
TBVOOS	100	1.46	1.47	1.50
	90	1.51	1.51	1.54
	77.6	1.56	1.56	1.60
	65	1.62	1.62	1.66
	>50	1.70	1.70	1.75
	≤50	1.80	1.80	1.81
	40	1.88	1.88	1.91
	26	2.30	2.30	2.42
	26 at > 50%F	3.11	3.11	3.25
	23 at > 50%F	3.36	3.36	3.50
	26 at ≤ 50%F	2.83	2.83	2.99
	23 at ≤ 50%F	3.11	3.11	3.28
FHOOS	100	1.46	1.46	---
	90	1.51	1.51	---
	77.6	1.56	1.56	---
	65	1.63	1.63	---
	>50	1.72	1.72	---
	≤50	1.80	1.80	---
	40	1.90	1.90	---
	26	2.41	2.41	---
	26 at > 50%F	2.70	2.70	---
	23 at > 50%F	2.88	2.88	---
	26 at ≤ 50%F	2.60	2.60	---
	23 at ≤ 50%F	2.77	2.77	---
PLUOOS	100	1.42	1.44	1.46
	90	1.48	1.48	1.51
	77.6	1.53	1.53	1.56
	65	1.72	1.73	1.73
	>50	---	---	---
	≤50	1.80	1.80	1.80
	40	1.88	1.88	1.90
	26	2.30	2.30	2.41
	26 at > 50%F	2.60	2.60	2.70
	23 at > 50%F	2.76	2.76	2.88
	26 at ≤ 50%F	2.49	2.49	2.60
	23 at ≤ 50%F	2.64	2.64	2.77

* 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 $MCPR_P$ Limits for All Fuel Types: Nominal Scram Time Basis (*continued*)*

Operating Condition	Power (% of rated)	ATRIUM-10XM		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast
TBVOOS FHOOS	100	1.49	1.50	---
	90	1.54	1.54	---
	77.6	1.60	1.60	---
	65	1.66	1.66	---
	>50	1.75	1.75	---
	≤50	1.81	1.81	---
	40	1.91	1.91	---
	26	2.42	2.42	---
	26 at > 50%F	3.25	3.25	---
	23 at > 50%F	3.50	3.50	---
	26 at ≤ 50%F	2.99	2.99	---
	23 at ≤ 50%F	3.28	3.28	---
TBVOOS PLUOOS	100	1.46	1.47	1.50
	90	1.51	1.51	1.54
	77.6	1.56	1.56	1.60
	65	1.72	1.73	1.74
	>50	---	---	---
	≤50	1.80	1.80	1.81
	40	1.88	1.88	1.91
	26	2.30	2.30	2.42
	26 at > 50%F	3.11	3.11	3.25
	23 at > 50%F	3.36	3.36	3.50
	26 at ≤ 50%F	2.83	2.83	2.99
	23 at ≤ 50%F	3.11	3.11	3.28
FHOOS PLUOOS	100	1.46	1.46	---
	90	1.51	1.51	---
	77.6	1.56	1.56	---
	65	1.72	1.73	---
	>50	---	---	---
	≤50	1.80	1.80	---
	40	1.90	1.90	---
	26	2.41	2.41	---
	26 at > 50%F	2.70	2.70	---
	23 at > 50%F	2.88	2.88	---
	26 at ≤ 50%F	2.60	2.60	---
	23 at ≤ 50%F	2.77	2.77	---
TBVOOS FHOOS PLUOOS	100	1.49	1.50	---
	90	1.54	1.54	---
	77.6	1.60	1.60	---
	65	1.73	1.74	---
	>50	---	---	---
	≤50	1.81	1.81	---
	40	1.91	1.91	---
	26	2.42	2.42	---
	26 at > 50%F	3.25	3.25	---
	23 at > 50%F	3.50	3.50	---
	26 at ≤ 50%F	2.99	2.99	---
	23 at ≤ 50%F	3.28	3.28	---

* 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 $MCPR_P$ Limits for All Fuel Types: Technical Specification Scram Time Basis*

Operating Condition	Power (% of rated)	ATRIUM-10XM		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast
Base Case	100	1.46	1.46	1.50
	90	1.50	1.50	1.55
	77.6	1.55	1.55	1.59
	65	1.61	1.61	1.66
	>50	1.68	1.68	1.75
	≤50	1.80	1.80	1.82
	40	1.88	1.88	1.94
	26	2.32	2.32	2.44
	26 at > 50%F	2.60	2.60	2.71
	23 at > 50%F	2.76	2.76	2.89
	26 at ≤ 50%F	2.49	2.49	2.61
	23 at ≤ 50%F	2.64	2.64	2.78
TBVOOS	100	1.50	1.50	1.54
	90	1.55	1.55	1.59
	77.6	1.59	1.59	1.64
	65	1.65	1.65	1.70
	>50	1.73	1.73	1.79
	≤50	1.81	1.81	1.84
	40	1.89	1.89	1.96
	26	2.34	2.34	2.47
	26 at > 50%F	3.12	3.12	3.27
	23 at > 50%F	3.37	3.37	3.52
	26 at ≤ 50%F	2.84	2.84	3.01
	23 at ≤ 50%F	3.12	3.12	3.30
FHOOS	100	1.50	1.50	---
	90	1.55	1.55	---
	77.6	1.59	1.59	---
	65	1.66	1.66	---
	>50	1.75	1.75	---
	≤50	1.81	1.81	---
	40	1.94	1.94	---
	26	2.44	2.44	---
	26 at > 50%F	2.71	2.71	---
	23 at > 50%F	2.89	2.89	---
	26 at ≤ 50%F	2.61	2.61	---
	23 at ≤ 50%F	2.78	2.78	---
PLUOOS	100	1.46	1.46	1.50
	90	1.50	1.50	1.55
	77.6	1.55	1.55	1.59
	65	1.73	1.74	1.75
	>50	---	---	---
	≤50	1.80	1.80	1.82
	40	1.88	1.88	1.94
	26	2.32	2.32	2.44
	26 at > 50%F	2.60	2.60	2.71
	23 at > 50%F	2.76	2.76	2.89
	26 at ≤ 50%F	2.49	2.49	2.61
	23 at ≤ 50%F	2.64	2.64	2.78

* 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 $MCPR_P$ Limits for All Fuel Types: Technical Specification Scram Time Basis (*continued*)*

Operating Condition	Power (% of rated)	ATRIUM-10XM		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast
TBVOOS FHOOS	100	1.54	1.54	---
	90	1.59	1.59	---
	77.6	1.64	1.64	---
	65	1.70	1.70	---
	>50	1.79	1.79	---
	≤50	1.83	1.83	---
	40	1.96	1.96	---
	26	2.47	2.47	---
	26 at > 50%F	3.27	3.27	---
	23 at > 50%F	3.52	3.52	---
	26 at ≤ 50%F	3.01	3.01	---
	23 at ≤ 50%F	3.30	3.30	---
TBVOOS PLUOOS	100	1.50	1.50	1.54
	90	1.55	1.55	1.59
	77.6	1.59	1.59	1.64
	65	1.74	1.75	1.77
	>50	---	---	---
	≤50	1.81	1.81	1.84
	40	1.89	1.89	1.96
	26	2.34	2.34	2.47
	26 at > 50%F	3.12	3.12	3.27
	23 at > 50%F	3.37	3.37	3.52
	26 at ≤ 50%F	2.84	2.84	3.01
	23 at ≤ 50%F	3.12	3.12	3.30
FHOOS PLUOOS	100	1.50	1.50	---
	90	1.55	1.55	---
	77.6	1.59	1.59	---
	65	1.74	1.75	---
	>50	---	---	---
	≤50	1.81	1.81	---
	40	1.94	1.94	---
	26	2.44	2.44	---
	26 at > 50%F	2.71	2.71	---
	23 at > 50%F	2.89	2.89	---
	26 at ≤ 50%F	2.61	2.61	---
	23 at ≤ 50%F	2.78	2.78	---
TBVOOS FHOOS PLUOOS	100	1.54	1.54	---
	90	1.59	1.59	---
	77.6	1.64	1.64	---
	65	1.76	1.77	---
	>50	---	---	---
	≤50	1.83	1.83	---
	40	1.96	1.96	---
	26	2.47	2.47	---
	26 at > 50%F	3.27	3.27	---
	23 at > 50%F	3.52	3.52	---
	26 at ≤ 50%F	3.01	3.01	---
	23 at ≤ 50%F	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 $MCPR_P$ Limits for Table 3.1 Temperature Range 1 for All Fuel Types: Nominal Scram Time Basis *

Operating Condition	Power (% of rated)	ATRIUM-10XM		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast
TBVIS	100	1.46	1.46	1.46
	90	1.51	1.51	1.51
	77.6	1.56	1.56	1.56
	65	1.72	1.73	1.73
	>50	---	---	---
	≤50	1.84	1.84	1.84
	40	2.07	2.07	2.07
	26	2.66	2.66	2.66
	26 at > 50%F	2.92	2.92	2.92
	23 at > 50%F	3.14	3.14	3.14
	26 at ≤ 50%F	2.82	2.82	2.82
	23 at ≤ 50%F	3.04	3.04	3.04
TBVOOS	100	1.49	1.50	1.50
	90	1.54	1.54	1.54
	77.6	1.60	1.60	1.60
	65	1.73	1.74	1.74
	>50	---	---	---
	≤50	1.85	1.85	1.85
	40	2.08	2.08	2.08
	26	2.67	2.67	2.67
	26 at > 50%F	3.44	3.44	3.44
	23 at > 50%F	3.69	3.69	3.69
	26 at ≤ 50%F	3.18	3.18	3.18
	23 at ≤ 50%F	3.51	3.51	3.51

* 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 $MCPR_P$ Limits for Table 3.1 Temperature Range 2 for All Fuel Types: Nominal Scram Time Basis *

Operating Condition	Power (% of rated)	ATRIUM-10XM		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast
TBVIS	100	1.46	1.46	1.46
	90	1.51	1.51	1.51
	77.6	1.56	1.56	1.56
	65	1.72	1.73	1.73
	>50	---	---	---
	≤50	1.85	1.85	1.85
	40	2.08	2.08	2.08
	26	2.68	2.68	2.68
	26 at > 50%F	2.94	2.94	2.94
	23 at > 50%F	3.15	3.15	3.15
	26 at ≤ 50%F	2.84	2.84	2.84
	23 at ≤ 50%F	3.06	3.06	3.06
TBVOOS	100	1.49	1.50	1.50
	90	1.54	1.54	1.54
	77.6	1.60	1.60	1.60
	65	1.73	1.74	1.74
	>50	---	---	---
	≤50	1.86	1.86	1.86
	40	2.09	2.09	2.09
	26	2.69	2.69	2.69
	26 at > 50%F	3.45	3.45	3.45
	23 at > 50%F	3.71	3.71	3.71
	26 at ≤ 50%F	3.20	3.20	3.20
	23 at ≤ 50%F	3.52	3.52	3.52

* 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 $MCPR_P$ Limits for Table 3.1 Temperature Range 1 for All Fuel Types: Technical Specification Scram Time Basis*

Operating Condition	Power (% of rated)	ATRIUM-10XM		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast
TBVIS	100	1.50	1.50	1.50
	90	1.55	1.55	1.55
	77.6	1.59	1.59	1.59
	65	1.74	1.75	1.75
	>50	---	---	---
	≤50	1.88	1.88	1.88
	40	2.11	2.11	2.11
	26	2.70	2.70	2.70
	26 at > 50%F	2.93	2.93	2.93
	23 at > 50%F	3.15	3.15	3.15
	26 at ≤ 50%F	2.83	2.83	2.83
	23 at ≤ 50%F	3.05	3.05	3.05
TBVOOS	100	1.54	1.54	1.54
	90	1.59	1.59	1.59
	77.6	1.64	1.64	1.64
	65	1.76	1.77	1.77
	>50	---	---	---
	≤50	1.90	1.90	1.90
	40	2.13	2.13	2.13
	26	2.72	2.72	2.72
	26 at > 50%F	3.46	3.46	3.46
	23 at > 50%F	3.71	3.71	3.71
	26 at ≤ 50%F	3.20	3.20	3.20
	23 at ≤ 50%F	3.53	3.53	3.53

* 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 $MCPR_P$ Limits for Table 3.1 Temperature Range 2 for All Fuel Types: Technical Specification Scram Time Basis*

Operating Condition	Power (% of rated)	ATRIUM-10XM		
		BOC to NEOC	BOC to EOCLB	BOC to End of Coast
TBVIS	100	1.50	1.50	1.50
	90	1.55	1.55	1.55
	77.6	1.59	1.59	1.59
	65	1.74	1.75	1.75
	>50	---	---	---
	≤50	1.89	1.89	1.89
	40	2.12	2.12	2.12
	26	2.72	2.72	2.72
	26 at > 50%F	2.95	2.95	2.95
	23 at > 50%F	3.16	3.16	3.16
	26 at ≤ 50%F	2.85	2.85	2.85
	23 at ≤ 50%F	3.07	3.07	3.07
TBVOOS	100	1.54	1.54	1.54
	90	1.59	1.59	1.59
	77.6	1.64	1.64	1.64
	65	1.76	1.77	1.77
	>50	---	---	---
	≤50	1.91	1.91	1.91
	40	2.14	2.14	2.14
	26	2.74	2.74	2.74
	26 at > 50%F	3.47	3.47	3.47
	23 at > 50%F	3.73	3.73	3.73
	26 at ≤ 50%F	3.22	3.22	3.22
	23 at ≤ 50%F	3.54	3.54	3.54

* 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 $MCPR_P$ Limits for All Fuel Types: Single Loop Operation for All Scram Times *

Operating Condition	Power (% of rated)	BOC to End of COAST ATRIUM-10XM
RCPOOS FHOOS	100	2.10
	43.75	2.10
	40	2.10
	26	2.46
	26 at > 50%F	2.73
	23 at > 50%F	2.91
	26 at ≤ 50%F	2.63
	23 at ≤ 50%F	2.80
RCPOOS TBVOOS PLUOOS FHOOS	100	2.10
	43.75	2.10
	40	2.10
	26	2.49
	26 at > 50%F	3.29
	23 at > 50%F	3.54
	26 at ≤ 50%F	3.03
	23 at ≤ 50%F	3.32
RCPOOS TBVOOS FHOOS1	100	2.15
	43.75	2.15
	40	2.15
	26	2.74
	26 at > 50%F	3.48
	23 at > 50%F	3.73
	26 at ≤ 50%F	3.22
	23 at ≤ 50%F	3.55
RCPOOS TBVOOS FHOOS2	100	2.16
	43.75	2.16
	40	2.16
	26	2.76
	26 at > 50%F	3.49
	23 at > 50%F	3.75
	26 at ≤ 50%F	3.24
	23 at ≤ 50%F	3.56

* 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 43.75% 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	29.0	Scram Region (Region I) Boundary Intercept on Natural Circulation Line (NCL)
A2	66.1	52.0	Controlled Entry Region (Region II) Boundary Intercept on MELLLA Line
B2	25.5	29.0	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	29.0	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	29.0	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:

$SRB \leq (0.61W_d + 63.3)$ Allowable Value

$SRB \leq (0.61W_d + 62.0)$ Nominal Trip Setpoint (NTSP)

where:

SRB = Rod Block setting in percent of rated thermal power (3952 MW_t)

W_d = Recirculation drive flow rate in percent of rated
(100% drive flow required to achieve 100% core power and flow)

and for single loop operation:

$SRB \leq (0.55(W_d-\Delta W) + 60.5)$ Allowable Value

$SRB \leq (0.55(W_d-\Delta W) + 58.5)$ Nominal Trip Setpoint (NTSP)

where:

SRB = Rod Block setting in percent of rated thermal power (3952 MW_t)

W_d = Recirculation drive flow rate in percent of rated
(100% drive flow required to achieve 100% core power and flow)

ΔW = Difference between two-loop and single-loop effective recirculation flow at the same core flow (ΔW=0.0 for two-loop operation)

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†	Notes from Table 3.3.2.1-1	Comment
> 27% and < 90%	< 1.74	(a), (b), (f), (h)	two loop operation
	< 1.78	(a), (b), (f), (h)	single loop operation
≥ 90%	< 1.38	(g)	two loop operation‡

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

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

‡ Greater than 90% rated power is not attainable in single loop operation.

Table 7.3 Control Rod Withdrawal Error Results

RBM HTSP Analytical Limit	CRWE OLMCPR
Unfiltered	
107	1.26
111	1.28
114	1.30
117	1.36

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

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:

SDM ≥ 0.38% dk/k

Reactor Engineering and Fuels - BWRFE
1101 Market Street, Chattanooga TN 37402

Appendix A: MBSP Maps

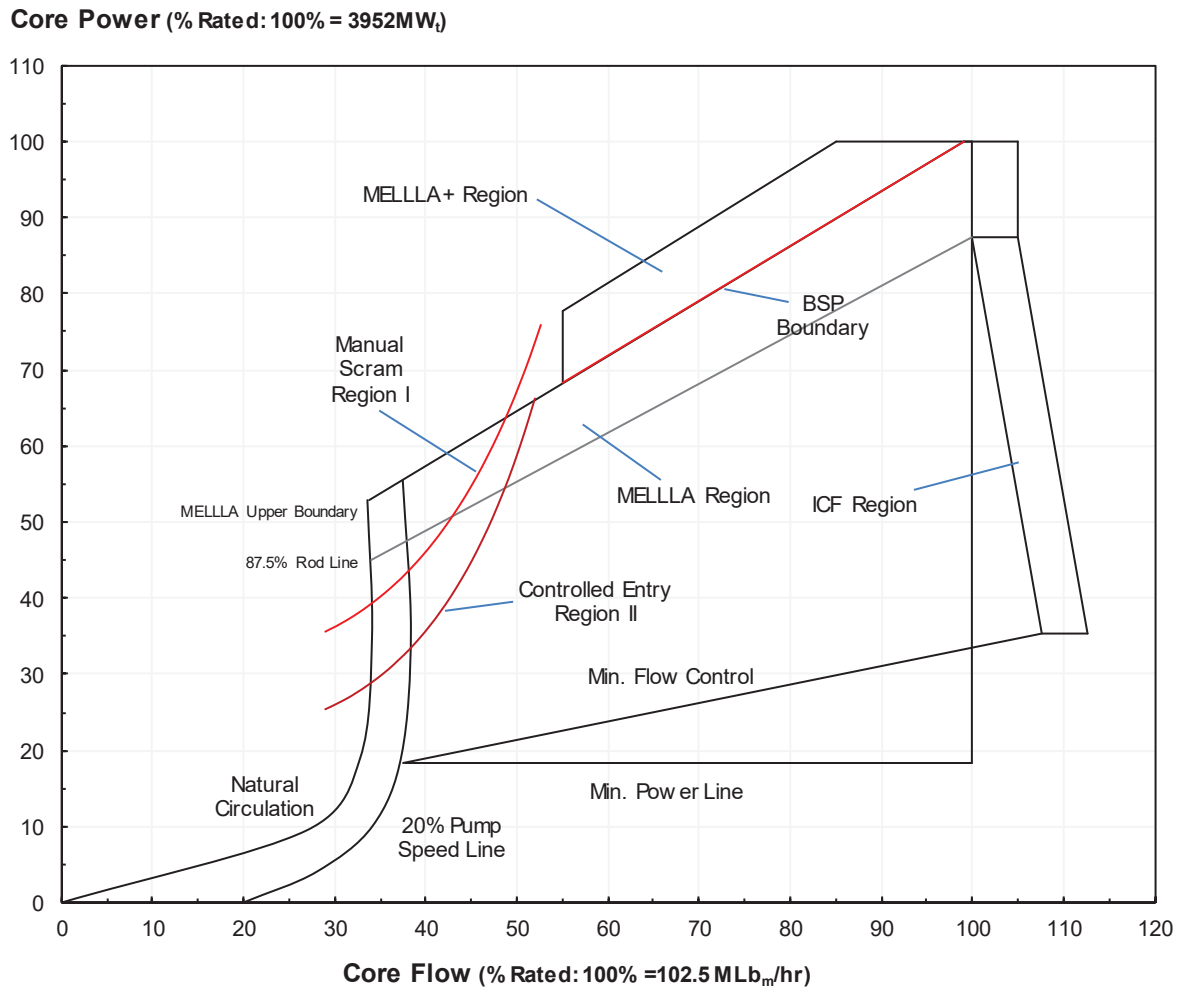


Figure A.1 MBSP Boundaries For Nominal Feedwater Temperature
(Operation in the MELLLA+ Region Prohibited for Feedwater Temperature greater than 10 degrees F below the Nominal Feedwater Temperature)

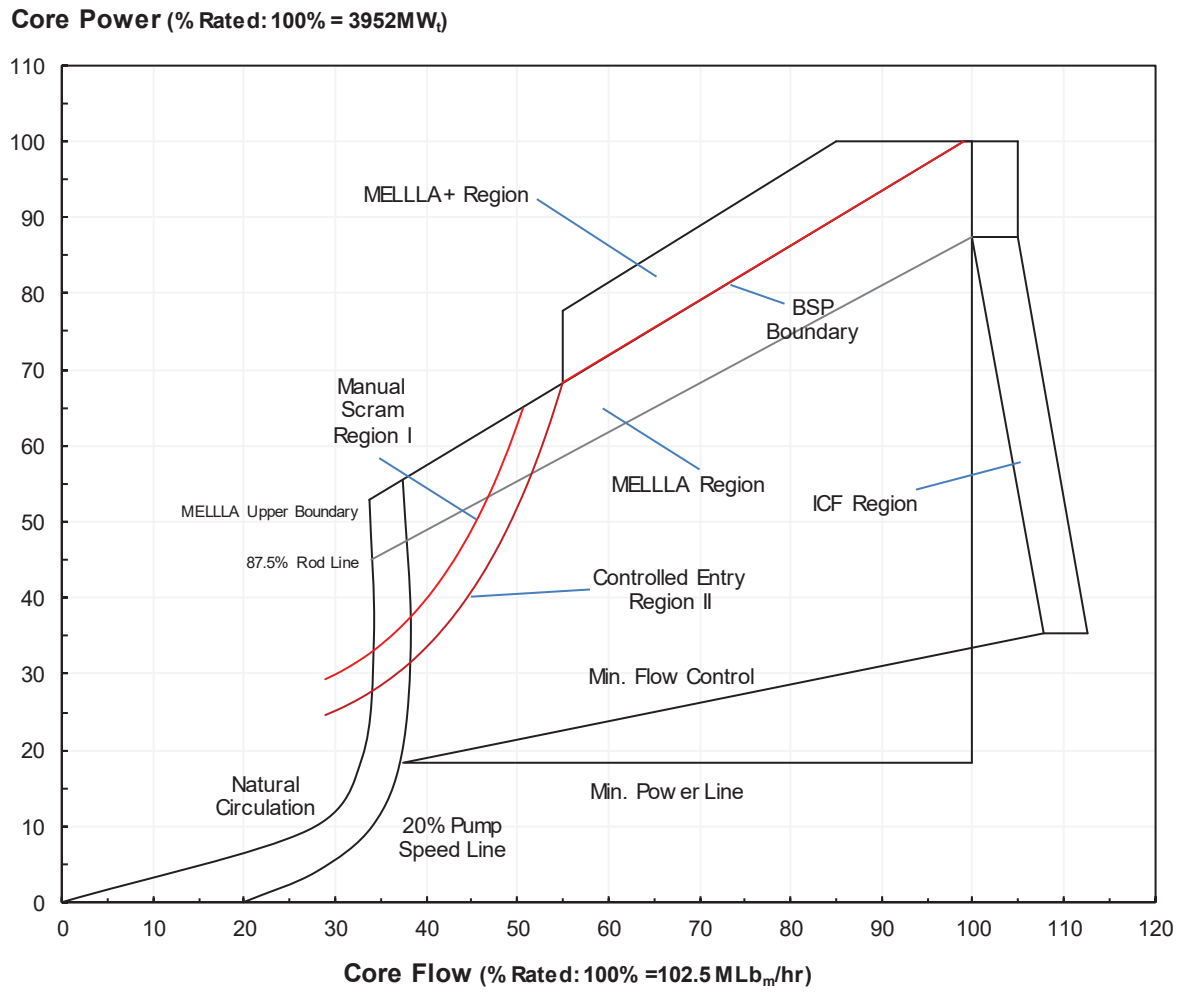


Figure A.2 MBSP Boundaries For Reduced Feedwater Temperature

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