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March 2, 2011

10 CFR 50.4

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U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Browns Ferry Nuclear Plant, Unit 2
Facility Operating License No. DPR-52
NRC Docket No. 50-260

Subject: **Browns Ferry Nuclear Plant, Unit 2 Core Operating Limits Report for Cycle 17 Operation**

In accordance with the requirements of Technical Specification 5.6.5.d, the Tennessee Valley Authority is submitting the Browns Ferry Nuclear Plant, Unit 2, Cycle 17, Core Operating Limits Report (COLR). The Unit 2, Cycle 17 COLR includes all modes of operation (Modes 1 through 5).

There are no new commitments contained in this letter. If you have any questions please contact Tom Matthews at (423) 751-2687.

Respectfully,

R. M. Krich

Enclosure: Core Operating Limits Report, (105% OLTP), for Cycle 17 Operation
TVA-COLR-BF2C17, Revision 0

cc: (Enclosure)
NRC Regional Administrator - Region II
NRC Senior Resident Inspector - Browns Ferry Nuclear Plant

D030
NRR

Enclosure
Tennessee Valley Authority
Browns Ferry Nuclear Plant
Unit 2

Core Operating Limits Report, (105% OLTP), for Cycle 17 Operation
TVA-COLR-BF2C17, Revision 0

(See Attached)

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Pages Affected: All
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TVA NPG

Nuclear Fuel Engineering - BWRFE
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Browns Ferry Unit 2 Cycle 17

Core Operating Limits Report, (105% OLTP)

TVA-COLR-BF2C17 **Revision 0 (Final)**
(Revision Log, Page v)

February 2011

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Revision Log

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Nomenclature

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
EOC	End of Cycle
EOOS	Equipment OOS
FFTR	Final Feedwater Temperature Reduction
FFWTR	Final Feedwater Temperature Reduction
FHOOS	Feedwater Heaters OOS
ft	Foot: english unit of measure for length
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)
MCPR	Minimum CPR
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
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
RPS	Reactor Protection System
RPT	Recirculation Pump Trip
RPTOOS	RPT OOS
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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PRNM Setpoint References

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1 Introduction

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

1.1 Purpose

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

1.2 Scope

This document will discuss the following areas:

- Average Planar Linear Heat Generation Rate (APLHGR) Limit
  (Technical Specifications 3.2.1 and 3.7.5)
- Linear Heat Generation Rate (LHGR) Limit
  (Technical Specification 3.2.3, 3.3.4.1, and 3.7.5)
- Minimum Critical Power Ratio Operating Limit (OLMCPR)
  (Technical Specifications 3.2.2, 3.3.4.1, and 3.7.5)
- Average Power Range Monitor (APRM) Flow Biased Rod Block Trip Setting
  (Technical Requirements Manual Section 5.3.1 and Table 3.3.4-1)
- Rod Block Monitor (RBM) Trip Setpoints and Operability
  (Technical Specification Table 3.3.2.1-1)
- Shutdown Margin (SDM) Limit
  (Technical Specification 3.1.1)

1.3 Fuel Loading

The core will contain all AREVA NP, Inc., ATRIUM-10 fuel. 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 in Reference 6.

1.4 Acceptability

Limits discussed in this document were generated based on NRC approved methodologies per References 7 through 23.

Table 1.1 Nuclear Fuel Types*

Fuel Description	Original Cycle	Number of Assemblies	Nuclear Fuel Type (NFT)	Fuel Names (Range)
ATRIUM-10 A10-4227B-15GV80-FBB	15	112	2	FBB001-FBB206
ATRIUM-10 A10-4239B-15GV80-FBB	15	81	3	FBB207-FBB317
ATRIUM-10 A10-3552B-10GV80-FBB	15	16	4	FBB319-FBB374
ATRIUM-10 A10-4218B-13GV80-FCC	16	16	6	FCC291-FCC306
ATRIUM-10 A10-3757B-10GV80-FCC	16	24	7	FCC311-FCC334
ATRIUM-10 A10-4019B-14GV80-FBC	16	167	8	FBC401-FBC568
ATRIUM-10 A10-3841B-14GV80-FBC	16	76	9	FBC569-FBC644
ATRIUM-10 A10-3799B-14GV80-FBD	17	136	10	FBD001-FBD136
ATRIUM-10 A10-4004B-15GV80-FBD	17	136	11	FBD137-FBD272

* 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:

APLHGR limit = MIN ($APLHGR_P$, $APLHGR_F$, $APLHGR_{SLO}$)

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 types, is identified in Reference 1 and shown in Figure 2.1.

2.2 Off-Rated Power Dependent Limit: $APLHGR_P$

Reference 1, for ATRIUM-10 fuel, does not specify a power dependent APLHGR. Therefore, $MAPFAC_P$ is set to a value of **1.0**.

2.2.1 <u>Startup without Feedwater Heaters</u>

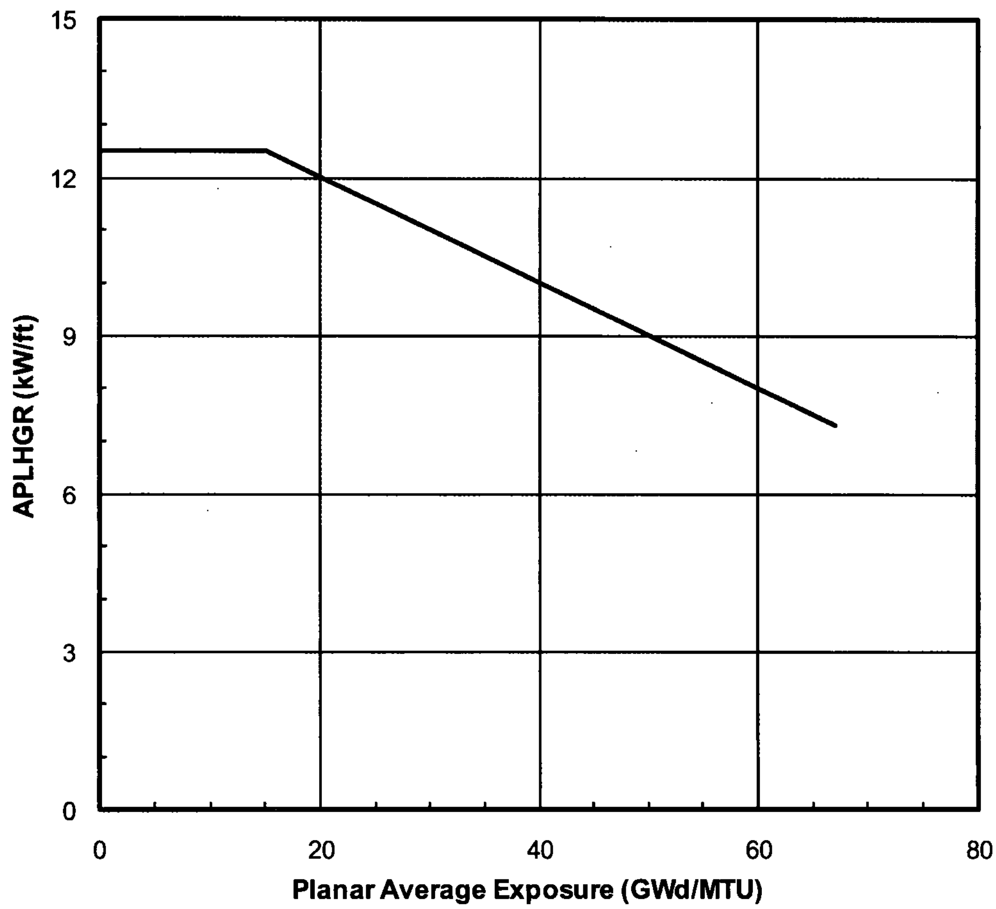
There is a range of operation during startup when the feedwater heaters are not placed into service until after the unit has reach a significant operating power level. No Additional power dependent limitation is required.

2.3 Off-Rated Flow Dependent Limit: $APLHGR_F$

Reference 1, for ATRIUM-10 fuel, 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-10 fuel is **0.85**, per Reference 1.



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

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

2.5 Equipment Out-Of-Service Corrections

The limit shown in Figure 2.1 is 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 (includes 1 SRVOOS)
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

Single Recirculation Loop Operation (SLO) requires the application of the SLO multipliers to the rated APLHGR limits as described previously.

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:

$LHGR\ limit = MIN\ (LHGR_P, LHGR_F)$

where:

$LHGR_P$	off-rated power LHGR limit	$[LHGR_{RATED} * LHGRFAC_P]$
$LHGR_F$	off-rated flow LHGR limit	$[LHGR_{RATED} * LHGRFAC_F]$

3.1 Rated Power and Flow Limit: $LHGR_{RATED}$

The rated conditions LHGR, for all fuel types, is identified in Reference 1 and shown in Figure 3.1. The LHGR limit is consistent with References 2, 3, and 4.

3.2 Off-Rated Power Dependent Limit: $LHGR_P$

The ATRIUM-10 fuel, 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 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 reach 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	Temperature Range 2
(% Rated)	(°F)	(°F)
25	160.0	155.0
30	165.0	160.0
40	175.0	170.0
50	185.0	180.0

3.3 Off-Rated Flow Dependent Limit: $LHGR_F$

The ATRIUM-10 fuel, LHGR limits are adjusted for off-rated flow conditions using the $LHGRFAC_F$ multiplier provided in Reference 1. The multiplier is shown in Figure 3.3.

3.4 Equipment Out-Of-Service Corrections

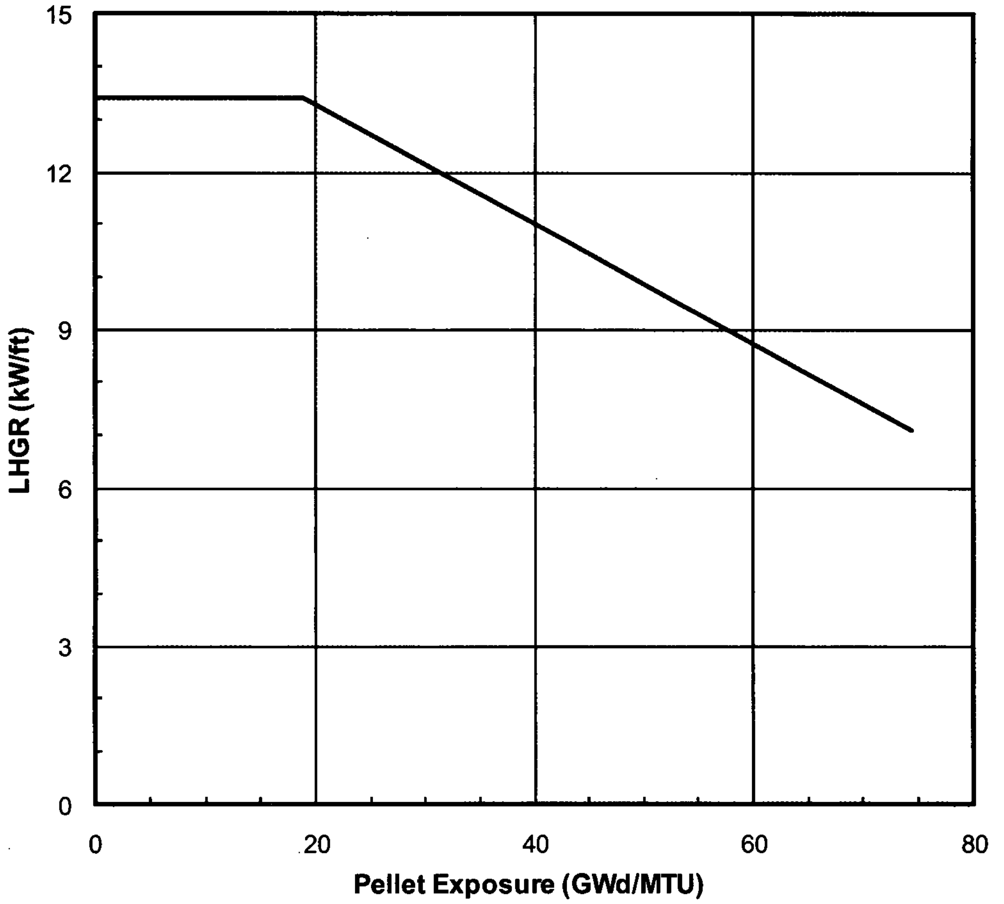
The limit shown in Figure 3.1 is applicable for operation with all equipment In-Service as well as the following Equipment Out-Of-Service (EOOS) options; including combinations of the options.*

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
SLO	Single Loop Operation, 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.

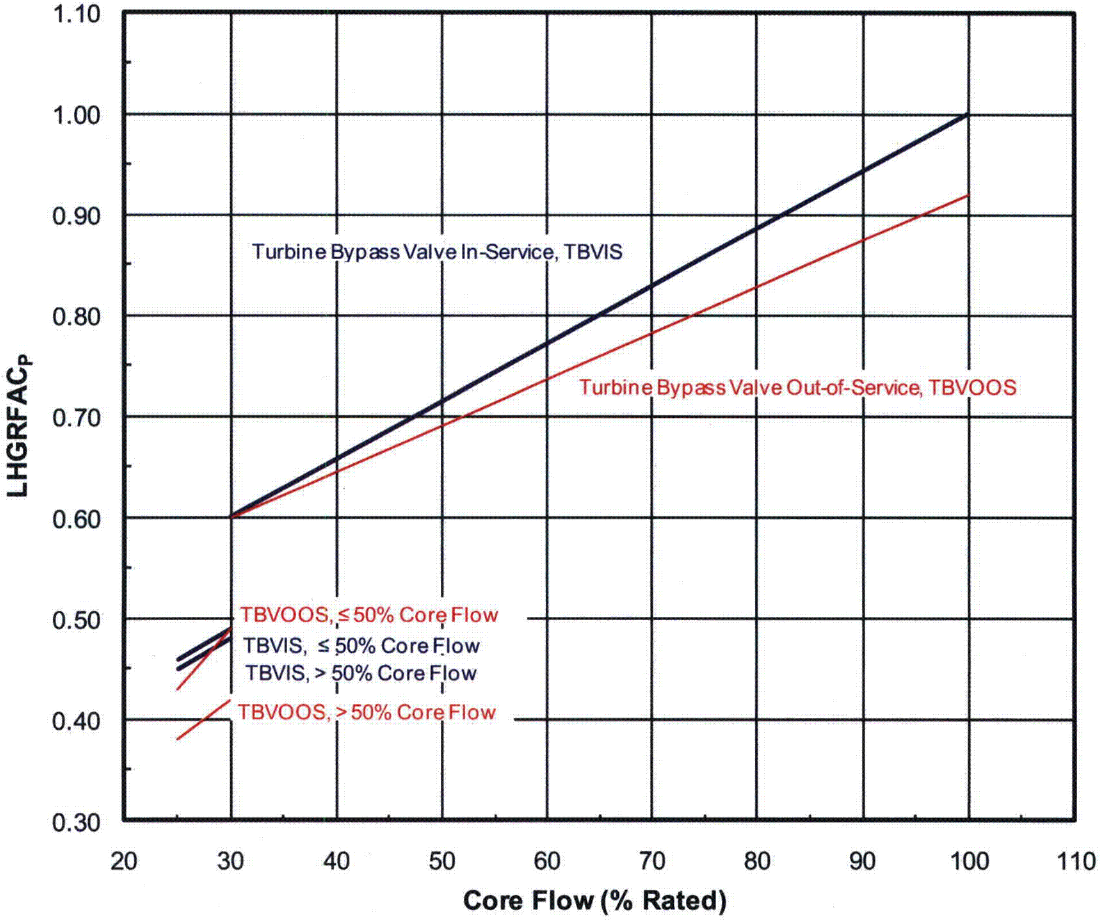
Off-rated power corrections shown in Figure 3.4 and Figure 3.5 are also dependent on operation of the Turbine Bypass Valve system. In this case, limits support FHOOS operation during startup. These limits have no dependency on RPTOOS, PLUOOS, or SLO.

* All equipment service conditions assume 1 SRVOOS.



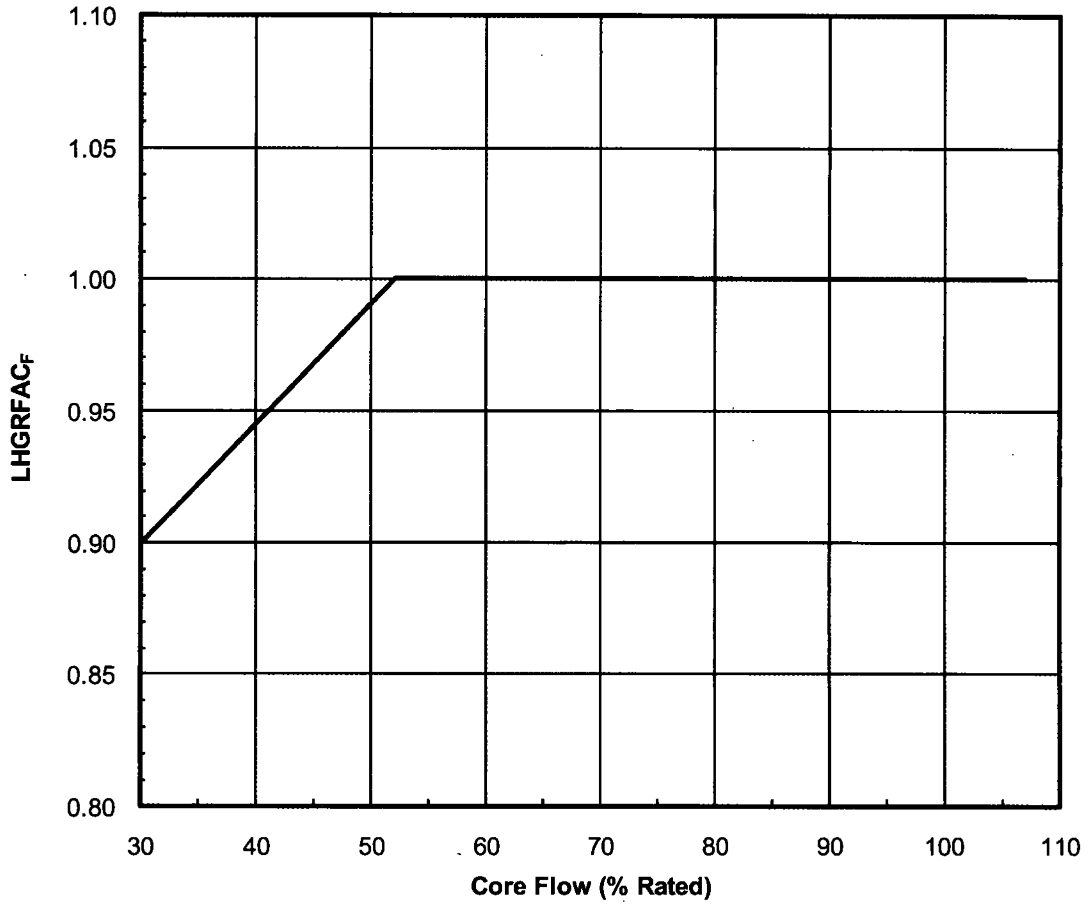
Pellet Exposure (GWd/MTU)	LHGR Limit (kW/ft)
0.0	13.4
18.9	13.4
74.4	7.1

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



Turbine Bypass In-Service		*Turbine Bypass Out-of-Service*	
Core Power (% Rated)	**$LHGRFAC_P$**	**Core Power (% Rated)**	**$LHGRFAC_P$**
100.0	1.00	100.0	0.92
30.0	0.60	30.0	0.60
Core Flow > 50% Rated		**Core Flow > 50% Rated**	
30.0	0.48	30.0	0.42
25.0	0.45	25.0	0.38
Core Flow ≤ 50% Rated		**Core Flow ≤ 50% Rated**	
30.0	0.49	30.0	0.49
25.0	0.46	25.0	0.43

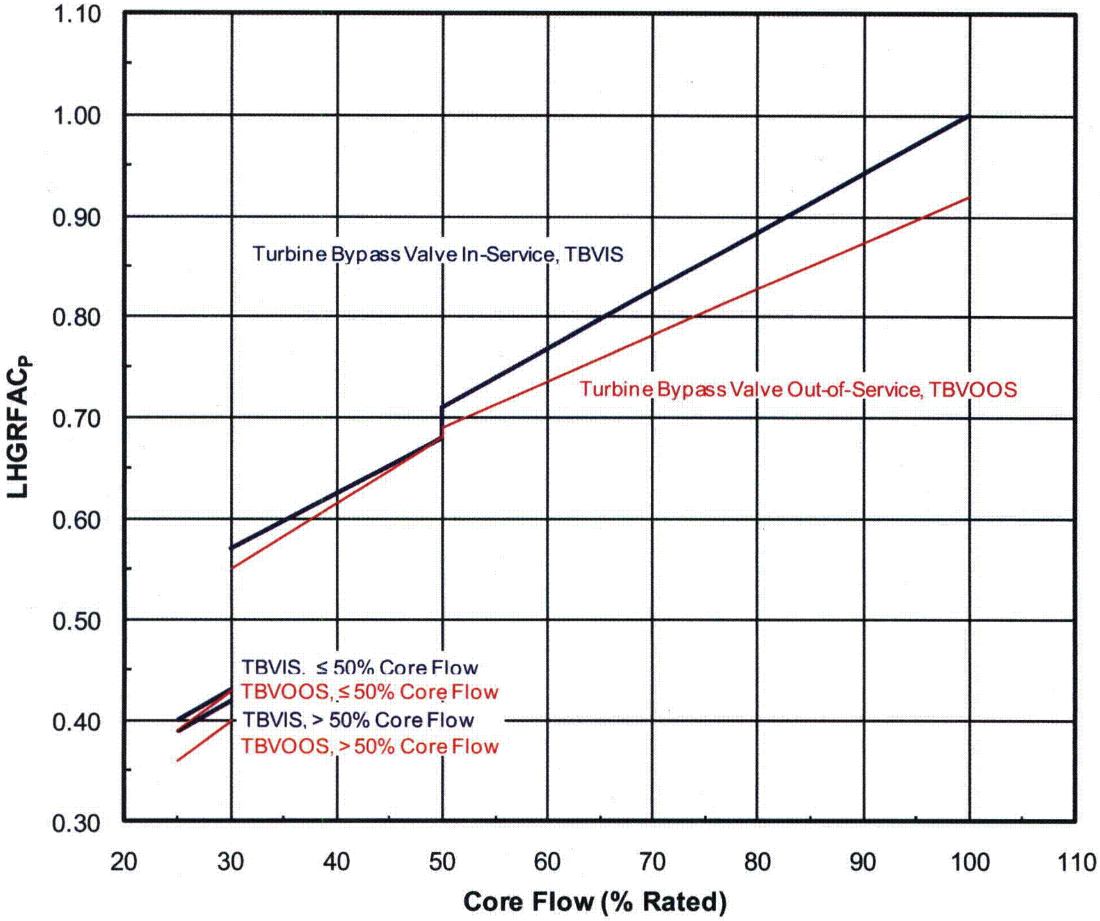
Figure 3.2 Base Operation $LHGRFAC_P$ for ATRIUM-10 Fuel
(*Independent of other EOOS conditions*)



Core Flow (% Rated)	LHGRFAC$_F$
30.0	0.9
52.0	1
107.0	1

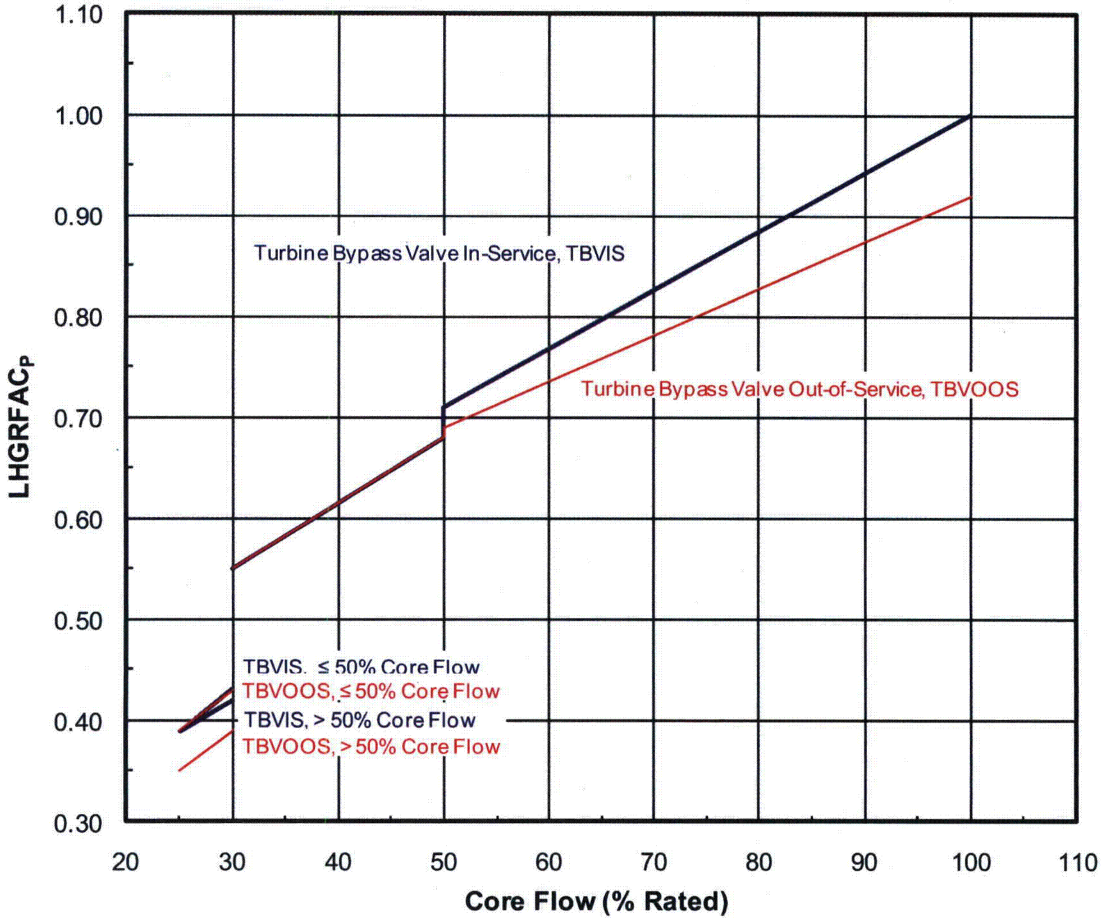
Figure 3.3 LHGRFAC$_F$ for ATRIUM-10 Fuel
(*Values bound all EOOS conditions*)

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



Turbine Bypass In-Service Core Power (% Rated)	LHGRFAC$_P$	*Turbine Bypass Out-of-Service* Core Power (% Rated)	LHGRFAC$_P$
100.0	1.00	100.0	0.92
50.0	0.71	50.0	0.69
50.0	0.68	50.0	0.68
30.0	0.57	30.0	0.55
Core Flow > 50% Rated		**Core Flow > 50% Rated**	
30.0	0.42	30.0	0.40
25.0	0.39	25.0	0.36
Core Flow ≤ 50% Rated		**Core Flow ≤ 50% Rated**	
30.0	0.43	30.0	0.43
25.0	0.40	25.0	0.39

Figure 3.4 Startup Operation LHGRFAC$_P$ for ATRIUM-10 Fuel:
Table 3.1 Temperature Range 1
(no Feedwater heating during startup)



Turbine Bypass In-Service		*Turbine Bypass Out-of-Service*	
Core Power (% Rated)	**LHGRFAC$_P$**	**Core Power (% Rated)**	**LHGRFAC$_P$**
100.0	1.00	100.0	0.92
50.0	0.71	50.0	0.69
50.0	0.68	50.0	0.68
30.0	0.55	30.0	0.55
Core Flow > 50% Rated		**Core Flow > 50% Rated**	
30.0	0.42	30.0	0.39
25.0	0.39	25.0	0.35
Core Flow ≤ 50% Rated		**Core Flow ≤ 50% Rated**	
30.0	0.43	30.0	0.43
25.0	0.39	25.0	0.39

Figure 3.5 Startup Operation LHGRFAC$_P$ for ATRIUM-10 Fuel:
Table 3.1 Temperature Range 2
(no Feedwater heating during startup)

4 OLMCPR Limits

(Technical Specification 3.2.2, 3.3.4.1, & 3.7.5)

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

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

where:

$MCPR_F$	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 the following tables, 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 <u>Startup without Feedwater Heaters</u>

There is a range of operation during startup when the feedwater heaters are not placed into service until after the unit has reach a significant operating power level. Additional power dependent limits are shown in Table 4.5 and Table 4.6, 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	**29,179.5 MWd / MTU**
BOC to EOC	EOC corresponds to	**31,822.1 MWd / MTU**
BOC to End of Coast	End of Coast	**32,730.9 MWd / MTU**

NEOC refers to a Near EOC exposure point.

* Reference 1 analysis results are based on information identified in Reference 5.

† Assumption basis is consistent with method used to perform actual timing measurements, (i.e., including pickup/dropout effects).

The EOC 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)

For exposure ranges up to NEOC and EOC, 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.

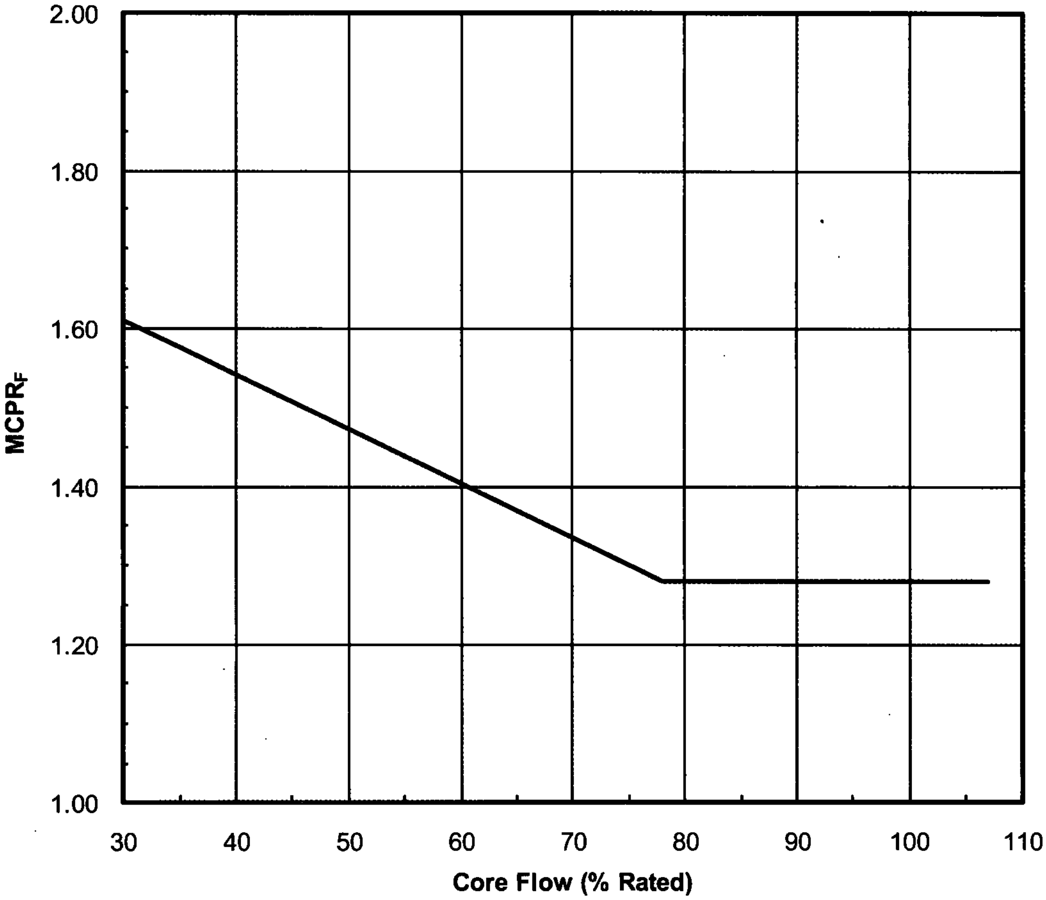
4.2.5 Single-Loop-Operation (SLO) Limits

$MCPR_P$ limits are increased by 0.02 to support SLO, per Reference 1.

4.2.6 Below Pbypass Limits

Below Pbypass (30% 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.



Core Flow (% Rated)	$MCPR_F$
30.0	1.61
78.0	1.28
107.0	1.28

Figure 4.1 $MCPR_F$ for ATRIUM-10 Fuel
(*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 Optimum Scram Time Basis*

Operating Condition	Power (% of rated)	BOC to NEOC	BOC to EOC	BOC to End of Coast
Base Case	100	1.38	1.41	1.44
	75	1.51	1.51	1.56
	65	1.60	1.61	1.68
	50	1.78	1.78	---
	50	1.85	1.85	1.90
	40	2.00	2.00	2.13
	30	2.29	2.29	2.44
	30 at > 50%F	2.79	2.79	2.90
	25 at > 50%F	3.08	3.08	3.22
	30 at ≤ 50%F	2.72	2.72	2.82
	25 at ≤ 50%F	2.97	2.97	3.10

* 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. For single-loop operation, $MCPR_P$ limits will be 0.02 higher.

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

Table 4.3 MCPR$_P$ Limits for Nominal Scram Time Basis*

Operating Condition	Power (% of rated)	BOC to NEOC	BOC to EOC	BOC to End of Coast
Base Case	100	1.41	1.42	1.44
	75	1.52	1.53	1.56
	65	1.62	1.62	1.68
	50	1.82	1.82	---
	50	1.86	1.86	1.90
	40	2.03	2.03	2.13
	30	2.32	2.32	2.44
	30 at > 50%F	2.79	2.79	2.90
	25 at > 50%F	3.08	3.08	3.22
	30 at ≤ 50%F	2.72	2.72	2.82
	25 at ≤ 50%F	2.97	2.97	3.10
TBVOOS	100	1.44	1.46	1.47
	75	1.57	1.57	1.60
	65	1.66	1.67	1.70
	50	1.83	1.83	---
	50	1.86	1.86	1.90
	40	2.04	2.04	2.13
	30	2.32	2.32	2.44
	30 at > 50%F	3.26	3.26	3.40
	25 at > 50%F	3.70	3.70	3.85
	30 at ≤ 50%F	2.85	2.85	3.00
	25 at ≤ 50%F	3.29	3.29	3.47
FHOOS	100	1.43	1.44	---
	75	1.55	1.56	---
	65	1.68	1.68	---
	50	---	---	---
	50	1.90	1.90	---
	40	2.13	2.13	---
	30	2.44	2.44	---
	30 at > 50%F	2.90	2.90	---
	25 at > 50%F	3.22	3.22	---
	30 at ≤ 50%F	2.82	2.82	---
	25 at ≤ 50%F	3.10	3.10	---
PLUOOS	100	1.41	1.42	1.44
	75	1.52	1.53	1.56
	65	1.76	1.77	1.77
	50	---	---	---
	50	1.86	1.86	1.90
	40	2.03	2.03	2.13
	30	2.32	2.32	2.44
	30 at > 50%F	2.79	2.79	2.90
	25 at > 50%F	3.08	3.08	3.22
	30 at ≤ 50%F	2.72	2.72	2.82
	25 at ≤ 50%F	2.97	2.97	3.10

* 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. For single-loop operation, MCPR$_P$ limits will be 0.02 higher.

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.

A 50% power step change for PLUOOS limits is not supported. When core power is ≤ 50%, the LRNB event is the same with, or without PLUOOS.

Table 4.3 MCPR$_P$ Limits for Nominal Scram Time Basis (*continued*)*

Operating Condition	Power (% of rated)	BOC to NEOC	BOC to EOC	BOC to End of Coast
TBVOOS FHOOS	100	1.46	1.47	---
	75	1.58	1.59	---
	65	1.70	1.70	---
	50	---	---	---
	50	1.90	1.90	---
	40	2.13	2.13	---
	30	2.44	2.44	---
	30 at > 50%F	3.40	3.40	---
	25 at > 50%F	3.85	3.85	---
	30 at ≤ 50%F	3.00	3.00	---
	25 at ≤ 50%F	3.47	3.47	---
TBVOOS PLUOOS	100	1.44	1.46	1.47
	75	1.57	1.57	1.60
	65	1.76	1.77	1.77
	50	---	---	---
	50	1.86	1.86	1.90
	40	2.04	2.04	2.13
	30	2.32	2.32	2.44
	30 at > 50%F	3.26	3.26	3.40
	25 at > 50%F	3.70	3.70	3.85
	30 at ≤ 50%F	2.85	2.85	3.00
	25 at ≤ 50%F	3.29	3.29	3.47
FHOOS PLUOOS	100	1.43	1.44	---
	75	1.55	1.56	---
	65	1.76	1.77	---
	50	---	---	---
	50	1.90	1.90	---
	40	2.13	2.13	---
	30	2.44	2.44	---
	30 at > 50%F	2.90	2.90	---
	25 at > 50%F	3.22	3.22	---
	30 at ≤ 50%F	2.82	2.82	---
	25 at ≤ 50%F	3.10	3.10	---
TBVOOS FHOOS PLUOOS	100	1.46	1.47	---
	75	1.58	1.59	---
	65	1.76	1.77	---
	50	---	---	---
	50	1.90	1.90	---
	40	2.13	2.13	---
	30	2.44	2.44	---
	30 at > 50%F	3.40	3.40	---
	25 at > 50%F	3.85	3.85	---
	30 at ≤ 50%F	3.00	3.00	---
	25 at ≤ 50%F	3.47	3.47	---

* 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. For single-loop operation, MCPR$_P$ limits will be 0.02 higher.

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.

A 50% power step change for PLUOOS limits is not supported. When core power is ≤ 50%, the LRNB event is the same with, or without PLUOOS.

Table 4.4 $MCPR_P$ Limits for Technical Specification Scram Time Basis*

Operating Condition	Power (% of rated)	BOC to NEOC	BOC to EOC	BOC to End of Coast
	100	1.43	1.43	1.45
	75	1.54	1.54	1.58
	65	1.65	1.65	1.72
	50	1.85	1.85	---
	50	1.87	1.87	1.93
Base Case	40	2.06	2.06	2.16
	30	2.36	2.36	2.47
	30 at > 50%F	2.79	2.79	2.90
	25 at > 50%F	3.08	3.08	3.22
	30 at ≤ 50%F	2.72	2.72	2.82
	25 at ≤ 50%F	2.97	2.97	3.10
	100	1.46	1.47	1.48
	75	1.58	1.58	1.61
	65	1.69	1.69	1.73
	50	1.86	1.86	---
	50	1.87	1.87	1.94
TBVOOS	40	2.07	2.07	2.16
	30	2.36	2.36	2.47
	30 at > 50%F	3.26	3.26	3.40
	25 at > 50%F	3.70	3.70	3.85
	30 at ≤ 50%F	2.85	2.85	3.00
	25 at ≤ 50%F	3.29	3.29	3.47
	100	1.45	1.45	---
	75	1.58	1.58	---
	65	1.72	1.72	---
	50	---	---	---
	50	1.93	1.93	---
FHOOS	40	2.16	2.16	---
	30	2.47	2.47	---
	30 at > 50%F	2.90	2.90	---
	25 at > 50%F	3.22	3.22	---
	30 at ≤ 50%F	2.82	2.82	---
	25 at ≤ 50%F	3.10	3.10	---
	100	1.43	1.43	1.45
	75	1.54	1.54	1.58
	65	1.77	1.78	1.79
	50	---	---	---
	50	1.87	1.87	1.93
PLUOOS	40	2.06	2.06	2.16
	30	2.36	2.36	2.47
	30 at > 50%F	2.79	2.79	2.90
	25 at > 50%F	3.08	3.08	3.22
	30 at ≤ 50%F	2.72	2.72	2.82
	25 at ≤ 50%F	2.97	2.97	3.10

* 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. For single-loop operation, $MCPR_P$ limits will be 0.02 higher.

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.

A 50% power step change for PLUOOS limits is not supported. When core power is ≤ 50%, the LRNB event is the same with, or without PLUOOS.

Table 4.4 MCPR$_P$ Limits for Technical Specification Scram Time Basis (*continued*)*

Operating Condition	Power (% of rated)	BOC to NEOC	BOC to EOC	BOC to End of Coast
TBVOOS FHOOS	100	1.48	1.48	---
	75	1.61	1.61	---
	65	1.73	1.73	---
	50	---	---	---
	50	1.94	1.94	---
	40	2.16	2.16	---
	30	2.47	2.47	---
	30 at > 50%F	3.40	3.40	---
	25 at > 50%F	3.85	3.85	---
	30 at ≤ 50%F	3.00	3.00	---
	25 at ≤ 50%F	3.47	3.47	---
TBVOOS PLUOOS	100	1.46	1.47	1.48
	75	1.58	1.58	1.61
	65	1.77	1.78	1.79
	50	---	---	---
	50	1.87	1.87	1.94
	40	2.07	2.07	2.16
	30	2.36	2.36	2.47
	30 at > 50%F	3.26	3.26	3.40
	25 at > 50%F	3.70	3.70	3.85
	30 at ≤ 50%F	2.85	2.85	3.00
	25 at ≤ 50%F	3.29	3.29	3.47
FHOOS PLUOOS	100	1.45	1.45	---
	75	1.58	1.58	---
	65	1.77	1.78	---
	50	---	---	---
	50	1.93	1.93	---
	40	2.16	2.16	---
	30	2.47	2.47	---
	30 at > 50%F	2.90	2.90	---
	25 at > 50%F	3.22	3.22	---
	30 at ≤ 50%F	2.82	2.82	---
	25 at ≤ 50%F	3.10	3.10	---
TBVOOS FHOOS PLUOOS	100	1.48	1.48	---
	75	1.61	1.61	---
	65	1.77	1.78	---
	50	---	---	---
	50	1.94	1.94	---
	40	2.16	2.16	---
	30	2.47	2.47	---
	30 at > 50%F	3.40	3.40	---
	25 at > 50%F	3.85	3.85	---
	30 at ≤ 50%F	3.00	3.00	---
	25 at ≤ 50%F	3.47	3.47	---

* 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. For single-loop operation, MCPR$_P$ limits will be 0.02 higher.

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.

A 50% power step change for PLUOOS limits is not supported. When core power is ≤ 50%, the LRNB event is the same with, or without PLUOOS.

Table 4.5 Startup Operation $MCPR_P$ Limits for Table 3.1 Temperature Range 1: Technical Specification Scram Time Basis*

Operating Condition	Power (% of rated)	BOC to NEOC	BOC to EOC	BOC to End of Coast
TBVIS	100	1.45	1.45	1.45
	75	1.58	1.58	1.58
	65	1.72	1.72	1.72
	50	1.93	1.93	1.93
	50	2.11	2.11	2.11
	40	2.38	2.38	2.38
	30	2.76	2.76	2.76
	30 at > 50%F	3.18	3.18	3.18
	25 at > 50%F	3.57	3.57	3.57
	30 at ≤ 50%F	3.07	3.07	3.07
	25 at ≤ 50%F	3.44	3.44	3.44
TBVOOS	100	1.48	1.48	1.48
	75	1.61	1.61	1.61
	65	1.73	1.73	1.73
	50	1.94	1.94	1.94
	50	2.11	2.11	2.11
	40	2.38	2.38	2.38
	30	2.76	2.76	2.76
	30 at > 50%F	3.64	3.64	3.64
	25 at > 50%F	4.12	4.12	4.12
	30 at ≤ 50%F	3.23	3.23	3.23
	25 at ≤ 50%F	3.76	3.76	3.76

* 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. For single-loop operation, $MCPR_P$ limits will be 0.02 higher.

Limits are applicable for all non-PLUOOS EOOS scenarios. PLU is inoperable for powers less than 50% rated power, therefore at these powers it can be considered a base case.

Table 4.6 Startup Operation $MCPR_P$ Limits for Table 3.1 Temperature Range 2: Technical Specification Scram Time Basis*

Operating Condition	Power (% of rated)	BOC to NEOC	BOC to EOC	BOC to End of Coast
TBVIS	100	1.45	1.45	1.45
	75	1.58	1.58	1.58
	65	1.72	1.72	1.72
	50	1.93	1.93	1.93
	50	2.12	2.12	2.12
	40	2.40	2.40	2.40
	30	2.78	2.78	2.78
	30 at > 50%F	3.19	3.19	3.19
	25 at > 50%F	3.60	3.60	3.60
	30 at ≤ 50%F	3.11	3.11	3.11
	25 at ≤ 50%F	3.46	3.46	3.46
TBVOOS	100	1.48	1.48	1.48
	75	1.61	1.61	1.61
	65	1.73	1.73	1.73
	50	1.94	1.94	1.94
	50	2.12	2.12	2.12
	40	2.40	2.40	2.40
	30	2.78	2.78	2.78
	30 at > 50%F	3.65	3.65	3.65
	25 at > 50%F	4.13	4.13	4.13
	30 at ≤ 50%F	3.24	3.24	3.24
	25 at ≤ 50%F	3.78	3.78	3.78

* 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. For single-loop operation, $MCPR_P$ limits will be 0.02 higher.

Limits are applicable for all non-PLUOOS EOOS scenarios. PLU is inoperable for powers less than 50% rated power, therefore at these powers it can be considered a base case.

5 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 24 & 25, and is defined by the following:

$SRB \leq (0.66(W-\Delta W) + 61\%)$	Allowable Value
$SRB \leq (0.66(W-\Delta W) + 59\%)$	Nominal Trip Setpoint (NTSP)

where:

SRB	=	Rod Block setting in percent of rated thermal power (3458 MW_t)
W	=	Loop recirculation flow rate in percent of rated
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%).

6 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 24 & 25, are shown in Table 6.1. 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, superceding values reported in References 24, 25, and 27.

Table 6.1 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 - filtered	121.7% 120.7%	120.0% 119.0%
ITSP - unfiltered - filtered	116.7% 115.7%	115.0% 114.0%
HTSP - unfiltered - filtered	111.7% 110.9%	110.0% 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 6.2. Cycle specific setpoint analysis results are shown in Table 6.3, per Reference 1.

Table 6.2 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
	< 1.75	(a), (b), (f), (h)	single loop operation
≥ 90%	< 1.42	(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 6.3 Control Rod Withdrawal Error Results

RBM HTSP Analytical Limit	CRWE OLMCPR
Unfiltered	
107	1.31
111	1.35
114	1.36
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).

7 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: Thermal-Hydraulic Stability

RPS Instrumentation

(Technical Specification 3.3.1.1)

Technical Specification Section 3.3.1.1, LCO 3.3.1.1 states:

The RPS instrumentation for each Function in Table 3.3.1.1-1 shall be OPERABLE.

Table 3.3.1.1-1, Function 2f, identifies the OPRM upscale function. This function must be operable in conjunction with the following surveillance requirements:

SR 3.3.1.1.1
SR 3.3.1.1.7
SR 3.3.1.1.13
SR 3.3.1.1.16
SR 3.3.1.1.17

<u>Background</u>

Browns Ferry uses the Option III stability Detect and Suppress solution as part of the PRNM system. The Option III system is based upon combining groups of local LPRM's into cells known as OPRM's. The OPRM's generate a combined LPRM signal that is examined for the characteristics of a reactor instability event, and if detected, a reactor trip is generated.

The PBDA is the licensing basis portion of the Option III system, requiring a cycle-specific calculation to determine the amplitude setpoint to generate a reactor trip in time to protect the fuel from exceeding the SLMCPR.

The OPRM Upscale Trip function is required to be operable when the plant is in a region of power-flow operation where actual thermal-hydraulic oscillations might occur (T.S. enabled region -- greater than 25% rated thermal power and less than 60% recirculation drive flow).

<u>Setpoints</u>

Instrument setpoints are established such that the reactor will be tripped before an oscillation can grow to the point where the SLMCPR is exceeded. An Option III stability analysis is performed for each reload core to determine allowable OLMCPR's as a function of OPRM setpoint. Analyses consider both steady state startup operation, and the case of a two recirculation pump trip from rated power.

The resulting stability based OLMCPR's are reported in Reference 1. The OPRM setpoint (*sometimes referred to as the Amplitude Trip, S_p*) is selected such that required margin to the SLMCPR is provided without stability being a limiting event. Analyses are based on cycle specific DIVOM analyses performed per Reference 23. The calculated OLMCPR's are shown in

Table A.1. Review of results, relative to the base case operation shown in COLR Table 4.2 indicates an OPRM setpoint of 1.14 can be supported. Extrapolation beyond a setpoint of 1.15 is not allowed.

Table A.1 OPRM Setpoints

OPRM Setpoint	OLMCPR (SS)	OLMCPR (2PT)
1.05	1.17	1.19
1.06	1.19	1.21
1.07	1.21	1.22
1.08	1.23	1.24
1.09	1.25	1.26
1.10	1.27	1.28
1.11	1.29	1.30
1.12	1.31	1.33
1.13	1.33	1.35
1.14	1.35	1.37
1.15	1.37	1.39

Backup Stability

Should the Option III system be declared inoperable, alternate methods/procedures (i.e., stability ICA's) are incorporated restricting plant operation in the high power, low core flow region of the power/flow map. ICA's contain specific operator actions, providing clear instructions (depending upon the plant type) for operator response to a reactor inadvertently (or under controlled conditions) entering any of the defined regions. ICA's provide appropriate guidance to reduce the likelihood of hydraulic instability, and enhance early detection in the very unlikely event a stability threshold is exceeded in spite of the ICA guidelines.

In July 2002, GE recommended the original ICAs, established generically in 1994, be re-evaluated to assure adequate conservatism, given the trend to higher energy cores and more aggressive fuel management strategies. The recommended replacement regions and the associated calculational procedure are referred to as BSP, and need to be confirmed on a plant/cycle specific basis. The vendor has performed an ICA/BSP confirmation calculation using the NRC approved method in Reference 22.

Based upon the above discussion, appropriate stability analyses and evaluations have been performed to satisfy licensing requirements.