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

December 19, 2008

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Mail Stop: OWFN, P1-35
Washington, D.C. 20555-0001

In the Matter of ) Docket No. 50-259
Tennessee Valley Authority )

**BROWNS FERRY NUCLEAR PLANT (BFN) - UNIT 1 - CORE OPERATING LIMITS REPORT (COLR), REVISION 1 FOR CYCLE 8 OPERATION**

In accordance with the requirements of Technical Specification 5.6.5.d, enclosed is the Unit 1 Cycle 8, Revision 1, Core Operating Limits Report. Revision 1 is an update of the Unit 1 Cycle 8, Revision 0, COLR that was issued October 23, 2008, on an interim basis, to support fuel loading.

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

Sincerely,

F. R. Godwin
Manager of Licensing
and Industry Affairs

Enclosure
cc: See page 2

D030

NRR

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ENCLOSURE

TENNESSEE VALLEY AUTHORITY
BROWNS FERRY NUCLEAR PLANT (BFN)
UNIT 1

CORE OPERATING LIMITS REPORT (COLR), REVISION 1
FOR CYCLE 8 OPERATION

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(SEE ATTACHED)

TVA Nuclear

**Nuclear Fuel Design - BWRFE**
1101 Market Street, Chattanooga, TN 37402

# Browns Ferry Unit 1 Cycle 8

## Core Operating Limits Report, (105% OLTP)

**TVA-COLR-BF1C8 Revision 1 (Final)**

**November 2008**

Prepared: _____ Date: 11/6/2008
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Verified: _____ Date: 11/7/2008
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Approved: _____ Date: 11/7/2008
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Reviewed: _____ Date: 11/8/2008
J. M. Keck, Supervisor, Reactor Engineering

Approved: _____ Date: 11/13/08
Chairman, PORC

# Table of Contents

Total Number of Pages = 38 (*including review cover sheet*)

# List of Tables

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# Revision Log

| Number | Page | Description |
|---|---|---|
| 1-R0 | All | New document, per NFDP-1, Section 3.2, Item N. |
| 1-R1 | 2-5 | Updated as a consequence of document revision |
| 2-R1 | 8 | Removed Reference 1 and added new References. References 2 & 3 renumbered to become References 7 & 8. |
| 3-R1 | 9 | Revised Section 1.2 for document scope. Revised Section 1.3 text to reflect SRLR applicability. |
| 4-R1 | 11 | Section 2 becomes Section 7, page 38. |
| 5-R1 | 11-37 | Sections 2-6: new material supporting all modes of plant operation. |

# Nomenclature

| | |
|---|---|
| APLHGR | Average Planar LHGR |
| APRM | Average Power Range Monitor |
| AREVA NP | Vendor (Framatome, Siemens) |
| ARTS | APRM, Rod Block Monitor, and Technical Specification Improvement Program |
| BOC | Beginning of Cycle |
| BWR | Boiling Water Reactor |
| CAVEX | Core Average Exposure |
| CD | Coastdown |
| COLR | Core Operating Limits Report |
| CPR | Critical Power Ratio |
| CPRFAC | Multiplier to determine off-rated OLMCPR, relative to rated conditions |
| CRWE | Control Rod Withdrawal Error |
| DTSP | Dual TSP |
| EIS | Equipment-In-Service |
| EOC | End of Cycle |
| EOFP | End of Full Power (no ICF or FFWTR) |
| EOOS | Equipment OOS |
| EOR | End of Rated Conditions |
| FFWTR | Final Feedwater Temperature Reduction |
| FHOOS | Feedwater Heaters OOS |
| GWd | Giga Watt Day |
| HPSP | High PSP |
| HTSP | High TSP |
| ICF | Increased Core Flow (beyond rated) |
| IPSP | Intermediate PSP |
| ITSP | Intermediate TSP |
| $K_P$ | Vendor Specific Nomenclature for CPRFAC |
| LHGR | Linear Heat Generation Rate |
| LHGRFAC | LHGR Multiplier (Power or Flow dependent) |
| LPRM | Low Power Range Monitor |
| LPSP | Low PSP |
| LRNB | Generator Load Reject, No Bypass |
| LTSP | Low TSP |
| MAPFAC | MAPLHGR multiplier (Power or Flow dependent) |
| MCPR | Minimum CPR |
| MOC | Middle of Cycle |
| MSIV | Main Steam Isolation Valve |
| MSIVOOS | MSIV OOS |

| | |
|---|---|
| MSR | Moisture Separator Reheater |
| MSROOS | MSR OOS |
| MTU | Metric Ton Uranium |
| MWd/MTU | Mega Watt Day per Metric Ton Uranium |
| NEOC | Near EOC |
| NFT | Nuclear Fuel Type |
| NRC | United States Nuclear Regulatory Commission |
| NSS | Nominal Scram Speed |
| NTSP | Nominal TSP |
| OLMCPR | MCPR Operating Limit |
| OOS | Out-Of-Service |
| OLTP | Original Licensed Thermal Power (100% OLTP, 3293 $MW_t$) |
| Pbypass | Power, below which TSV Position and TCV Fast Closure Scrams are bypassed |
| PLU | Power Load Unbalance |
| PLUOOS | PLU OOS |
| PSP | Power Setpoint |
| RBM | Rod Block Monitor |
| RPT | Recirculation Pump Trip |
| RPTOOS | RPT OOS |
| SDM | Shutdown Margin |
| SLMCPR | MCPR Safety Limit |
| SLO | Single Loop Operation |
| SRV | Safety Relief Valve |
| SRVOOS | SRV OOS |
| TAU | Vendor Specific Variable ($\tau$) Representing Scram Timing. |
| TBV | Turbine Bypass Valve |
| TBVIS | Turbine Bypass Valves IS |
| TBVOOS | Turbine Bypass Valves OOS |
| TCV | Turbine Control Valve |
| TIP | Transverse In-Core Probe |
| TIPOOS | TIP OOS |
| TLO | Two Loop Operation |
| TSP | Trip Setpoint |
| TSSS | Technical Specification Scram Speed |
| TSV | Turbine Stop Valve |
| TVA | Tennessee Valley Authority |

# References

1. 0000-0077-8380-SRLR, Revision 0, **Supplemental Reload Licensing Report Browns Ferry 1 Reload 7 Cycle 8**, Global Nuclear Fuels, Inc., August 2008.

2. 0000-0044-1520-SRLR, Revision 0, **Supplemental Reload Licensing Report Browns Ferry 1 Reload 6 Cycle 7**, Global Nuclear Fuels, Inc., January 2007.

3. 0000-0077-8380-FBIR, Revision 0, **Fuel Bundle Information Report Browns Ferry 1 Reload 7 Cycle 8**, Global Nuclear Fuels, Inc., August 2008.

4. 0000-0043-8325-FBIR, Revision 0, **Fuel Bundle Information Report Browns Ferry 1 Reload 6 Cycle 7**, Global Nuclear Fuels, Inc., May 2006.

5. 0000-0079-8898-R0, Revision 0, **Browns Ferry Nuclear Plant Unit 1 Reload 7 Cycle 8 Off-Rated Limits Validation at a Rated Thermal Power of 3458 $MW_t$**, GE Hitachi Nuclear Energy, July 2008.

6. GNF S-0000-0091-6104, Revision 0, **GESTAR II Re-Examination of Bases for Browns Ferry Unit 1 Cycle 8**, Global Nuclear Fuels, Inc., November 7, 2008.

Methodology References

7. NEDE-24011-P-A-16, **General Electric Standard Application for Reactor Fuel**, October 2007.

8. NEDE-24011-P-A-16-US, **General Electric Standard Application for Reactor Fuel (Supplement for United States)**, October 2007.

PRNM Setpoint References

9. Filtered Setpoints - EDE-28-0990 Rev. 3 Supplement E, "PRNM (APRM, RBM, and RFM) Setpoint Calculations [ARTS/MELLL (NUMAC) - Power-Uprate Condition] for Tennessee Valley Authority Browns Ferry Nuclear Plant", October 1997

10. Unfiltered Setpoints - EDE-28-0990 Rev. 2 Supplement E, "PRNM (APRM, RBM, and RFM) Setpoint Calculations [ARTS/MELLL (NUMAC) - Power-Uprate Condition] for Tennessee Valley Authority Browns Ferry Nuclear Plant", October 1997.

11. GE Letter LB#: 262-97-133, *Browns Ferry Nuclear Plant Rod Block Monitor Setpoint Clarification - GE Proprietary Information*, September 12, 1997

12. NEDC-32433P, **Maximum Extended Load Line Limit and ARTS Improvement Program Analyses for Browns Ferry Nuclear Plant Unit 1, 2, and 3**, GE Nuclear Energy, April 1995

# 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 Global Nuclear Fuels, Inc., GE13/GE14 fuel. Nuclear fuel types used in the core loading are shown in Table 1.1. The core shuffle and final loading were assessed to determine Reference 1 applicability relative to minor loading changes. The vendor has determined Reference 1 remains applicable, per Reference 6.

## 1.4 Acceptability

Limits discussed in this document were generated based on NRC approved methodologies per References 7 and 8.

Table 1.1 Nuclear Fuel Types*

| Fuel Description | Original Cycle | Number of Assemblies | Nuclear Fuel Type (NFT) | Fuel Names (Range) |
|---|---|---|---|---|
| GE13-P9DTB156-NOG-100T-146-T6-2887 | 7 | 56 | 3 | JLX101-JLX156 |
| GE13-P9DTB163-NOG-100T-146-T6-2888 | 7 | 52 | 12 | JLX157-JLX208 |
| GE14-P10DNAB157-NOG-100T-150-T6-2889 | 7 | 9 | 4 | JLX209-JLX432 |
| GE14-P10DNAB377-16GZ-100T-150-T6-2890 | 7 | 95 | 5 | JLX433-JLX528 |
| GE14-P10DNAB402-16GZ-100T-150-T6-2891 | 7 | 32 | 6 | JLX529-JLX560 |
| GE14-P10DNAB350-16GZ-100T-150-T6-2892 | 7 | 32 | 7 | JLX561-JLX592 |
| GE14-P10DNAB419-16GZ-100T-150-T6-2894 | 7 | 32 | 9 | JLX613-JLX644 |
| GE14-P10DNAB368-15GZ-100T-150-T6-2895 | 7 | 72 | 10 | JLX645-JLX716 |
| GE14-P10DNAB402-19GZ-100T-150-T6-2896 | 7 | 24 | 11 | JLX717-JLX740 |
| GE14-P10DNAB377-17GZ-100T-150-T6-2897 | 7 | 32 | 13 | JLX741-JLX772 |
| GE14-P10DNAB406-16GZ-100T-150-T6-3078 | 8 | 48 | 14 | JYE101-JYE148 |
| GE14-P10DNAB406-15GZ-100T-150-T6-3079 | 8 | 64 | 16 | JYE245-JYE308 |
| GE14-P10DNAB418-16GZ-100T-150-T6-3080 | 8 | 72 | 18 | JYE357-JYE428 |
| GE14-P10DNAB400-17GZ-100T-150-T6-3081 | 8 | 96 | 15 | JYE149-JYE244 |
| GE14-P10DNAB417-16GZ-100T-150-T6-3082 | 8 | 48 | 17 | JYE309-JYE356 |

* 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:

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

## 2.1 Rated Power and Flow Limit: $\text{APLHGR}_{RATED}$

The rated conditions APLHGR, for the different fuel types, are identified in References 1 & 2, and are shown in Figure 2.1 (GE13) and Figure 2.2 (GE14).

## 2.2 Off-Rated Power Dependent Limit: $\text{APLHGR}_P$

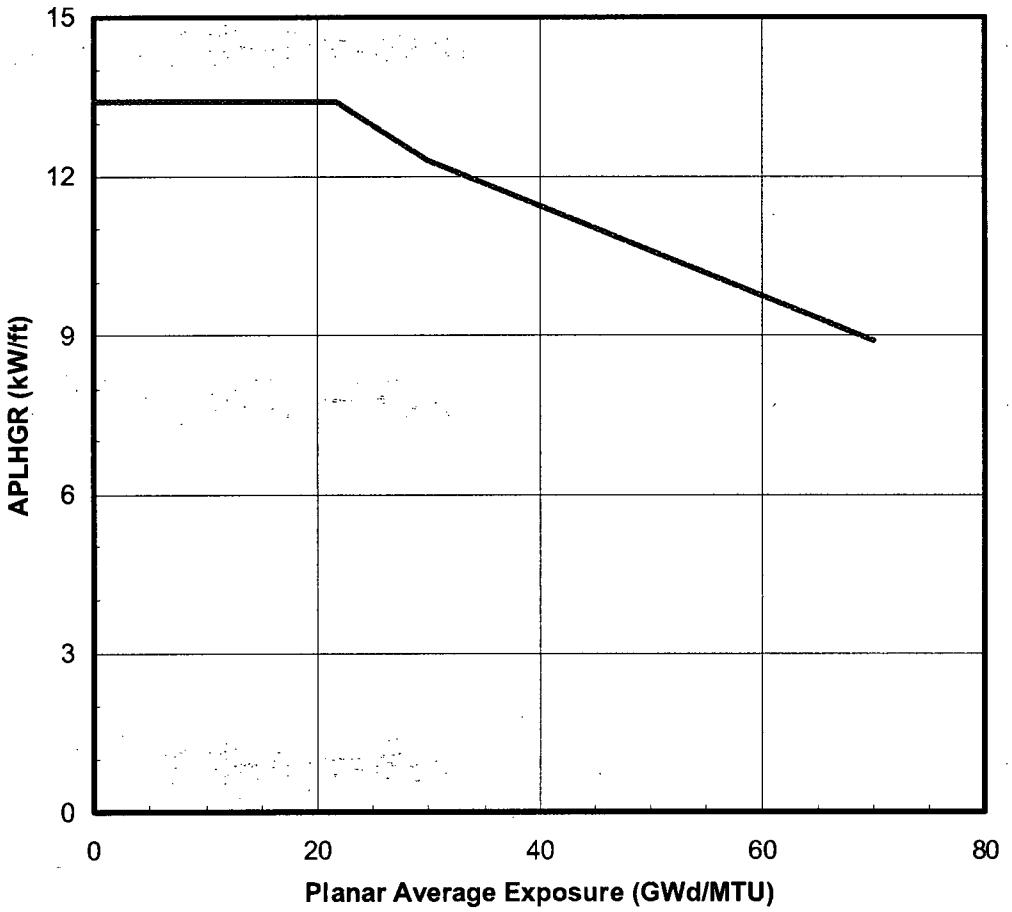
References 1 & 8, for both GE13 and GE14 fuel, does not specify a power dependent APLHGR. Therefore, $\text{MAPFAC}_P$ is set to a value of **1.0**.

## 2.3 Off-Rated Flow Dependent Limit: $\text{APLHGR}_F$

Reference 1 & 8, for both GE13 and GE14 fuel, does not specify a flow dependent APLHGR. Therefore, $\text{MAPFAC}_F$ is set to a value of **1.0**.

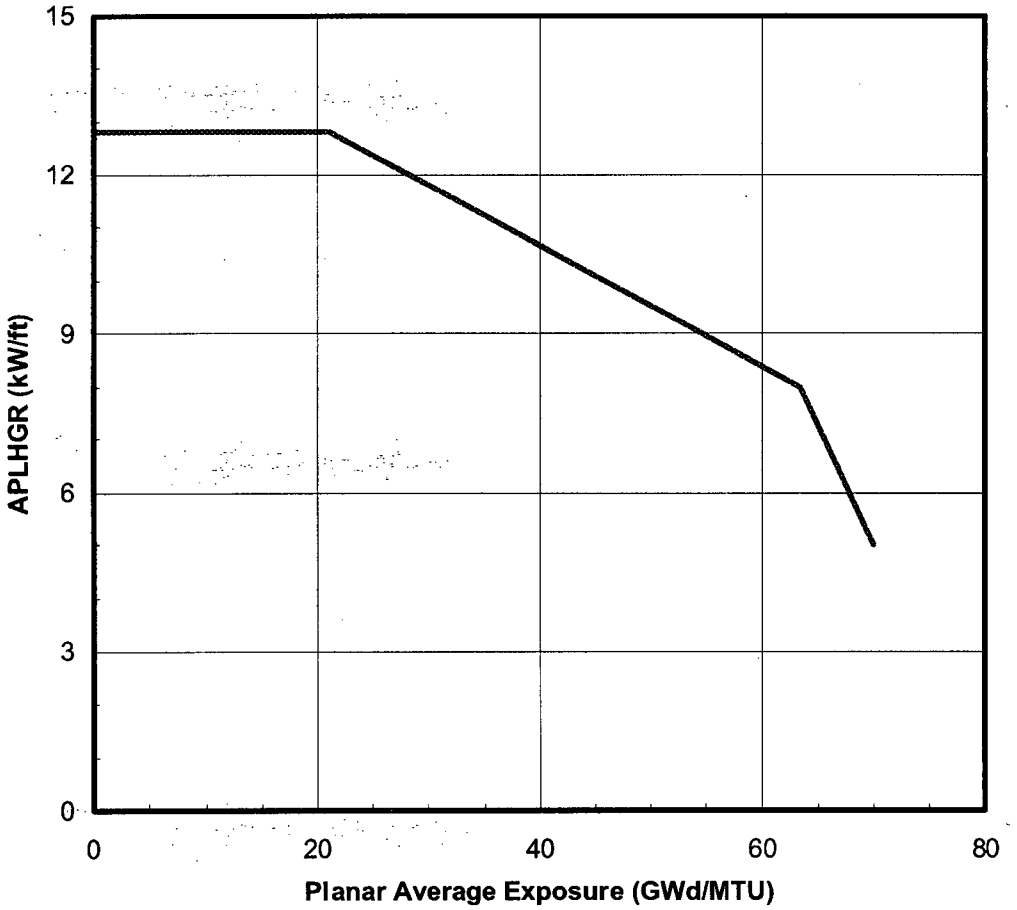
## 2.4 Single Loop Operation Limit: $\text{APLHGR}_{SLO}$

The single loop operation multiplier for GE13 fuel is **0.87**; and for GE14 fuel is **0.93**, per Reference 1.




| Planar Avg. Exposure (GWd/MTU) | Planar Avg. Exposure (GWd/ST) | APLHGR Limit (kW/ft) |
|---|---|---|
| 0.00 | 0.00 | 13.42 |
| 21.74 | 19.72 | 13.42 |
| 30.00 | 27.22 | 12.29 |
| 70.00 | 63.50 | 8.90 |

Figure 2.1 $APLHGR_{RATED}$ for GE13 Fuel




| Planar Avg. Exposure (GWd/MTU) | Planar Avg. Exposure (GWd/ST) | APLHGR Limit (kW/ft) |
|---|---|---|
| 0.00 | 0.00 | 12.82 |
| 21.09 | 19.13 | 12.82 |
| 63.50 | 57.61 | 8.00 |
| 70.00 | 63.50 | 5.00 |

Figure 2.2 $APLHGR_{RATED}$ for GE14 Fuel

## 2.5 Equipment Out-Of-Service Corrections

The limit 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. All equipment service conditions support 1 SRVOOS.

| | |
|---|---|
| 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 |

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:

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

where:

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

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

The rated conditions LHGR, for both fuel types, are identified in References 3 & 4, and are shown in Figure 3.1 (GE13) and Figure 3.2 (GE14) for UO2 fuel. Separate, concentration dependent limits apply for rods containing Gadolinium; for each bundle design LHGR limits are provided in References 3 & 4.

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

For GE13/14 fuel, LHGR limits are adjusted for off-rated power conditions using the $\text{LHGRFAC}_P$ multiplier provided in Reference 5 The multiplier is dependent on EOOS conditions. Consequently, the multipliers are shown in Figure 3.3 thru Figure 3.6, for various EOOS conditions/combinations.

## 3.3 Off-Rated Flow Dependent Limit: $\text{LHGR}_F$

For GE13/14 fuel, LHGR limits are adjusted for off-rated flow conditions using the $\text{LHGRFAC}_F$ multiplier provided in Reference 5. $\text{LHGRFAC}_f$ is fuel type independent. There are no EOOS dependencies for the multiplier. The multiplier is shown in Figure 3.7.

## 3.4 Single Loop Operation Limit: $\text{LHGR}_{SLO}$

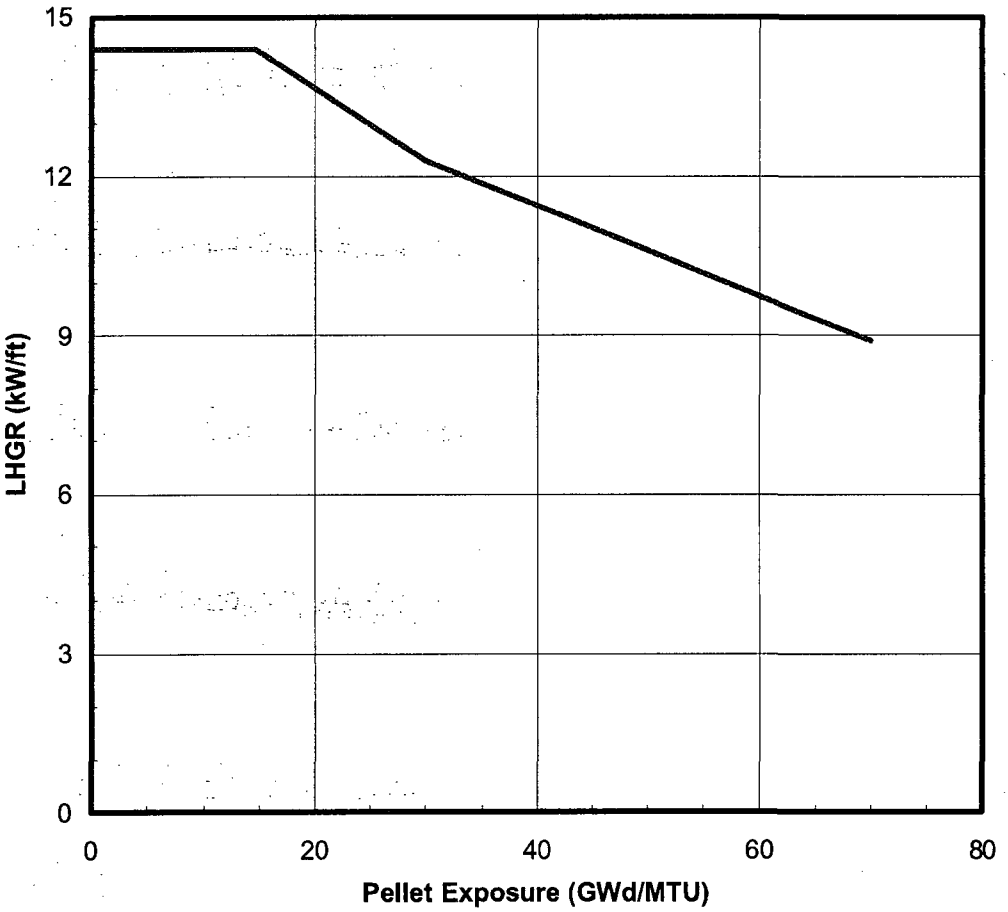
The single loop operation multiplier for GE13 fuel is **0.87**; and for GE14 fuel is **0.93**, per Reference 1.

## 3.5 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. All equipment service conditions support 1 SRVOOS.

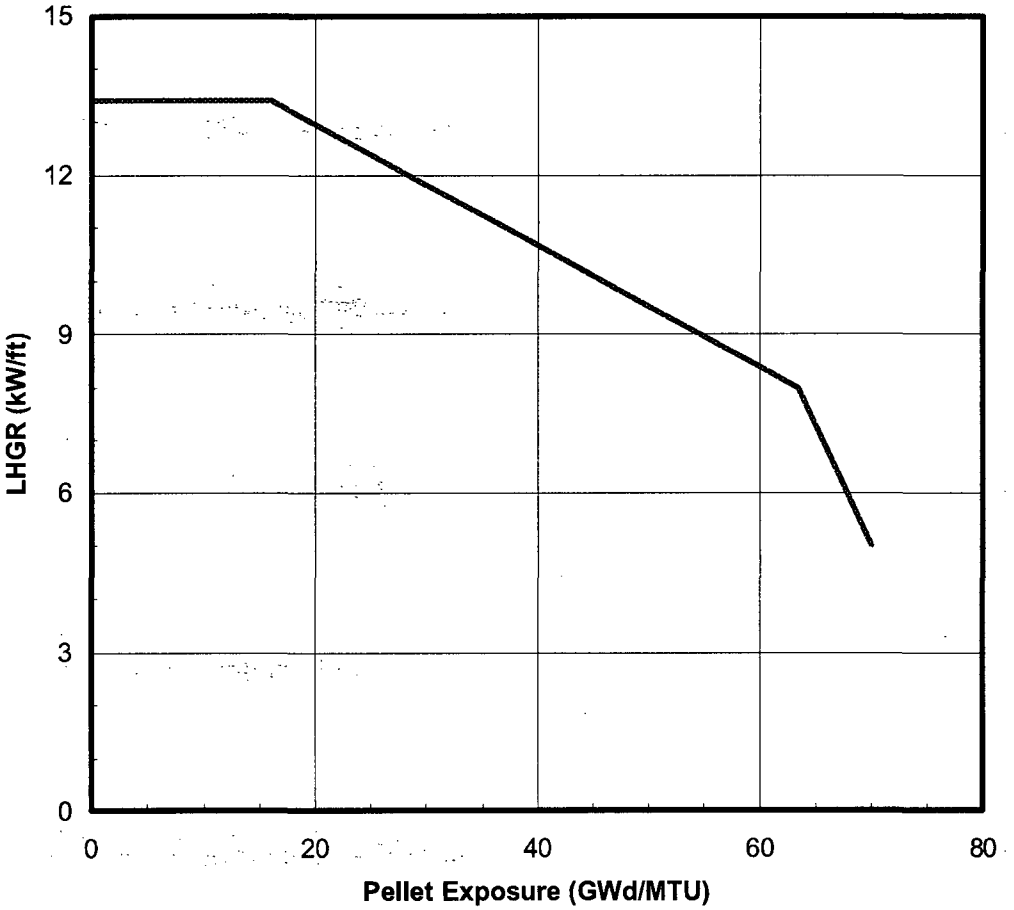
| | |
|---|---|
| In-Service | All equipment In-Service |
| RPTOOS | EOC-Recirculation Pump Trip Out-Of-Service |
| TBVOOS | Turbine Bypass Valve(s) Out-Of-Service |
| PLUOOS | Power Load Unbalance Out-Of-Service |
| FHOOS (or FFWTR) | Feedwater Heaters Out-Of-Service or Final Feedwater Temperature Reduction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

Off-rated power corrections shown in Figure 3.3 thru Figure 3.6 cover various EOOS scenarios. The limits have no dependency on FHOOS/FFWTR.



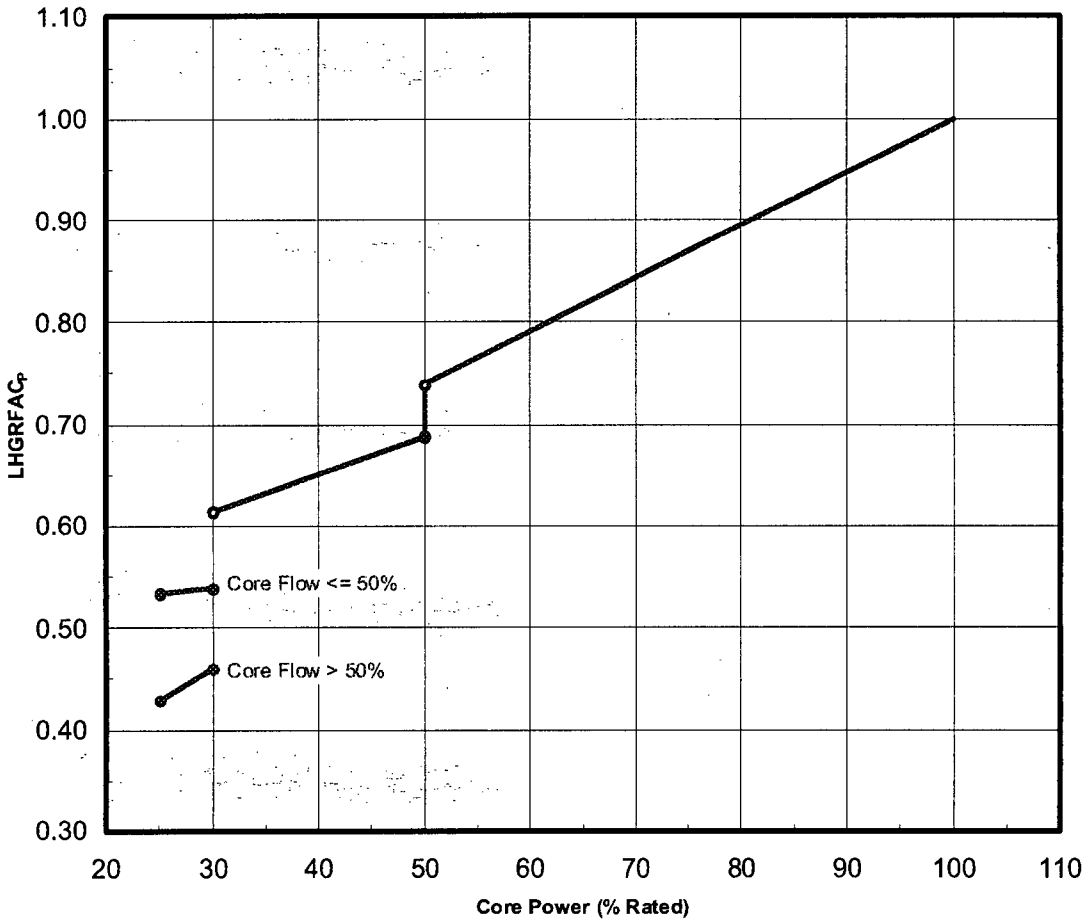

| Pellet Exposure (GWd/MTU) | Pellet Exposure (GWd/ST) | LHGR Limit (kW/ft) |
|---|---|---|
| 0.00 | 0.00 | 14.40 |
| 14.60 | 13.24 | 14.40 |
| 30.00 | 27.22 | 12.29 |
| 70.00 | 63.50 | 8.90 |

Figure 3.1 $LHGR_{RATED}$ for GE13 $UO_2$ Fuel



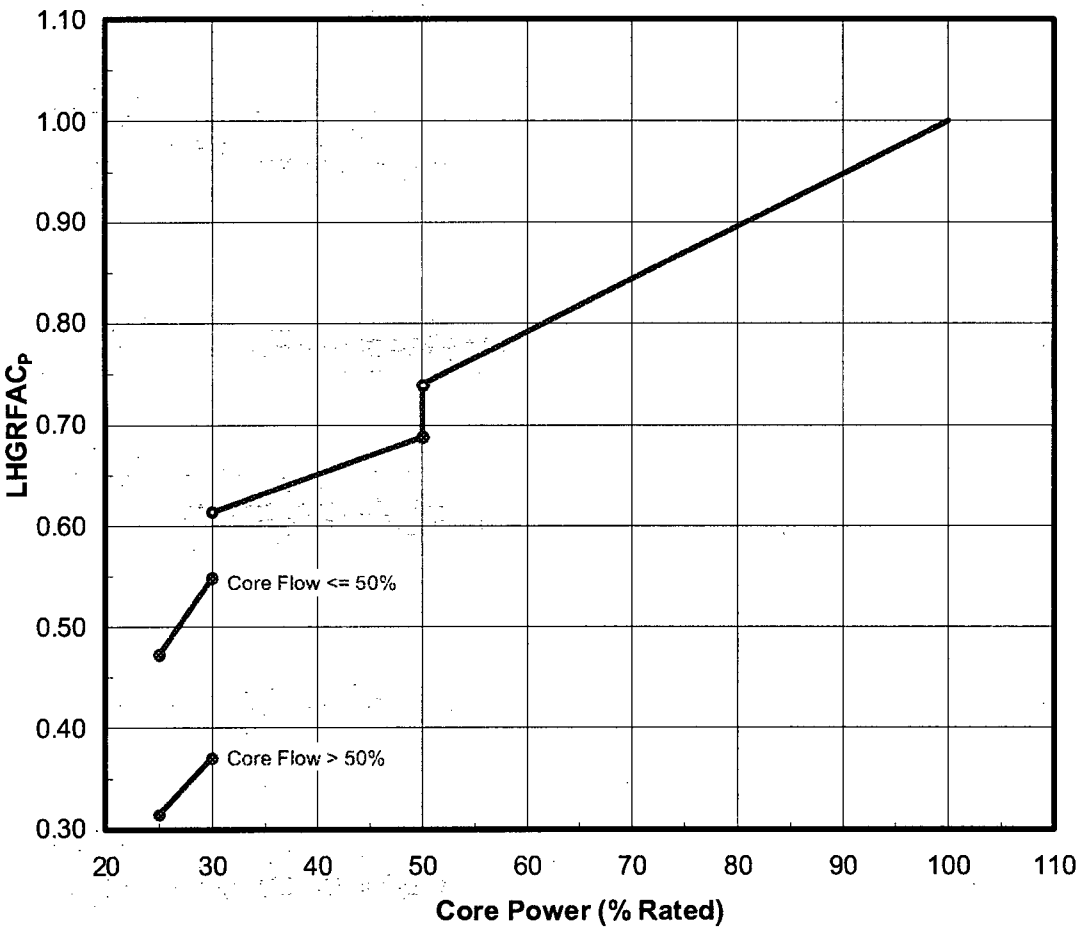

| Pellet Exposure (GWd/MTU) | Pellet Exposure (GWd/ST) | LHGR Limit (kW/ft) |
|---|---|---|
| 0.00 | 0.00 | 13.40 |
| 16.00 | 14.51 | 13.40 |
| 63.50 | 57.61 | 8.00 |
| 70.00 | 63.50 | 5.00 |

Figure 3.2 $LHGR_{RATED}$ for GE14 $UO_2$ Fuel



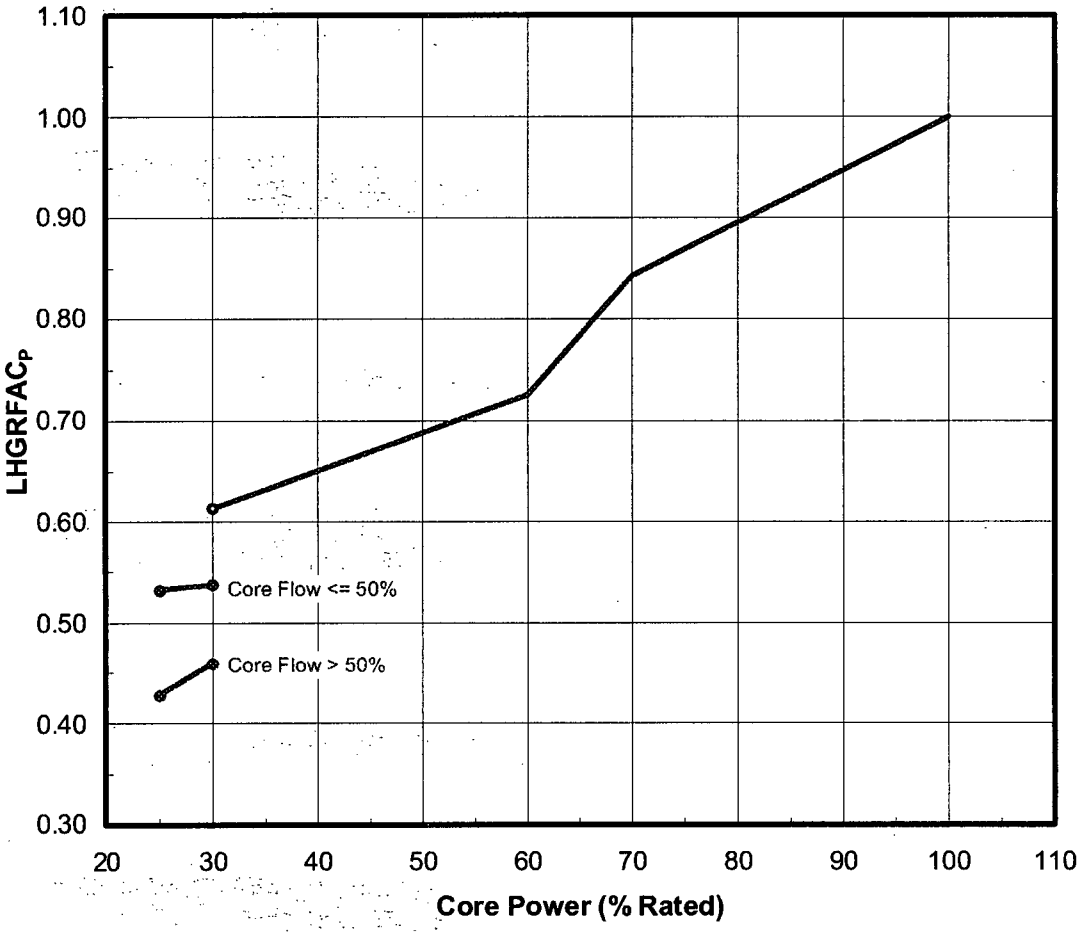

| Core Power (% Rated) | $LHGRFAC_P$ |
|---|---|
| 100.0 | 1.000 |
| 50.0 | 0.739 |
| 50.0 | 0.688 |
| 30.0 | 0.614 |
| **Core Flow > 50% Rated** | |
| 30.0 | 0.460 |
| 25.0 | 0.428 |
| **Core Flow <= 50% Rated** | |
| 30.0 | 0.538 |
| 25.0 | 0.533 |

Figure 3.3 $LHGRFAC_P$ for All EIS or RPTOOS Conditions
(*with and without FHOOS*)



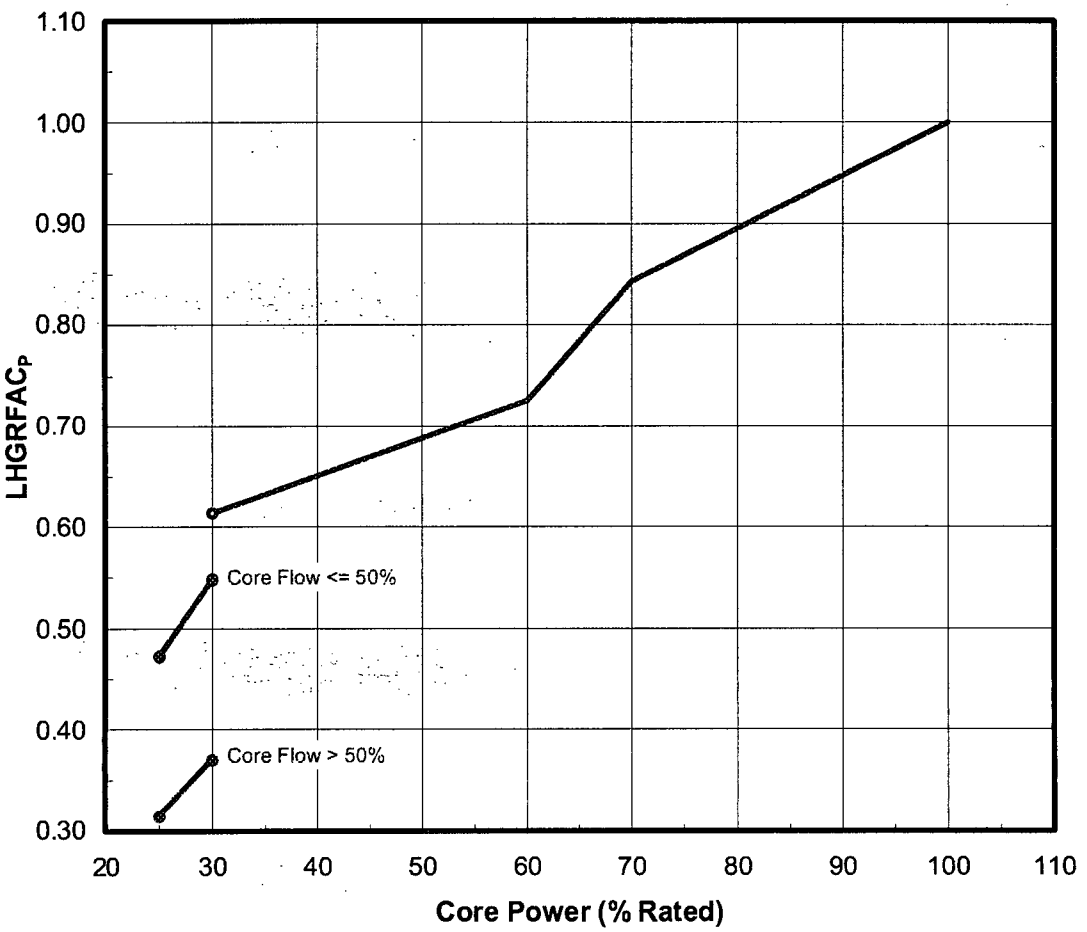

| Core Power (% Rated) | $LHGRFAC_P$ |
|---|---|
| 100.0 | 1.000 |
| 50.0 | 0.739 |
| 50.0 | 0.688 |
| 30.0 | 0.614 |
| **Core Flow > 50% Rated** | |
| 30.0 | 0.371 |
| 25.0 | 0.315 |
| **Core Flow <= 50% Rated** | |
| 30.0 | 0.549 |
| 25.0 | 0.473 |

Figure 3.4 $LHGRFAC_P$ for RPTOOS and TBVOOS Conditions
(*with and without FHOOS*)



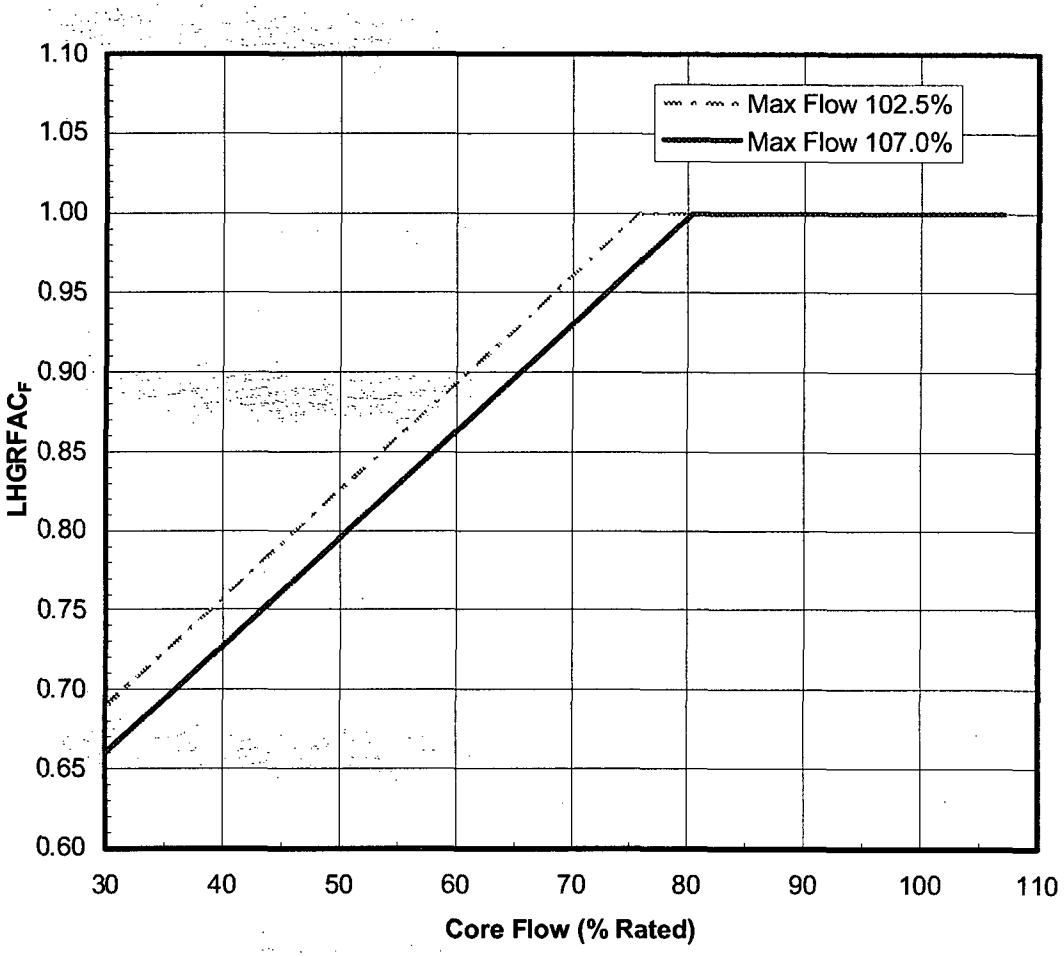

| Core Power (% Rated) | $LHGRFAC_P$ |
|---|---|
| 100.0 | 1.000 |
| 70.0 | 0.843 |
| 60.0 | 0.725 |
| 30.0 | 0.614 |
| **Core Flow > 50% Rated** | |
| 30.0 | 0.460 |
| 25.0 | 0.428 |
| **Core Flow <= 50% Rated** | |
| 30.0 | 0.538 |
| 25.0 | 0.533 |

Figure 3.5 $LHGRFAC_P$ for RPTOOS and PLUOOS Conditions
(*with and without FHOOS*)




| Core Power (% Rated) | $LHGRFAC_P$ |
|---|---|
| 100.0 | 1.000 |
| 70.0 | 0.843 |
| 60.0 | 0.725 |
| 30.0 | 0.614 |
| **Core Flow > 50% Rated** | |
| 30.0 | 0.371 |
| 25.0 | 0.315 |
| **Core Flow <= 50% Rated** | |
| 30.0 | 0.549 |
| 25.0 | 0.473 |

Figure 3.6 $LHGRFAC_P$ for RPTOOS, TBVOOS, and PLUOOS Conditions
(*with and without FHOOS*)




*Max. Core Flow of 102.5%*

| Core Flow (% Rated) | LHGRFAC$_F$ |
|---|---|
| 30.0 | 0.69 |
| 75.8 | 1 |
| 102.5 | 1 |

*Max. Core Flow of 107.0%*

| Core Flow (% Rated) | LHGRFAC$_F$ |
|---|---|
| 30.0 | 0.66 |
| 80.3 | 1 |
| 107.0 | 1 |

Figure 3.7 LHGRFAC$_F$
(*Values bound all EOOS conditions*)

(*102.5% maximum core flow line is used to support 100% rated flow operation*)
(*107.0% maximum core flow line is used to support 105% rated flow operation, ICF*)

# 4 OLMCPR Limits

**(Technical Specification 3.2.2, 3.3.4.1, & 3.7.5)**

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

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

where:

| | | |
|---|---|---|
| $MCPR_P$ | off-rated power MCPR limit | $[MCPR_{RATED} * K_P]$ |
| $MCPR_F$ | off-rated flow MCPR limit | |
| $MCPR_{SLO}$ | SLO MCPR limit | $[MCPR_P$ + SLO Adder$]$ |

## 4.1 Rated Power and Flow Limit: $MCPR_{RATED}$

The rated conditions MCPR, for both fuel types, are identified in Reference 1. The rated power and flow limits for various cycle exposure windows, and EOOS scenarios, are shown in Figure 4.2 thru Figure 4.5.

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

### *4.1.1 Scram Timing Dependence*

The $MCPR_{RATED}$ has a scram timing dependence which is assessed after control blade timing shortly after startup, and is discussed as follows:

$$\tau = 0.0 \quad \text{or,}$$

$$\frac{\tau_{ave} - \tau_B}{\tau_A - \tau_B}\,, \quad \text{whichever is greater}$$

where: $\tau_A$ = **1.096** sec (analytical Option A scram time limit based on dropout time for notch position 36)

$$\tau_{ave} = \frac{\sum_{i=1}^{n} \tau_i}{n}$$

$$\tau_B = \mu + 1.65 * \sigma * \left[\frac{N}{n}\right]^{\frac{1}{2}}$$

where: $\mu$ = **0.830** sec (mean scram time used in transient analysis based on dropout time for notch position 36)

$\sigma$ = **0.019** sec (standard deviation of $\mu$)

N = Total number of active rods measured in Technical Specification Surveillance Requirement SR 3.1.4.1

n = Number of surveillance rod tests performed to date in cycle

$\tau_i$ = Scram time (dropout time) from fully withdrawn to notch position 36 for the $i^{th}$ rod

For reactor startup, Option A limits ($\tau$=1.0) shall be used prior to the determination of $\tau$ in accordance with SR 3.1.4.1.

### *4.1.2 Equipment Out-Of-Service (EOOS) Options*

All equipment service conditions support 1 SRVOOS. EOOS options, including combinations, 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 |
| PLUOOS | Power Load Unbalance Out-Of-Service |
| FHOOS (or FFWTR) | Feedwater Heaters Out-Of-Service (or Final Feedwater Temperature Reduction) |

### *4.1.3 Exposure Dependent Limits*

Exposures are tracked on a cycle exposure basis. Higher exposure limits are always more limiting, and may be used for any cycle exposure up to the ending exposure. Cycle Exposure Ranges are defined as follows:

BOC to MOC: where MOC corresponds to **EOR* - 2725 MWd/MTU** (2472 MWd/ST).
BOC to EOC

EOC exposure includes cycle extension options such as final feedwater reduction (FFTR) and power coastdown.

## 4.2 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 5. Limits are valid for all EOOS combinations. No adjustment is required for SLO conditions.

* EOR is defined as the end of rated power capability for rated core flow and nominal feedwater temperature conditions.

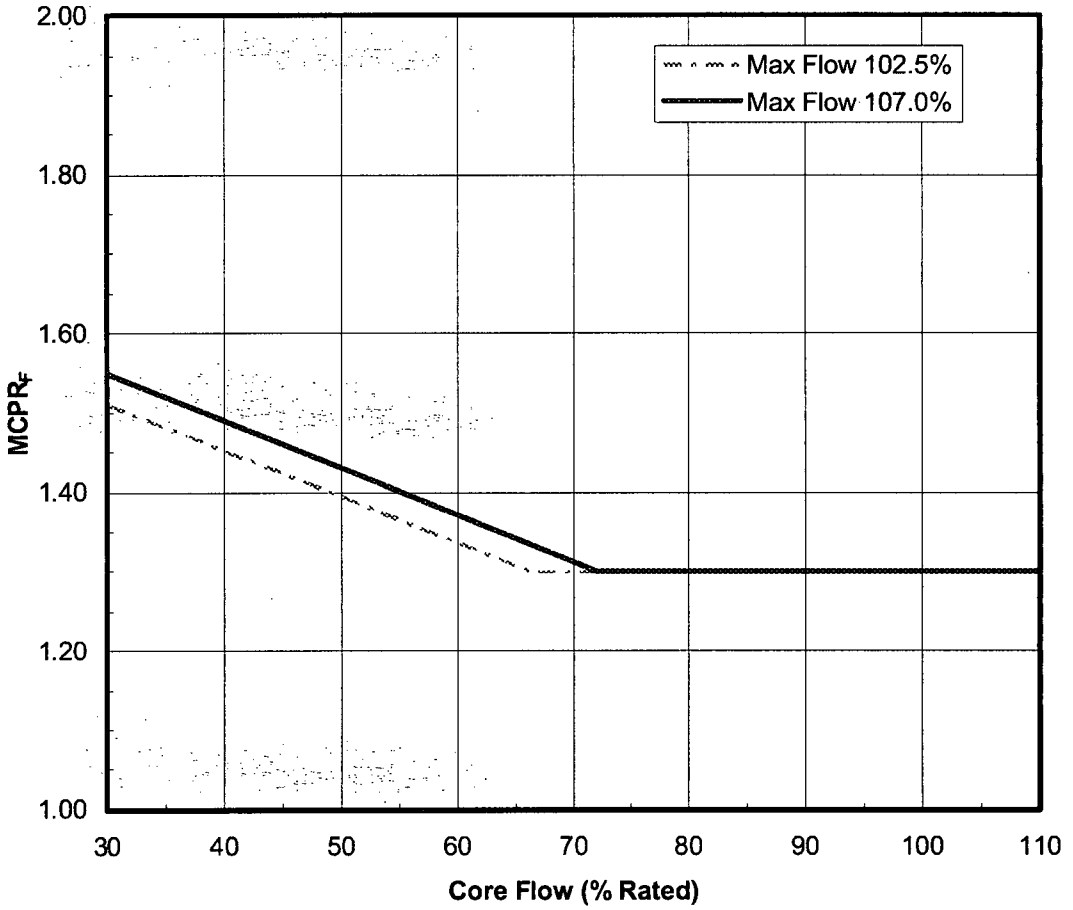
## 4.3 Single Loop Operation Limit: $MCPR_{SLO}$

The single loop operation adder for both GE13 and GE14 fuel is **0.02**, per Reference 1.

## 4.4 Power Dependent MCPR Limit: $MCPR_P$

$MCPR_P$ limits are dependent upon core power level (% of Rated) and EOOS conditions. $K_p$ Multipliers and/or $MCPR_P$ values are provided in Figure 4.6 thru Figure 4.9. Determination of power dependent MCPR is differentiated relative to Pbypass (30% Rated Power) as follows:

$P \geq 30\%$ (above Pbypass): $MCPR_P = [MCPR_{RATED} * K_P]$
$P < 30\%$ (below Pbypass): $MCPR_P = MCPR_P$

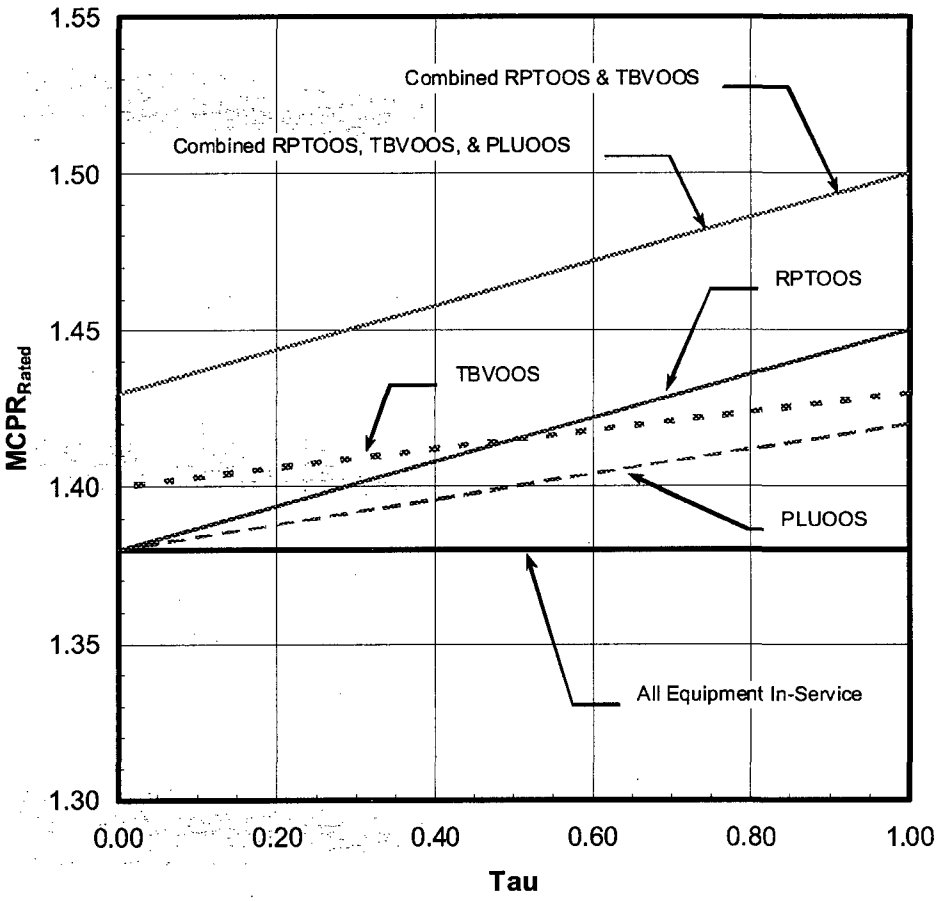



| *Max. Core Flow of 102.5%* | |
|---|---|
| **Core Flow (% Rated)** | **MCPR$_F$** |
| 30.0 | 1.51 |
| 66.3 | 1.30 |
| 110.0 | 1.30 |

| *Max. Core Flow of 107.0%* | |
|---|---|
| **Core Flow (% Rated)** | **MCPR$_F$** |
| 30.0 | 1.55 |
| 71.9 | 1.30 |
| 110.0 | 1.30 |

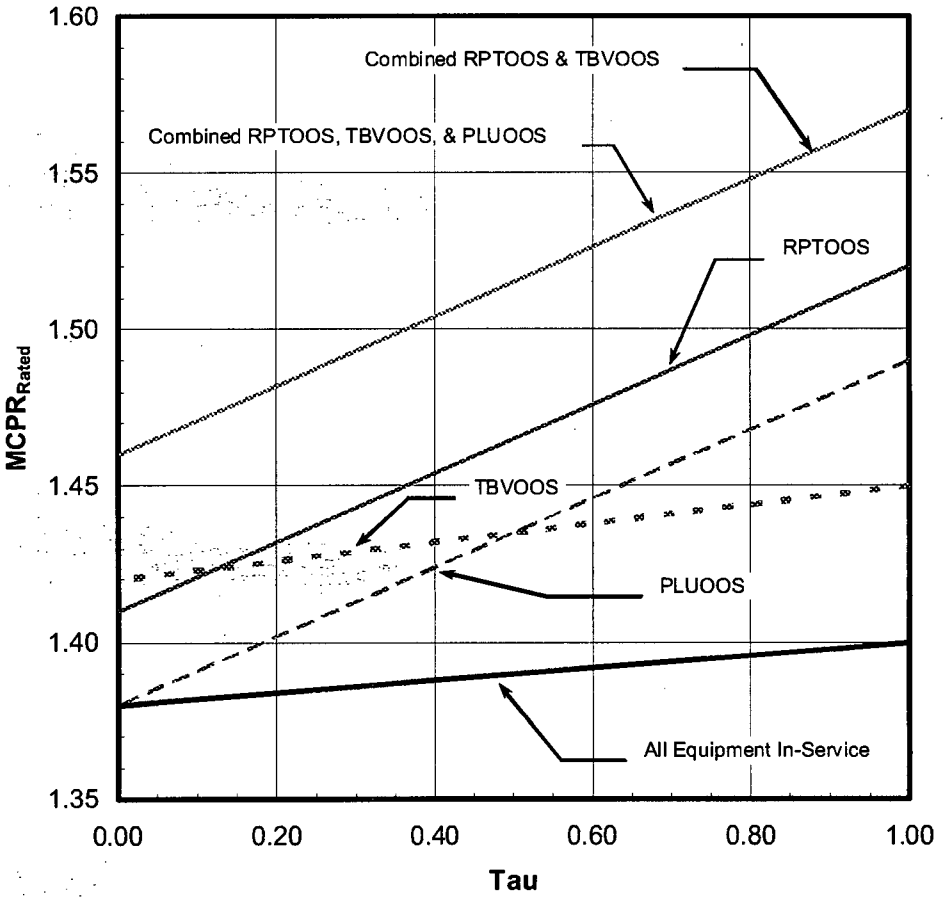
Figure 4.1 MCPR$_F$
(*Values bound all EOOS, and SLO conditions*)

(*102.5% maximum core flow line is used to support 100% rated flow operation*)
(*107.0% maximum core flow line is used to support 105% rated flow operation, ICF*)



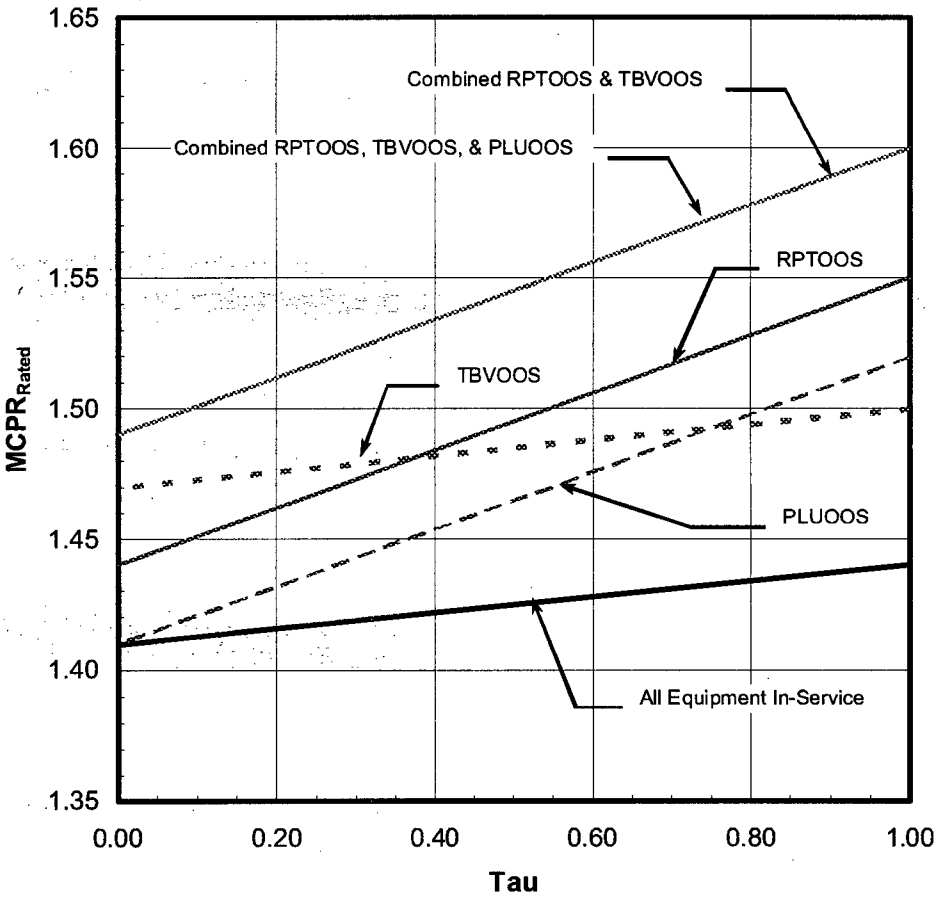

| Out-of-Service Condition | Option A Tau = 1.0 | Option B Tau = 0.0 |
|---|---|---|
| All Equipment In-Service | 1.38 | 1.38 |
| RPTOOS | 1.45 | 1.38 |
| TBVOOS | 1.43 | 1.40 |
| PLUOOS | 1.42 | 1.38 |
| Combined RPTOOS & TBVOOS | 1.50 | 1.43 |
| Combined RPTOOS, TBVOOS, & PLUOOS | 1.50 | 1.43 |

Figure 4.2 MCPR$_{Rated}$ for GE13: BOC to MOC Exposure
(*Values support 1SRVOOS & FHOOS/FFTR conditions*)



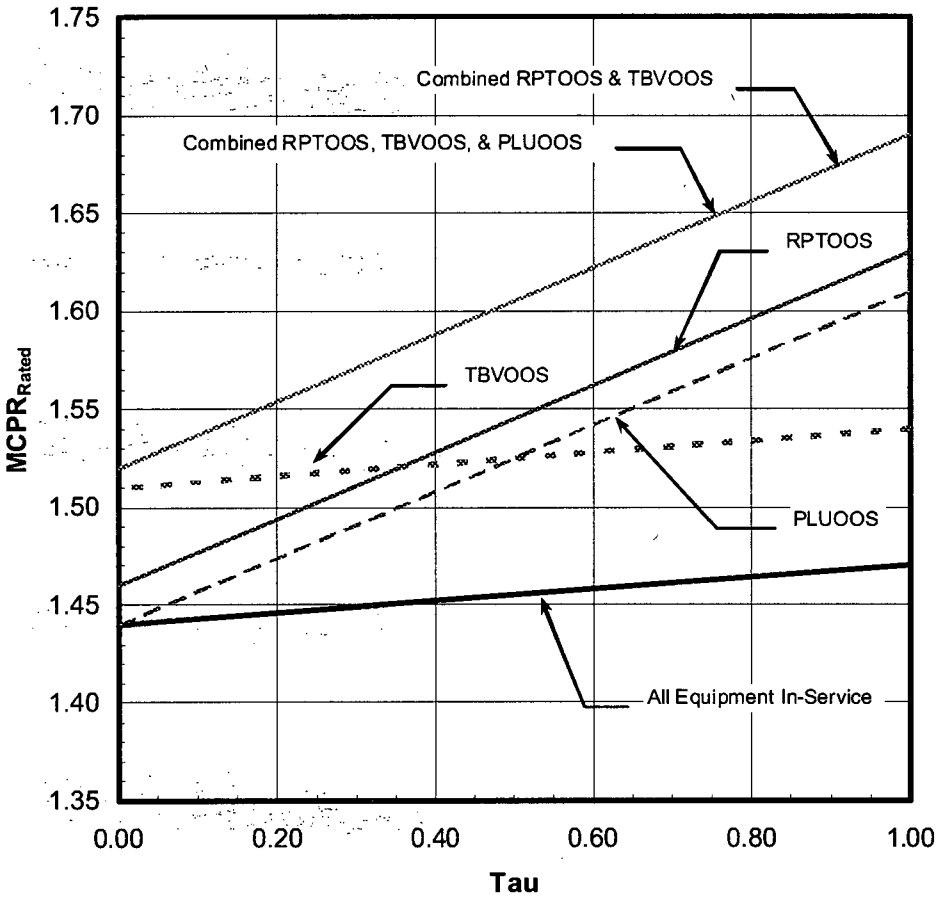

| Out-of-Service Condition | Option A Tau = 1.0 | Option B Tau = 0.0 |
|---|---|---|
| All Equipment In-Service | 1.40 | 1.38 |
| RPTOOS | 1.52 | 1.41 |
| TBVOOS | 1.45 | 1.42 |
| PLUOOS | 1.49 | 1.38 |
| Combined RPTOOS & TBVOOS | 1.57 | 1.46 |
| Combined RPTOOS, TBVOOS, & PLUOOS | 1.57 | 1.46 |

Figure 4.3 $MCPR_{Rated}$ for GE13: BOC to EOC Exposure
(*Values support 1SRVOOS & FHOOS/FFTR conditions*)



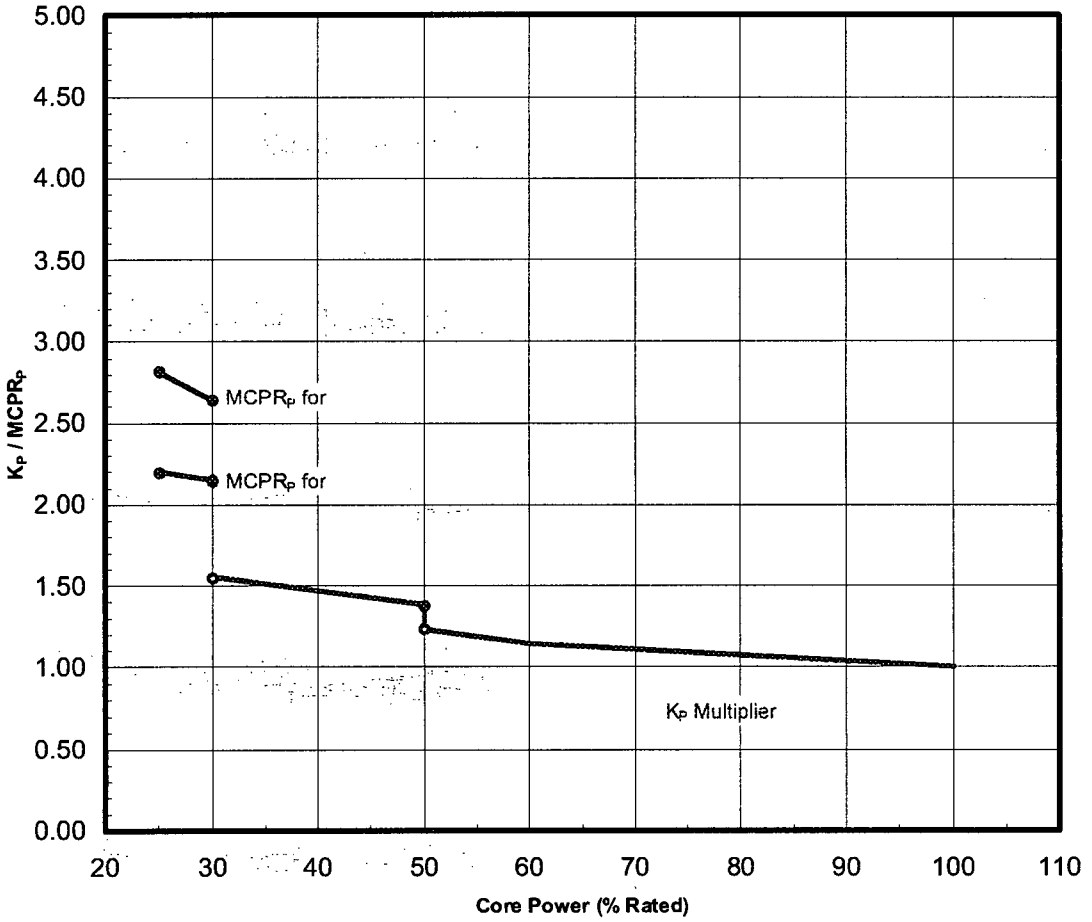

| Out-of-Service Condition | Option A Tau = 1.0 | Option B Tau = 0.0 |
|---|---|---|
| All Equipment In-Service | 1.44 | 1.41 |
| RPTOOS | 1.55 | 1.44 |
| TBVOOS | 1.50 | 1.47 |
| PLUOOS | 1.52 | 1.41 |
| Combined RPTOOS & TBVOOS | 1.60 | 1.49 |
| Combined RPTOOS, TBVOOS, & PLUOOS | 1.60 | 1.49 |

Figure 4.4 $MCPR_{Rated}$ for GE14: BOC to MOC Exposure
(*Values support 1SRVOOS & FHOOS/FFTR conditions*)



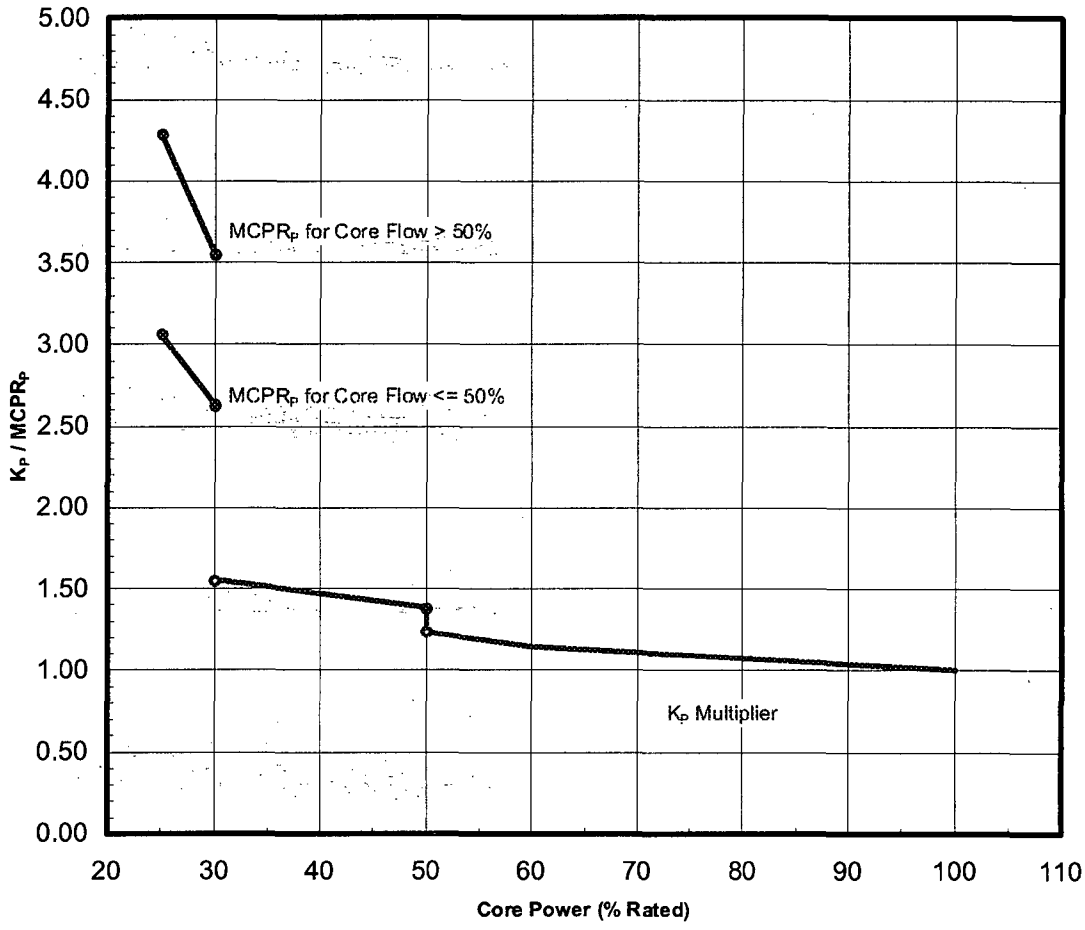

| Out-of-Service Condition | Option A Tau = 1.0 | Option B Tau = 0.0 |
|---|---|---|
| All Equipment In-Service | 1.47 | 1.44 |
| RPTOOS | 1.63 | 1.46 |
| TBVOOS | 1.54 | 1.51 |
| PLUOOS | 1.61 | 1.44 |
| Combined RPTOOS & TBVOOS | 1.69 | 1.52 |
| Combined RPTOOS, TBVOOS, & PLUOOS | 1.69 | 1.52 |

Figure 4.5 $MCPR_{Rated}$ for GE14: BOC to EOC Exposure
(*Values support 1SRVOOS & FHOOS/FFTR conditions*)



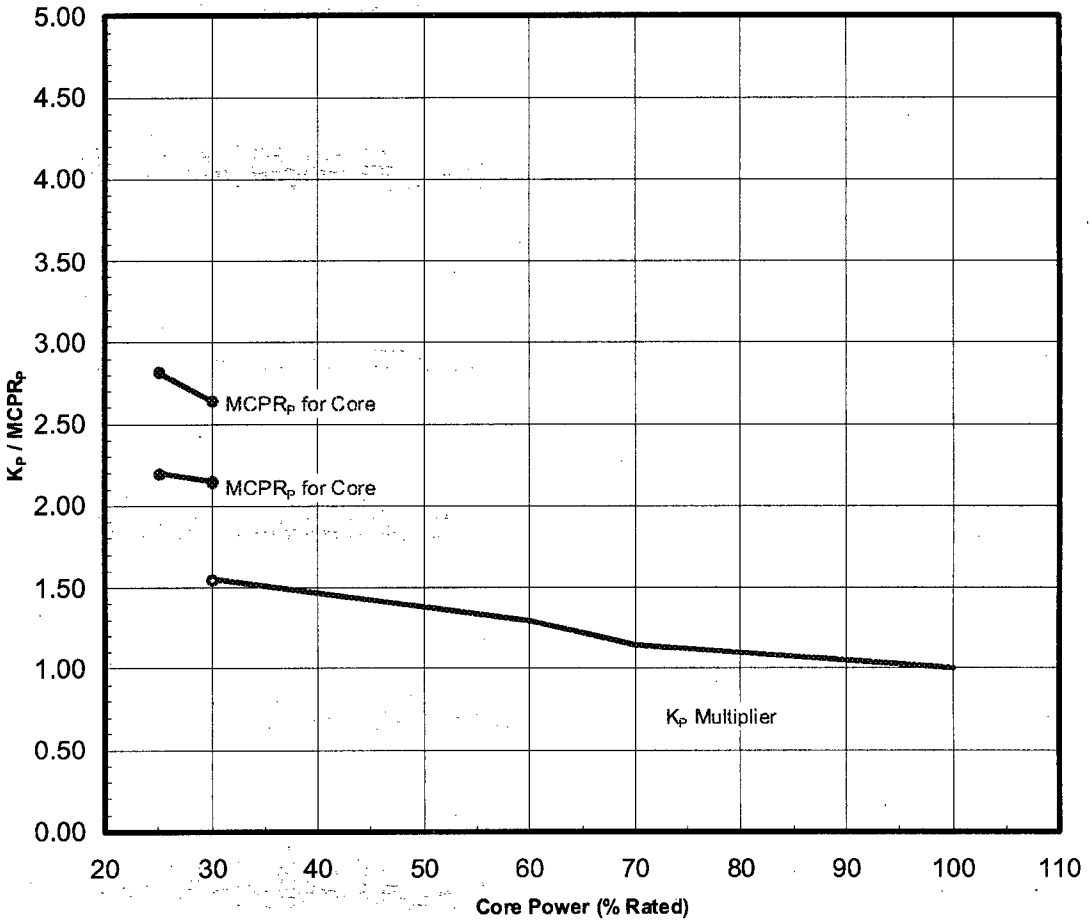

| Core Power (% Rated) | $K_P$ |
|---|---|
| 100.0 | 1.000 |
| 60.0 | 1.150 |
| 50.0 | 1.237 |
| 50.0 | 1.384 |
| 30.0 | 1.552 |
| **Core Flow > 50% Rated** | |
| | **$MCPR_P$** |
| 30.0 | 2.640 |
| 25.0 | 2.820 |
| **Core Flow <= 50% Rated** | |
| | **$MCPR_P$** |
| 30.0 | 2.150 |
| 25.0 | 2.200 |

Figure 4.6 $K_P$ Multiplier and $MCPR_P$ for All Equipment In Service or RPTOOS
(*Values support 1SRVOOS & FHOOS/FFTR conditions*)



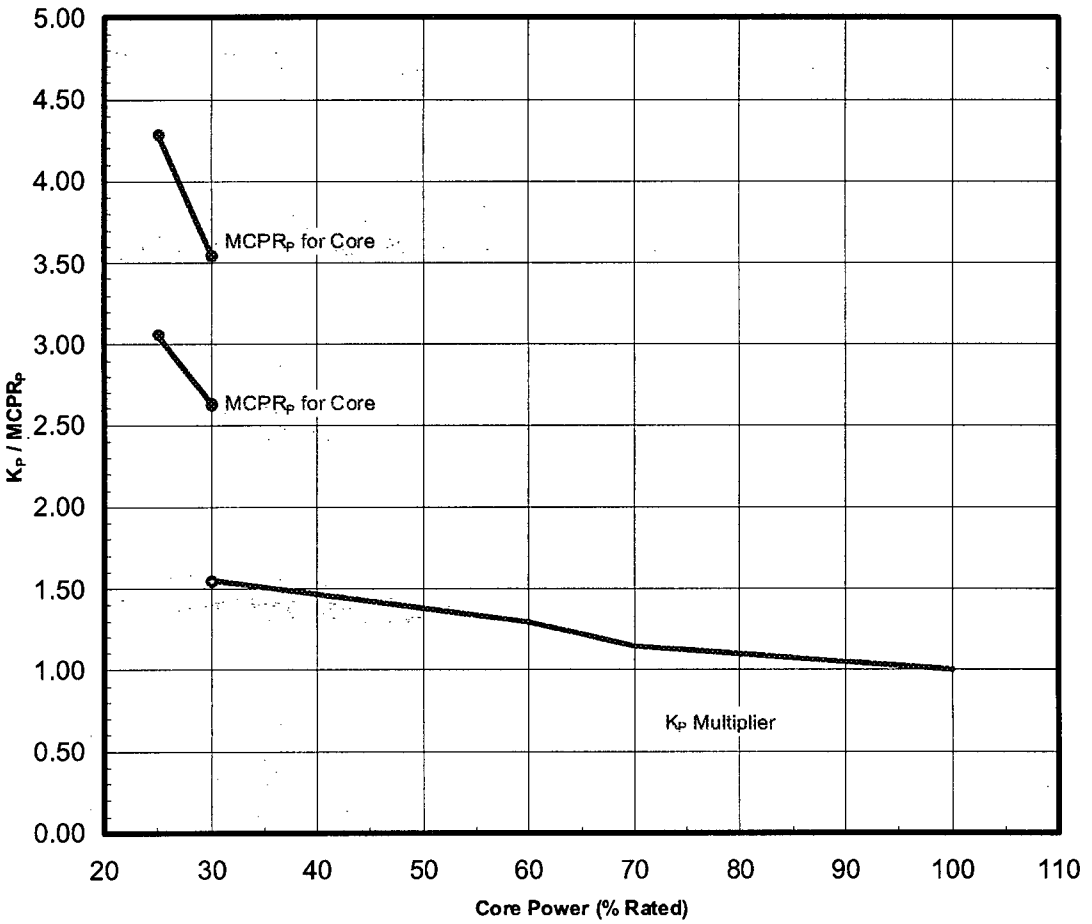

| Core Power (% Rated) | $K_P$ |
|---|---|
| 100.0 | 1.000 |
| 60.0 | 1.150 |
| 50.0 | 1.237 |
| 50.0 | 1.384 |
| 30.0 | 1.552 |
| **Core Flow > 50% Rated** | |
| | **$MCPR_P$** |
| 30.0 | 3.550 |
| 25.0 | 4.290 |
| **Core Flow <= 50% Rated** | |
| | **$MCPR_P$** |
| 30.0 | 2.630 |
| 25.0 | 3.060 |

Figure 4.7 $K_P$ Multiplier and $MCPR_P$ for RPTOOS and TBVOOS
(*Values support 1SRVOOS & FHOOS/FFTR conditions*)




| Core Power (% Rated) | $K_P$ |
|---|---|
| 100.0 | 1.000 |
| 70.0 | 1.150 |
| 60.0 | 1.300 |
| 30.0 | 1.552 |
| **Core Flow > 50% Rated** | |
| | **$MCPR_P$** |
| 30.0 | 2.640 |
| 25.0 | 2.820 |
| **Core Flow <= 50% Rated** | |
| | **$MCPR_P$** |
| 30.0 | 2.150 |
| 25.0 | 2.200 |

Figure 4.8 $K_P$ Multiplier and $MCPR_P$ for RPTOOS and PLUOOS
(*Values support 1SRVOOS & FHOOS/FFTR conditions*)




| Core Power (% Rated) | $K_P$ |
|---|---|
| 100.0 | 1.000 |
| 70.0 | 1.150 |
| 60.0 | 1.300 |
| 30.0 | 1.552 |
| **Core Flow > 50% Rated** | |
| | **$MCPR_P$** |
| 30.0 | 3.550 |
| 25.0 | 4.290 |
| **Core Flow <= 50% Rated** | |
| | **$MCPR_P$** |
| 30.0 | 2.630 |
| 25.0 | 3.060 |

Figure 4.9 $K_P$ Multiplier and $MCPR_P$ for RPTOOS, TBVOOS, and PLUOOS
(*Values support 1SRVOOS & FHOOS/FFTR conditions*)

# 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 9 & 10, 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

$\Delta W$ = Difference between two-loop and single-loop effective recirculation flow at the same core flow ($\Delta W$=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 9 & 10, are shown in Table 6.1. Setpoints are based on an HTSP, unfiltered analytical limit of 117%. 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.

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 | 124.7% | 123.0% |
| | - filtered | 123.5% | 121.8% |
| ITSP | - unfiltered | 119.7% | 118.0% |
| | - filtered | 118.7% | 117.0% |
| HTSP | - unfiltered | 114.7% | 113.0% |
| | - filtered | 113.7% | 112.0% |
| DTSP | | 90% | 92% |

Generic CRWE based OLMCPR values were reported and verified per References 9, 10, 11, and 12. However, Reference 12 generic values were developed assuming a SLMCPR ≤ 1.07. Consequently, cycle specific CRWE analyses were performed to support the current SLMCPR; values are reported in Reference 1. Cycle specific analysis results indicate the SLMCPR remains protected for RBM inoperable conditions (i.e., unblocked). RBM setpoints in Technical Specification Table 3.3.2.1-1 are applicable as shown in Table 6.2.

Table 6.2 RBM Setpoint Applicability

| Thermal Power (% Rated) | Applicable MCPR† | Notes from Table 3.3.2.1-1 | Comment |
|---|---|---|---|
| > 27% and < 90% | < 1.70 | (a), (b), (f), (h) | two loop operation |
| | < 1.74 | (a), (b), (f), (h) | single loop operation |
| ≥ 90% | < 1.40 | (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.

# 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**