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RBG-48110

August 19, 2021

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

Subject: River Bend Station Core Operating Limits Report (COLR) - Cycle 22, Revision 1

River Bend Station, Unit 1
NRC Docket No. 50-458
Renewed Facility Operating License No. NPF-47

The Enclosure to this letter contains Revision 1 of the River Bend Station Core Operating Limits Report for Cycle 22. This report is submitted in accordance with Technical Specification 5.6.5.d of Appendix A of the Facility Operating License.

This letter does not contain any new commitments.

If you require additional information, please contact Mr. Tim Schenk at (225) 381-4177 or tschenk@entergy.com.

Respectfully,

Tim Schenk

Digitally signed by Tim Schenk
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Date: 2021.08.18 10:25:59 -05'00'

Tim Schenk

TAS/baj

Enclosure: River Bend Station Core Operating Limits Report - Cycle 22, Revision 1

cc: NRC Regional Administrator - Region IV
NRC Project Manager - River Bend Station
NRC Senior Resident Inspector - River Bend Station

**Enclosure**

**RBG-48110**

**River Bend Station Core Operating Limits Report - Cycle 22, Revision 1**

**(44 Pages Total)**

# River Bend Station
# Core Operating Limits Report
# Cycle 22
# Revision 1

| REVISION HISTORY | |
|---|---|
| Revision | Revision Description |
| 0 | Initial Issue |
| 1 | Revised all MCPR operating limits to account for reduced margin specified in SC 21-04. Due to a possible metastable flow condition resulting in a higher loss coefficient, all MCPR operating limits have been increased to ensure MCPR limits are not exceeded in the presence of this higher loss coefficient. |
| | |

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## 1.0 PURPOSE

The COLR is controlled as a License Basis Document and is revised accordingly for each fuel cycle or remaining portion of a fuel cycle. Any revisions to the COLR must be submitted to the NRC for information as required by Tech Spec 5.6.5 and tracked by RBS License Commitment L11358.

## 2.0 SCOPE

As defined in Technical Specification 1.1, the COLR is the document that provides the core operating limits for the current fuel cycle. This document is prepared in accordance with Technical Specification 5.6.5 for each reload cycle using NRC-approved analytical methods.

The limits included in this report are:

1) LCO 3.2.1, Average Planar Linear Heat Generation Rate (APLHGR)
2) LCO 3.2.2, Minimum Critical Power Ratio (MCPR), including power and flow dependent limits
3) LCO 3.2.3, Linear Heat Generation Rate (LHGR), including power and flow dependent limits
4) LCO 3.2.4, Fraction of Core Boiling Boundary (FCBB)
5) LCO 3.3.1.1, RPS Instrumentation (RPS), Function 2.b
6) LCO 3.3.1.3, Periodic Based Detection System (PBDS)

## 3.0 REFERENCES

This section contains the background, cycle-specific, and methodology references used in the current cycle reload analysis.

## 3.1 Current Cycle References

3.1.1 ECH-NE-20-00036, Rev. 0, “Supplemental Reload Licensing Report for River Bend Station – Unit 1, Reload 21, Cycle 22”, GNF, 006N2913, Rev. 0, November 2020.

3.1.2 ECH-NE-20-00035, Rev. 0, “Fuel Bundle Information Report for River Bend Station – Unit 1 Reload 21 Cycle 22”; GNF, 005N2044, Rev.0, October 2020.

3.1.3 Letter, R. E. Kingston to G. W. Scronce, “Time Constant Values for Simulated Thermal Power Monitor”, RBC-46410, November 30, 1995.

3.1.4 RBS Updated Safety Analysis Report

3.1.5 GNF006N4896, Rev. 0, “Updated Loading Pattern for River Bend – Unit 1 Cycle 22”, KGO-ENO-LD1-21-036, March 2021.

3.1.6 ECH-NE-21-00006 Rev. 0, “GESTAR II Section 3.4 Compliance Evaluation for River Bend – Unit 1 Cycle 22”, GNF, 006N4923 Rev.0, March 2021.

3.1.7 ECH-NE-18-00033 Rev. 0, Entergy Operations, Inc. River Bend Station TRACG Implementation for Reload Licensing Transient Analysis (T1309); GEH 003N9955-R0, July 2018.

3.1.8 SC 21-04, Rev. 1, “Fuel Support Side Entry Orifice Meta-Stable Flow for 2 Beam Locations in the BWR/6 Reactors”, GEH, June 17, 2021.

3.1.9 CA-00028382, “LD1 C22 OPL-7 R3 Discussion”, GNF, KGO-ENO-LD1-21-098, July 2021. Issued as Appendix B of ECH-NE-21-00004, Rev. 1.

## 3.2 Methodology References

**The following are applicable to GNF supplied fuel.**

3.2.1 NEDE-24011-P-A-30-US, “General Electric Standard Application for Reactor Fuel (GESTAR-II)”, April 2020.

3.2.2 NEDC-33270P, Revision 11, “GNF2 Advantage Generic Compliance with NEDE-24011-P-A (GESTAR II)”, August 2020.

3.2.3 NEDC-33879P, Revision 4, “GNF3 Generic Compliance with NEDE-24011-P-A (GESTAR II)”, August 2020.

## 4.0 DEFINITIONS

4.1 Average Planar Linear Heat Generation Rate (APLHGR) - the APLHGR shall be applicable to a specific planar height and is equal to the sum of the linear heat generation rates for all the fuel rods in the specified bundle at the specified height divided by the number of fuel rods in the fuel bundle.

4.2 Average Planar Exposure - the Average Planar Exposure shall be applicable to a specific planar height and is equal to the sum of the exposure of all the fuel rods in the specified bundle at the specified height divided by the number of fuel rods in the fuel bundle.

4.3 Critical Power Ratio (CPR) - the ratio of that power in the assembly, which is calculated by application of the fuel vendor’s appropriate boiling correlation, to cause some point in the assembly to experience boiling transition, divided by the actual assembly operating power.

4.4 Core Operating Limits Report (COLR) - The River Bend Station specific document that provides core operating limits for the current reload cycle in accordance with Technical Specification 5.6.5.

4.5 Linear Heat Generation Rate (LHGR) - the LHGR shall be the heat generation per unit length of fuel rod. It is the integral of the heat flux over the heat transfer area associated with the unit length.

4.6 Minimum Critical Power Ratio (MCPR) - the MCPR shall be the smallest CPR which exists in the core.

4.7 MCPR Safety Limit (SLMCPR, $MCPR_{99.9\%}$) - the cycle specific minimum value of the CPR that ensures that 99.9% of the fuel rods avoid boiling transition during any moderate frequency transient.

4.8 $SLMCPR_{95/95}$ – the cycle independent, fuel design dependent MCPR safety limit found in the technical specifications that ensures there is a 95% probability at a 95% confidence level that no rods will be susceptible to transition boiling.

4.9 Aligned Drive Flow – Adjusted FCTR card input drive flow signal that accounts for actual variations in the core flow to drive flow relationship.

4.10 Monitored Region – The area of the core power and flow operating domain where the reactor may be susceptible to reactor instabilities under conditions exceeding the licensing basis of the current reactor system.

4.11 Restricted Region – The area of the core power and flow operating domain where the reactor is susceptible to reactor instabilities in the absence of restrictions on core void distributions.

4.12 Setpoint “Setup” – A FCTR card feature that sets the normal “non-setup” E1A APRM flow–biased scram and control rod block trip reference setpoints associated with the Exclusion and Restricted Regions higher to permit required reactor maneuvering in the Restricted Region when stability controls are in effect.

4.13 End of Rated (EOR) - the cycle exposure corresponding to all rods out, 100% power/100% flow, and normal feedwater temperature. (corresponding to Core Average Exposure 36,012 MWd/MT, or 32,670 MWd/ST) [Reference 3.1.1. Section 3].

4.14 MOC - Middle of Cycle (EOR – 4,431 MWd/MT, 4,020 MWd/ST) [Reference 3.1.1, Table 1].

4.15 EOC - End of Cycle

4.16 FFWTR – Final Feedwater Temperature Reduction.

4.17 FHOOS – Feedwater Heater Out of Service.

4.18 PROOS – Pressure Regulator Out of Service.

4.19 SLO – Single Loop Operation.

4.20 TBOOS –Turbine Bypass Out of Service

4.21 AREVA – AREVA NP Inc.

4.22 GNF – Global Nuclear Fuel

4.23 EOC-RPT – End of Cycle Recirculation Pump Trip

4.24 Reference Core Loading Pattern – The Core Loading Pattern Used for Reload Licensing Analysis.

4.25 Application Condition – The combination of equipment out of service conditions for which LHGRFAC and MCPR limits are determined [Reference 3.1.1, Section 11]. The Application Conditions are as follows:

| Application Condition | FWHOOS / FFWTR | EOC-RPT OOS | PROOS | TBOOS |
|---|---|---|---|---|
| 1 | X | | | |
| 2 | X | X | | |
| 3 | X | | X | |
| 4 | X | | | X |
| 5 | X | X | | X |
| 6 | X | | X | X |
| 7 | X | X | X | X |

All application conditions address the licensed core flow.

4.26 $P_{bypass}$ – Reactor Thermal Power (RTP) level below which the Turbine Stop Valve position and the Turbine Control Valve fast closure scrams are bypassed. Per TS Table 3.3.1.1-1, $P_{bypass}$ RTP = 40% RTP.

4.27 Operating Limit MCPR (OLMCPR) - Limiting transients are analyzed either with TRACG or other NRC-approved methodologies. The types of transients evaluated are loss of flow, increase in pressure and power, positive reactivity insertion, and coolant temperature increase. The TRACG methodology calculates an operating limit MCPR (OLMCPR) for the transient initial condition that will result in no more than 0.1% of the fuel rods susceptible to boiling transition. The other methodologies calculate a reduction in CPR for each transient, with the largest change in CPR (delta-CPR) resulting from the limiting transient. When the largest delta-CPR is added to the MCPR SL, an OLMCPR is obtained. The OLMCPR, calculated by either the TRACG or other methodology, sets the core operating limits.

## 5.0 CORE DESIGN

### 5.1 Reference Core Loading Pattern

The original Reference Core Loading pattern is presented in Reference 3.1.1. The Updated Core Loading (ULP) pattern is presented in Reference 3.1.5. Reference 3.1.6 confirmed the applicability of the limits presented in this COLR to the Cycle 22 ULP.

### 5.2 Control Rods

The River Bend core utilizes the GE design control rods, non GE design CR-82M and CR-82M-1 bottom entry cruciform control rods. These control rod designs are discussed in more detail in Reference 3.1.4, Sections 4.1 and 4.2.

## 6.0 AVERAGE PLANAR LINEAR HEAT GENERATION RATE (APLHGR)

Per Technical Specification 3.2.1, all APLHGR values shall not exceed the exposure-dependent limits reported as follows:

| Fuel Type | Figure |
|---|---|
| GNF2 | 6.1-1a |
| GNF3 | 6.1-1b |

For single loop operation (SLO), an ECCS/LOCA multiplier of 0.83 [Reference 3.1.1, Table 10] is applied to the APLHGR limits for all fuel types.

## 7.0 MINIMUM CRITICAL POWER RATIO (MCPR)

For Cycle 22, the cycle specific SLMCPR ($MCPR_{99.9\%}$) for Two Loop Operation (TLO) is 1.09. The cycle specific SLMCPR ($MCPR_{99.9\%}$) for Single Loop operation is 1.12. [Reference 3.1.1, Section 11]

Per Technical Specification 3.2.2, the MCPR values shall be equal to or greater than the operating limit for operation at ≥ 23.8% of rated thermal power. The operating limit is the maximum of the flow-dependent minimum critical power ratio ($MCPR_F$) and the power-dependent minimum critical power ratio ($MCPR_P$).

For power level less than $P_{bypass}$, the MCPRp can be directly read from Figure 7.0.a for AOO application conditions when Pressure Regulator is operable or from Figure 7.0.b, when Pressure Regulator is out of service.

Above $P_{bypass}$, the MCPRp is the product of the rated power and flow MCPR application condition operating limit presented in Table 7.0 [Ref. 3.1.1, Section 11, Limiting Pressurization Events OLMCPR Summary Table], and the K(P) factor presented in Figure 7.0.a for AOO application conditions when Pressure Regulator is operable, or from Figure 7.0.b, when Pressure Regulator is out of service.

$MCPR_F$ and $MCPR_P$, including the calculated $MCPR_P$ limits for thermal powers above $P_{bypass}$, are provided in Sections 7.1 and 7.2 below. These limits address the Cycle 22 cycle exposure ranges, two loop (TLO) and single loop operation (SLO), and seven application conditions. There is no MCPR distinction between GNF2 and GNF3.

GEH Safety Communication 21-04 (Reference 3.1.8) identifies a metastable flow condition that may exist in a BWR/6 in core locations fed by a side entry orifice adjacent to two core support cross beams. The vendor has been unable to determine the frequency of occurrence of this flow condition, if any. This flow condition results in a higher loss coefficient and lower CPR (applied as higher MCPR limits). To be conservative, it is assumed this condition always exists, so a MCPR penalty is always applied. Revision 1 of the COLR updates all MCPR operating limits to apply the penalty recommended by SC 21-04, as directed by Reference 3.1.9.

During SLO, the Operating Limit MCPR shall be increased to account for the Pump Seizure limit and the higher SLMCPR in SLO. The GNF3 Rated Power Equivalent SLO Pump Seizure event OLMCPR is limiting at 1.48 for BOC-EOC operation (1.56 when applying the SC 21-04 penalty). The GNF2 Rated Power Equivalent SLO Pump Seizure event OLMCPR is limiting at 1.47 for BOC-EOC operation (1.54 when applying the SC 21-04 penalty), but the more limiting GNF3 Rated SLO OLMPCR limit will be applied to GNF2. For SLO, the $MCPR_F$ and $MCPR_P$ below $P_{bypass}$ operating limits are either 0.03 or 0.04 greater than the two loop value [Reference 3.1.1, Section 11]. For calculated $MCPR_P$ limits for thermal powers above $P_{bypass}$, use SLO figures provided for Section 7.2 below.

## 7.1 Flow-Dependent Minimum Critical Power Ratio ($MCPR_F$) Values:

The $MCPR_F$ curves from Reference 3.1.1, Appendix D, applicable to all Cycle 22 exposures for TLO and SLO limits are found in the following figure:

| Application Condition | Figure<br>TLO and SLO<br>GNF2 and GNF3 |
|---|---|
| 1-7 | 7.1-1 |

## 7.2 Power-Dependent Minimum Critical Power Ratio ($MCPR_P$) Values:

The TLO and SLO $MCPR_P$ curves include the Reference 3.1.1, Appendix D reported $MCPR_P$ for thermal powers no larger than $P_{bypass}$, and the calculated $MCPR_P$ limits for thermal powers above $P_{bypass}$. For the SLO MCPRp curves, the more limiting GNF3 limits are also applied to GNF2 fuel type. They are found in the following figures:

| Application Condition | Figure | |
|---|---|---|
| | BOC – MOC | MOC - EOC |
| | GNF2 and GNF3 | GNF2 and GNF3 |
| 1, 4 | 7.2-1a | 7.2-1b |
| 2, 5 | 7.2-2a | 7.2-2b |
| 3, 6 | 7.2-3a | 7.2-3b |
| 7 | 7.2-4a | 7.2-4b |

More limiting values of the power dependent limits may be used in lieu of those indicated by a particular operating mode. For example, EOC values may be used instead of the MOC values.

## 8.0 LINEAR HEAT GENERATION RATE (LHGR)

Per Technical Specification 3.2.3, the LHGR values for any rod at any axial location shall not exceed the exposure-dependent limits multiplied by the smaller of either the power-dependent or flow-dependent LHGR factors.

For single loop operation (SLO), ECCS/LOCA multiplier of 0.83 [Reference 3.1.1, Table 10] is applied to the $LHGR_F$ limits for all fuel types.

For two recirculation loop and single recirculation loop operation the LHGR multiplier is as follows:

For two recirculation loop operation:

$LHGRFAC = MIN (LHGRFAC_P, LHGRFAC_F)$

For single loop operation:

$LHGRFAC = MIN (LHGRFAC_P, LHGRFAC_{F(SLO)})$

## 8.1 Exposure-Dependent Linear Heat Generation Rate (LHGR) Values:

GNF2 and GNF3 exposure-dependent LHGR values are considered GNF proprietary and will not be contained in the COLR. As described in Reference 3.1.2, Section 1, the GNF2 LHGR values may be found in Reference 3.2.2 and the GNF3 LHGR values may be found in Reference 3.2.3.

## 8.2 Flow-Dependent Linear Heat Generation Rate Factors ($LHGRFAC_F$) Values:

The $LHGRFAC_F$ curves are from Reference 3.1.1, Appendix D and are found on Figure 8.2-1a for TLO, and on Figure 8.2-1b for SLO. Figures 8.2-1a and Figure 8.2-1b are valid for all Cycle 22 fuel types in BOC to EOC exposure range.

## 8.3 Power-Dependent Linear Heat Generation Rate Factors ($LHGRFAC_P$) Values:

The $LHGRFAC_P$ curves are from Reference 3.1.1, Appendix D and are found in the following figures:

| Application Conditions | Figure | |
|---|---|---|
| | GNF2<br>TLO and SLO, BOC-EOC | GNF3<br>TLO and SLO, BOC-EOC |
| 1, 2,4, and 5 | 8.3-1a | 8.3-1b |
| 3,6, and 7 | 8.3-2a | 8.3-2b |

More limiting values of the power dependent multipliers may be used in lieu of those indicated by a particular operating mode.

## 9.0 STABILITY

The following Technical Specifications / Technical Requirements contain stability related requirements:

- TS 3.2.4, Fraction of Core Boiling Boundary (FCBB)
- TS 3.3.1.1, RPS Instrumentation (RPS)
- TS 3.3.1.3, Periodic Based Detection System (PBDS)
- TR 3.3.1.1, RPS Instrumentation (RPS)
- TR 3.3.2.1, Control Rod Block Instrumentation

## 9.1 Stability Region Boundaries and Setpoints

This section contains region boundaries, setpoints and other stability related requirements. The stability region boundaries and setpoints are as follows

| Description | Figure |
|---|---|
| Monitored Region Boundary (Case 1) | 9.1-1 |
| Monitored Region Boundary (Case 2) | 9.1-2 |
| APRM Flow Biased Simulated Thermal Power – High Scram Setpoints and Restricted Region Boundary (Two Recirculation Loop Operation – Case 1) | 9.1-3 |
| APRM Flow Biased Simulated Thermal Power – High Scram Setpoints and Restricted Region Boundary (Two Recirculation Loop Operation – Case 2) | 9.1-4 |
| APRM Flow Biased Simulated Thermal Power – High Scram Setpoints and Restricted Region Boundary (Single Recirculation Loop Operation – Case 1) | 9.1-5 |
| APRM Flow Biased Simulated Thermal Power – High Scram Setpoints and Restricted Region Boundary (Single Recirculation Loop Operation – Case 2) | 9.1-6 |
| APRM Flow Biased Neutron Flux - High Rod-Block Setpoints (Two Recirculation Loop Operation – Case 1) | 9.1-7 |
| APRM Flow Biased Neutron Flux - High Rod-Block Setpoints (Two Recirculation Loop Operation – Case 2) | 9.1-8 |
| APRM Flow Biased Neutron Flux - High Rod-Block Setpoints (Single Recirculation Loop Operation – Case 1) | 9.1-9 |
| APRM Flow Biased Neutron Flux - High Rod-Block Setpoints (Single Recirculation Loop Operation – Case 2) | 9.1-10 |

Note: For Figures 9.1-3 to 9.1-10, the Nominal Setpoints should be used for indicating the entry into a particular stability region as allowed and appropriate actions be taken prior to the entry

In the table above, two distinct operating states (Case 1 and Case 2) are considered. These are described as follows:

**Case 1 - Normal Feedwater Heating Operation or Low Reactor Power :**

$T_{FW}(\text{at rated}) \geq T_{FW}^{DESIGN}(\text{at rated}) - 50^\circ F$, and rated equivalent at off-rated reactor conditions

**OR**

$P \leq 30\%\ \text{RTP}$

**Case 2 - Reduced Feedwater Heating Operation:**

$T_{FW}(\text{at rated}) < T_{FW}^{DESIGN}(\text{at rated}) - 50^\circ F$

**AND**

$P > 30\%\ \text{RTP}$

The APRM Flow Biased Simulated Thermal Power - High scram setpoint and Restricted Region Boundary, and APRM Flow Biased Neutron Flux – High Rod-Block Setpoints are given in terms of aligned drive flow. The aligned drive flow is calculated from the input drive flow using the following relationship:

$$W_D = \frac{101.209 \times \Delta^{40} - 31.028 \times \Delta^{100} + 70.181 \times W_{\tilde{D}}}{70.181 - \left(\Delta^{100} - \Delta^{40}\right)}$$

Where: $W_{\tilde{D}}$ = FCTR card input drive flow in percent rated,

$W_D$ = Aligned drive flow in percent rated,

$\Delta^{40}$ = Low flow drive flow alignment setting, and

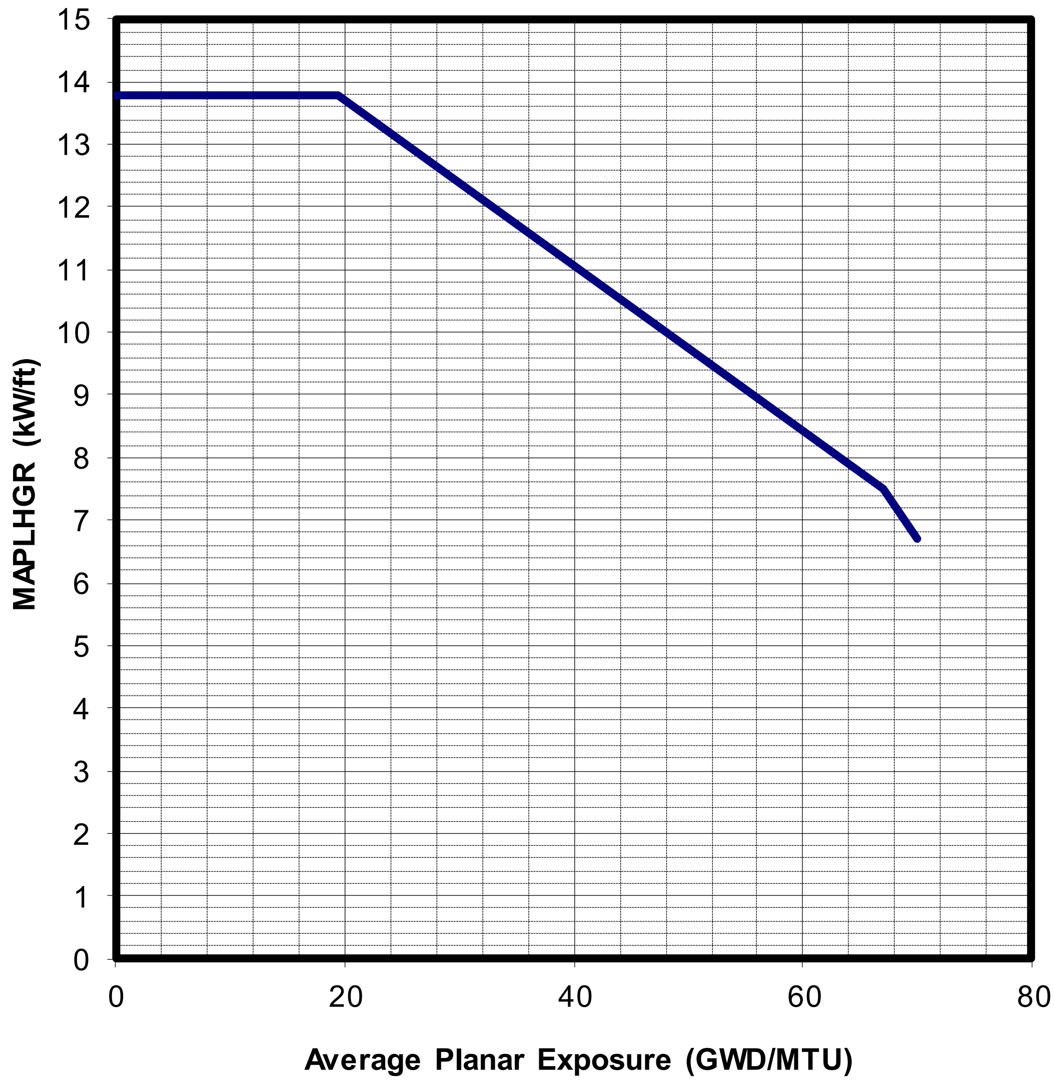
$\Delta^{100}$ = High flow drive flow alignment setting.

## 9.2 APRM Flow Biased Simulated Thermal Power−High Time Constant (SR 3.3.1.1.14)

The simulated thermal power time constant is 6 ± 0.6 seconds (Reference 3.1.3). Thus the maximum simulated thermal power time constant for use in meeting the surveillance requirement is 6.6 seconds.

**FIGURE 6.1-1a. MAXIMUM AVERAGE PLANAR LINEAR HEAT GENERATION RATE (MAPLHGR) VERSUS AVERAGE PLANAR EXPOSURE**

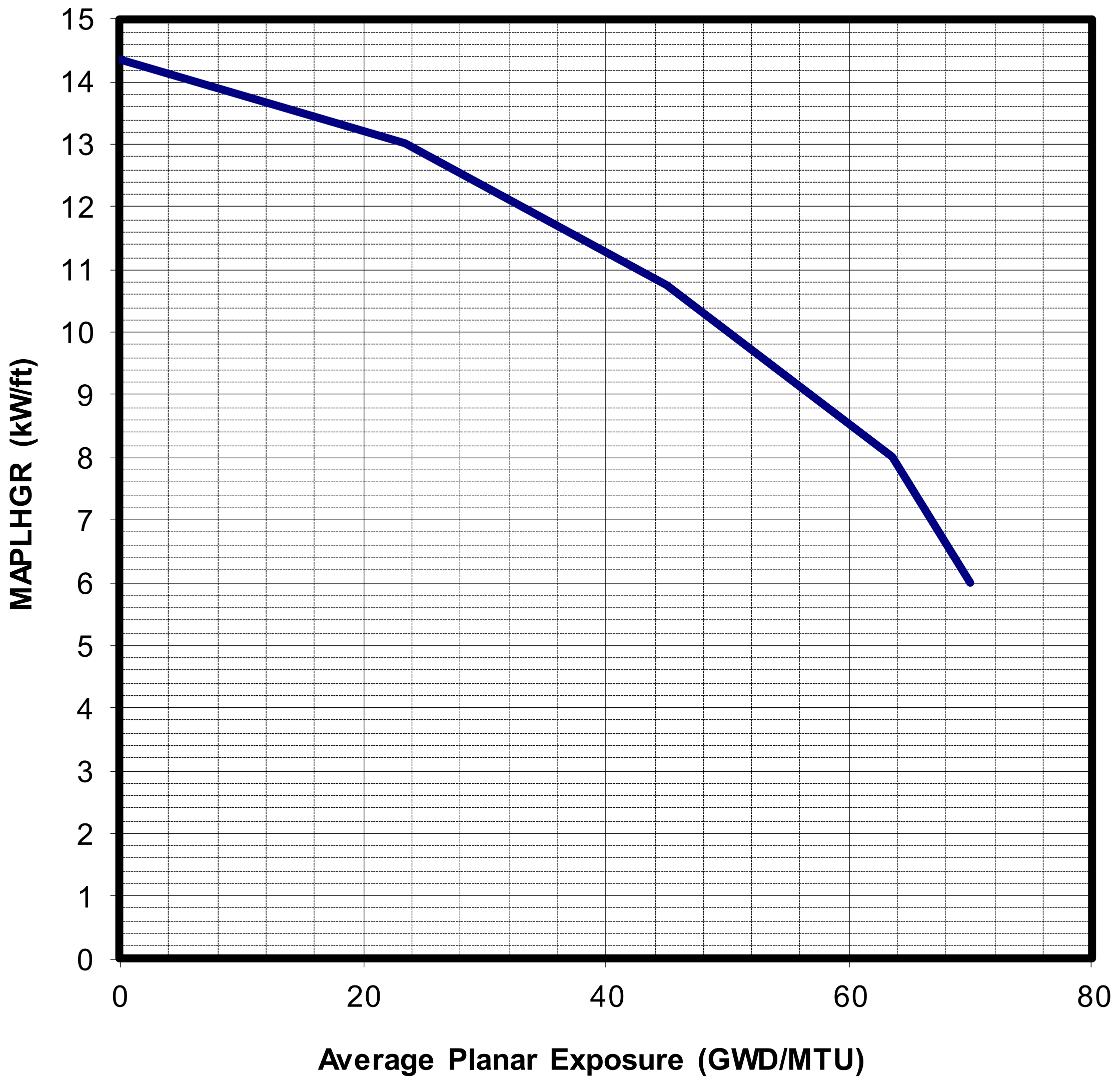
**FUEL TYPE: GNF2**




| Average Planar Exposure (GWd/MT) | MAPLHGR Limit (kW/ft) |
|---|---|
| 0.00 | 13.78 |
| 19.31 | 13.78 |
| 67.00 | 7.50 |
| 70.00 | 6.69 |

**FIGURE 6.1-1b. MAXIMUM AVERAGE PLANAR LINEAR HEAT GENERATION RATE (MAPLHGR) VERSUS AVERAGE PLANAR EXPOSURE**

**FUEL TYPE: GNF3**

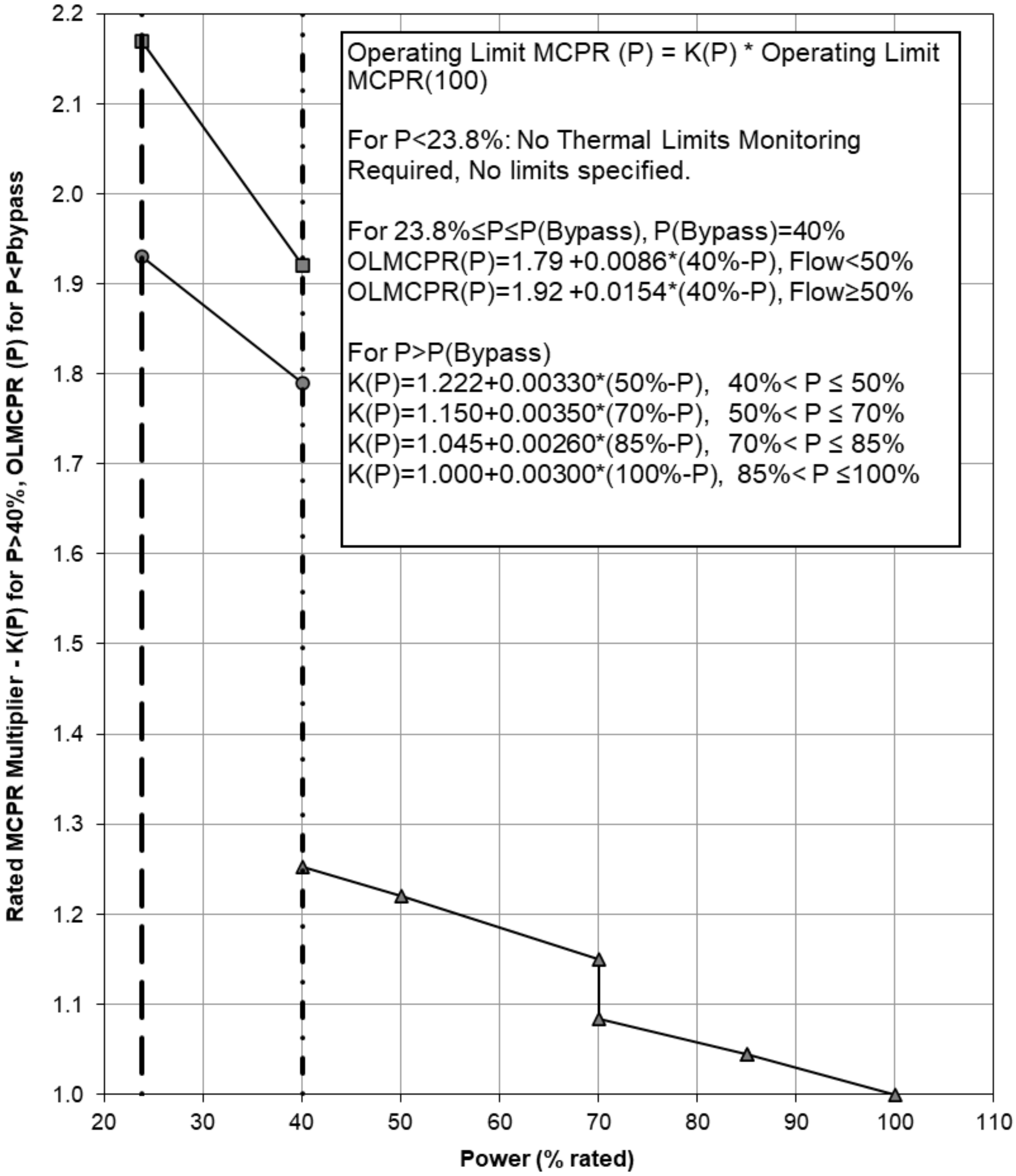



| Average Planar Exposure (GWd/MT) | MAPLHGR Limit (kW/ft) |
|---|---|
| 0.00 | 14.36 |
| 23.40 | 13.01 |
| 45.00 | 10.75 |
| 63.50 | 8.00 |
| 70.00 | 6.00 |

**Table 7.0: OLMCPR Summary Table**

| Application Condition | Operating Limit MCPR (OLMCPR) 100% RTP, GNF2 and GNF3, TLO | |
|---|---|---|
| | BOC – MOC | MOC – EOC |
| 1 | 1.32 | 1.38 |
| 2 | 1.34 | 1.41 |
| 3 | 1.33 | 1.39 |
| 4 | 1.32 | 1.38 |
| 5 | 1.34 | 1.41 |
| 6 | 1.33 | 1.39 |
| 7 | 1.34 | 1.41 |

Figure 7.0.a - MCPRp limit and K(P) multiplier for Application Conditions 1, 2, 4, and 5



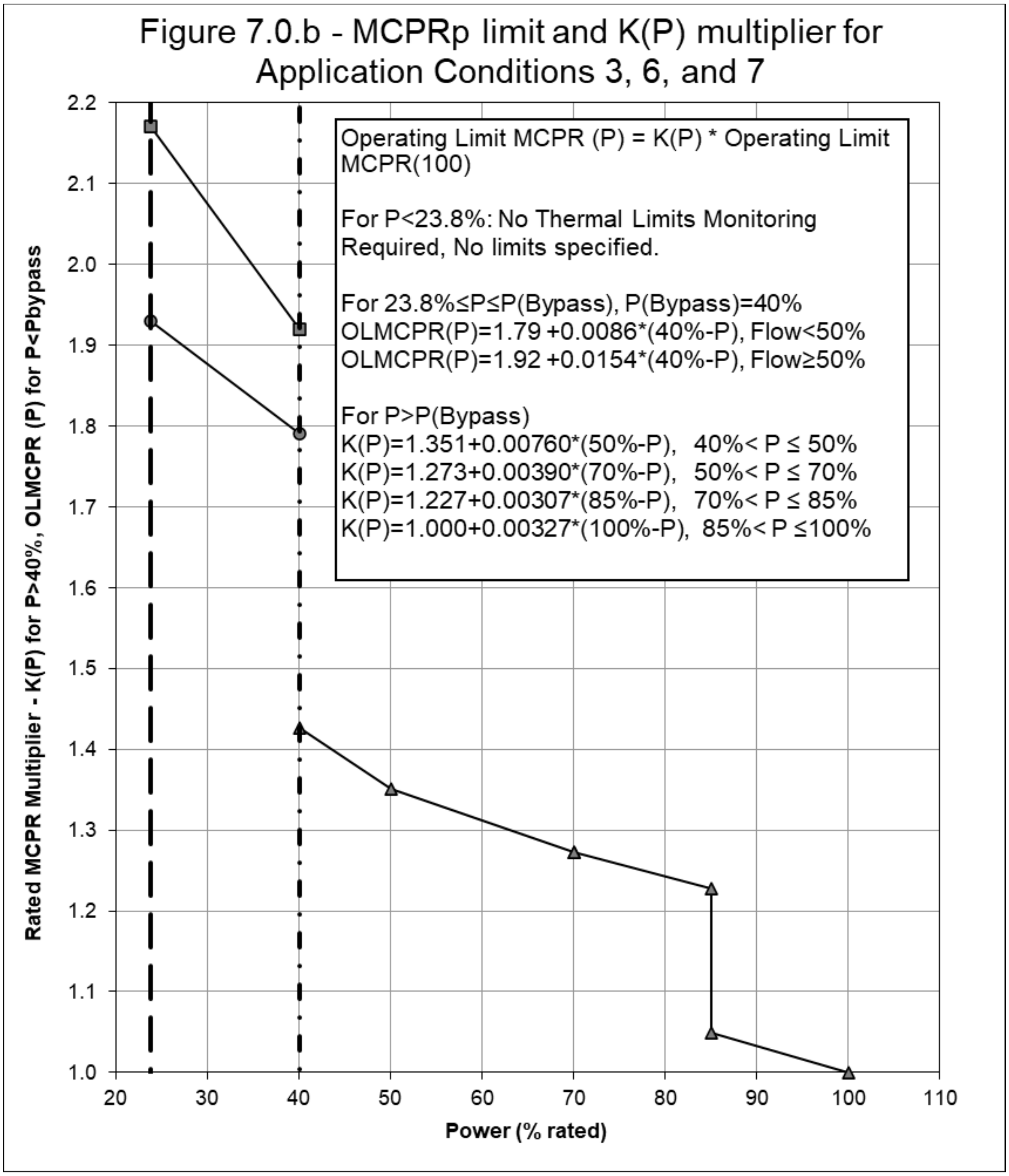
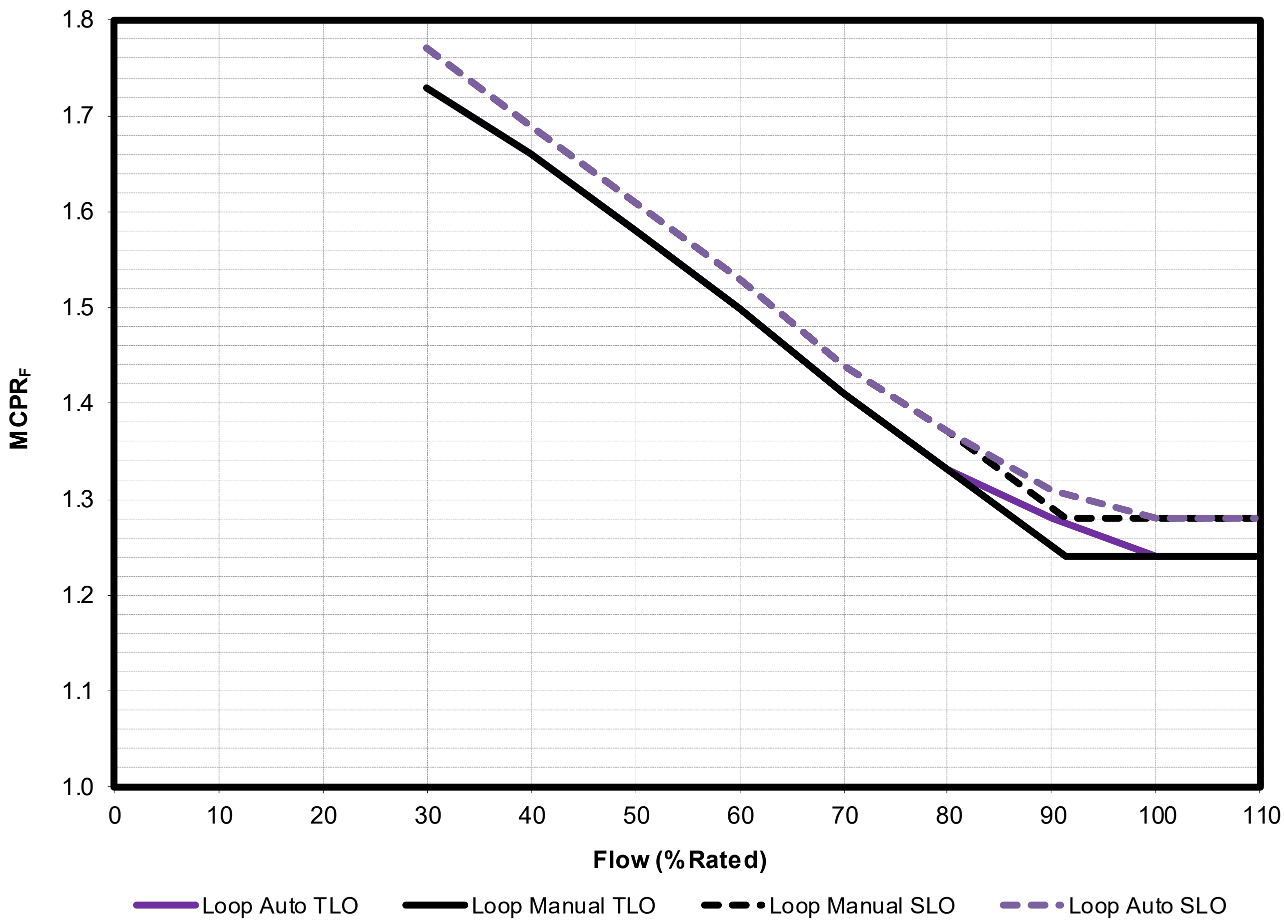


Figure 7.0.b - MCPRp limit and K(P) multiplier for Application Conditions 3, 6, and 7
Operating Limit MCPR (P) = K(P) * Operating Limit MCPR(100)
For P<23.8%: No Thermal Limits Monitoring Required, No limits specified.
For 23.8%≤P≤P(Bypass), P(Bypass)=40%
OLMCPR(P)=1.79 +0.0086*(40%-P), Flow<50%
OLMCPR(P)=1.92 +0.0154*(40%-P), Flow≥50%
For P>P(Bypass)
K(P)=1.351+0.00760*(50%-P), 40%< P ≤ 50%
K(P)=1.273+0.00390*(70%-P), 50%< P ≤ 70%
K(P)=1.227+0.00307*(85%-P), 70%< P ≤ 85%
K(P)=1.000+0.00327*(100%-P), 85%< P ≤100%
Rated MCPR Multiplier - K(P) for P>40%, OLMCPR (P) for P<Pbypass
Power (% rated)
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
20
30
40
50
60
70
80
90
100
110

**FIGURE 7.1-1** **OPERATING LIMIT MCPR VERSUS CORE FLOW ($MCPR_F$), TLO and SLO**
**APPLICATION CONDITION: 1-7**
**FUEL TYPE: GNF2 & GNF3**



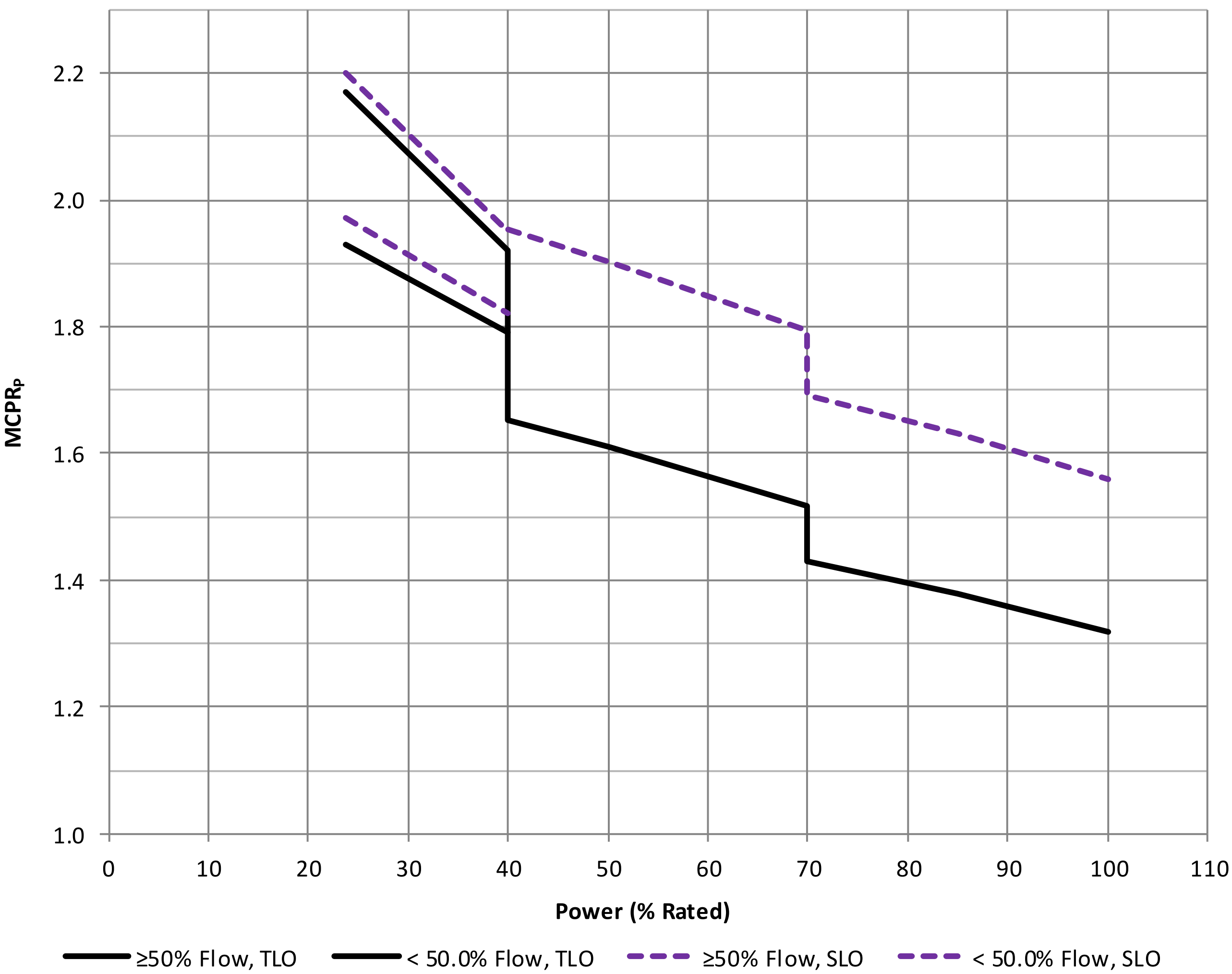

| Flow (% Rated) | Loop Manual TLO | Loop Auto TLO | Loop Manual SLO | Loop Auto SLO |
|---|---|---|---|---|
| 30.0 | 1.73 | 1.73 | 1.77 | 1.77 |
| 40.0 | 1.66 | 1.66 | 1.69 | 1.69 |
| 50.0 | 1.58 | 1.58 | 1.61 | 1.61 |
| 60.0 | 1.50 | 1.50 | 1.53 | 1.53 |
| 70.0 | 1.41 | 1.41 | 1.44 | 1.44 |
| 80.0 | 1.33 | 1.33 | 1.37 | 1.37 |
| 90.0 | | 1.28 | | 1.31 |
| 91.3 | 1.24 | | 1.28 | |
| 100.0 | 1.24 | 1.24 | 1.28 | 1.28 |
| 109.5 | 1.24 | 1.24 | 1.28 | 1.28 |

**FIGURE 7.2-1a.** **OPERATING LIMIT MCPR VERSUS CORE POWER ($MCPR_P$) for TLO and SLO**

**APPLICATION CONDITION:** **1 and 4**

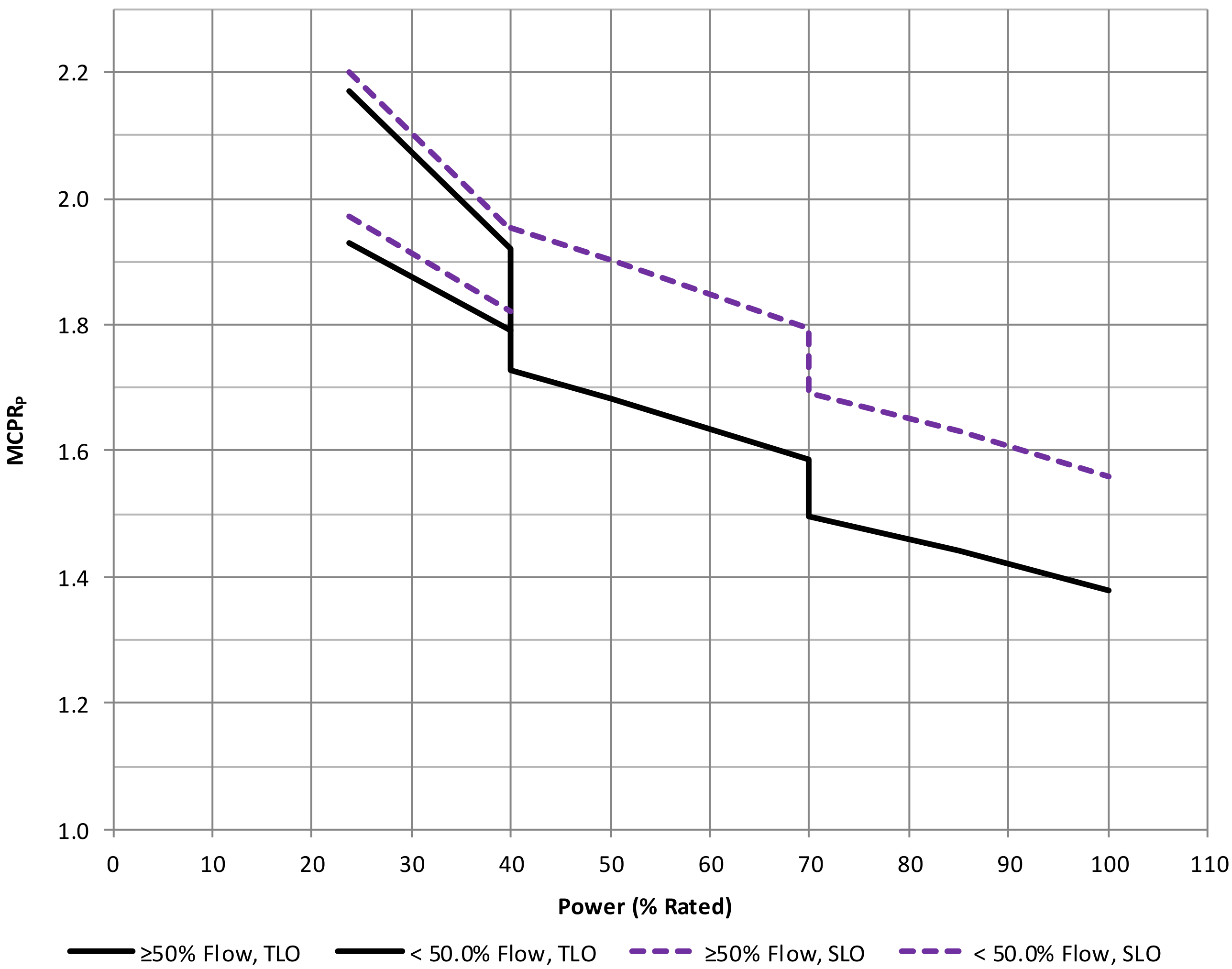
**EXPOSURE RANGE:** **BOC TO MOC**

**FUEL TYPE:** **GNF2 & GNF3**




| Power (% Rated) | < 50.0% Flow, SLO | ≥50% Flow, SLO | Power (% Rated) | < 50.0% Flow, TLO | ≥50% Flow, TLO |
|---|---|---|---|---|---|
| 23.8 | 1.97 | 2.20 | 23.8 | 1.93 | 2.17 |
| 40.0 | 1.82 | 1.95 | 40.0 | 1.79 | 1.92 |
| 40.0 | | 1.95 | 40.0 | | 1.65 |
| 50.0 | | 1.90 | 50.0 | | 1.61 |
| 70.0 | | 1.79 | 70.0 | | 1.52 |
| 70.0 | | 1.69 | 70.0 | | 1.43 |
| 85.0 | | 1.63 | 85.0 | | 1.38 |
| 85.0 | | 1.63 | 85.0 | | 1.38 |
| 100.0 | | 1.56 | 100.00 | | 1.32 |

**FIGURE 7.2-1b. OPERATING LIMIT MCPR VERSUS CORE POWER (MCPR$_P$) for TLO and SLO**
**APPLICATION CONDITION: 1 and 4**
**EXPOSURE RANGE: MOC TO EOC**
**FUEL TYPE: GNF2 & GNF3**



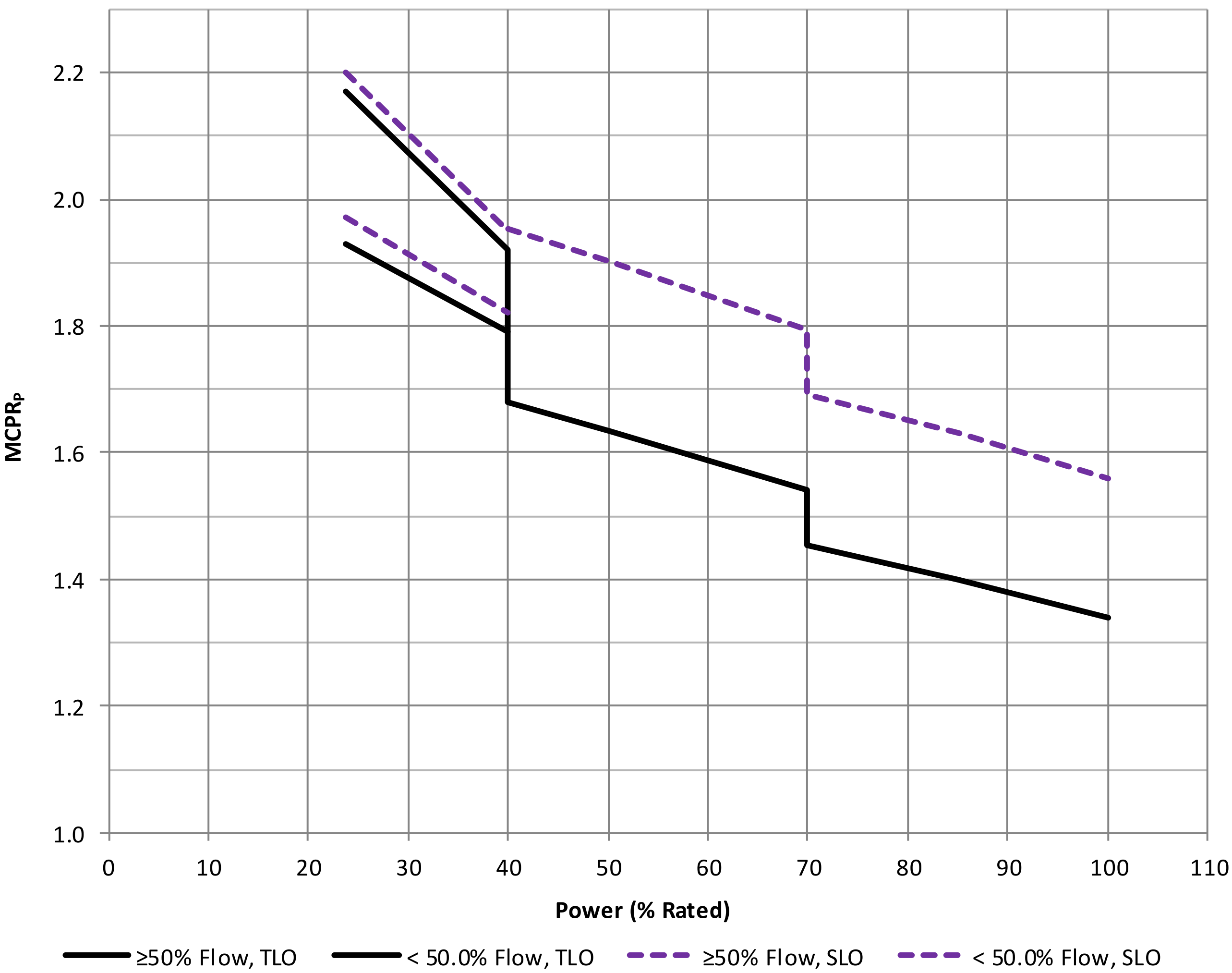

| Power (% Rated) | < 50.0% Flow, SLO | ≥50% Flow, SLO | Power (% Rated) | < 50.0% Flow, TLO | ≥50% Flow, TLO |
|---|---|---|---|---|---|
| 23.8 | 1.97 | 2.20 | 23.8 | 1.93 | 2.17 |
| 40.0 | 1.82 | 1.95 | 40.0 | 1.79 | 1.92 |
| 40.0 | | 1.95 | 40.0 | | 1.73 |
| 50.0 | | 1.90 | 50.0 | | 1.68 |
| 70.0 | | 1.79 | 70.0 | | 1.59 |
| 70.0 | | 1.69 | 70.0 | | 1.50 |
| 85.0 | | 1.63 | 85.0 | | 1.44 |
| 85.0 | | 1.63 | 85.0 | | 1.44 |
| 100.0 | | 1.56 | 100.0 | | 1.38 |

**FIGURE 7.2-2a.** **OPERATING LIMIT MCPR VERSUS CORE POWER ($MCPR_P$) for TLO and SLO**

**APPLICATION CONDITION: 2 and 5**

**EXPOSURE RANGE: BOC TO MOC**

**FUEL TYPE: GNF2 & GNF3**



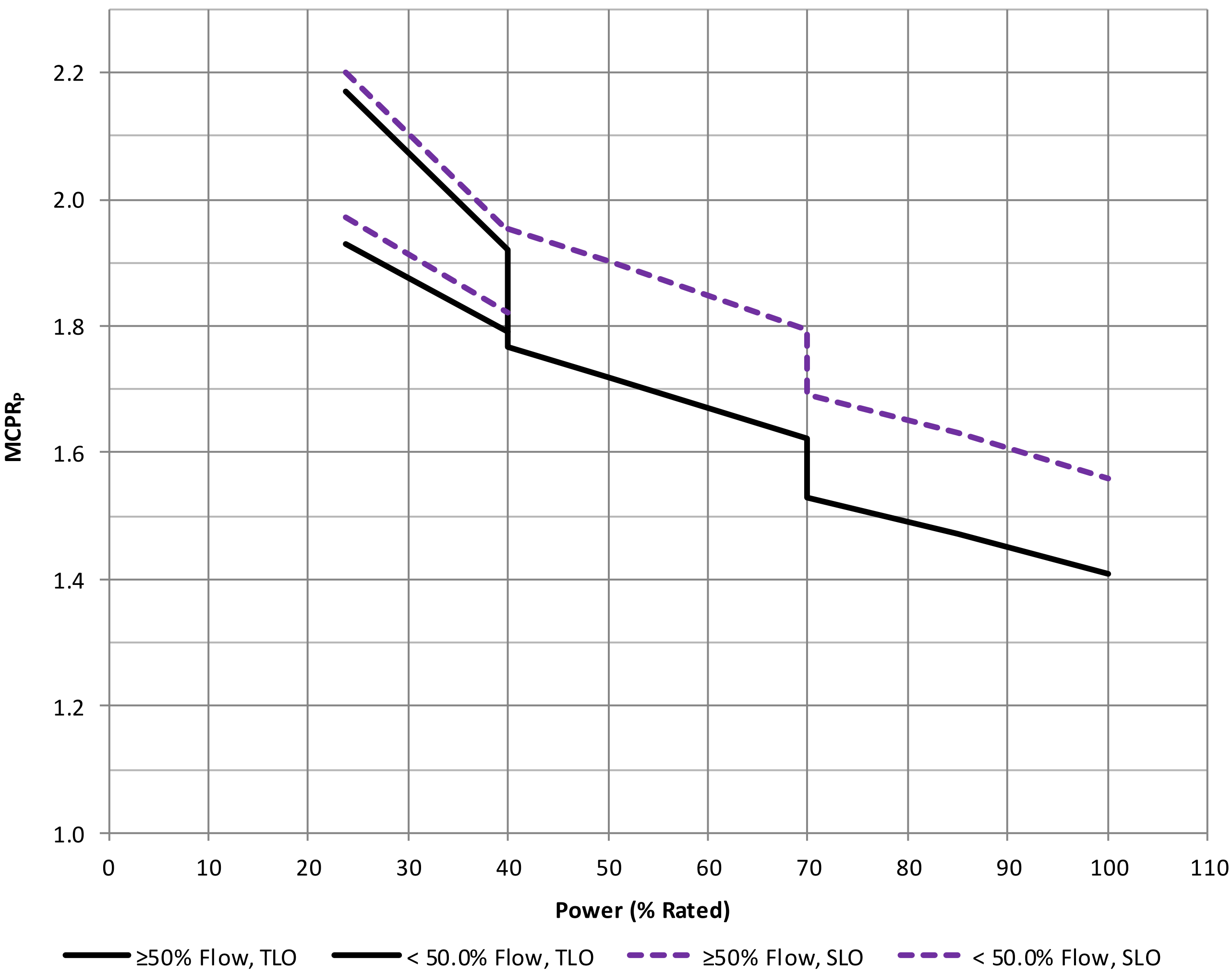

| Power (% Rated) | < 50.0% Flow, SLO | ≥50% Flow, SLO | Power (% Rated) | < 50.0% Flow, TLO | ≥50% Flow, TLO |
|---|---|---|---|---|---|
| 23.8 | 1.97 | 2.20 | 23.8 | 1.93 | 2.17 |
| 40.0 | 1.82 | 1.95 | 40.0 | 1.79 | 1.92 |
| 40.0 | | 1.95 | 40.0 | | 1.68 |
| 50.0 | | 1.90 | 50.0 | | 1.63 |
| 70.0 | | 1.79 | 70.0 | | 1.54 |
| 70.0 | | 1.69 | 70.0 | | 1.45 |
| 85.0 | | 1.63 | 85.0 | | 1.40 |
| 85.0 | | 1.63 | 85.0 | | 1.40 |
| 100.0 | | 1.56 | 100.0 | | 1.34 |

**FIGURE 7.2-2b. OPERATING LIMIT MCPR VERSUS CORE POWER ($MCPR_P$) for TLO and SLO**

**APPLICATION CONDITION: 2 and 5**

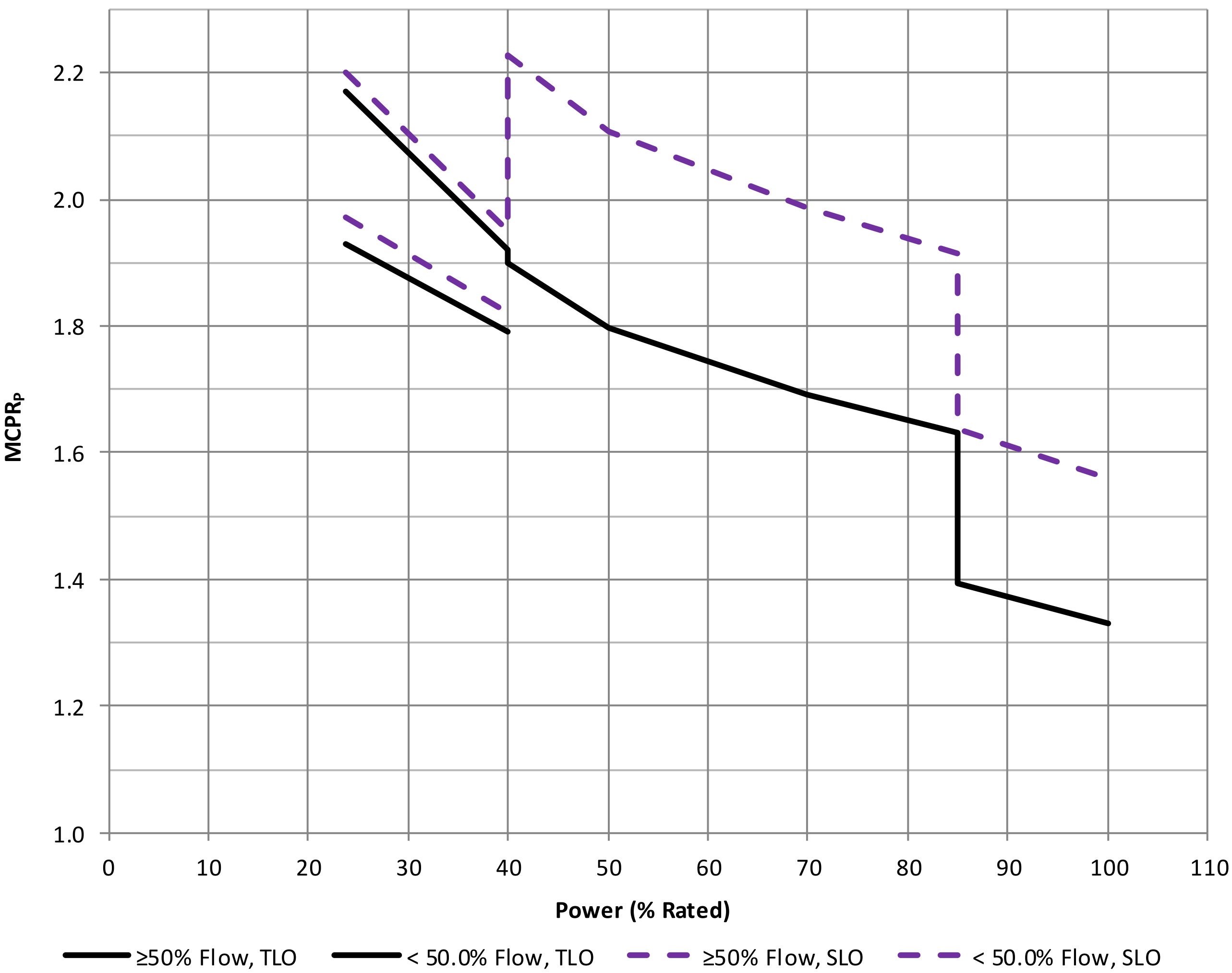
**EXPOSURE RANGE: MOC TO EOC**

**FUEL TYPE: GNF2 & GNF3**




| Power (% Rated) | < 50.0% Flow, SLO | ≥50% Flow, SLO | Power (% Rated) | < 50.0% Flow, TLO | ≥50% Flow, TLO |
|---|---|---|---|---|---|
| 23.8 | 1.97 | 2.20 | 23.8 | 1.93 | 2.17 |
| 40.0 | 1.82 | 1.95 | 40.0 | 1.79 | 1.92 |
| 40.0 | | 1.95 | 40.0 | | 1.77 |
| 50.0 | | 1.90 | 50.0 | | 1.72 |
| 70.0 | | 1.79 | 70.0 | | 1.62 |
| 70.0 | | 1.69 | 70.0 | | 1.53 |
| 85.0 | | 1.63 | 85.0 | | 1.47 |
| 85.0 | | 1.63 | 85.0 | | 1.47 |
| 100.0 | | 1.56 | 100.0 | | 1.41 |

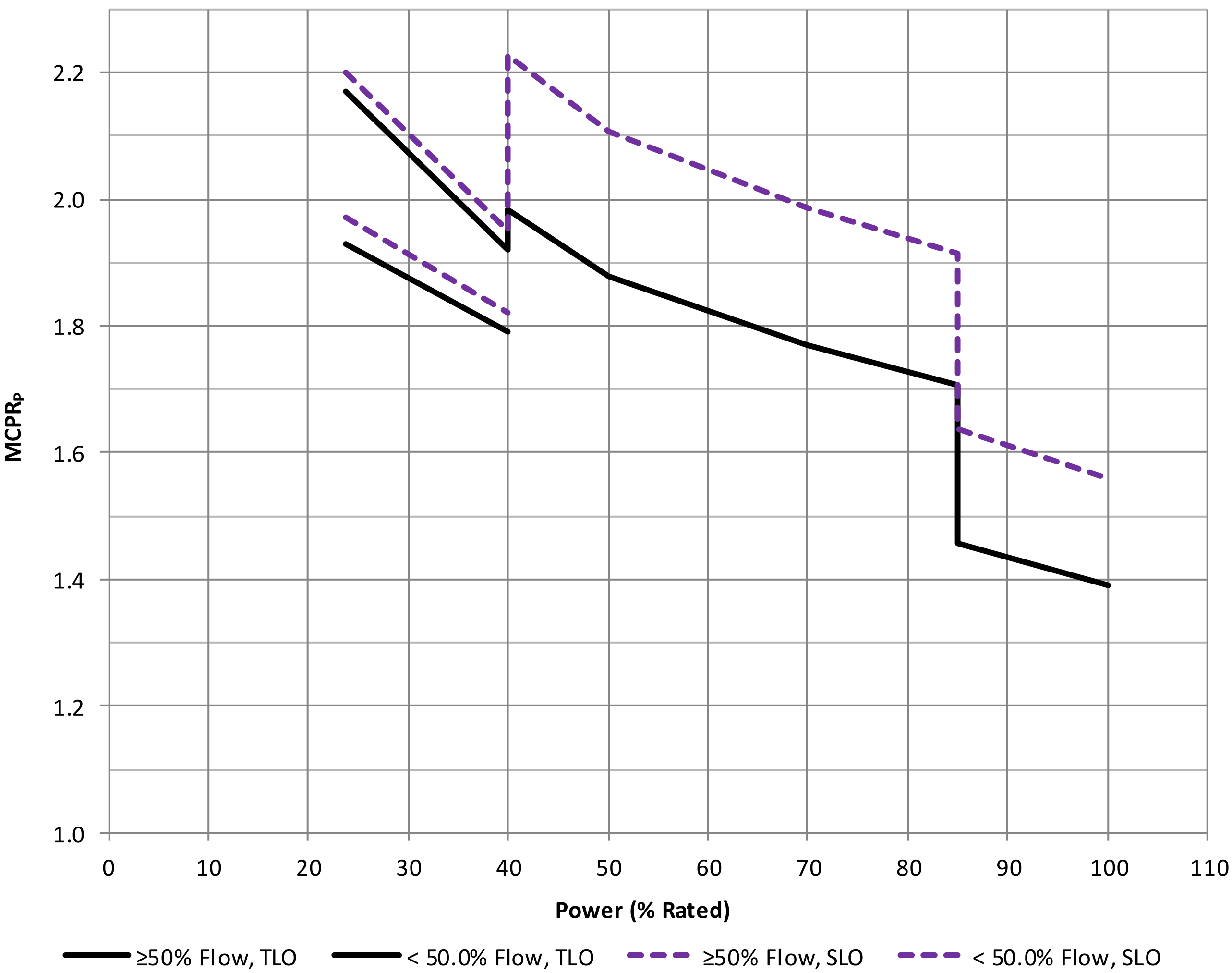
**FIGURE 7.2-3a.** **OPERATING LIMIT MCPR VERSUS CORE POWER ($MCPR_P$) for TLO and SLO**
**APPLICATION CONDITION: 3 and 6**
**EXPOSURE RANGE: BOC TO MOC**
**FUEL TYPE: GNF2 & GNF3**




| Power (% Rated) | < 50.0% Flow, SLO | ≥50% Flow, SLO | Power (% Rated) | < 50.0% Flow, TLO | ≥50% Flow, TLO |
|---|---|---|---|---|---|
| 23.8 | 1.97 | 2.20 | 23.8 | 1.93 | 2.17 |
| 40.0 | 1.82 | 1.95 | 40.0 | 1.79 | 1.92 |
| 40.0 | | 2.23 | 40.0 | | 1.90 |
| 50.0 | | 2.11 | 50.0 | | 1.80 |
| 70.0 | | 1.99 | 70.0 | | 1.69 |
| 70.0 | | 1.99 | 70.0 | | 1.69 |
| 85.0 | | 1.91 | 85.0 | | 1.63 |
| 85.0 | | 1.64 | 85.0 | | 1.40 |
| 100.0 | | 1.56 | 100.0 | | 1.33 |

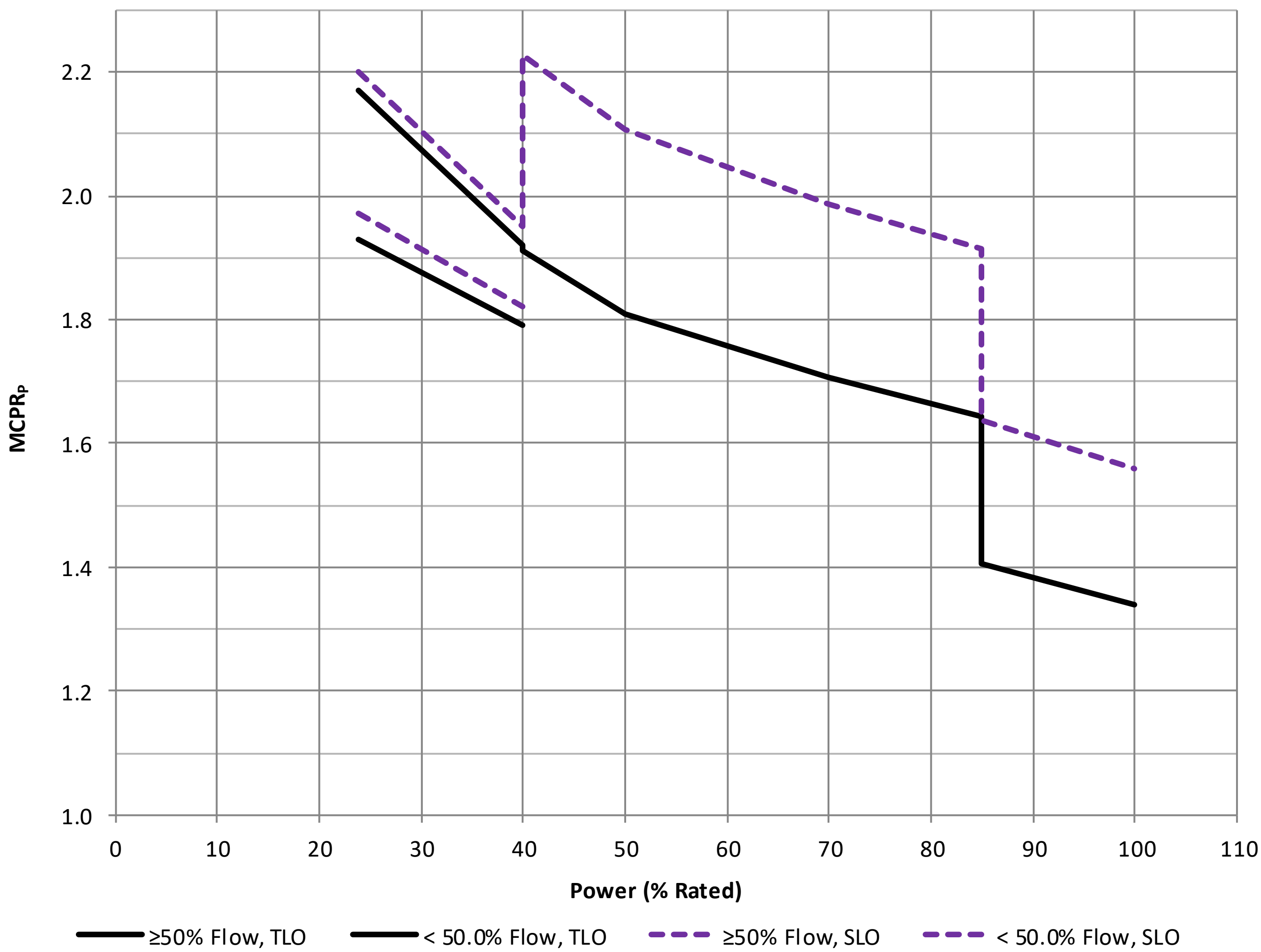
**FIGURE 7.2-3b.** **OPERATING LIMIT MCPR VERSUS CORE POWER ($MCPR_P$) for TLO and SLO**

**APPLICATION CONDITION:** 3 and 6
**EXPOSURE RANGE:** MOC TO EOC
**FUEL TYPE:** GNF2 & GNF3




| Power (% Rated) | < 50.0% Flow, SLO | ≥50% Flow, SLO | Power (% Rated) | < 50.0% Flow, TLO | ≥50% Flow, TLO |
|---|---|---|---|---|---|
| 23.8 | 1.97 | 2.20 | 23.8 | 1.93 | 2.17 |
| 40.0 | 1.82 | 1.95 | 40.0 | 1.79 | 1.92 |
| 40.0 | | 2.23 | 40.0 | | 1.98 |
| 50.0 | | 2.11 | 50.0 | | 1.88 |
| 70.0 | | 1.99 | 70.0 | | 1.77 |
| 70.0 | | 1.99 | 70.0 | | 1.77 |
| 85.0 | | 1.91 | 85.0 | | 1.71 |
| 85.0 | | 1.64 | 85.0 | | 1.46 |
| 100.0 | | 1.56 | 100.0 | | 1.39 |

FIGURE 7.2-4a. OPERATING LIMIT MCPR VERSUS CORE POWER (MCPR$_P$) for TLO and SLO
APPLICATION CONDITION: 7
EXPOSURE RANGE: BOC TO MOC
FUEL TYPE: GNF2 & GNF3



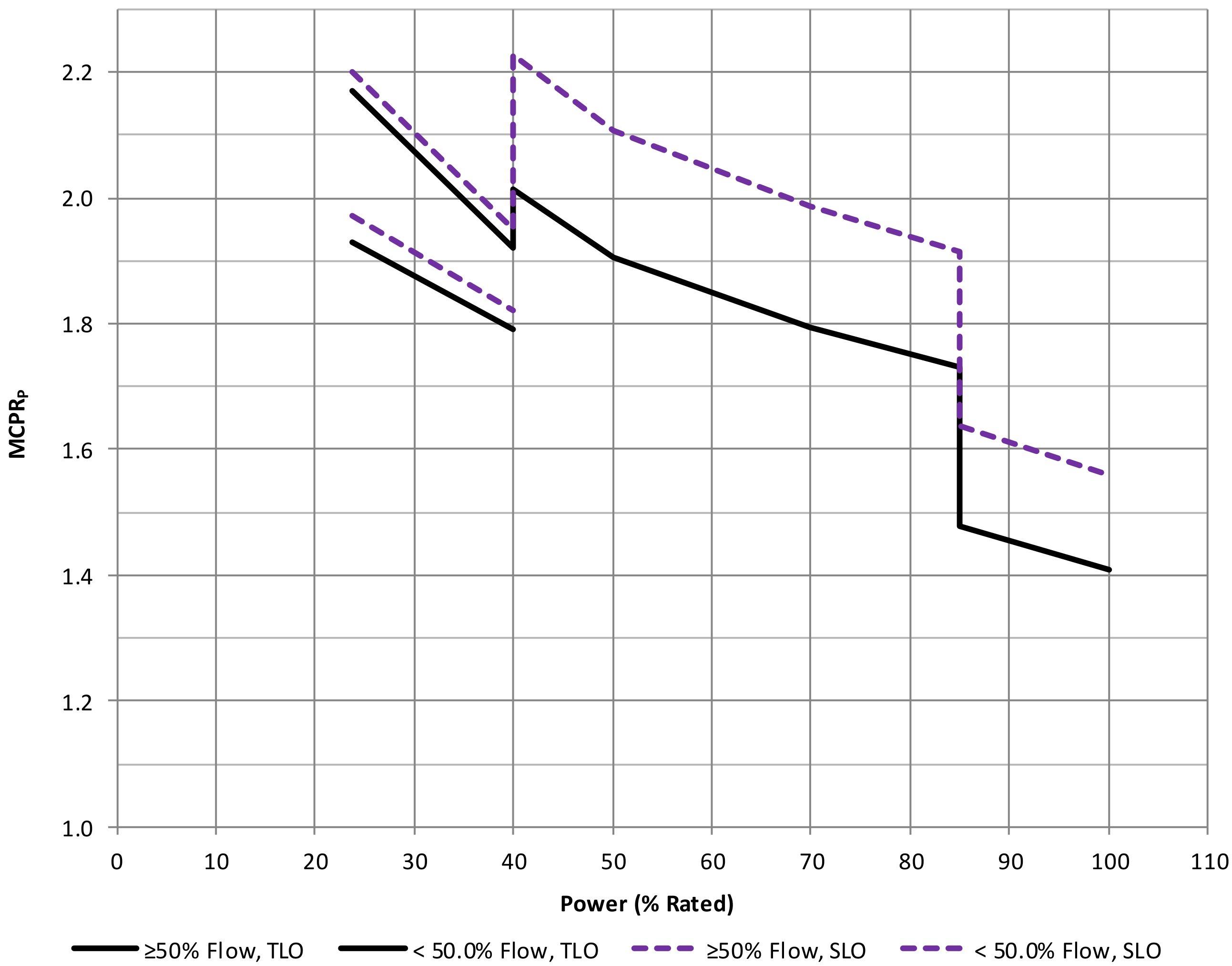

| Power (% Rated) | < 50.0% Flow, SLO | ≥50% Flow, SLO | Power (% Rated) | < 50.0% Flow, TLO | ≥50% Flow, TLO |
|---|---|---|---|---|---|
| 23.8 | 1.97 | 2.20 | 23.8 | 1.93 | 2.17 |
| 40.0 | 1.82 | 1.95 | 40.0 | 1.79 | 1.92 |
| 40.0 | | 2.23 | 40.0 | | 1.91 |
| 50.0 | | 2.11 | 50.0 | | 1.81 |
| 70.0 | | 1.99 | 70.0 | | 1.71 |
| 70.0 | | 1.99 | 70.0 | | 1.71 |
| 85.0 | | 1.91 | 85.0 | | 1.64 |
| 85.0 | | 1.64 | 85.0 | | 1.41 |
| 100.0 | | 1.56 | 100.0 | | 1.34 |

**FIGURE 7.2-4b. OPERATING LIMIT MCPR VERSUS CORE POWER (MCPR$_P$) for TLO and SLO**

**APPLICATION CONDITION: 7**

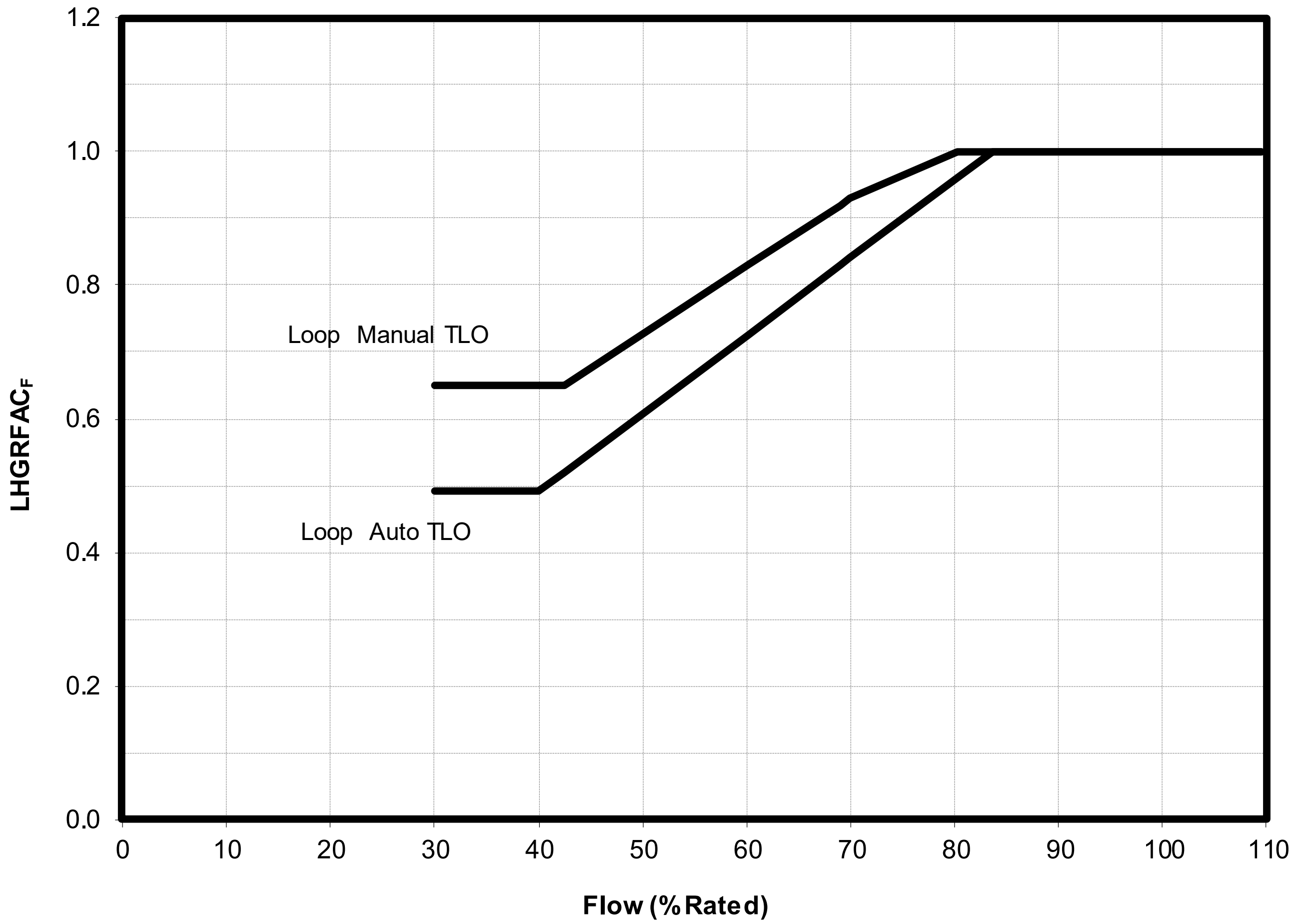
**EXPOSURE RANGE: MOC TO EOC**

**FUEL TYPE: GNF2 & GNF3**



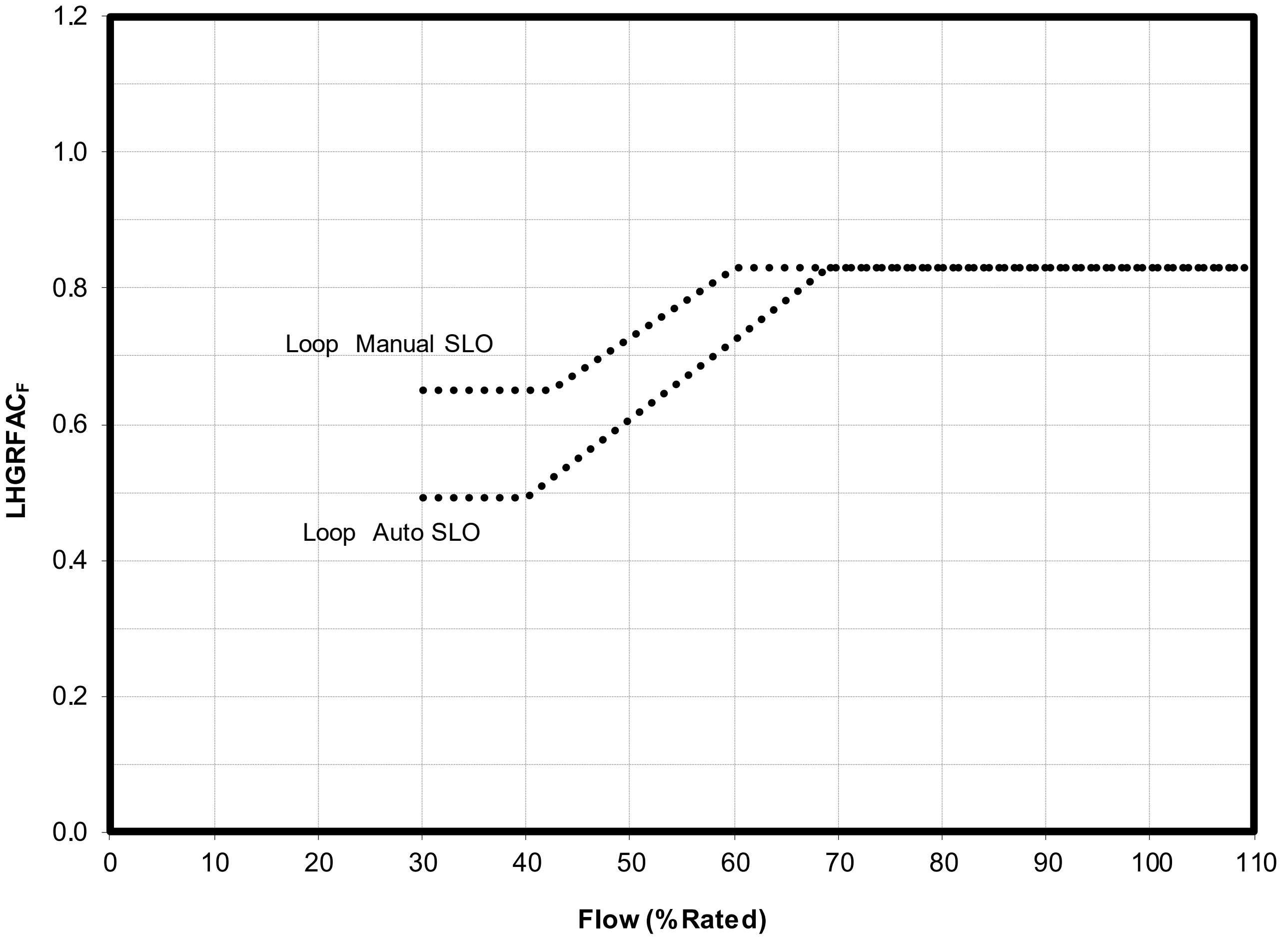

| Power (% Rated) | < 50.0% Flow, SLO | ≥50% Flow, SLO | Power (% Rated) | < 50.0% Flow, TLO | ≥50% Flow, TLO |
|---|---|---|---|---|---|
| 23.8 | 1.97 | 2.20 | 23.8 | 1.93 | 2.17 |
| 40.0 | 1.82 | 1.95 | 40.0 | 1.79 | 1.92 |
| 40.0 | | 2.23 | 40.0 | | 2.01 |
| 50.0 | | 2.11 | 50.0 | | 1.90 |
| 70.0 | | 1.99 | 70.0 | | 1.79 |
| 70.0 | | 1.99 | 70.0 | | 1.79 |
| 85.0 | | 1.91 | 85.0 | | 1.73 |
| 85.0 | | 1.64 | 85.0 | | 1.48 |
| 100.0 | | 1.56 | 100.0 | | 1.41 |

**FIGURE 8.2-1a.** **LHGRFAC MULTIPLIER VERSUS CORE Flow (LHGRFAC$_F$), TLO**
**APPLICATION CONDITION: 1-7**
**FUEL TYPE: GNF2 & GNF3 TLO**




| Flow (% Rated) | Loop Manual | Loop Auto |
|---|---|---|
| 30.0 | 0.650 | 0.491 |
| 40.0 | 0.650 | 0.491 |
| 42.4 | 0.650 | 0.519 |
| 60.1 | 0.830 | 0.726 |
| 69.1 | 0.921 | 0.830 |
| 70.0 | 0.930 | 0.841 |
| 80.3 | 1.000 | 0.961 |
| 83.7 | 1.000 | 1.000 |
| 100.0 | 1.000 | 1.000 |
| 109.5 | 1.000 | 1.000 |

**FIGURE 8.2-1b.** **LHGRFAC MULTIPLIER VERSUS CORE Flow (LHGRFAC$_F$), SLO**
**APPLICATION CONDITION:** **1-7**
**FUEL TYPE:** **GNF2 & GNF3 SLO**



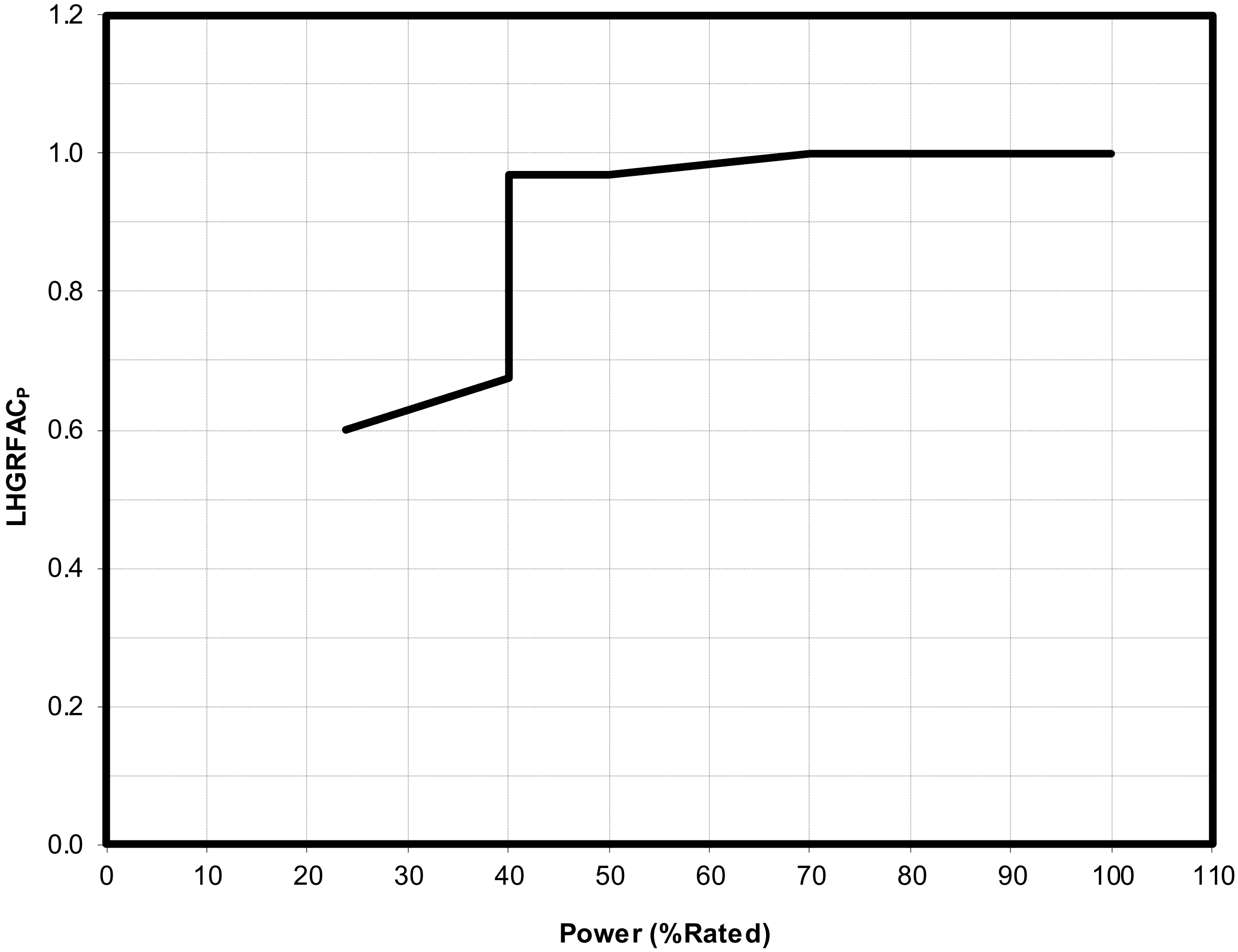

| Flow (% Rated) | Loop Manual | Loop Auto |
|---|---|---|
| 30.0 | 0.650 | 0.491 |
| 40.0 | 0.650 | 0.491 |
| 42.4 | 0.650 | 0.519 |
| 60.1 | 0.830 | 0.726 |
| 69.1 | 0.830 | 0.830 |
| 70.0 | 0.830 | 0.830 |
| 80.3 | 0.830 | 0.830 |
| 83.7 | 0.830 | 0.830 |
| 100.0 | 0.830 | 0.830 |
| 109.5 | 0.830 | 0.830 |

FIGURE 8.3-1a. LHGRFAC MULTIPLIER VERSUS CORE POWER ($LHGRFAC_P$), TLO+SLO

APPLICATION CONDITION: 1, 2, 4, and 5

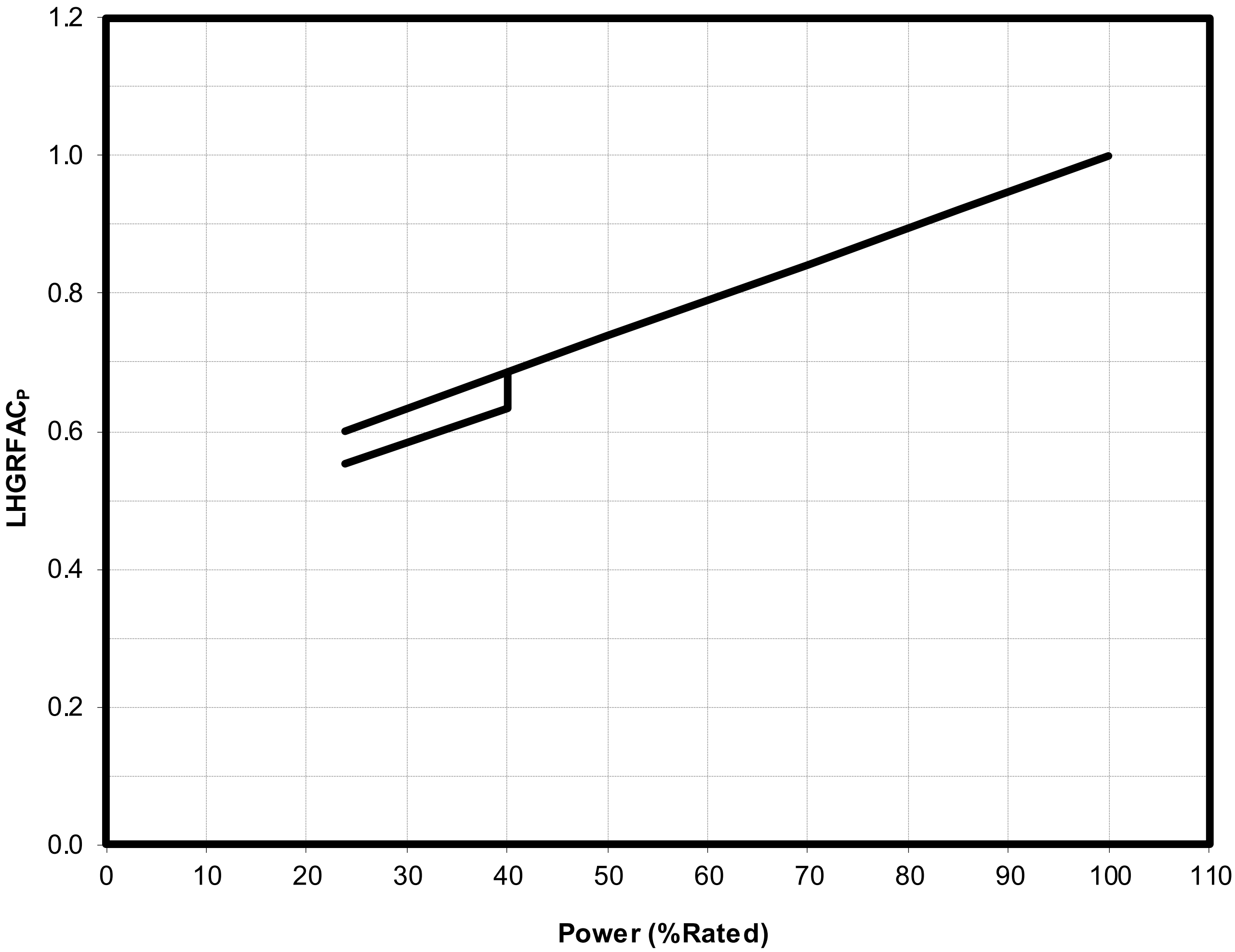
EXPOSURE RANGE: BOC-EOC

FUEL TYPE: GNF2



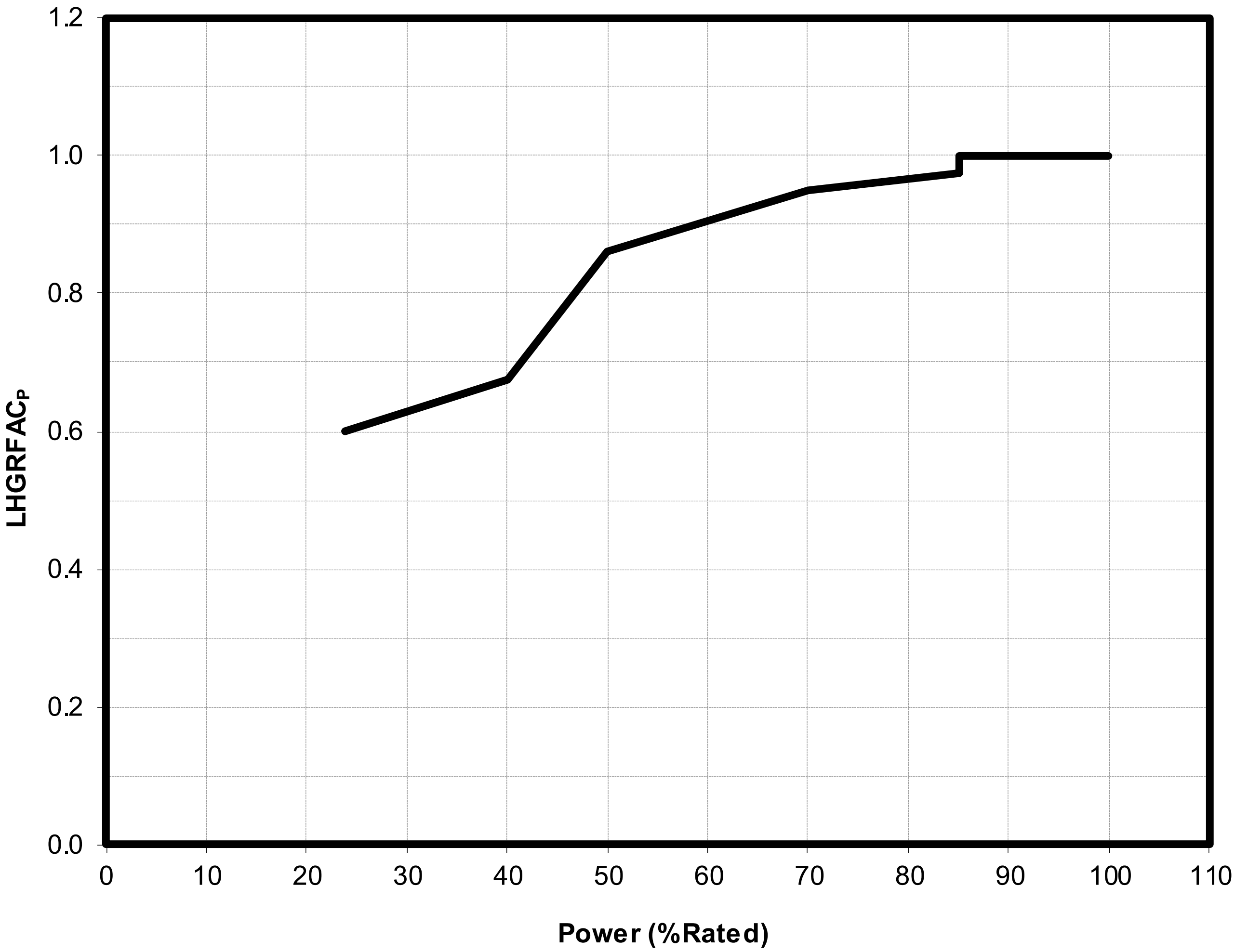

| Power (% Rated) | <50.0% Flow | ≥50% Flow |
|---|---|---|
| 23.8 | 0.600 | 0.600 |
| 40.0 | 0.675 | 0.675 |
| 40.0 | | 0.970 |
| 50.0 | | 0.970 |
| 70.0 | | 1.000 |
| 85.0 | | 1.000 |
| 85.0 | | 1.000 |
| 100.0 | | 1.000 |

FIGURE 8.3-1b. LHGRFAC MULTIPLIER VERSUS CORE POWER ($LHGRFAC_P$), TLO+SLO
APPLICATION CONDITION: 1, 2, 4, and 5
EXPOSURE RANGE: BOC-EOC
FUEL TYPE: GNF3



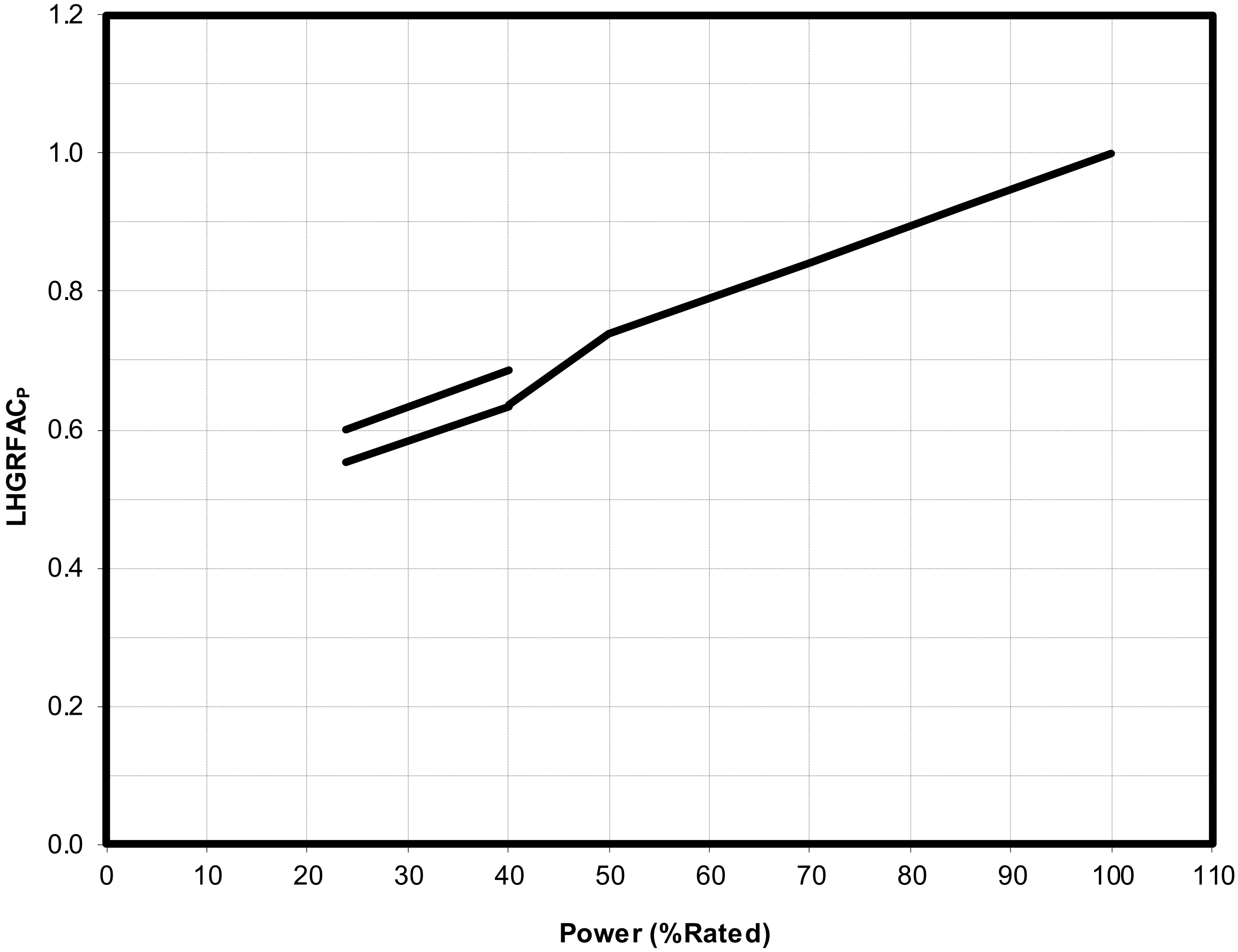

| Power (% Rated) | <50.0% Flow | ≥50% Flow |
|---|---|---|
| 23.8 | 0.601 | 0.552 |
| 40.0 | 0.687 | 0.634 |
| 40.0 | | 0.687 |
| 50.0 | | 0.739 |
| 70.0 | | 0.843 |
| 85.0 | | 0.922 |
| 85.0 | | 0.922 |
| 100.0 | | 1.000 |

**FIGURE 8.3-2a.** **LHGRFAC MULTIPLIER VERSUS CORE POWER (LHGRFAC$_P$), TLO+SLO**
**APPLICATION CONDITION: 3, 6, and 7**
**EXPOSURE RANGE: BOC-EOC**
**FUEL TYPE: GNF2**




| Power (% Rated) | <50.0% Flow | ≥50% Flow |
|---|---|---|
| 23.8 | 0.600 | 0.600 |
| 40.0 | 0.675 | 0.675 |
| 40.0 | | 0.675 |
| 50.0 | | 0.860 |
| 70.0 | | 0.950 |
| 85.0 | | 0.975 |
| 85.0 | | 1.000 |
| 100.0 | | 1.000 |

**FIGURE 8.3-2b.** **LHGRFAC MULTIPLIER VERSUS CORE POWER ($LHGRFAC_P$), TLO+SLO**
**APPLICATION CONDITION:** **3, 6, and 7**
**EXPOSURE RANGE:** **BOC-EOC**
**FUEL TYPE:** **GNF3**




| Power (% Rated) | <50.0% Flow | ≥50% Flow |
|---|---|---|
| 23.8 | 0.601 | 0.552 |
| 40.0 | 0.687 | 0.634 |
| 40.0 | | 0.635 |
| 50.0 | | 0.739 |
| 70.0 | | 0.843 |
| 85.0 | | 0.922 |
| 85.0 | | 0.922 |
| 100.0 | | 1.000 |

**Figure 9.1-1: Monitored Region Boundary (Case 1)**

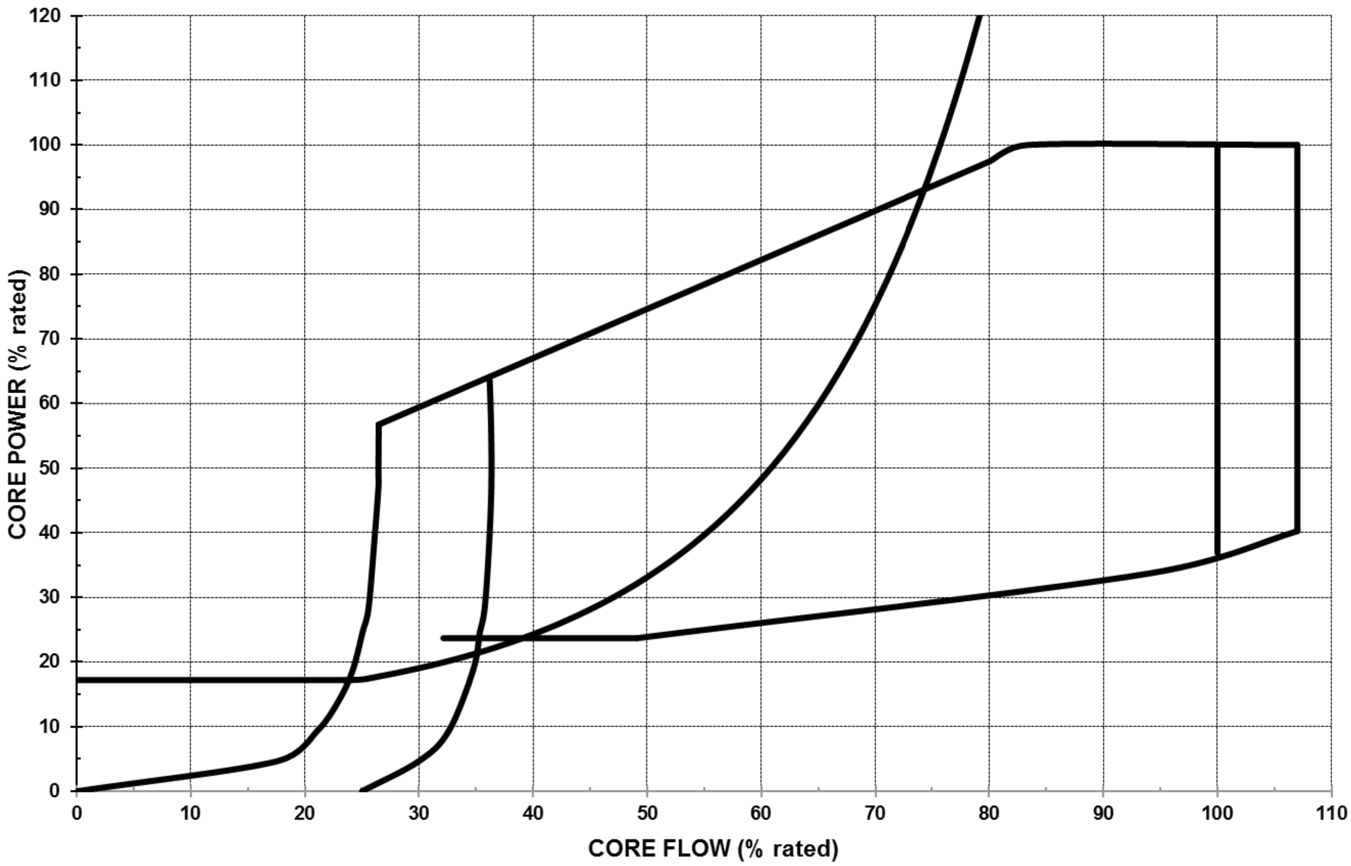


**Figure 9.1-2: Monitored Region Boundary (Case 2)**

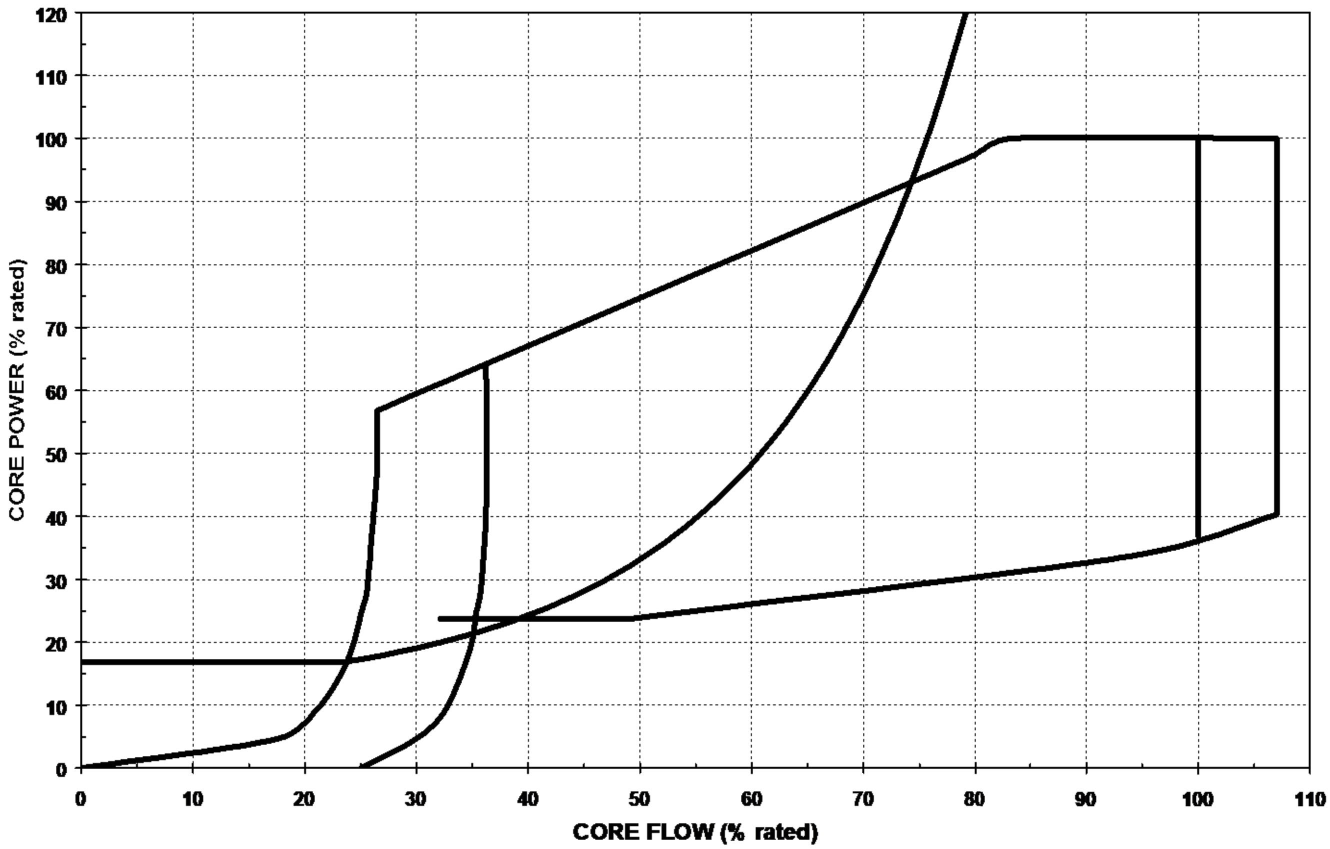


**Figure 9.1-3: APRM Flow Biased Simulated Thermal Power – High Scram Setpoints and Restricted Region Boundary (Two Recirculation Loop Operation – Case 1)**

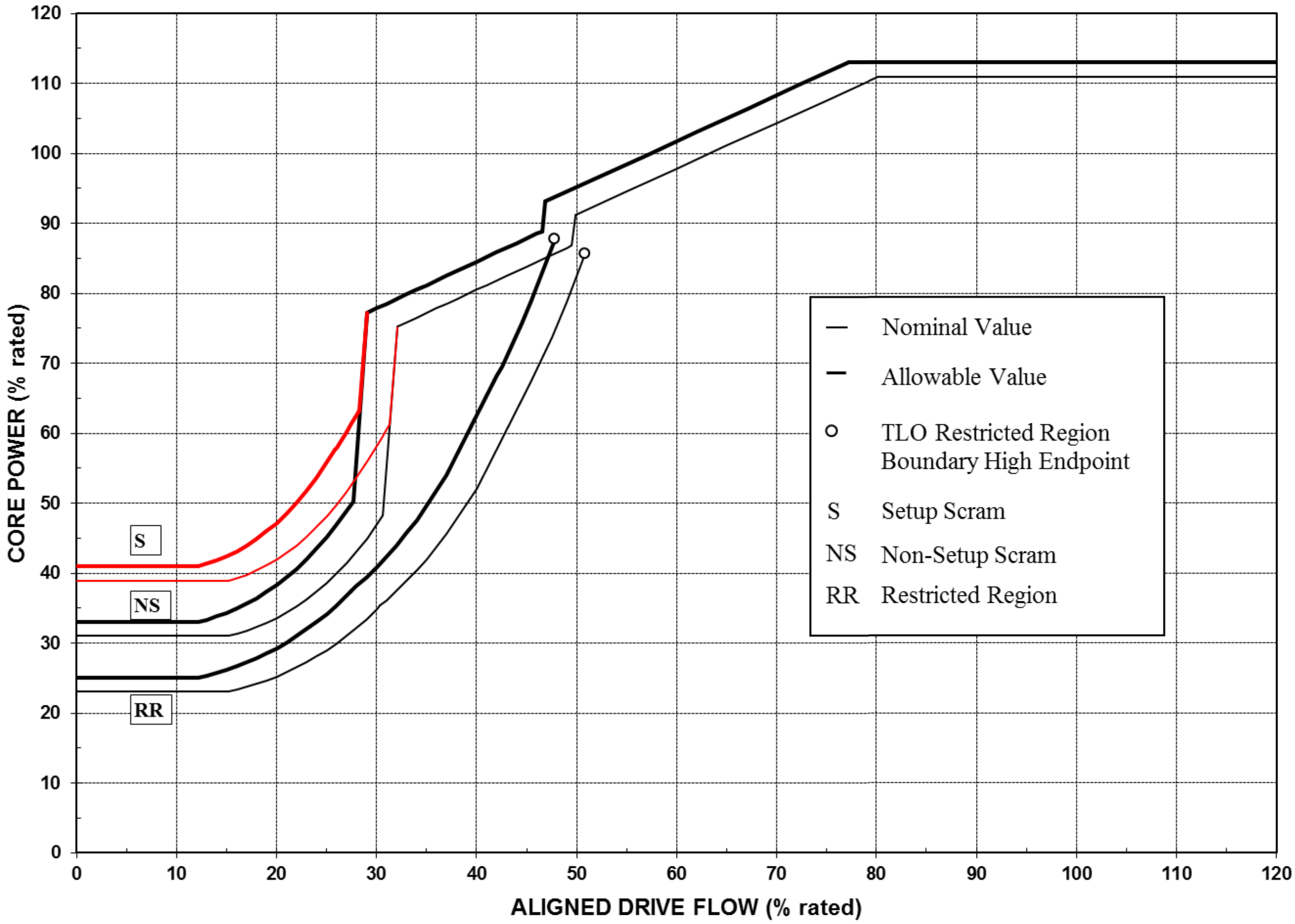


**Figure 9.1-4: APRM Flow Biased Simulated Thermal Power – High Scram Setpoints and Restricted Region Boundary (Two Recirculation Loop Operation – Case 2)**

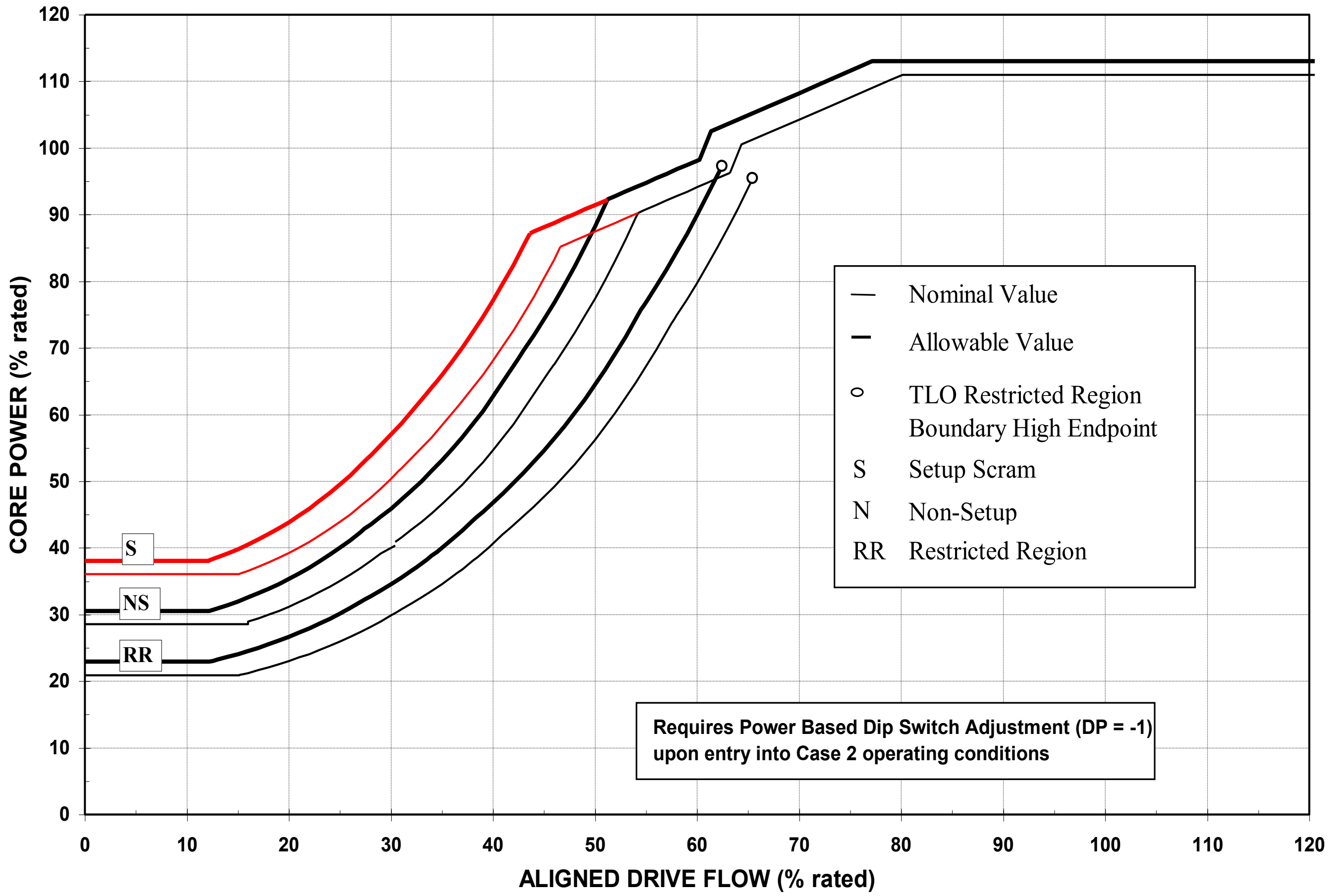


**Figure 9.1-5: APRM Flow Biased Simulated Thermal Power – High Scram Setpoints and Restricted Region Boundary (Single Recirculation Loop Operation – Case 1)**

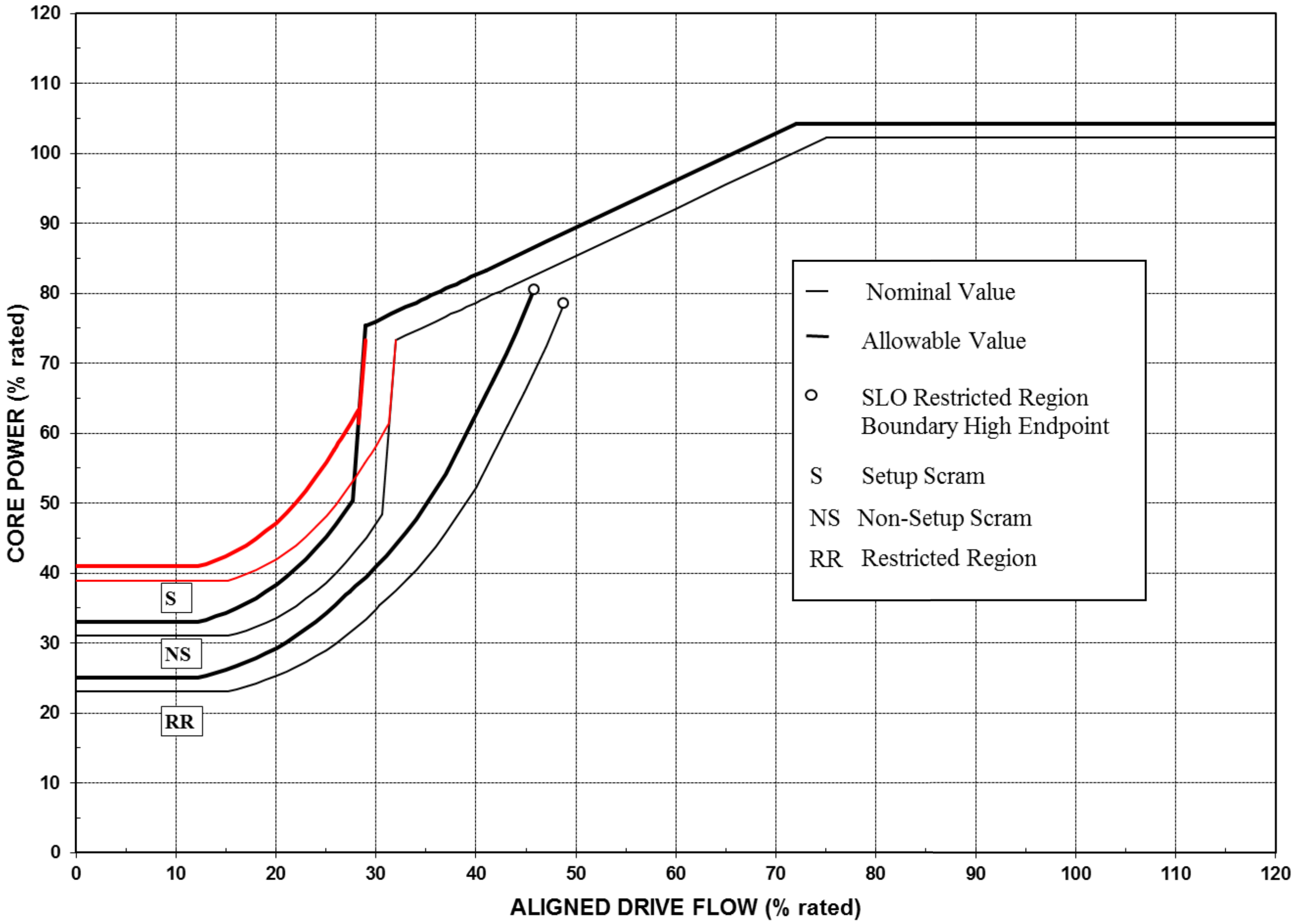


**Figure 9.1-6: APRM Flow Biased Simulated Thermal Power – High Scram Setpoints and Restricted Region Boundary (Single Recirculation Loop Operation – Case 2)**

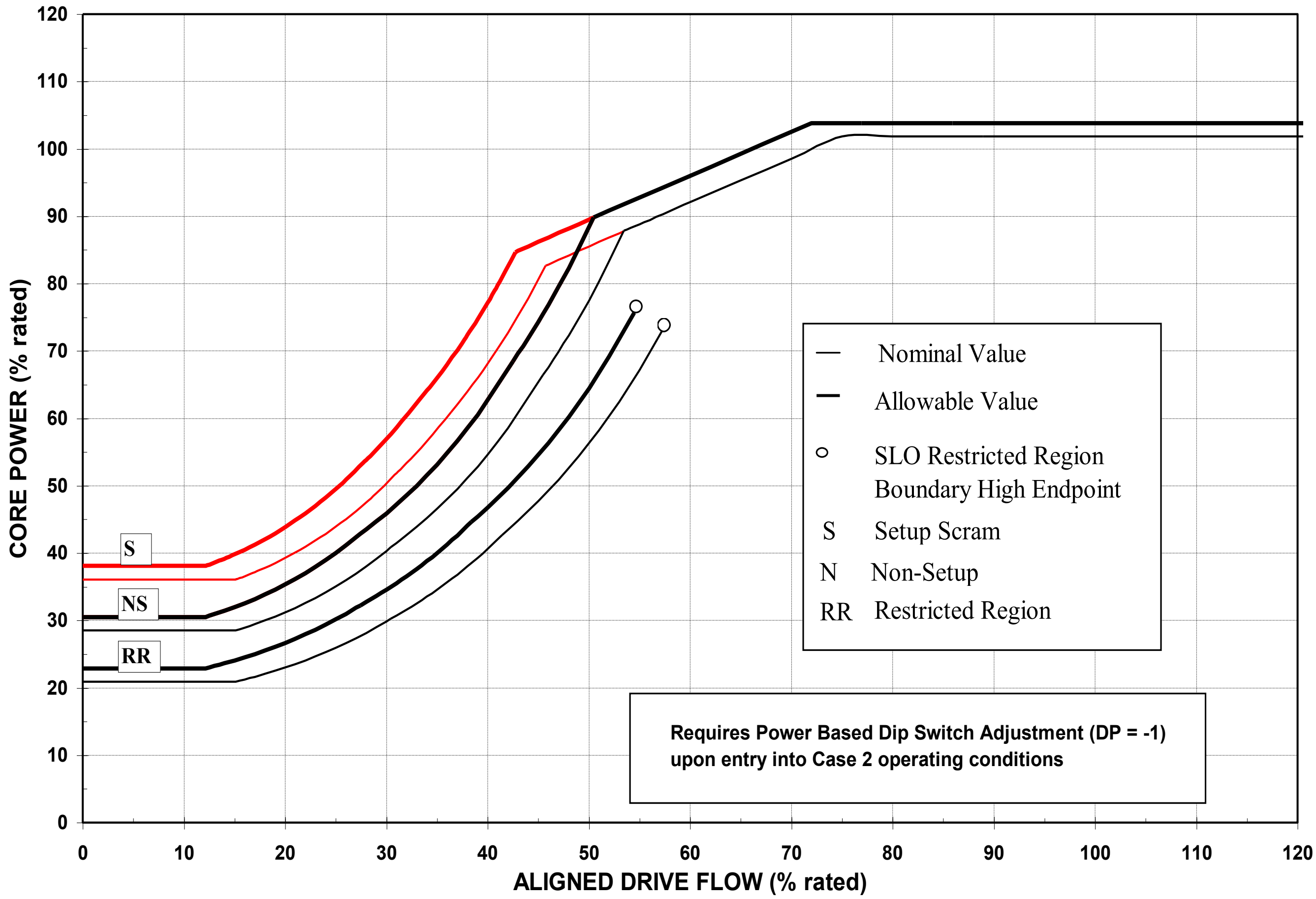


**Figure 9.1-7: APRM Flow Biased Neutron Flux - High Rod-Block Setpoints (Two Recirculation Loop Operation – Case 1)**

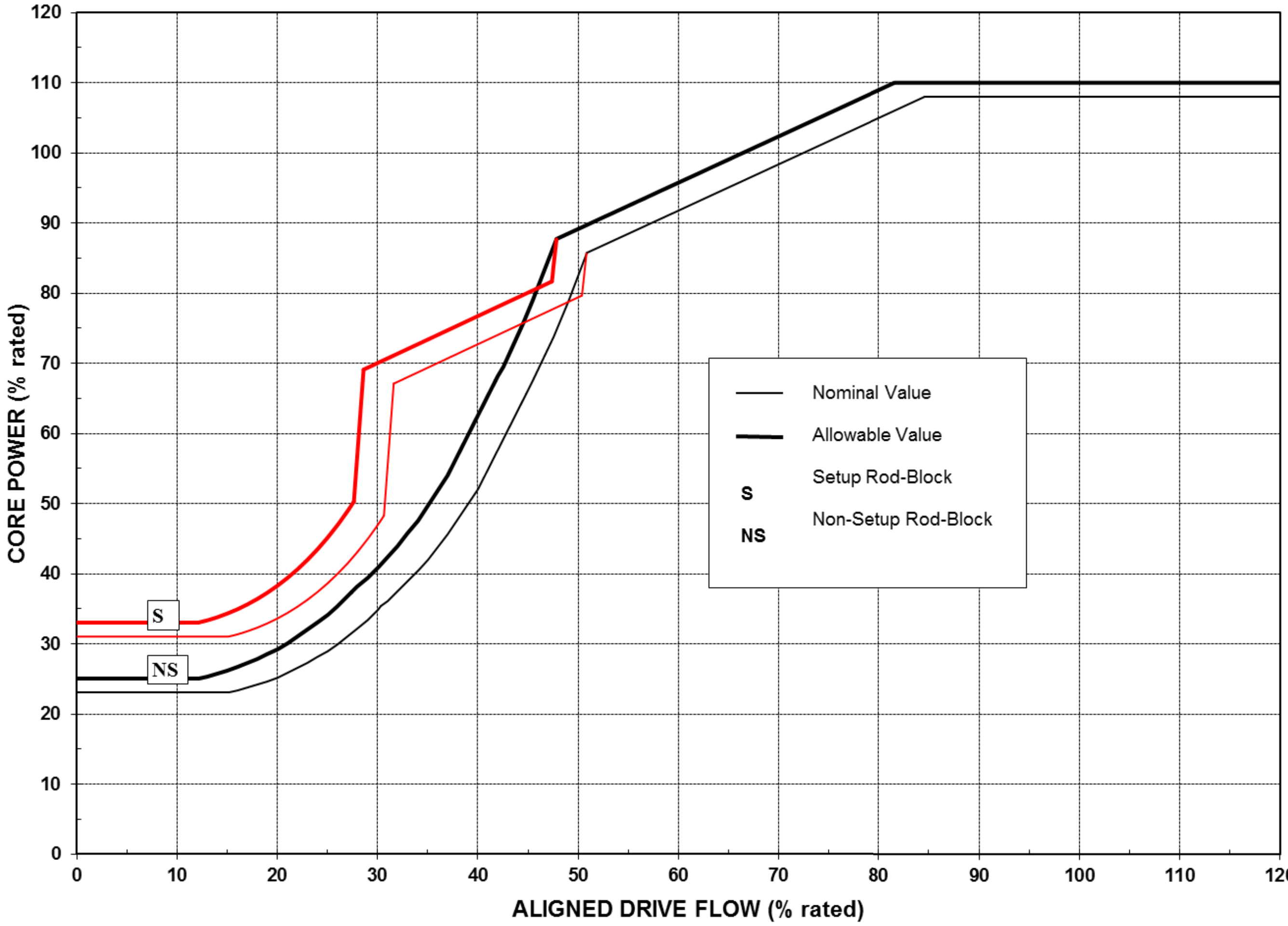


**Figure 9.1-8: APRM Flow Biased Neutron Flux - High Rod-Block Setpoints (Two Recirculation Loop Operation – Case 2)**

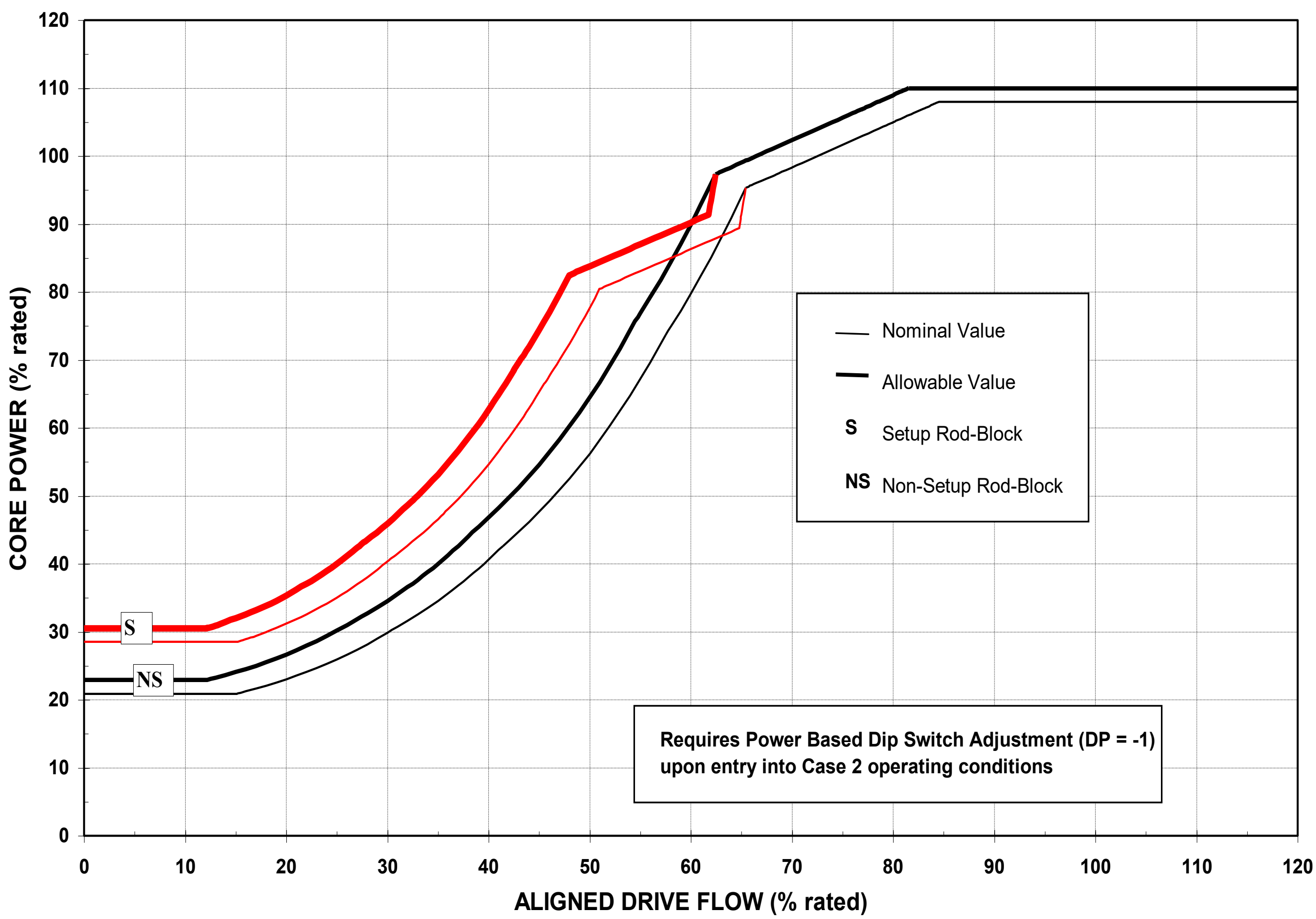


**Figure 9.1-9: APRM Flow Biased Neutron Flux - High Rod-Block Setpoints (Single Recirculation Loop Operation – Case 1)**

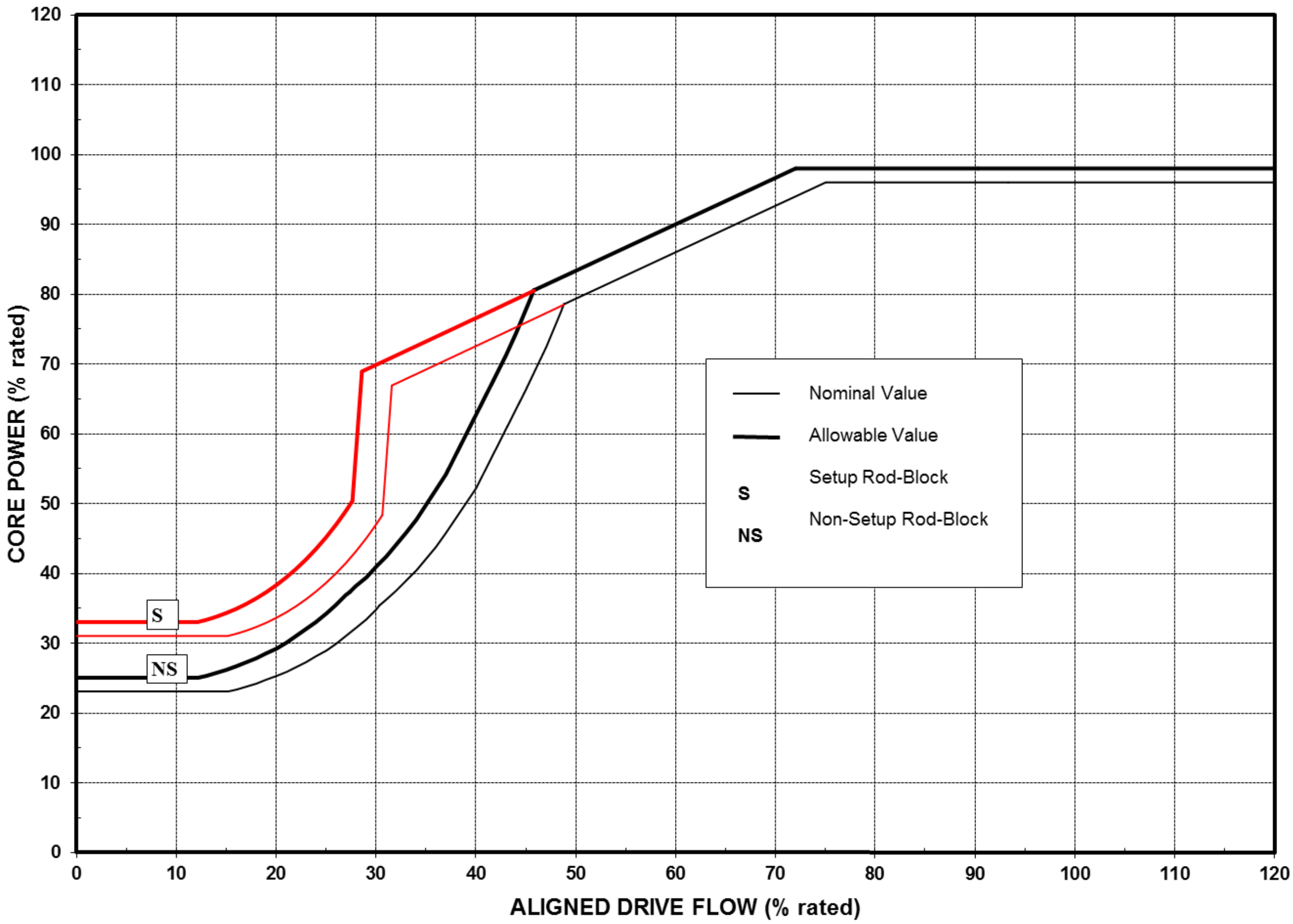
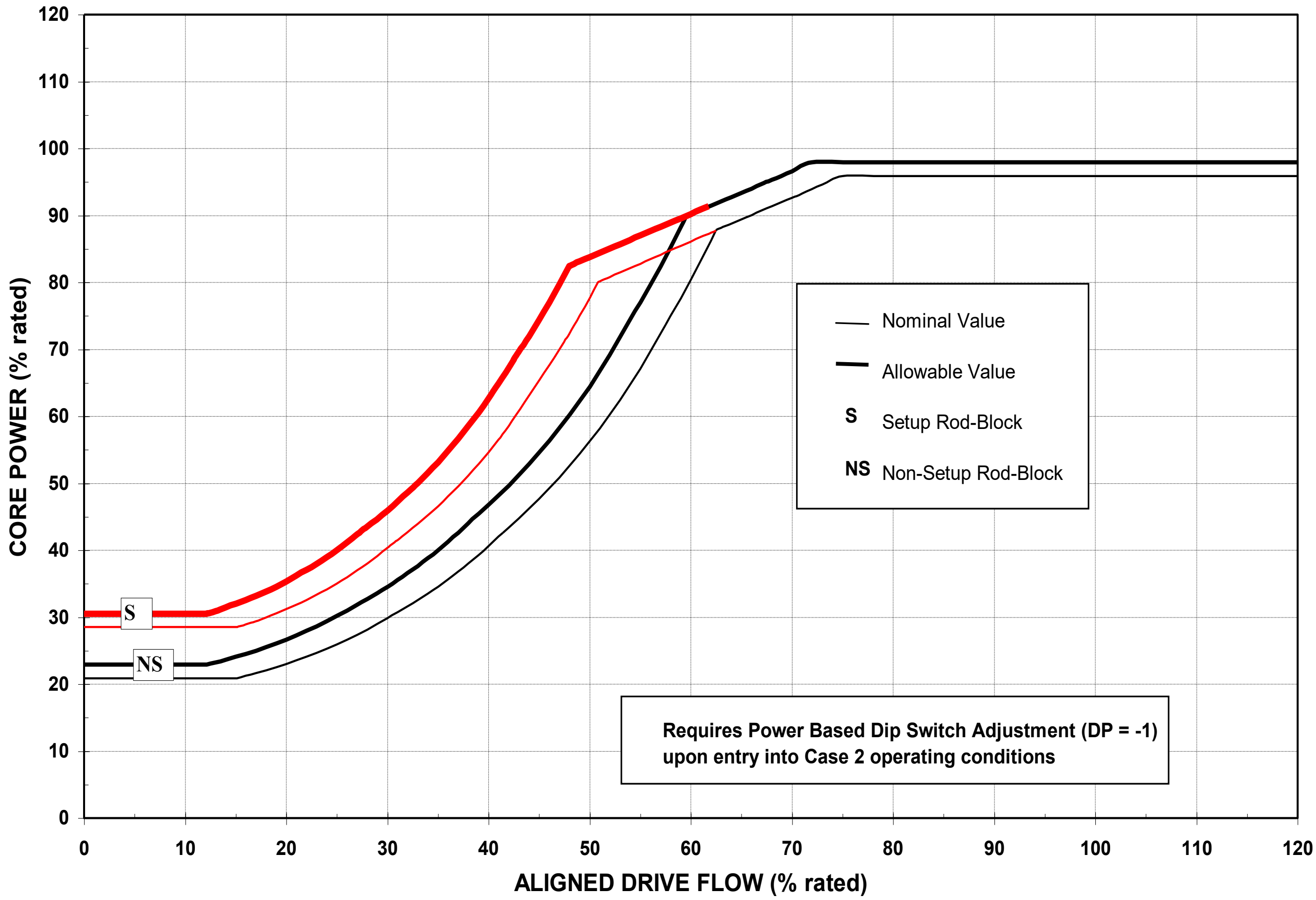


**Figure 9.1-10: APRM Flow Biased Neutron Flux - High Rod-Block Setpoints (Single Recirculation Loop Operation – Case 2)**



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